THE INDUSTRIAL SELF-INSTRUCTOR.

THE

INDUSTRIAL SELF-INSTRUCTOR

AND TECHNICAL JOURNAL.

CONTAINING INSTRUCTIONS IN

The Leading Branches of Technical Science and Industrial Arts and Processes.

COMPRISING

BUILDING AND MECHANICAL DESIGN AND CONSTRUCTION— MATERIALS USED IN THE ARTS AND SCIENCES— MANUFACTURES—CHEMICAL INDUSTRY— ART MANUFACTURES—RURAL WORK— TECHNICAL DRAWING AND DESIGN;

WITH PRACTICAL USEFUL AND TECHNICAL NOTES, FACTS, AND FIGURES, FOR READY REFERENCE.

BY NUMEROUS PRACTICAL WRITERS AND TECHNICAL EXPERTS

Profusely Illustrated

WITH

WORKING DRAWINGS, DESIGNS, AND DIAGRAMS.

VOLUME II.

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called upon to erect or see erected, he must not suppose that we forget or overlook the claims of the design, or as it is popularly called the style of architecture, of the house. We are fully alive to the high purposes of what, for lack of a better term, is known somewhat vaguely as "the beautiful in art" in the life of man. So high, indeed, that no architect or builder should, even if he could, ignore its claims to his most careful consideration. But while we must, and to the fullest, admit the high purposes which beauty of form and of character give, say to a casket, we still contend for the accuracy of the principle which demands that the casket should itself be truly fitted to fulfil the purposes for which it is confessedly or professedly made. Fitness, therefore, must be considered in every design of a house—fitness for the purpose for which the house claims to have an existence. On the importance of fitness in *design* or *style of architecture,* we could say much here, but the reader interested in the points of the discussion connected with it may find something of practically suggestive value in the several papers in this work more or less directly concerned in what is popularly called design,—such as those under the heads of "The Cabinet Maker," "Form and Colour in Industrial Decoration," and in the papers on "Ornamental Construction in Wood, Stone, and Metal," or in the paper "The Ornamental Draughtsman."

The Design or Style should be subordinated to the Plan of the House.

But this principle of "fitness," which cannot be ignored, or if not positively set aside, minimised, without loss, demands that while the design or style of a house shall be carefully attended to, it must be subordinated to, and tend to secure completely the object for which the house is to be erected, which object is, in fact, the very reason of its intended existence. That object is neither more nor less than this. That the house be fitted to live in, and that living in the widest sense demands, not only attention to health, but to comfort, this being, as we have in preceding paragraphs attempted to show, dependent upon what are called the conveniences of the house. Simply obvious as this consideration is, it nevertheless is true that to its being so often overlooked by some architects and builders we owe the fact that we have so many ill contrived, most inconvenient houses, characterised by more than one of those faults in planning, to some of which we have already directed the attention of our readers. This unfortunate result —unfortunate in but too many ways for those who inhabit the houses so designed and planned—arises from the fact that young or inexperienced architects are so much interested in the external design, that their plan is entirely subordinated to this. There are many considerations existing to account for this tendency of some young architects, but which need not be alluded to here further than to say that there exists a temptation to make a house design a vehicle, so to say, for the conveying of certain notions or crotchets they may have as to what style of architecture is best applied to house decoration or beautifying. This should be met by a strong determination to resist it. As also in the case of that other temptation, so strong with some architects at the beginning of their career, which urges them to make a "design," the characteristics of the style of which shall at least be this. It will show to all men who look, or care to look upon it—or advertise the fact, so to say—that they are able to design pretty, elegant, fine or beautiful houses, or by whatever title their claim to consideration may be called. But whatever be the inciting cause, whatever the temptation, it is nevertheless the practical fact, in such a supposed case, that the design or external style of the house being the main thing with such architects, its plan is so entirely subordinated to the design or style external, that it may or may not be inconvenient, but whether or no, or how, it must give way to the demands of the style or external design.

Practice of Careful and Experienced Architects in relating and subordinating the Design to the Plan.

The extreme case above named may not be met with very frequently, but met not altogether seldom it is. Experienced and true architects know well that there is something more than external design or style of the house required, and that it will be but a poor place to live in if the claims of the plan are overlooked or their importance minimised. They know that the only safe rule to follow is that the *plan shall dictate the design, not the design the plan.* They keep steadily in mind the vital truth that a house is a place to live in, not primarily to look at only. They remember that, as living comprises many details, the first thing to do is to make sure that the plan or internal arrangements and the conveniences of a house shall, to the utmost extent, meet the requirements of this "living," and that he will be but a poor architect who cannot conform his design to the plan or internal arrangement of the house thus carefully considered to be the best, and yet make the external design in all respects good. Our belief, in fact, in this matter is that this system of working—and which we maintain without fear of its accuracy being disproved—gives an infinitely wider and higher scope to ability to design or adapt a style or design, than the other system of making the style the primary point, and torturing more or less the plan or internal arrangement, so that it can work in as best it may with the form of outline which the design or style primarily decided on has more or less necessitated.

THE ROAD MAKER.

His Work in the Laying-out of Roads in Rural, Suburban and Town Districts, their Construction, Repair, and in the Choice and Use of the Various Materials employed.

CHAPTER III.

The last paragraph in preceding chapter concerned itself with the cross section of the road, and we there gave the proportion of convexity to a given breadth. This small curve or rise should not be by two planes meeting in a ridge at the mid-breadth of the road; but one-third of the horizontal breadth of the road, at each side, should be divided into four equal parts, and the rise at each segment should be increased in direct proportion as the distance increases from the extremities of the breadth of the road. These slopes will then be straight planes; and the connecting arch spanning over the middle third part of the horizontal breadth of the road, and to which the slopes at the sides are tangents, in order to obtain a correct form of convexity, particularly in roads of great breadth, should be divided into eight equal parts. The best form for the middle convexity of a road is a parabola.

Rule and Diagram for describing the Curved Form of a Road.

In order that the rule about to be given for describing the curved convexity of the middle portion of the road may be more readily comprehended, the following diagram, representing one-half the section of such convexity, is given in fig. 3; in which *a b c d e* is half the parabolic arch; *l a* half the ordinate terminating in the curve at the point of contact, *a*, of the inclined plane of the slope of one of the sides with the arch of the curved portion of the convexity of the road; *f a* is a portion of such inclined plane; *h b*, *i c*, *k d*, are three abscissæ of three diameters of the curve, at equal distances from each other, and extended without the curve to meet the tangent *f a* produced to *g* in the several points *n*, *o*, *p*; *l e* is an abscissa of the axis of the curve by the semi-ordinate *l a*, and extended beyond the curve to meet the tangent produced to *g*; and *a q* is a portion of a diameter of the curve from the horizontal level of the breadth of the road, and meeting the curve at the point of contact, *a*, of the inclined plane of the slope of one of the sides with the curved convexity of the middle of the road. The length of the diameter of which *a q* is a portion, or the height of the inclined slope of the side above the horizontal level of the breadth of a road, is the product of the height of the crown above the horizontal level of the breadth of a road multiplied by ·8.

The semi-ordinate *l a* being parallel to the horizontal level of the breadth of a road; the straight line *a g* being the extension of the tangent of which *a f* is a portion; the lines *h n*, *i o*, *k p*, and *l g* being parallel to each other, and at right angles to *a l*; then, the right-angled triangles *a h n*, *a i o*, *a k p*, and *a l g* are similar to each other, and to the right-angled triangles formed by the diameter of which *a q* is a portion, one-third the horizontal breadth of a road, and the length of the slope of the side. The abscissa *h b* is $\frac{7}{8}$ths of *h n*, the same abscissa produced to meet the tangent at *n*; the abscissa *i c* is $\frac{3}{4}$ths of *i o*; the abscissa *k d* is $\frac{5}{8}$ths of *k p*, and the abscissa *l e* is $\frac{1}{2}$ of *l g*. (For the mathematical terms here used see the series of papers under the head of "The Geometrical Draughtsman.")

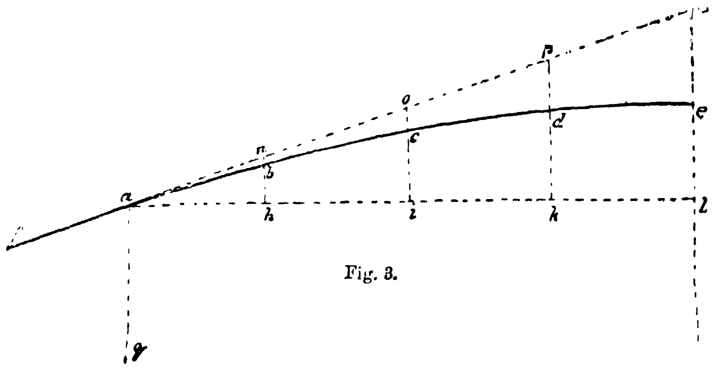


Fig. 3.

Supposing a road to have a height at the crown of its surface of 1 above its horizontal to a breadth of 60 feet when completed, and a height of 1 to 80 previous to the covering being laid on, the following table of the heights for both rates of rise at the several divisions of the breadth when it is 1 is obtained from the foregoing facts, by which to calculate the said heights for any given breadth of road:—

		Height at the crown 1 to 60 of breadth.	Height at the crown 1 to 80 of breadth.
1. 1-12th of breadth . . .	Straight surface.	·003′	·0025′
2. ,, ,, . . .		·006′	·005′
3. ,, ,, . . .		·01′	·0075′
4. ,, ,, at *a*	Fig. 3. Curved surface.	·013′	·01′
9. 1-24th ,, at *b*		·0147916′	·01109375′
10. ,, ,, at *c*		·01583′	·001875′
11. ,, ,, at *d*		·0164583′	·0123375′
12. ,, ,, at crown *e*		·016′	·0125′

Rule to find the heights at the several points on the surface indicated in the last diagram.—Multiply the breadth of the road by the multiplier in the foregoing table, for the height at the point of the breadth that may be required, and the product will be the height sought. The following are examples of the above :—

Required the several heights of the surface of the cross section of a road when completed, the breadth being 45 feet.

The product of 45	multiplied by		·003′	is	·15′
"	"	"	·006′	"	·3′
"	"	"	·01′	"	·45′
"	"	"	·013′	"	·6′
"	"	"	·0147916′	"	·66′
"	"	"	·01583′	"	·71′
"	"	"	·0164583′	"	·74′
"	"	"	·016′	"	·75′

Required the heights above the horizontal of the surface of a road previous to the covering being laid the breadth being 36 feet, and the rate of convexity being 1 foot at the crown for 80 feet of breadth.

The product of 36	multiplied by		·0025′	is	·09′
"	"	"	·005′	"	·18′
"	"	"	·0075′	"	·27′
"	"	"	·01′	"	·36′
"	"	"	·01109375′	"	·39′
"	"	"	·011875′	"	·42′
"	"	"	·01234375′	"	·44′
"	"	"	·0125′	"	·45′

The Materials for the Covering of Roads known as "Road Metal"—Macadam's System of Road Making.

The soil on which a road is to be made, after being thoroughly drained, and its surface brought to the form prescribed above, and made even, will then be in a condition to receive its covering of stone.

Under most circumstances of traffic and soil, the covering of a road may be entirely of stone broken into small pieces; but in some cases it may be necessary to underlay the surface covering with a rough pavement. The first-mentioned description of road was introduced, and afterwards brought to great perfection, by the late Mr. John Loudon McAdam, in the early part of the present century, and it has from that circumstance been generally known as a McAdamized road, and being adequate to the requirements of most circumstances at a much less cost, the consideration of its construction will have priority over that of the latter-mentioned, which, however, will afterwards be treated of.

In the system of road making now to be discussed, a smooth surface and good road may be made of any description of stone, provided it be properly applied; but the durability of such covering of a road will be according to the combined properties of hardness and toughness of the material.

Materials used in the Macadam System of Road Making—Green Whinstone—Granite.

Of the materials suitable for the covering of roads, the following is an enumeration, in order of fitness, with the specific fitness of each for the purpose.

1st. *Green Whinstone* is undoubtedly, of all other materials, the best adapted for the covering of roads. It combines great hardness with toughness, it breaks, with clean, solid angles in its fracture—a property which adapts its particles for binding into a solid mass with a smooth surface. This stone, when of the right variety, possesses every property for forming the best and most durable road covering. There is, however a variety of whinstone stone, or basalt of a very dark colour, which, although very hard when quarried, speedily disintegrates into a soft powdery substance by the action of the atmosphere, and is therefore unfitted for the covering of roads subject to heavy traffic.

2nd. *Granite*, equally as tough, if not tougher than the best whinstone, is coarser in texture, not so hard, or the fracture so clean as whinstone; from which it will readily be understood not to have an equal property of binding into a solid mass with so smooth a surface as whinstone.

Materials used in the Macadam System of Road Making.—Flints, Limestone, Gravel, Sandstone.

3rd. *Flints* are extremely hard, but deficient in toughness, and therefore easily break down into sand under heavy traffic; although, to the extent of their durability, they form a smooth surface when properly prepared.

4th. *Limestones*, with the exception of soft chalks, which are unfitted for the covering of roads, all bind well into a smooth surface; but all being affected by atmospheric action, even the hardest is less durable than any of the materials previously noticed.

5th. *Gravel*, by which term is to be understood the mixture of various sizes and descriptions of water-worn stones, frequently found in beds of various thicknesses near the surface of the soil. The e, of course, partake in their leading properties of the character of the nodules which mostly prevail in the mixture. When the gravel is clear of soil, and the nodules of a homogeneous character—which is seldom the case—broken into angular pieces, it frequently makes an excellent and durable covering for roads.

6th. *Sandstone* has its particles too slightly cohering for the purpose of road making where there may be a considerable amount of traffic. It is, however, a most suitable material for the *pitching* or rough pavement for underlaying the surface when a road is so constructed.

Besides the natural stones noticed above, the *slag* from the smelting of iron ore makes excellent roads in summer, and in dry weather; but, it being frequently a soluble silicate of lime, it generally dissolves into a viscous mud in winter, and in wet weather. In order to avoid the expense of cost of carriage, the material for road making will generally be what can be obtained in the neighbourhood of the road to be made.

THE GEOMETRICAL DRAUGHTSMAN.

HIS WORK IN THE CONSTRUCTION OF THE FIGURES AND PROBLEMS OF PLANE GEOMETRY, USEFUL IN TECHNICAL WORK.

CHAPTER III.

Oblique Lines.

OBLIQUE lines are lines which are neither vertical nor horizontal. The surfaces of the declivities of roads, or of the roofs of buildings, are illustrations of oblique lines. Assuming the lines *a b*, *b c*, fig. 3,

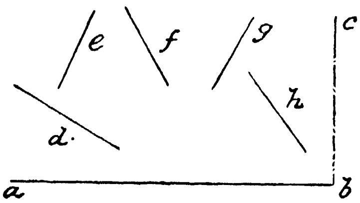


Fig. 3.

to be the lower edge and right-hand edge of a sheet of paper or a drawing board, the lines *d f*, *c g h*, are all oblique, or placed at angles to the sides *a b*, *b c*. This brings us to the consideration of

Parallel Lines.

Parallel lines are lines which are placed in such relation to each other that they can never meet, to whatever distance they may be prolonged or extended. The tracks of the wheels of a carriage on the snow or on the road, or the metals of a railway, are examples of parallel lines. All vertical or horizontal lines are parallel to each other, as at *a* and *b*, fig. 4,

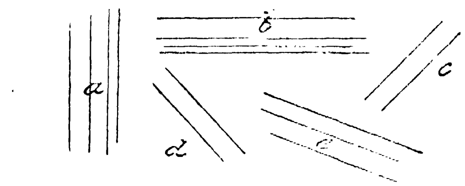


Fig. 4.

drawn when the drawing board is made use of, by means of the T-square, which is placed along the lower edge or a side edge or end, according to the kind of parallel lines desired. When the drawing board is not used, or when we wish to draw lines parallel to one another, but oblique to the edges of the paper, as the lines *c*, *d*, fig. 4, we use one or other of the two forms of parallel ruler.

The Parallel Ruler.—Its two Forms, and Methods of Using them.

This is of two kinds, one of which is shown at *a b*, fig. 5. In this the rule or ruler is made of ebony or of box, or other hard wood, and has a bevelled edge, *c c*, fig. 5, which is covered with an ivory scale divided generally into inches and tenths or eighths, from which measurements can be pricked off to the paper. The rule is made to slide along the surface of the paper on the small rollers or cylinders, *d d*, grooved in their surface longitudinally. In using this care must be taken to keep the ruler advanced equally, as any undue pressure of the hand may cause one end, as *b*, to advance quicker than the other end, as *a*, which would, of course, destroy the parallelism of the ruler to the line originally drawn along its edge, *c c*, and to which another line is required parallel to it.

The old-fashioned form, which, if slower in being used, is, for beginners at least, less liable to errors of adjustment, is shown at *e f*, fig. 5. It is made with two flat rulers, each with a bevelled edge, but on opposite surfaces or faces of the rulers. The rulers *e e* and *f f* are jointed together by hinges, *g g*, connected at opposite ends to each of the rulers. Thus, when a line has been drawn along the edge of *e e*, and another line to be parallel to it is drawn, say at the point *h*; while the ruler *f f* is kept in position on the paper by the left hand, the ruler *e e* is moved upwards by the right, till the edge cuts or comes up to the point *h*. It is then held down by the left hand, which is now taken off the ruler *f f*, and the

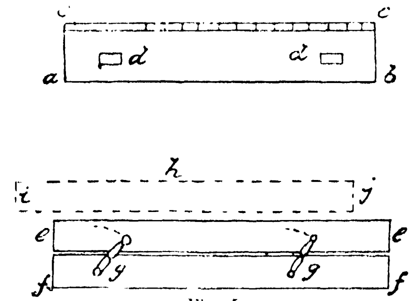


Fig. 5.

line is then drawn along the edge *i i* by the pencil held in the right hand. The pupil will perceive that great care will be required in using these instruments, so that the original adjustment to the line first drawn must be maintained in moving the rulers across the surface of the paper, otherwise the lines drawn through other points will not be parallel to each other.

Angles: Their Varieties and Peculiarities.

We now come to the consideration of "angles." When two lines not parallel to each other meet in a point common to both, as the lines *a*, *b*, *c*, *d*, fig. 6, to the lines *e*, *f*, *g*, *h*, meeting in the points *i*, *j*, *k*, *l*, we say that they form an angle, and that the indefinite space comprised between the two lines which meet in one point is an angular space. The lines which form an angle are called the sides of the angle, as *a e*, and the point of intersection, as *i*, the "apex" or point. Two angles are equal when the distance between, or degree of slope of their sides, is the same. We measure angles, then, by the distance between, and not the length, of their sides. Of two angles, the largest is the one the sides of which are farthest apart, and conversely. Thus, with the two legs of a compass, which have always the same length, we may make angles of all extents and varieties. The following are the different kinds of angles.

Right Angles.

When a line meets another so as to form two adjacent equal angles, these angles are called right angles, and the lines which form them are called

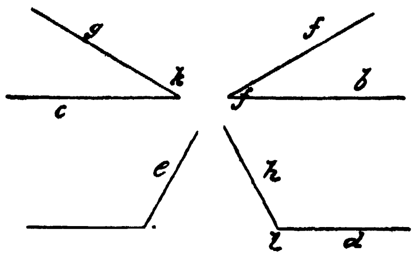


Fig. 6.

perpendicular to one another, whatever be their position in space or on the paper. Thus the lines *c d, g h, k l, m n*, fig. 7, are all at right angles to the lines *a b, e f, i j*, and *o p*, although those last are all of different kinds of lines, as horizontal (*a b*), vertical (*ef*), and oblique (*i j, o p*). And all the angles are right angles, and therefore all are equal to one another—*i.e.*, as the angles *a c d, e g h, i k l*, and *n m p* are all right angles, and are equal to the adjacent angles on the opposite side of the line, as the angles

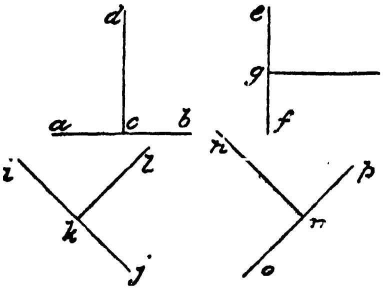
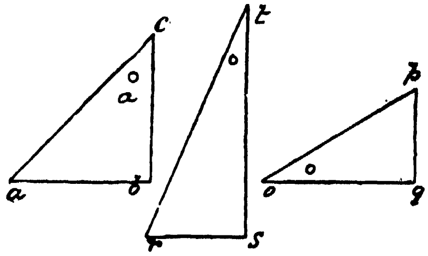


Fig. 7.

d c b, f g h, j k l, and *p m n*. All right angles are equal. A vertical line is always perpendicular to a horizontal line. Every line which is not perpendicular to another may be considered as oblique with reference to it; and the kind and degree of obliquity, as the relative lines in fig. 6, decide the character or kind and the extent or measure of the angle.

The Drawing or Delineation of Right Angles.—Set-Squares.

In drawing right angles quickly — that is, in drawing lines which are perpendicular to another—the instrument or implement called the "set-square" is used. This is shown at *a b c* in fig. 8, and is made of hard wood, varying in thickness according to the size from one-sixteenth up to three-sixteenths of an inch. of large dimensions a small hole, as *d*, is cut through the square, near one of the apexes, by which the implement can be hung up on a nail to be within easy reach. The hole also affords a grip or hold to the fingers in moving the set-square over the surface of the paper. If the T-square and drawing board be used by the geometrical draughtsman, when the blade of the T-square is set or adjusted to draw horizontal lines—which in drawings are those placed parallel to the long side or upper and lower edges of the board— lines at right angles to those horizontal lines, or perpendicular to them, can be drawn in any number and at any distance required, by adjusting



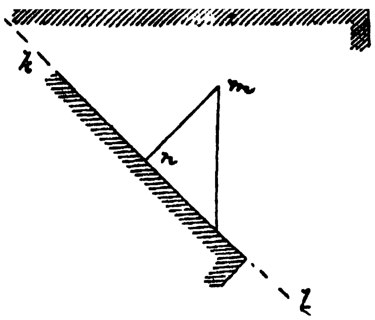


Fig. 8.

the set-square, *a b c d*, to the edge of the blade of the T-square, as shown at *e f, g h i*. All lines drawn along the edge, *h i*, as that at *j*, are at right angles to a line drawn along the edge of the blade, *e f*, of the T-square.

The Varieties and Use of Set-squares.

The same use can be made of the set-square ("right-angled," as *a b c d*, fig. 8), when the geometrical draughtsman does not use the drawing board and T-square, but only a ruler or "straight-edge," as at *k l* in fig. 8. Here all lines, as before, drawn along the edge, *m n*, of the set-square, are at right angles to the line drawn along the edge, *k l*, of the straight-edge or ruler. A right angle is always one of 90°. (For the division of a circle into certain parts called "degrees," written as just given—thus, °, see a paragraph and illustration farther on.)

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER VII.

The Terms used in Converting Heat into Power.—The "Unit" of Work done, or the Mechanical Power or Force exerted by Certain Amounts of Heat.—The Unit of Heat.

WE have said that the most convenient way of converting heat into physical force is through the agency of water submitted to the powers known scientifically as evaporation, popularly and familiarly as boiling, and this through the direct agency of the combustion of fuel or coal, which has been aptly, and indeed truly, described as "bottled-up sun rays." This agency gives us the nomenclature or terms for stating the convertibility of heat into force, or force into heat. The unit used is, of water "one pound," of heat "one degree" (Fahrenheit scale). A very distinct and conclusive set of experiments has been made by various able scientists, amongst whom Dr. Joule, of Manchester, is conspicuous, not only as having been practically the first to lead the way in this most valuable line of physical investigation, but from the accuracy and variety of his experiments, and the elaborate way in which he has formulated them for practical purposes. The result of these investigations has been the establishment of the relationship subsisting between heat and force, or that which gives us what we conveniently, if not very scientifically, call mechanical power. This relationship is shown thus. The amount of heat required to raise, or which is absorbed by, a pound of water one degree in temperature, is precisely equivalent or equal to the mechanical work done or physical labour exerted in raising 772 pounds a vertical height of one foot; or as it may be expressed in units in both cases, heat taken by one pound of water raised one degree in temperature, Fahrenheit scale, is equal to the force or the mechanical work done in raising one pound through a height equal to 772 feet.

Vast Importance of the Science of Thermo-dynamics to the Engineer in making Motive Power Machines, of whatever Kind.

We shall in future chapters, and also in other papers, such as "The Steam Engine User" and "The Furnace Builder," see how important this law which gives the relationship of heat and force is to the engineer in applying heat to the production or creation of mechanical power, whether he so applies it through the agency of the mechanism of the steam engine, the hot-air or caloric engine, or the gas engine. For it gives him, as we have already hinted at, the clue, so to say, by which he can discover whether he is getting the greatest amount of work done of which the heating agent is capable, and the way in which heat is lost by the creation of motion which does not give useful mechanical work; for as force is but another expression for the expenditure of a given amount of heat, and as force, to be useful to man, is to create motion, all force must by consequence be expenditure of heat, and if motion be not wholly useful in the doing of mechanical work, it must be wasteful of this heat. The field thus opened up to the engineer of the future is as important for the mechanical issues it involves as it is wide in extent. Investigations made in experimental working carried out with the various mechanisms by which heat is converted into force or mechanical power, will not only tend, as they are already so tending, to our getting the highest degree of working or practical efficiency out of our steam engines, which at present have been truly characterised as wasteful in almost the highest degree, but may in course of time bring out an altogether new mechanism, by which heat may be converted into force in the most direct way, and with the highest degree of mechanical efficiency. What has been said on this point will have abundant illustration in future paragraphs. In its statement the student will have perceived that there has been a term frequently used, and one which is, so to say, perpetually recurring in all mechanical disquisitions; this will be quite as appropriate a place for giving that explanation of it which it is necessary for the student to have as any other which might be chosen, as it has such a close connection with the subject of this present paragraph. The term here alluded to is—

"Work done" by the Exercise of Energy, Force or Power.—"Mechanical Work"—"Mechanical Efficiency"—"Effective Work"—"Effective Force."—Some Considerations connected with those Equivalent or Convertible Technical Terms.

For this term "work done," the terms "effective work" or the "mechanical efficiency" or the "effective force" of a machine or piece of mechanism is sometimes substituted as synonymous; but there is a distinction or difference between them, more or less precise, which may be treated by the reader as we proceed. The term which forms the title to this paragraph is, however, that which is generally employed, and gives, if not precisely the most accurate, certainly the most easily understood, indication of what is meant to be conveyed by it. There is no term so universally understood as that of "work done," in connection with which there are so many associations, not a few of which are suggestive of painful labour. But notwithstanding this general application of its meaning, there exists such a confusion of ideas as to the methods by which work is done, that many have a difficulty to understand that the work done by a man or by a horse is, to use the term we have decided on, as much mechanical work as that done by a special machine with the operation of which the term is alone popularly used; and that the method of expressing the value of mechanical work os applicable equally to manual and animal labour, ir work done, as to that of a machine. Indeed, it is from animal power that the measure usual in all calculations of mechanical work—say, as done by a steam engine or a water-wheel—is derived: hence the well-known term horse-power, contracted forms of expression being H. P., or still more contracted, HP. What is meant by this we shall immediately see.

Elements or Factors used in all Calculations of "Mechanical Work" or "Efficiency" or "Effective Force," "Weight" and Space"—Practical Statements in Connection therewith.

The two elements involved in all calculations of "mechanical work" are weight and space or distance; the equivalent terms of weight are force or pressure. Weight itself is expressed by the term gravitation, the phenomena of which, forming so important a department of mechanics, will be described and illustrated in future paragraphs. The "unit" of weight used in calculations of mechanical work is the "pound"; the "unit" of space or distance passed through by that weight is the "foot"—1 ft. The space passed through is generally considered as vertical space or distance, being usually expressed as so many feet high; and this more from the character of the experiments made by Watt in estimating the value of a horse-power—he having, as the most convenient way of applying this kind of muscular force, used a weight attached to a rope hanging vertically and passed over a pulley which gave the character of the horizontal line of draught of the horse as it walked along a level surface, dragging, pulling or raising up the suspended weight. But the unit of space is equally applicable whatever may be the direction in which that space or distance is passed through, horizontal as well as vertical, the term "high" being so long established, and being that moreover in general use, denoting vertical space or distance passed through. If we suppose we have one unit of weight or force represented by a mass of metal, and this of course 1 lb. in weight, and if it be passed through a space of twelve inches or one foot, we have as the result a "unit of work"—*i.e.*, one unit of mechanical work has been performed. If we have a distance or a space of a thousand feet passed through or over by the one-pound mass, we have as the result a thousand units of mechanical work performed. The expressions here used are convertible, so that if we have different proportions of units we still have the same equivalent of units of mechanical work performed. Thus, if in place of having a mass of metal of one pound weight to deal with, which is passed through a given space, we have one of one hundred pounds, and the space or distance through which it is raised or over which it is passed is only ten feet, we have the same number of units of mechanical work performed as if the weight had been one pound and the space a thousand feet—namely, a thousand units of work. The simple rule being, that if we multiply the pounds force or pressure exerted by the space through which this is passed, we have in the result the number of units of mechanical work performed, so that if 1×1000, 100×10 are both equal to 1000, then 500 lb. of weight raised through 50 ft. of space is precisely equal in units of mechanical work to a weight of 50 lb. raised through a height of 250 ft. This simple law, the convertibility of units of space and weight, is so to say necessary, inasmuch as the mechanic has to do with varying forces and pressures and variable spaces or distances, but its application is alike simple in all cases.

The "Units" of "Mechanical Work" expressed in the Term "Foot-pounds."

The units of mechanical work performed by given weights or pressures passing through spaces are generally known by the term compounded of the two elements—namely, "foot-pounds." This term is applicable to any expression of mechanical work, no matter whether calculated in connection with machines in which it be small or large in amount. But if "work" done or "duty" performed is high or great in amount, a term expressive of a higher value than a foot-pound is much more convenient, if for no other reason than this—that the number of figures required to denote foot-pounds in powerful machines would be very cumbersome. Hence the term of a higher value to which we have already referred—namely, "horse power"—is that used in connection with machines exerting what is called great power. The horse-power unit, or that which is taken to represent the mechanical work done by a horse, is 33,000 "foot-pounds," or a weight of 33,000 pounds raised one foot high—which is, from what we have said above, convertible, so that 10 lb. raised through 3,300 ft. would be equal to the above, just as 1 lb. raised through 33,000 ft. would give the same result. The foot-pounds indicaing the power of a man amount to 3,300; this term "man-power" has only come into use practically or conveniently since the introduction of gas and caloric or hot-air engines of small powers for the doing of general work, as driving sewing machines, working printing presses, and the like. In place of using the term "amount," or "total quantity of work done," by any exertion of force, power or energy, the term "rate" is used as the "rate at which work was done," the "unit" rate being a horse-power or 33,000 foot-pounds per minute, as above explained. We shall have something more to say hereafter about those terms connected with work done or power exerted.

"Time" the Final Factor or Element in Calculations as to Mechanical Work.

The application of this principle of estimating the amount of mechanical work done by various machines, acting under one or other of the natural forces we have described in the preceding paragraph, is comparatively simple. But another element is introduced into the calculation—that of "time"—exemplified in the expression with which even our most youthful students in mechanics will be familiar: so many pounds raised, so many "feet high per minute." The three elements or units are of weight (1 lb.), of space or distance (1 foot), of time (1 minute). If we know, for example, the pressure of a certain force passing through a certain space during a certain number of minutes, multiplying these into one another and dividing the result by 33,000, the horse-power unit, we ascertain the horse-power of the machine in which the above calculations are met with. The most familiar example of this is the steam engine. In this the pressure of the steam on the surface of the piston, representing the "weight" or "force" in the cases named above, multiplied by the "space" or distance passed through or over in the given "time" per minute, and divided by the horse-power unit, 33,000, gives the power. But this is not the effective, but only the nominal power. The various practical considerations connected with the conditions known as "effective" and "nominal" horse-power will be found fully discussed in the chapters which take up the subject of the steam engine in its various forms. (See "The Steam Engine User.")

Theoretical Mechanical Efficiency.—Losses of it in Practice —General Glance at the Causes of Loss.

In no case do we derive the full or effective power; in other words, we never get all the "work" done which the force agent is able to give, or what is "theoretically" due to it. The sources or causes of loss of power in the adaptation of the various "forces" we have named (see a preceding paragraph) are numerous. Some are inevitable, and depend upon laws hereafter to be noticed; others—and those constitute the great majority, and are the most fruitful causes of loss of power or of work done—arise from the defects either in the character of the machine we use to adapt the force or power, or in the mechanical construction of its parts, and the mode by which we "take" or "lead" off the power of the machine to the work which is to be done. Those latter sources of loss of power should indeed be classed as "waste" of it. For while a machine, as the steam engine, may be—and the latter indeed seems to be—the most effective arrangement by which we can adapt, or so to say yoke to our work, the natural force at our disposal, and we therefore, for the time at least, cannot make a better use of it, any loss of power arising from positively defective arrangements or construction, which the mechanic can avoid or prevent, is neither more nor less than waste; and this is wilful if a mechanic is indifferent about giving the very best work he can give, or if, knowing that there is a better way than his own, he is careless to learn what that is, or if knowing it, from the force of pure prejudice against it, no matter how or from what motives arising, he will not accept it. We shall have occasion to see, in the various notes on practical mechanism in the series of papers entitled "The General Machinist"), how in those directions just noticed we lose or waste so much of the power which the natural forces we employ can give us,—so large a percentage, indeed, even in the best forms of what are called prime movers or motors, that the youthful student in mechanism may rest assured that there remains a vast and wide field in which he and his compeers can do great work in the way of economy of force yet. He need not fear, as some seem to fear, that so much has been done in the past in the way of inventing and constructing machines, that there is little left to be done in the future. So far is this from being the case, that it may be said, so far at least, of our motive powers, that we have but as yet taken up the hem or fringe, of the subject; the great expanse of the material being as yet practically untouched. In all considerations connected with the adaptation to mechanical work of the natural sources of power other than those of wind and water, the student must ever bear in mind that heat is the only source of power. This heat being of necessity applied or made practically available in combustion with something natural, such as water in the case of the steam engine, common air in the case of the caloric or hot-air engine, and gas in the gas engine, the student is apt to consider those elements as the "be all and the end all" of his mechanical work; they are, however, but the vehicles by which he applies the power of heat force, and as it is heat which gives those elements what power —if we may use this mode of putting the point —they possess, it is obviously to heat that the mechanic must direct his attention. How to use it —that is, how to adapt mechanical arrangements and combinations so that the maximum of power contained, so to say, in the "heat force," will be obtained with the minimum of cost—is the problem which the mechanic has to solve. That it has not yet been solved—is far indeed from being so, despite all the advance mechanics has made—may be learned by even but a cursory examination of the whole subject. The various practical points unsolved in this problem will engage our attention either in succeeding chapters of this section of our work, or in the special papers "The Steam Engine User" and "The General Machinist."

The Terms "Motion" and "Force," as used in Preceding Paragraphs.

In the paragraphs of the preceding chapter the student will have noted the frequency with which the term "motion" has been used. It is one of the peculiarities, as indeed, in one sense, it may be said to be one of the difficulties, in arranging a description of the science of mechanics, in which the subjects will be perfectly consecutive, that terms are of necessity used in discussing one subject, before they can be fully explained, and which can only be done in discussing another subject, and that the one to which the terms naturally belong; the difficulty, such as it is—and it is one which appertains to the exposition of nearly, if not quite, all other branches of science—is not, however, so great as it appears to be. When we adopt, as in the present series of papers we have adopted, what appears to be the most natural way of treating a subject, the different parts flow out naturally from one another; and although terms are employed to explain the subjects first treated of, those must for the time be taken as granted. And no practical loss to the student will arise, inasmuch as those terms will be fully explained in the proper sequence of place; and as a rule it will be found that when there used in anticipation, the particular force of their application to the point being discussed will not be lost.

We have, in the preceding chapters, begun the general subject with that of force, assuming—and the assumption is a safe one—that the machinist can do no work through the agency of mechanism without a force of some kind, and that, therefore, we may begin with this; and we shall see, as we proceed, that all the other subjects to be considered flow naturally out of this, the leading one. And if the reader will refer to the special paragraph, he will see that in our definitions of what force is, or rather what scientific men have decided to call by this name —a "something," the phenomena or effects of which are well known and can be practically availed of, but but how it is caused they do not know—in those definitions the student will perceive that this "force," this "something," is that which causes "*motion.*" Those two terms embrace every consideration connected with mechanism. With force the mechanic knows that he can have motion, and with motion he can do the work he designs to do. He knows this, so to say, intuitively, without any teaching; but unless he knows a vast deal more than this, he will be unable to apply to the best advantage those two characteristics of all machines doing work. To the points constituting this additional and absolutely necessary knowledge we now direct the attention of the student, leaving the definition of the term force as given in a previous paragraph. It would seem that the natural way would have been, to have first examined or defined what motion was, as the "something" called force seems always to be productive of motion; although, in looking further into it, it will be remembered that force may produce rest. But as far as the machinist is concerned, it matters little, practically, whether he has "motion" defined and considered first, or, on the contrary, "force"; still we have taken the latter first, as from it flow naturally the other points, energy and power, which, as we have seen, are often confounded with force and considered synonymous with it. And in one way this sequence of consideration of certain subjects which we have adopted may be looked upon as the most natural, inasmuch as under ordinary circumstances the machinist knows that he must have the energy and the power or force of some kind, before he can have his machine to do work, and being assured of that, he proceeds to design his mechanical arrangements by which the motions he desires are obtained.

Motion.—Some Points connected with this Condition of Matter.

As in the case of force, so in the definition of motion, some have indulged in metaphysical abstractions leading to statements and expressions which have a much more powerful tendency to confuse the mind of the reader than to enlighten it as to what the subject is. Here again the practical reader will do well, for the present at least, to refrain from all such abstruse considerations, and content himself with what he knows—we may say intuitively almost—as to what motion is. Derived from the Latin *motio*, and this from *movere*, signifying to move, he knows that motion is something quite different from that position or condition to which he gives the name of rest. And further, that in his mind, when it is applied to himself, or any part of himself, or to any other body exterior to himself, he invariably and without any hesitation associates with the term a change of place of the body. If at one space of time we see a body in one place or position, and find it at another time in another place, we have not the slightest doubt in our own mind that the change of place must have been the result of motion. We thus have the simplest of all definitions of the term motion—"a change of place of a body." And this involves the idea of a comparison with other bodies or another body. Motion in bodies is therefore relative, and can only be described or conceived of in relation to another body; it is thus an object of comparison. We have said that the readiest, and we might call it the popular way of conceiving of, and in a manner therefore defining motion, is that it is the condition of a body opposite to that which we call rest.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER IV.

AT the conclusion of preceding chapter, in describing generally the two classes of steam engines, high-pressure and condensing, we stated that the latter derived its name from the fact that the steam was condensed in the "condenser" after leaving the cylinder. The condenser is in connection directly with the main steam cylinder, and when the steam in the steam cylinder or main cylinder has finished its work it rushes into the condensing cylinder. A stream of cold water is continually flowing into this, and therefore causes a vacuum, more or less perfect, and as soon as the communication is opened between the steam cylinder and the condensing cylinder the steam in the main cylinder is drawn from it.

The "high pressure" steam engine is so called chiefly from its use of steam supplied at a very high pressure. There is no particular or fixed pressure of steam used for either class of engine, but we may expect to find in the generality of cases that the high-pressure engine will have about double the pressure of steam to that of the condensing engine. The high-pressure engine is better known, because so much more extensively used, and it allows the steam after it leaves the cylinder to be conducted through a pipe into the open air. It will be clearly comprehended, from the description given of the two classes of engines and their requirements, that there is no difference in the indicating appliance in principle or detail. The same indicator will answer either—*i.e.* for both kinds of engine—only the high-pressure engine must have a spring in it strong enough for the steam pressure which is in the boiler, as no greater pressure—practically, for reasons hereafter described, a lower—can be in the cylinder of the engine than that which is in the boiler. The same spring which is in the indicator for the high-pressure will also answer for the low-pressure or condensing engine. The objection to the use of a strong spring for indicating the condensing engine is that the steam in the cylinder is of a less pressure, and therefore the diagram is smaller. The smaller the diagram the more difficult it is to read it. Therefore the indicator is provided with two springs, one for each class of engine. The difference is perhaps in the following ratio: say, low-pressure spring, 20 lb. to the inch; high-pressure spring, 40 lb. to the inch. The two springs fit the same cylinder of the indicator.

The drawing given of the indicator shows the arrangement of the springs, the cylinder, and the drum round which the paper is fixed, and how this is moved so as to give upon the paper the diagram representing the form of figure which is so caused by the operation of the steam in the main cylinder of the steam engine.

General Remarks as to the Features and Use of Steam Engine Indicators.

The use of the indicator, and the way by which it acts in describing or writing upon the paper which is on the drum or cylinder, so as to give information of how steam operates upon the steam engine, and how it gives out the power which is needed, and further to understand how it should form a diagram so that the proprietor might have the best result as to the working of the engine for safety, and that of being so regulated as to produce the greatest amount of economy as to the consumption of fuel, will now be generally gone into. To those whose curiosity leads them to look out for causes of such effects as are produced from the use of steam through a machine which gives out apparently unlimited power, as the steam engine, the labour will be well remunerated by studying the mechanism of an indicator and the way in which it performs its work. It is, as we have said, a trustworthy instrument,—never known to fail in its work when manipulated by a careful hand, even by one with but little practice in taking diagrams by its means. Its simple form and the simple mode of its action renders it capable of being used by any one of ordinary capacity when once seen at work. Many other mechanical appliances are so complicated that they cannot be relied upon except they are operated upon by those who have had years of experience in the use of them—in short, that of an apprenticeship—and then serious doubts are often entertained of the results being correct. The mechanism of the indicator is, however, simple in its action, and its result may lead an inquiring mind to design mechanical appliances of importance for other purposes, of a simple and reliable form. The indicator being of small size, it can easily be removed; it is therefore less objectionable in use, being only a few pounds in weight—two, three, or four pounds—different makers having different weights and different forms. But they all produce the same result; all have to be applied at the same place and in the same way, and to be worked in the same manner. The difference in form of the indicator does not in any degree disqualify the operator for using another maker's indicator; nor does one maker's instrument limit the calculator of the figures (diagrams) to one particular form of calculation,—and thus the knowledge of one is available for all that come under the notice of the engineer. We think we have seen all the different makers' that are in use. We have alluded to that class of indicators which have cylinders or drums on which to fix the paper which has to receive the diagram, and this we have done for the best of reasons—namely, because the cylinder indicator is almost the only one in use. We have indicated engines with one which had a plate attached to it in the place of a cylinder, to receive the pencil impression. The only reason we have for referring to the last named is, because it is barely possible that such a one may in some way or other be accidentally seen in use, but this is not very probable. The application of it to the cylinder of a steam engine would be precisely the same as those we have so fully referred to as regards the working when attached to the cylinder and also in the calculation of the diagram. The figure would also show the state of steam—*i.e.*, how it was operating—exactly as those indicators having the cylinder. It is not found to be so convenient in the operation, or for moving about. We believe what we have here stated to be the cause of its want of success.

There are, as we have before remarked, several makers of indicators; but the principal makers of the instrument show but one great difference, which though we call it a great difference, is but in the arrangement of the cylinder upon which the paper is stretched. In one form the paper cylinder is detached, in the other arrangement it is placed round or encircles the working part.

Mode of Attaching the Indicator to and Connecting its Working Part with the Interior of the Steam Engine Cylinder.

In the early days of the indicator employment, the operator had to make use of the tallow or grease tap, in which to fix the tap of the indicator. A variety of sizes of plugs had therefore to be provided by those who were engaged to test engines by indicators, and for some time such an operation was only performed by special persons. Forty years ago perhaps not more than one or two steam users in Lancashire made much use of the instruments; therefore no convenient arrangements were made. As they came more and more into use a proper and convenient plan was hit upon, and the contrivance adopted is now attached to almost every steam engine cylinder, and is known by the name of the "indicator tap." It is a simple tap, much like a common gas tap, with a thread on both ends—*i.e.*, one end outside, the other end inside. One end is screwed into the cylinder cover, and by this means a communication is opened to the steam in the main cylinder of the engine. The opposite end of the tap has also an inner thread, and this receives the screwed end of the indicator (see fig. 1). At one time the tap of the indicator when it was closed shut in a portion of steam; this prevented the pencil from adjusting itself for a short time, on account of the steam that was left in the indicator above the tap; the pencil being attached to the spring of the piston in the indicator. Like many other little troubles, it in course of time was remedied. This was done by drilling a small hole in the plug of the tap. When the steam was turned off—*i.e.* the connection between the cylinder of the steam engine and that of the indicator cut off—the hole thus allowed the steam which was penned up to escape, and therefore the pencil was allowed to go to the proper place, and that is opposite to the cipher or zero point, which is on the plate attached to that portion which contains the spring.

Importance of attending to the Position of the Pencil in relation to the Zero Point or Cipher of the Indicator.

When there is neither steam nor vacuum acting on the piston of the indicator, the finger or pointer should be directed to the zero or cipher point. This must be observed always whenever an indicator diagram is to be taken. It is all important in the condensing engine, because the true state of the vacuum is required; if it be deficient, then the superintendent at once sets to work to find out the cause of the incompleteness. In the case of indicating a high-pressure steam engine the little leakage of steam makes but a trifling difference—nothing to be concerned about.

The arrangement of the finger or hand or pointer should not be neglected. It is necessary that it should be set correctly in case of indicating a high-pressure engine. In case more pressure is shown on the diagram called "back pressure" than is considered necessary, it requires attention, as that takes away a portion of power from the engine. Therefore the pointer should be directed to the cipher on the plate. We have many times witnessed cases where the pointer has been neglected with those who have not sufficiently considered those important points we have named. Once well done, twice done. However simple an instrument is, and however easy it is in its use, there are always some little but important points to be observed, in order that its full benefit can be obtained. Some of our readers may consider our remarks on these small matters as unimportant; but we refer to them because we wish to give the full benefit to them of experience and observation on the various, but important parts which ought to be observed, whereby the fullest advantage which can accrue from the system of using the indicator may be guaranteed.

General Description of the Indicator in its Mechanical Arrangements.

We shall now describe the indicator as to its mechanism. The indicator is made of brass. The only parts which are other than brass are the spring and piston rod, which are steel. Perhaps no other metal is so suitable for springs as steel, on account of its adaptability to the changes to which it is subjected—that of continual contraction and expansion. It is of the greatest consequence that the spring should be made of the most improved steel, and the most suitable for the frequent changes which it has to undergo. The other part, which is also made of steel, is termed the "piston rod." It is also of particular importance that this should be of steel, and also of a "firm" class, because much depends upon the rigidity of so thin a piece of metal. It is about one-eighth of an inch in diameter, and the slightest defect as to the truth of it would materially affect the registering on the paper, and therefore the diagram would be unreliable, being incorrect, and would thus mislead, by producing what was not the real state of affairs. It would be, in other words, a guess, and not a reality. This rod being very thin, but stiff, of course keeps its original position—*i.e.*, when it leaves the hands of the maker it is quite straight. It is attached at one end to the piston, and at the other end is passed through a small gland or hole at the top or opposite end of the indicator; and therefore the reader will at a glance see the importance of it keeping its original position, otherwise a binding would be caused as it passes up with the pressure of steam which presses against the piston once in every stroke of the engine, and therefore so delicately a constructed instrument would be at fault in its registration. Unnecessary friction must be always avoided in all nicely adjusted machines. The spring and the piston are two important items in an indicator. Both require to be carefully handled when taken out to be cleaned or in any other way removed.

The working part is the piston, which is contained in the cylinder. The "cylinder," "piston," and "piston rod" are in reality the same in arrangement and principle of action as those parts of a steam engine, but of course in miniature. The cylinder contains the piston, and the piston rod is secured to the piston. Instead of the piston and piston rod producing any motive power, the spring already explained is the resistance which only allows the piston to move to a distance, according to the amount of pressure which comes in contact with it. The spring is calculated to move a certain distance vertically for each pound of pressure of steam per inch acting upon the piston of the indicator; and as the steam leaves the main steam cylinder, or in any other way alters its pressure, the diagram registers the result. The cylinder is brass, cast solid, and then bored out to the dimension required—say half an inch. The cylinder is fitted with a piston, a piece of brass. This piece of brass is turned down to the size required, or nearly so. Then it is very accurately ground to fit the cylinder—*i.e.*, so as to prevent steam from passing it. For condensing engines it is necessary to have it so well fitted that a pressure of steam (equal to the perfect vacuum) of fifteen pounds could not escape, because the vacuum would be incorrect. A little steam passing the cylinder where a very high pressure of steam is required is a matter of no great practical consequence. The piston rod is secured to the piston by being screwed into it. The remainder of the cylinder is bored out much larger, so that it is but a mere shell, and in this enlarged part the spring is contained. This larger part of the tube gives the opportunity of having the spring larger in diameter. The spring is a coil, and upon it is attached the pencil holder. As the spring is acted upon by either steam to raise the pencil holder, or the vacuum to depress it, so is the line placed upon the paper which is upon the cylinder, and thus the line registers the result and leaves the operator to read that which is drawn upon it. Upon the higher part of the cylinder, that which contains the spring is furnished with a scale marked with pounds, commencing with 0 or zero; at the centre, and above it is numbered in pounds, for the use of a condensing engine, up to twenty pounds or a little more, and below the 0, on the same scale, it is marked in the same way down to fifteen pounds —beginning in both cases at the cipher, the number 1, and so on up to the extent the spring is calculated to work or register upwards; but in numbering downwards begins with the number 1 to fifteen pounds from the cipher 0.

The Cylinder or Drum of the Indicator on which the Paper is Fixed to receive the Pencilled Diagram.—How the Drum receives its Motion.

The drum by which the paper is folded round is a hollow one, having a bottom in it. As we have before referred to different arrangements, we shall now explain how they are attached to the cylinder. Only one principle can be adopted on one indicator. It is necessary that the drum should, by some means or other, have an arrangement by which it can be moved backwards and forwards—that is, made to turn horizontally round, first in one direction and then in another. This motion must be done systematically, because the steam acts upon the cylinder of the steam engine with order and regularity at every stroke of the engine, and therefore the drum of the indicator must commence its stroke precisely at the same time as that of the steam engine from whence it receives its steam, to cause it to register the result of the steam and vacuum which is going on at the time. This is done by having a cord or string, as *j k*, fig. 1, round the bottom part of the drum *g g*, and at the other end of the string a hook is secured to it. From some part of the engine another string (twine) is fixed, and the hook is attached to its end. In beam engines the string is tied round one of the radius rods of the parallel motion (see a succeeding chapter) near that part where it is secured to the spring or working beam, so that the traverse or turn-round in a circular direction of the drum will not go quite once round, and as it reverses the stroke it allows the drum to go back to the same position as it was when it was first moved. This alternate circular motion of the drum corresponds to the vertical up-and-down motion of the engine piston, and makes the same number of back and forward movements as the piston of the steam engine does. It is needful that we should inform the reader that a provision is made to draw the drum back to its original position during every stroke of the engine, and that is done by the aid of a spring which is attached to its interior. We need not further explain how the spring performs its work in drawing the drum back to its first position. It is understood by most men that when a round coiled spring, like that of a watch, is extended but is set at liberty to return, there is no longer that tendency to draw, but the reverse, leaving it to take its natural course, of coiling again; and every time this is done the drum is brought back, and so the motions continue as long as the hook is attached to the string which is fixed to the radius rod. It seems necessary here to give the reader, if he is unacquainted with the different forms of steam engines, a word or two on the beam engine—which, however, will be fully described in a succeeding chapter. A beam engine receives its name from the fact that it has a central beam which passes from the top of the piston-rod at one end of the engine, and at the other end of the beam is attached to the connecting-rod at the opposite end, and the connecting rod is fixed to the crank. The beam must have a place somewhere between, upon which it can rest. It is supported in the midway by a centre which passes through it and works in a pedestal, one on each side of the beam. It is often called a sway-beam, on account of its being in the position that it can be moved up and down by the motion of the piston-rod. The other kind of stationary engine we allude to here is called "horizontal," which make of engine has received its name from its general position. The cylinder of a beam engine stands on one end, but the cylinder of a horizontal engine lies on its foundation or bed plate lengthwise. The motion required to work the indicator as above is differently arranged when indicating the horizontal engine. The motion has to be arrived at in a different way; but it must be in such a form that the drum of the indicator must be at the extent of its motion one way, when the piston is at one end of the main cylinder. This is precisely the same as the beam engine in that respect. The motion is therefore arrived at by fixing a rod of some kind at a distance from the piston-rod, which is allowed to rest against a cross-head connecting the piston-rod and the connecting-rod. The motion required being but a short one, the string attached to it and then hooked to the one which is connected to the drum, must be to that part of the rod which gives but a short distance or short stroke, the length being thus regulated. The only difference between the beam engine and the horizontal engine is in obtaining the required length of traverse or turn-round of the drum on its axis.

The Method of obtaining the Pencilled Lines of the Diagram given by the Indicator.

A pencil is fixed to the spring, which moves up and down the cylinder of the indicator, and it travels up and down as the piston of the indicator is moved by the pressure of steam or vacuum. It will be seen from the following diagrams that either the drum or the pencil must rise and fall to indicate the various forms of the diagrams. The pencil rises and falls with the different pressures which act upon the spring, through the piston. The general motion has been already explained in describing fig. 1.

Keeping of the Indicator in Good Order.—Some Points connected with its Adjustment.

It is of the utmost importance that the working parts of the indicator should be kept clean. The piston requires to be taken out occasionally and wiped very clean with a dry cloth, and when put into its place it should have a few drops of clean oil put into the cylinder part, and the piston should be worked up and down several times by hand, to be sure that it moves freely in its place. We have already hinted at the method of fixing it upon the cylinder. The most general way which is now adopted is by having a tap screwed into the cylinder lid, and then the indicator is screwed upon it. It is also desirable to have a tap for the same purpose fixed at the lower part of the cylinder. In arranging the valves of the steam engine, they are regulated to admit the steam on the bottom side of the piston, so as to force the piston up—and also to admit of steam to press it down—and in this way the engine is kept in motion. In order to have the valves adjusted in such a form that about the same quantity of steam can be disposed to each side of the piston, and thus insure an even motion of the engine, the use of the bottom tap is indispensable if the engine is to be set perfectly even on both sides of the piston. It sometimes happens that the indicator has to be worked horizontally at the bottom of the cylinder, as a matter of convenience for adjusting the string to the motion of the engine, and thus enabling it to be kept from friction on any part of it, and therefore avoiding any irregularity (tight and slack string). The string should be kept free from anything that would retard its free motion.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER VIII.

At the end of last chapter we referred to Plates L. and LI. as examples of the "acanthus" leaf, of which also fig. 38 is an example, fig. 37 being the block. The student will find this form of ornament—the acanthus—pervade the Greek, Roman, Venetian and Renaissance styles, and he will do well to study carefully its form, as we shall have to speak of this again.

We shall proceed now to a new subject, and give the student some drawings of leaves from nature.

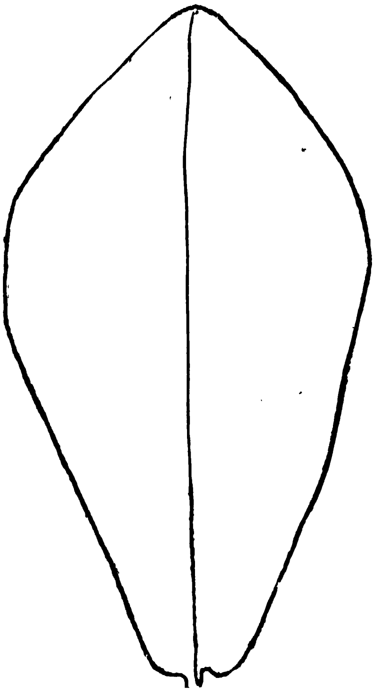


Fig. 39.

These play an important part in ornamental art. With the exception of one (figs. 42-3, the mallow), they are frequently found in decoration. The first is the ivy leaf (figs. 1 and 2—fig. 2 being the "block" of fig. 1—Plate XVI.). This leaf the student will find is used to decorate mouldings very frequently. Fig. 40 is the oak leaf, which the student will draw very carefully. Of this fig. 39 shows the block shape on a smaller scale. It will be good practice if the student will get an oak leaf and draw it from nature, after he has drawn the copy. He cannot too soon accustom himself to draw from nature. At whatever time of his practice he begins to draw from it, he will find it so difficult, that the sooner he begins to face the difficulty, and to overcome it, the better for himself, as it will hasten his progress. The student will observe these leaves are what is technically termed "blocked in."

In the examples given in figs. 29 to 38, and figs. 1, 2, Plate XVI., and figs. 39 and 40, and described in the preceding chapter, the student will have observed that each "study" or subject is illustrated by two drawings, one composed of a simple outline only, straight lines alone being frequently employed. These outlines are what are termed the "blocking in" of the subject to be drawn or copied. This work,

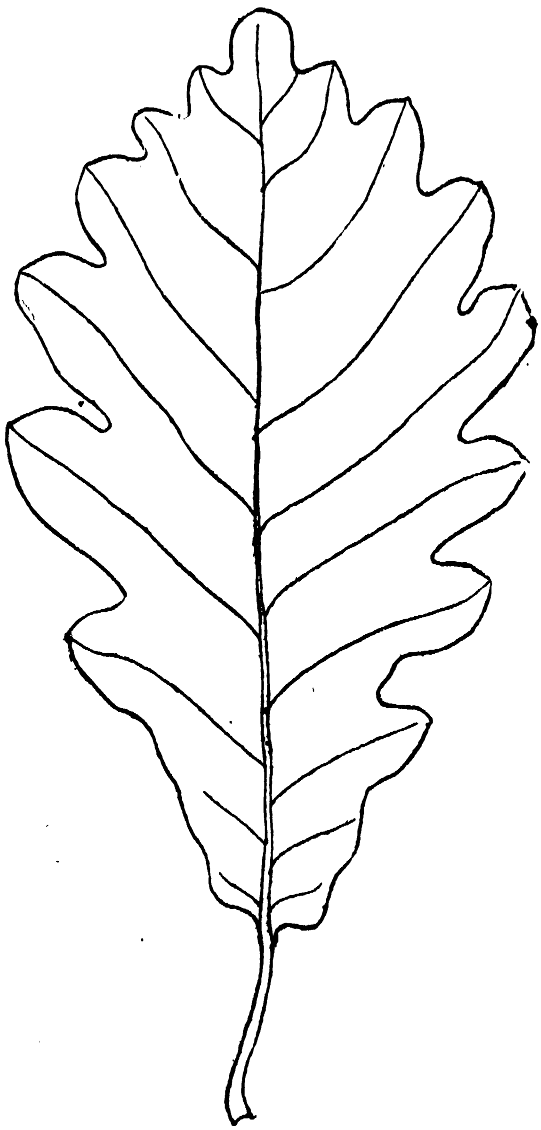


Fig. 40.

preliminary to making the finished drawing, with all its details more or less minute, should be done by the student in every case. This part of the student's practice is so important—although some altogether, and to their great loss as draughtsmen, omit it—that we specially draw attention to it.

The student has now had some practice in straight and curved lines. The example, figs. 1 and 2, Plate XVI., before him, is a new departure; he will see that the form he is about to draw (fig. 2, Plate XVI.) is composed of straight lines, giving something like the shape of the leaf in fig. 1, Plate XVI. This we call the "blocking in" of the leaf. We would particularly direct the student's attention to it, for he will find all his subsequent studies blocked in, and this is done in order to save his time and hasten progress. Therefore let him draw the blocking in very correctly, and it will save time, as it is easier to rub out a simple shape, which takes less time to draw, should it be wrong, than a more complex one. He ought not to begin the finished drawing until he has done his blocking in rightly. When he has finished his block correctly, proceed to draw within it your curved lines. When he has drawn all his curved lines correctly, having compared it with the copy, he may rub out the block and finish the drawing like the copy. Whether it be a simple leaf, like the copy in fig. 1, Plate XVI., or a complex design, such as in Plates LXVII., LXVIII., the shape should be blocked in first, so that the pupil may see what space the design will cover on the object to be decorated. He can then fill in the block with any shapes he pleases. He will find this blocking in extremely useful in practice, and when he comes to draw the "human figure," which he must do if he is going to be an ornamental draughtsman, he will find blocking in indispensable, for the figure should stand right upon its legs, blocked in in straight lines, before ever he attempts to draw the shape of a single part.

The pupil will observe that we say, that he must learn the "human figure." We say so, from the knowledge of the history of ornamental art, that there never was a good school of ornament which was not founded on a knowledge of the human form. And observe, we say "draw" the human figure: it is not necessary that the pupil should paint it, for that is a long process, but he should draw the figure both from the antique and from life. For drawing from the living model will teach him to appreciate the antique, and will also show him what use the ancients made of the human form, and how beautiful they made it. He can compare the shapes of each part of his models with the antique, and he will see that they made each part beautiful and well shaped, so that they appear to have selected the best developed forms of each part of the human body.

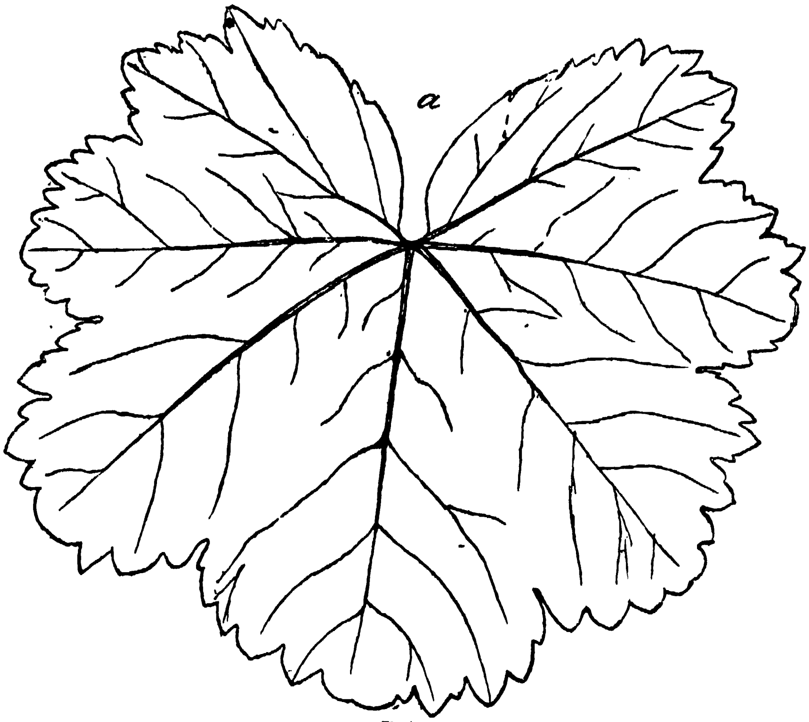


Fig. 41.

We recommend the student to draw from the life and the antique together; beginning to draw from the life from the first. Thus, say that the draughtsman is going to draw a head, we would recommend that he should draw a skull, and compare all the planes of the skull with the planes of the human head. We have said thus much in order to impress on the student the importance of the study he is entering on. We are addressing students who mean to be ornamentists, or art workmen, and whose aim, we hope, is to raise the art industry of the country, and to establish a national style in ornament. But there is one outlook for them, and we tell it them candidly here, and that is "hard work." To learn art they must remember the words of Milton, and "scorn delights and live laborious days," and they will find happiness in them. We shall have more to say in a succeeding chapter on the subject of figure drawing.

We would now direct the student to a practice which too often retards the progress of those learning to draw. We allude to measuring the lengths of lines either by a pencil or bits of paper. What we would impress on the student is, that he should first draw the line as exactly as he can, and *then* measure it. By that means he will learn to draw accurately by his eye, and he will find that this delicate organ of vision, if he will cultivate and train it, will measure more accurately for him than any compass or other artifice or mechanical help. For the last court of appeal in all drawing is, or ought to be, the eye. The drawing

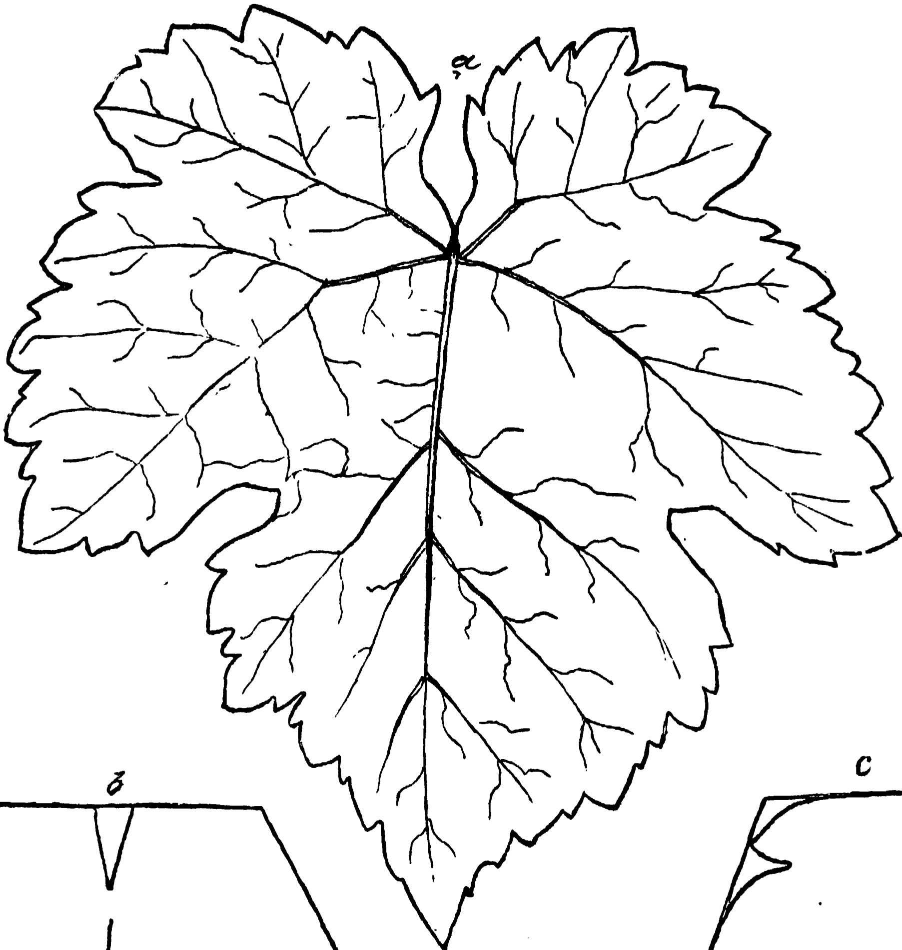


Fig. 42.

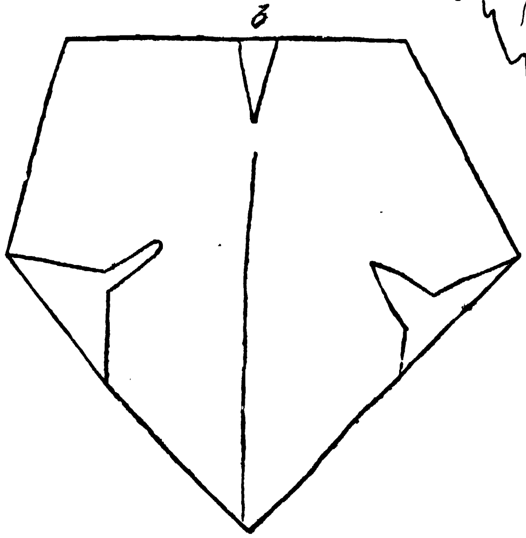


Fig. 43.

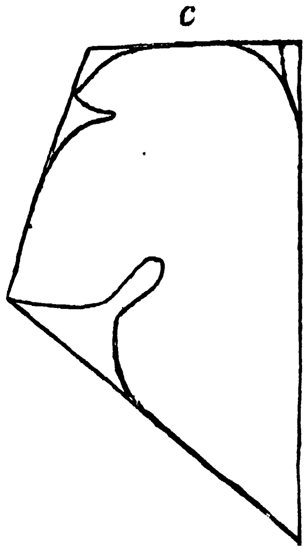


Fig. 44.

when finished must *look* right. The student may measure his lines, and find that they measure right in length, and so far as he can test them by mechanical measurement they are right, and yet his drawing does not look right. The student must cultivate his eye from the first, and he will find that after some practice he will not think of measuring, as he will regard it as waste of time.

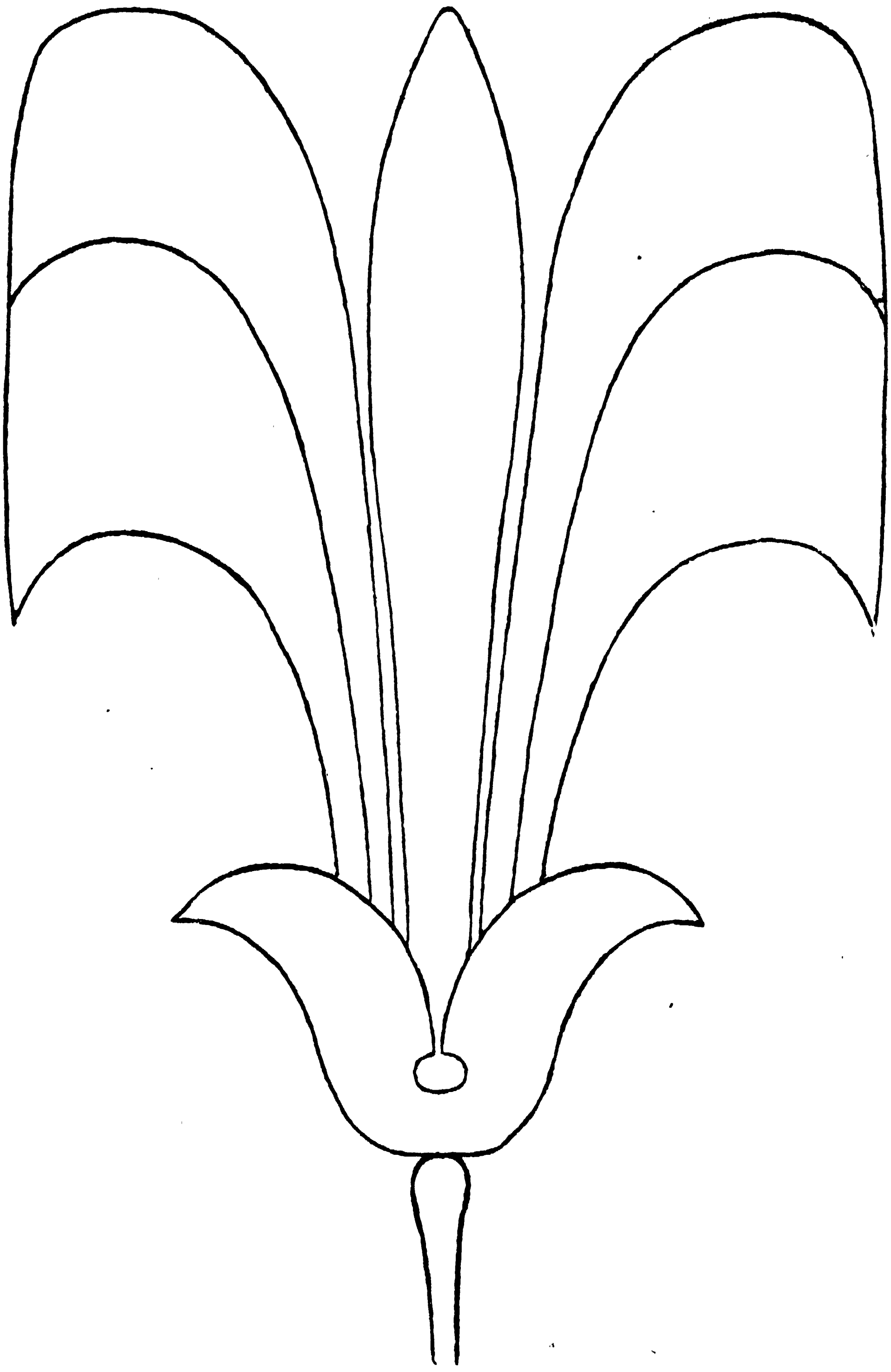


Fig. 45.

THE FARMER AS A TECHNICAL WORKMAN.

His Tools, Implements, Machines and Materials. —The Principles of his Work in its Various Departments.

CHAPTER III.

At the conclusion of the preceding chapter we stated that circumstances had concurred in giving the popular impression that farming was a mere collection of confused risks, to which might be added that farmers were men who carried on their business without method, as if they had nothing fixed to go upon—each man being, so to say, a law unto himself, each asserting that law to be the right one. The general public may well be excused for holding opinions like this, as they can scarcely be expected to know the conditions which bring about what seems to them to be but a collection of contradictory opinions. For some farmers the same excuse cannot be offered, unless that be an excuse that they have not applied themselves to ascertain, not what are the leading principles of the science so far as the science is established, but what are simply the facts which they can derive from observation, or failing that labour, the lighter, if it be as it is the more limited one, of hearsay. For lack of observation there can be no excuse, for lack of knowledge which implies labour there may be some—although the "some" will not by all be accorded them, as if a thing is worth doing at all it is worth doing as well as it can be done; and this will not be unless the laws and principles affecting their work be studied and, as far as may be, applied to its practice.

Difficulties connected with the Soil.

Some conception of the difficulties attendant upon the elimination or deduction of a set of laws upon which practice in farming might be based, and of what the usual results of actual practice or of experiment may be and are, may be gathered by supposing the soil in its interior or hidden mass to be a huge chemical laboratory. In this are stored up a vast variety of substances, some lying inert, and, so to say, dead; others in the active life of chemical combination with others—those forming compound bodies or resultants. These in turn come, or are brought by one agency or another into contact with another set, or in contact with other simple substances. Now, all this work, more or less extensively, but generally in some degree always going on, is, be it remembered, going on in the dark, wholly beyond the region of possible detection, the mere substances present, and how they are present in the soil, being only supposed or conjectured—of which nothing is absolutely *known*. So quite unknown is the condition in which the soil is, its physical properties, or what is called its mechanical state; the fact also whether water is or is not present, and what are the constituents of *this* water, is unknown; also the facilities or the reverse for the admission of air to any part of the mass. Bewildering as all this is, how infinitely more puzzling the problem becomes when to this unknown condition of the great mass of soil with which we *must* deal if we attempt to grow anything at all, we add other substances, such as seeds and manures, and by this or that cultural or arable treatment change the condition of the mass, bringing it under other and new influences! These all bring about new combinations; but what they are, and of course what the results are, while we may conjecture, and that so reasonably and closely, that we almost hit—often in fact do—upon what such effects are, we cannot positively say. This is difficult indisputably when we consider the whole as a question or series of questions of chemistry alone; but how much more difficult does the position become when we begin to deal with questions of physiology, which we *must* do in dealing with the plants, the growing of which is the ultimate aim, the primary object of all arable culture! And here we are brought face to face with life. True, it is only vegetable life—a life so low in the scale, as we conceive it, that some will hesitate to call it life at all. But life nevertheless it is, and life with all its own peculiarities. These the farmer must take note of as influencing his work; and influence it they do whether he takes note of them or not, or believes or the reverse that they are worth taking note of.

Great Progress made in Farming, notwithstanding the Difficulties connected with its Practice—Farming as a Science.

All these circumstances and conditions of what the farmer has to deal with make up, as the reader will now perceive, such a complicated array of difficulties that one might be justified in assuming that to attempt to reconcile them and to eliminate or deduce from them what will be anything like a practically useful set of laws or rules, or even hints, for use would seem to be utterly hopeless. It is well for the advancement of civilisation that such a view has not been taken by all. It is the proud prerogative of man to investigate, as it is one of his highest privileges to carry investigation into all things unknown to him. And the man of mind is ever ready to work in adding to the little he does the more that he may know. The chain, so to say, of circumstances which he desires to forge he knows must be made link by link—and that chain he has not seldom to lay completely in the dark. And the chain may be broken, or a link lost, and all that he knows is that it is so. But because he does not know at what point the rupture is, or of what kind, still he does not sit down to mourn at the loss.

He only the more determines that he will if possible haul up, so to say, the chain, and mend it as best he may, or, failing that, forge another. Idle he will not, cannot be, so long as the necessity to have a chain at all exists. And it is just one of the great encouragements which the learner, or he who daily working wishes to work his best, has, that the more knowledge one gains the greater becomes the power to gather and store up additions to it. Attainment is often confounded with progress, but progress is not satisfied with attainment; when one point is reached or attained, another step forward is made to reach another point, to attain a new thing. And thus step by step from ignorance we reach to knowledge. How step by step progress has been made in the science of farming we shall see as we proceed.

Climatic Influences as affecting the Results and modifying the Practice of Farming.

Returning, after this not useless but in fact practically necessary digression—if such therefore it may be called—to the sequence of the points we were naming, we would observe here that the effects of climatic influences or manurial and cultural results as regards seed and soil, although singularly overlooked even by many in the present day, was not so in olden times. This may be more or less directly proved by the existence of old saws and sage proverbs, worth remembering for the practical knowledge they carry with them. Thus, however well calculated the manure may seem to be to suit the particular soil and seed, the absence or presence of sunny or rainy weather at a particular stage or at stages of the growth of the plants may just be the circumstances which may modify, as they in practice generally are found to modify, the action of the manure, and to set aside and defeat all the calculations and predictions of the farmer. So that it not seldom happens that the scientific farmer, who has taken extra pains with his land, and has manured it in accordance with the rules of science, is beaten in every respect as regards the value of his crop by the old-fashioned farmer who laughs at progress and has a quiet sneer at science, who has only given his land a good stirring and cleared it well, and kept the after crops well from weeds and left the rest to nature. So that in this wise it results that science with some does not make the progress it ought to make. Not that science is wrong, but that the peculiar circumstances modifying its influence or practice are not taken into account as they ought to be. That this arises from ignorance of them there is no doubt, and it will only be when they are widely known and fully considered that we shall see fewer examples of disappointment and loss arise. That climate has a remarkable influence upon the effect of manures upon seeds, and not less upon the growth of resulting plants, is beyond a doubt; but how it acts, and at what precise period of their growth, or whether it extends over a long period or through the whole of this, we do not as yet know. We have only arrived at that stage of agricultural progress when the most we can do is but to conjecture, and following up this, make experiments in the hope that we shall thus deduce laws—if laws there be, which some doubt—that regulate the action of manures, the growth of the plants to which they are applied, and the climatic influences which act upon them during their various stages of growth. We all are well acquainted with the fact, for example, that some winds are more detrimental to the growth of plants than others. The east and north-east winds are pre-eminently unfavourable to rapid and healthy growth—possessing the same influences upon plants apparently that they do upon the human body, few not knowing from experience how disagreeable that influence is. Those who have closely noted the effects of those winds upon certain crops have some very curious and somewhat startling experiences to narrate. But how about winds which we are accustomed to consider genial to vegetation?—they sometimes will act most ungenially, sometimes in quite a startling way. And the influence of some winds in bringing up or on insect attacks of the most pernicious kind is but too well known.

Difficulty in ascertaining with Definite Scientific Precision the Results of Farming Work.

At present it must be confessed—and there is more hope of the future in plainly looking difficulties in the face than turning one's back upon and ignoring them—we are surrounded with many difficulties as regards the action generally of vegetable life. We cannot—with the utmost degree of precision open to the farmer or the chemist—tell of what the soil considered as a whole consists, what are its constituents and characteristics: even the sample, so to say, of one part of a field affords no guide as to what that will be of another; and even if we find this with accuracy we cannot tell how they all act upon one another as individuals, or how they act as a whole —"behave,"—to quote a chemist's term. Nor, to open up still more widely the field of difficulty, can we tell how they act individually or as a whole upon the manures we apply, and—still further increasing the "whirligigs of the problem"—how the soil constituents and those of the manure act upon the plant. We in truth cannot yet say what are the causes of fertility, nor how what we call, and to a certain extent really know to be fertilising substances, are assimilated by the plants under all conditions, nor how what constituents are in the soil are imparted to and give life, vigour, and increase to the plants.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER III.

IN connection with the subject of last paragraph in preceding chapter, which is here referred to, let the reader carefully note that we are now concerning ourselves with the old, or what might be called the ordinary steel, alone used; for it was that which alone could be obtained before the metals of the new processes we have named were discovered or made in practically useful and available weights or quantities. It is much easier to say what steel is than what it is not; but neither the one nor the other is positively easy to say. Here it is necessary to state or assume that the reader knows the two forms in which iron is usually met with: namely, pig iron, which, being capable of being when in a fluid state run into moulds, is termed also cast iron; and malleable iron, which, capable of being hammered or wrought into any definite form or shape desired, is also known, and generally, as wrought iron. Of those two, the great and broad distinction between them is that cast or pig iron cannot be hammered or rolled into various forms, its chief characteristics being hardness and brittleness; wrought or malleable iron, on the contrary, can be hammered or rolled or drawn out into various forms, its chief feature being its toughness and ductility. We do not lose sight of the fact here, that there *is* a malleable cast iron; but this, the result of a special process which ordinary cast iron undergoes, is a new product with new characteristics. Neither do we ignore the fact that, although wrought iron is not cast by being run out into moulds in a fluid state, still there is a product of the Bessemer process which is wrought iron, and which yet is produced in a fluid state—the ingot metal which the same process claims to be a steel being, in fact, in the opinion of not a few, neither more nor less than good, or rather very superior, wrought or malleable iron. But those two exceptions are only so in name, if even they be that; and do not affect the very broad and marked distinction between the two irons, cast and wrought, we have specifically named above.

Various Definitions of Steel—The Old or Recognised Metal so called.

Now, steel—the old-fashioned steel, universally admitted by all to be this—is neither pig or cast iron, the produce of the blast, nor malleable or wrought iron, the produce of the puddling furnace (for description of iron making see the papers under the title of "The Iron Maker," etc., etc.). It is a body or substance intermediate between the two—distinct in itself, yet possessing the characteristics of the two. If a definition be axiomatic, it is true to say that it is safe; but if it be based upon unknown qualities, not points precisely and accurately determined upon, it can neither be precise nor safe. Is it true, then—as the above definition, such as it is, states or holds—that steel is an intermediary material between cast and wrought iron, any given "make," merely one of a number or series, which begins "with the most impure pig iron, and ends with the softest and purest malleable cast iron"? If this be so, even the reader who may not be well versed in the facts of metallurgy will be able, on thinking the matter out, to see this: That there must be an uncertainty as to the product, seeing that the two irons of which it is composed, different in character as regards the classes, are, in the wide varieties of which each class is composed, so uncertain as regards *their own* condition and composition. For it requires no great knowledge of what the qualities of different varieties of iron are, to know that there is a very remarkable difference between them—this being perhaps specially so in the case of pig iron, which is that form of cast iron used in the manufacture of wrought iron. When the value of the factors of a question is uncertain, uncertainty must be the characteristic of the value of the product. And if one fact be more clearly established and more generally agreed upon than another in the subject of iron, it is that ordinary pig irons are notorious for their impurity or impurities, even if they be not, as they have been said by high authority to be, merely "a medley of impurity"—the best being bad at the best, as possessing what it would be better if it did not possess. Let it be noted carefully here that we include in this statement only the ordinary cast iron made in the usual way—what in fact is commercially known as "pig," not including the superior quality made by improved processes which we shall elsewhere describe, and which is perhaps best known as "ingot iron." Now, apart from the fact that definitions dependent upon unknown, at least uncertain things, must be more or less uncertain, there remains this objection to the usually accepted definition of steel,—that difficulties are incurred in the way of arriving at a clear and precise definition of the term, from the fact that there are so many varieties of the iron from which steel is made, and which from the terms of the above definition are the ends of the chain of which steel is, so to say, the connecting intermediary or central link.

Contrast now the definition of steel that we have given above, and which is that which has been repeated again and again, and is still being so, "even in our best text-books," with the simplicity and precision of this of an authority who certainly has some—we might safely say high—claims to be one on the subject. "Steel," says this authority, "is simply a compound of iron and carbon." Thus, as this authority states, "perfect steel would be that in which nothing else existed but pure iron and pure carbon; and although this may not be attainable, the excellence of any given sample of steel is proportionate to its approximation to this standard." But, as we have already stated, the accuracy of this, or indeed any other definition, save that we have above named as the popular one, is keenly contested by many. The opinions on the subject are in truth, what we have said they are, "very different and conflicting."

Still it is, we think, obvious that a definition of this character is more scientific simply because it is more precise, dealing with but two elements, each of which are known and the qualities of both also known—*pure* iron and *pure* carbon—in place of dealing with elements more or less numerous, and which are not well known—some not known at all. At the best, what we know, or presume to know, of them is but conjectural. We trust the reader will perceive that there lies more in the mere definition of a material than some are disposed to admit—that the mere consideration of the circumstances which affect the decision as to what the definition is to be, is likely to lead to a better and clearer understanding of what the material is, and this the more careful the consideration given is. Certainly it is but in vain to expect good results of any kind to flow from that ready acceptance which so many are well content to give of any definition, no matter what, simply because the majority accept it as correct; and this on the ground that what everybody says must be true. A haphazard method of deciding a point, we fear, but too often adopted! Not a few, indeed, in their ignorance on the whole subject, and of the important practical point it involves, and up to which it leads, deem the question What is steel? absurd—its reply, at all events, of no great moment in any case. Such readily get rid of the whole matter by considering it or treating it in the way not seldom adopted in daily life, as thus: "'What is steel?' what's the use of asking!—any fool knows what steel is." No doubt each fool does know what it is, just as he knows everything or anything else—that is, if he himself is to be accepted as the guarantor of his own knowledge. And no doubt his reply would be paraphrasing the well-known saying of a man—some other "fool"—in similar circumstances: "Why, iron and steel are just- -are just—are iron and steel!"

Great Antiquity of the Art of Steel Making.

Having glanced in the first chapter at some points of the general subject necessary to be understood, we are now prepared to enter into the practical details of steel making. This may be said to be one of the oldest arts in which man now excels. If we except bronze—which, from all evidence, seems to have been the first metal used for the making of tools used in the peaceful avocations, or of swords and spears in the warlike occupations of life—steel is literally the oldest of all the metals used by man. We should probably use the term iron, as it is used by most writers, to indicate the metal used by man in the earliest stages of his civilisation; but not merely from certain definite expressions used in ancient writings, even in the Homeric poems, there is abundant evidence that the metal so long known as steel, with all its distinguishing peculiarities—specially that of its capability of giving a sharp cutting edge—must have been known at a very early period in man's history. Iron in its ordinary state would not have answered the conditions of the cases named in ancient writings; and from the very nature of the metal we know that it would be so. The distinction—although not formulated precisely—between iron, with its capability of being hammered, rolled or welded, and steel, with that of having a fine or cutting edge given to it, was practically known to the earliest workers in iron. But so far as researches have shown, though chiefly after all as far as conjecture has gone, it is questionable whether they had for long a knowledge of a process of iron working by which they could get, *at will*, merely malleable iron, or steel with its different characteristic.

Steel a Chance Product of the Early Methods of Making Iron.—Suggestive Points connected with this.

The probability is that, at least for a long period, the iron workers did not really know what would be the actual product of these operations; that while making, they thought, only iron, they in fact not unfrequently stumbled upon steel; discovering, at those early periods, modes of making this metal which are now looked upon, and indeed claimed, to be quite new discoveries. We are inclined to the belief, in looking at the materials they were from their circumstances compelled to use, and which will be noticed presently, that the early so-called iron workers were, if their proper term be given to them, in point of fact, steel workers, to a much larger extent than what some of us are inclined to credit. That steel, even at a very early period in the history of civilisation, must have been made in large quantities, or rather weights, is evident enough from all we read, and all that we conjecture—and that with so much reason that we may accept of it as fact; the use of weapons of war, such as swords, spears, javelins, arrow-heads, and the like, and at later stages of the terrible weapon of the middle ages, the battle-axe, must have been vastly more extensive than a merely passing thought given to the subject is likely to lead one to conclude. Those numerous hordes of powerful warriors, yet undisciplined, and the even still greater armies of disciplined troops, must of necessity have required weapons which in the aggregate must have represented really enormous weights of metal.

THE MARKET GARDENER.

HIS WORK IN PRODUCING IN BULK, VEGETABLES, FRUIT, AND FLOWERS.

CHAPTER II.

Early History of Vegetable Culture—England continued.

FROM what in the preceding chapter we have said of the condition both of farming and gardening in the Low Countries of the Continent, and of the traffic in vegetables carried on between those localities and our own country, the reader will be prepared to learn that market gardening first began to be practised as a special trade in the vicinity of the Metropolis. This arose not merely from the fact that the port of London was the centre of such Continental traffic as then existed, but because the wealth of the country being chiefly concentrated there, and the population being of the densest, there was naturally a better market offered for such produce as the market gardeners could supply, and in which higher prices could be obtained than in the provinces. It was long indeed before the trade extended its operations to the outlying districts of the country. Kent, Essex, and Surrey for long monopolised it; and it is in those counties that it flourishes now on the largest scale and in its most complete development. Now, of course, other large cities have their localities and systems of market gardening—to wit, Manchester in the northern and Birmingham in the midland counties. In the neighbourhood of those cities—and in naming them we exclude from the list other large and populous places simply from lack of space—the work done in point of scientific utility and practical technical skill in market gardening, is second to none.

Importance of Market Garden Produce, Vegetables and Fruit, as Food for the People.—Increasing Consumption a Feature of the Times we live in.

Such is the growing taste for vegetables amongst all classes of the population, that there may be said to be a difficulty to make the supply capable of meeting the demand. Already the production of what may be called the common vegetables, as cabbages in all their varieties, carrots, turnips, peas, and salads, can only be characterised by the term "enormous"; while even of the less commonly used and much higher priced produce, such as asparagus, the supply is each day becoming larger and larger. The land occupied in the growing of market produce cannot be far short of forty millions of acres for the United Kingdom, while the capital employed can only be guessed at; it may, however, be put down safely as embracing a few millions—probably four or five. But great as the consumption of vegetables is in this country, it may perhaps surprise many of our readers to learn that in our culinary system, nationally considered, vegetables play a very secondary part. We have to cross the Channel before we can understand how much more important a part they could play in our domestic economy if we willed that they should. The further north we go, the less important a position do we find vegetables occupy in our domestic cuisine or cookery. And just as we find that not only is there a much greater variety of individual crops, but a much higher rate of consumption, throughout England than there is in and throughout Scotland, so do we find that the comparison can be made with similar, but much more pronounced, results between England and the Continent. Half, if not all, the pleasure of Continental travelling lies in the habit of taking advantage of the wide and varied fields of observation; and nothing surprises the observant traveller who for the first time goes what is generally called "abroad"—as if there were no other places in the "wide, wide world" deserving the term—as the wide variety of vegetables placed upon his table, to say nothing of their large consumption by all classes of society, and at almost every meal. He meets for the first time with vegetables he may not have read of, even though he may be called a widely-read man; but even of those familiar to him he sees such a wide variety, such a number of "species," as completely to surprise, if not to bewilder him. There is no doubt that we have yet nationally much to learn in the matter of the "economy of vegetables," as it may be called—not merely in the way of adding so materially to the food of the people, increasing its economy, but also as playing a most important part in promoting and maintaining sound and vigorous health. At present, large as is the consumption of vegetables amongst us—very large as compared with that only of some forty or fifty years ago—it is confined almost exclusively to the rich, and to the better-off people of the middle classes. We here refer, of course, to the regular consumption of vegetables as forming an important and integral part of our daily food. Occasional consumption of vegetables may, of course, be said to be the characteristic of all classes, even of the poorest. But with the great majority of the industrial population the only vegetable seen regularly on the table is the "universal potato." It is only occasionally that a cabbage or turnip is met with at their meals; they form no part of the daily cooking, daily looked for and enjoyed. Indeed, amongst the very poorest it may safely be said that if they get potatoes they consider themselves well off; and it is only the rarest chance which affords them the taste even of a simple cabbage. But there is no doubt that, nationally, we are learning much in this great and important department of domestic economy. A good deal of the indifference met with about it has arisen largely from prejudice.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER VII.

ON THE DIFFERENT CLASSES OF PRINTS OR "STYLES."

It is frequently possible to produce the same printed effect in two or more different ways—that is, by using different kinds of dyes and adopting different processes. Thus, a print consisting of a pattern containing, say scarlet, black, green, and blue, and having almost exactly the same appearance in each case, can be obtained in at least four different ways, which may be enumerated thus: (1) Fast extract style; (2) Turkey red discharge style; (3) Pigment style; and (4) Loose steam style; besides one or two other methods kept secret. Of these the first three are fast effects, the last loose; but in each case a print differing but little in appearance will be obtained. It is also possible to produce the same by a combination of two of these styles; thus, the extract method may contain pigment colours. For convenience, however, we class calico printing into nine great styles, according to the description of colours of which the print is chiefly or entirely composed. These "styles" may be classed as follows:—

1. Pigment style, in which the colours consist of "pigments" or mineral substances which are fastened to the cloth by the action of albumen and heat.
2. Loose steam style, in which the colours mostly wash off in cold water. The dyes are dissolved in water, alcohol, acetic acid, and applied with starch, etc.
3. Fast steam style, comprising the great majority of colours in common use. The colours comprising these are frequently used in combination with alizarine extract colours.
4. Extract alizarine style, containing alizarine colours; these are fast colours.
5. Alizarine dyed style.
6. Resist style.
7. Discharge Turkey red.
8. Discharge indigo.
9. Discharge bronze.

Although these divisions include the majority of colours in general use amongst calico printers, yet it does not embrace every class of work; for instance, *Printed Indigo style* is a modern and highly developed department of printing which is not referred to above, but which finds treatment appropriately elsewhere.*

1. Pigment Style.

This style comprises prints in which the whole or part of the colours are pigment—or mineral—colouring matters, which are insoluble before being applied. The pigment, in a very fine powder, is intimately incorporated with a glutinous paste containing some such substance as will, by the action of heat, fix, cement or *glue* it to the cloth. The agent now almost invariably employed is albumen. Albumen dissolves in cold water, and forms a thick glutinous paste, which can freely enter the fibres of the cloth. On mixing the pigment with this paste, printing and *steaming*, the albumen *coagulates* or becomes insoluble, and firmly holds the pigment—by simple mechanical adhesion—to the fabric. We give a few practical recipes for the preparation of various pigment colours for the printing machine.

ULTRAMARINE BLUE.

Deep Blue.

Ultramarine, deep blue shade	17½ lb.
Water	1 gall.

Mix smooth, and add gradually, with careful stirring,

Blood albumen (8 lb. paste)	2½ galls.
Pigment paste *	1 "

Pale Blue.

Ultramarine, light shade	2½ lb.
Water	8½ pints.
Egg albumen (6 lb. paste)	10 "
Gum dragon (8 oz. paste)	22 "

PIGMENT SCARLET.

Deep Shade (seldom used).

Vermilion	20 lb.
Water	2½ gall.

Mix into a smooth paste, and mix into

Pigment paste	2 "
Blood albumen, 6 lb. per gallon	4 "

Vermilion is largely used in discharge indigo style.

PIGMENT RED.

Deep Shade (seldom used).

Pigment red paste (lead oxide)	20 lb.
Water	2½ galls.

Mix into a smooth paste with

Pigment paste	3½ "
Blood albumen (6 lb. per gallon)	3 "

PIGMENT RED ULTRAMARINE.

Pale Shade (seldom used).

Ultramarine red	30 lb.
Water	4 galls.
Gum dragon (8 oz. per gallon)	2 "
Albumen	4 "

PIGMENT GREENS.

Dark Chrome Green.

Chrome green paste (mostly hydrate of chromium)	15 lb.

Mix gradually into a smooth paste, if necessary [illegible]

Water	2 galls.

Add gradually, with constant stirring, to a paste consisting of

Pigment paste	1 gall.
Blood albumen (6 lb. per gallon)	3 galls.

* The author has treated this subject briefly in a "Note" in vol. i. of the TECHNICAL JOURNAL, page 186, to which the reader is requested to refer.

* The composition of the pigment paste referred to in these recipes is given in Chapter III., page 170, vol. i. of the TECHNICAL JOURNAL. See also Chapters II. and III. for paste, etc.

Light Chrome Green.

Dark green, as above	5 galls.
Gum dragon (8 oz. per gallon)	5 „
Extract paste	2 „

These two shades of green, and others near them, are very largely used.

PIGMENT BROWNS.

Pigment brown (mostly hydrate of iron)	12½ lb.
Water, mixed smooth	1½ galls.
Pigment paste	3 „
Blood albumen (6 lb. per gallon)	2½ „
Gum dragon	3 „

Mixed in the same manner as dark pigment green. Many qualities of pigment brown in the market, when made into "colour" in the above manner, and reduced with gum dragon about 10 to 30 times, give various shades of *buff*.

PIGMENT BUFF.

Pigment buff (hydrate and carbonate of iron)	10 to 40 oz.
Water, mixed smooth	1 to 4 pints.

Added gradually to

Gum dragon (8 oz. per gallon)	5 galls.
Egg albumen (4 lb. per gallon)	1 to 4 quarts.

Buffs are also produced by reducing *brown* mixed with *yellow* pigments.

PIGMENT YELLOWS AND ORANGES.

Deep Chrome Yellow.

Pigment yellow paste, containing 60 per cent. of solid yellow chromate of lead	1 gall.

Mixed gradually with

Gum dragon (8 oz. per gallon)	1 „
Pigment paste	1 „
Blood albumen (4 lb. per gallon)	2 „

or if it be necessary, use egg albumen in place of blood.

Light Chrome Yellow.

The above reduced with an equal measure of gum dragon gives a moderately pale shade.

Deep Orange.

Pigment Orange paste, containing 50 per cent. of red chromate of lead	3½ quarts.

Mixed in same proportions as yellow.
Pale Orange is seldom applied.

PIGMENT OLIVE.

Pure Shade.

Dark Pigment Yellow	5 galls.
2 lb. Pigment Black	1 to 8 pints.

To obtain a bluer shade mix with pigment chrome green.

PIGMENT OLIVE.

Dark Brown Shade.

Dark Pigment Yellow	2 galls.
Dark Pigment Orange	3 „
2 lb. Pigment Black	2 pints to 1 gall.

Dark Mixture Green, No. 1.

Dark Ultramarine Blue colour, as above	3 galls.
Deep Chrome Yellow, as below	1 „
Gum dragon	2 „

Dark Mixture Green, No. 2.

Substitute the Ultramarine in Green No. 1 by Prussian Blue, and a rather duller shade of green is obtained, which has the disadvantage over the latter that it does not stand dilute alkalies nor strong soaping.

There are other pigments used more or less extensively in this country and America and the Continent, but which are mixed in a similar way to the above, and therefore need not here be further noticed.

Most of the pigments, when fixed with the requisite amount of albumen, form colours unsurpassed for fastness against friction, light boiling soapsuds, and air. We may mention, however, as a notable exception, Prussian blue, which is readily destroyed by strong soap solution. Ultramarine, although fast against soap, is at once destroyed by dilute mineral acids and many salts.

2. Loose Steam Work.

This consists of effects produced by printing solutions of any colouring matter with or without mordant, and steaming, which either partially fixes them or simply brightens them. It need hardly be added that, as the name implies, they give colours which are mostly not intended to withstand washing in water, or other strong influence. The most important colours which are chiefly used for this style are cochineal, aniline scarlet, many loose aniline colours, and many wood colours. In most cases the solution of the dye is simply mixed with starch paste and printed on, and the goods then steamed and passed through cold water open, and dried. In some cases a little of a tin salt, or cream of tartar, or other substance, is added, in order to "spring" the colour or brighten it. All the examples of loose steam colours given below are for moderately deep shades.

LOOSE STEAM SCARLET.

Aniline Scarlet, Ponceau, or Croceine	3½ lb.
Pour on this, with stirring, boiling water	3 quarts.
Pour the hot solution, with stirring, into hot starch paste (1 or 1¼ lb. paste)	17 quarts.

This gives an exceedingly brilliant scarlet, which, of course, washes off in cold water. Before the discovery of aniline scarlet, cochineal served the same purpose.

LOOSE STEAM BLUE.

Alkali Blue	10 ounces.
Acetic acid at 4° T.	½ gall.
Warm till dissolved, pass through fine calico, and add to alum in a starch paste (see p. 170, vol. i.)	4½ galls.

This is an exceedingly bright and pure blue.

LOOSE STEAM YELLOW.

Auramine powder	2½ lb.
Acetic acid at 3° T.	1 gall.
Heat till perfectly dissolved, and mix into alumina starch paste	4 galls.
Then add citric acid, powder	10 ounces.

Mix till all dissolved.

LOOSE STEAM GREEN.

Aniline Crystal Green	15 ounces.
Acetic acid at 3° T.	1 gall.
Alumina paste	4 galls.

LOOSE STEAM VIOLET.

Methyl Violet, powder	10 ounces.
Acetic acid at 3° T.	1 gall.
Starch paste	4 „

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART.

CHAPTER V.

In the last paragraph of preceding chapter we drew attention to certain points connected with force and motion to be taken into consideration, and stated if forces were equal in amount, there would be no motion in the body. If they are unequal, the stronger force will influence the weaker, and not only destroy the force of the latter, but impart what may be called the surplus of its forces to it, so that the weaker will be compelled to go back, as it were, and follow the direction of the stronger force. Thus we can suppose a steamer capable of going along under steam at the rate of ten miles an hour, but to be under the influence of a tidal current which we may suppose to run also at the same rate of ten miles: if the direction of the current exerting a force equivalent to a motion of ten miles an hour be the same as the direction in which the vessel is working under steam, the force of which is equivalent to an equal rate, the speed of the vessel will be twenty miles an hour. If the vessel were steaming against the current she would make no headway at all, but would simply remain stationary—the forces being equal; but if she ceased steaming she would be carried back by the current at the rate of ten miles an hour. Two boats or floating balls, one of which (*a*, fig. 7) was driven in the direction of the arrow *b*, with a certain force calculated to carry it to the point *e*, meeting another boat, as *c*, driven by a force *d*, equal to force *b*, would meet at a point *e*, central to both, and would stop there—motion being, so to say, destroyed, the two equal forces *b* and *d* having neutralised each other, as explained in the paper on mechanics above alluded to. Motion is always in straight lines. The boats or balls *f* and *i*, acted upon by forces *g* and *j*, will proceed in the straight lines *g h* and *j k*, coincident with the lines of direction of the forces *g* and *j*. The forces we have named act either in the same direction as above just alluded to, or in opposite directions, as at *b* and *d*, and may be either single forces or each the sum of several forces. But a vessel, as at *a*, fig. 8, may be placed under the influence of two forces, one of which acts in the direction of the arrow *b*, and the other in that of the arrow *c*. In this case we have two forces acting in directions quite different from each other—so much so that they diverge from a point which is common to both at right angles. We shall see presently that the angle may be other than a right angle, and how the difference of the angle made by the two lines *b e* and *d f* influence the direction of motion. The young reader, in thinking over the condition of a vessel, as *g* in same figure, as acted upon by a force represented

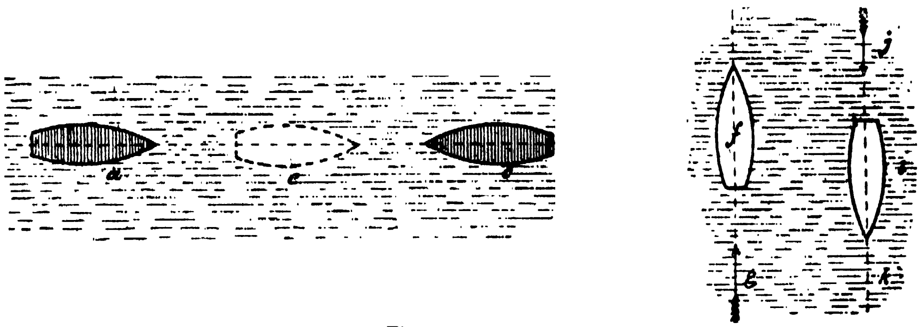


Fig. 7.

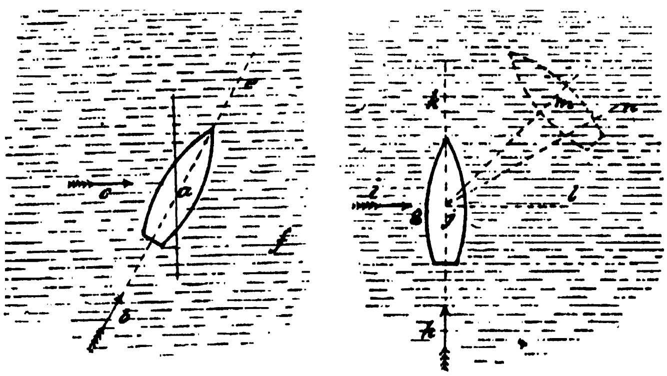


Fig. 8.

by the arrow *h*, and by another force represented by the arrow *i*, but in another direction, might and at first probably would suppose that the vessel under the influence of the two forces would, to use the popular phrase, be hauled or "slewed" round, as it were, somehow in a direction between the two directions *of forces h and i, intersecting in the point j*, thus going in a curve more or less pronounced, as shown in dotted lines. But, as already stated, motion is always and naturally taken in a straight line; the new line of motion will therefore not be as just stated, but be in a straight line, oblique, or at an angle to the lines *h k*, *i l*, and *g*, as in the line *j m*.

This course, somewhere between the two lines of forces, which is the result of the action of these on the same body, as *g*, depends for its direction on the obliquity of the angle, as *h j m* or *h j n*, and this upon the relation which the two forces represented by the arrows *h* and *i* have to each other. Thus, suppose

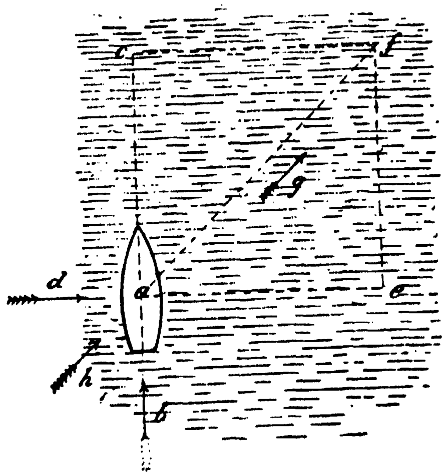


Fig. 9.

that, as in diagram fig. 9, we have a body, say a boat, *a*, placed under the influence of a force represented by the arrow *b*, which would, if acting alone, carry the body *a* as far as the point *c*, at which it would come to rest. The body *a* is, however, placed under the influence of another force represented by the arrow *d*, which, if acting alone, would carry it to the point *e*, where it would come to rest. As the result of those two influences, which the reader must remember are acting on the body simultaneously—that is, precisely at the same moment of time—the body moves off in a direction between the two forces *b* and *d*, as shown by the arrow *g*, and to a distance *f*, just as if there were but one force, acting in direction of arrow *h*. This point *f* is at the angle where the two lines produced from points *c* and *e*, and parallel to *a e*, *a c*, meet. In other words, the direction of the new motion is the diagonal of a square, and the length of the line is equal to that diagonal, and is just as much longer than the length of line, as *a e* or *a c*, due to one or other of the forces *b* and *d* taken singly, as the diagonal, *a f*, of a square is longer than the side of it, as *a e* or *a c*. It follows, therefore, that this diagonal will vary in length as the difference between the two forces varies: where the forces are equal, as in fig. 9, the diagonal is that of a square; where they are unequal, as in fig. 10, the diagonal is that of a parallelogram. And this is found thus: Let *a* be the body placed under the influence of a force, as *b*, which, acting alone, would carry it to the point *c*, where it would come to rest; let *d* represent a force which would carry the body *a* to the point *e*: the length and direction of the diagonals are found by drawing lines parallel to *a c*, *a e*, which meet and cut each other in a point, as *f*. We thus have a parallelogram, *a e f c*, the diagonal of which, as *a f*, gives both the length and the direction of the line of motion. This new line is called technically the

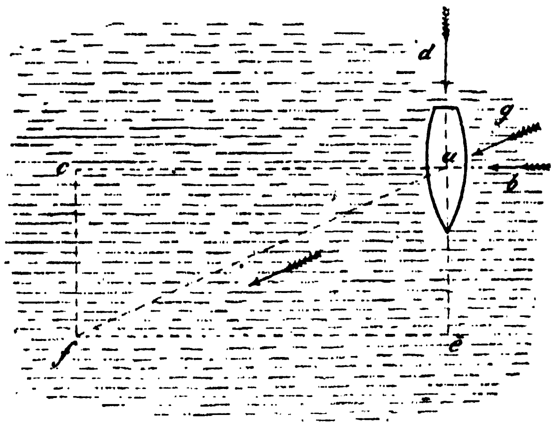


Fig. 10.

"resultant" of the two forces, and any one of the diagrams we have obtained in figs. 9 and 10, as *a e f c*, *a c f e*, is known as the "parallelogram of forces." In all cases the body, as *a* in figs. 9 and 10, will move in the direction under the influence of two forces no further from the point *a* than the extremity, as *f a*, a line which is the diagonal of a parallelogram the sides of which are *a c*, *a e*. And this holds equally true whether the lines of direction of the two forces are at right angles to each other, as in diagrams 9 and 10, or oblique to each other, as in fig. 11, at *a* and *b*, acting on *c*. If these forces acting upon the body *c* are equal to each other, the distances to which each will carry the body, if acting singly, will be equal, say to points *d* and *e*; and by producing from these points lines parallel to *c e* and *c d*, they cut or meet in the point *f*, forming a parallelogram known geometrically as a rhombus, the diagonal of which, as *c f*, is the length and the direction of the new line of motion, as if the body *c* were acted upon by a single force, as at *b*.

The length of the diagonal and the form of the parallelogram of forces depend upon the relation of the angles of the lines or direction of the forces to one another. Thus, in figs. 9, 10, and 11, we show forces acting at different angles; these acting as at *b d*, fig. 9, will form either squares, as in the diagram, or rectangles if acting as at *b d* in diagram fig. 10. The forces acting at the angle *c*, fig. 11, will form a rhombus, as in diagram; and those forces acting as at *a* and *b*, fig. 12, will form a lozenge-shaped figure or rhomboid, as in the diagram. The more closely the lines of the forces act together, converging towards the body on which they act, the longer will be the diagonal. Thus, in diagram fig. 12 we have the lines of the two forces *a* and *b* approaching pretty closely to each other as they strike the body at *c*; the direction in which the force *b* tends to drive the ball *c* is in the line *b d*, that of the force *a* on *c* is the line *c e*; the resultant of these two forces is a long diagonal *c f*, and a narrow compressed-looking

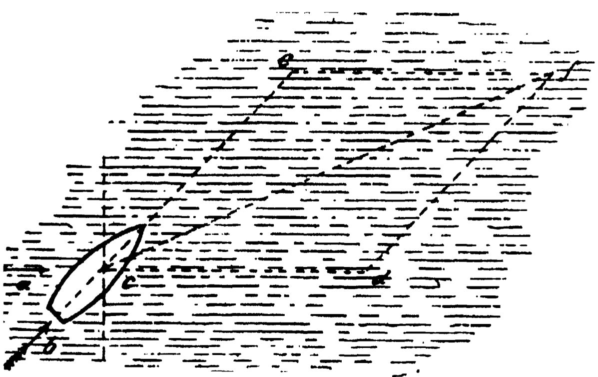


Fig. 11.

parallelogram of forces, *c d f e*. If the forces act in opposite directions, but crossing each other's path obliquely, the diagonal is short. The parallelogram of forces in this case is shown in fig. 12. In this the body *g* is struck simultaneously by two forces *h* and *i* acting in opposite directions, but obliquely—the force *h* tending, if acting singly, to drive the body *g* in the direction *h g j*, that of force *i* in the direction *i g k*; the resultant of these is in the direction of the short diagonal *g l*, the parallelogram of forces being completed by drawing from points *j* and *k* lines parallel to the lines of direction of forces *g k*, *g j*, meeting in point *l*; the points *j* and *k* are those to which the forces *h* and *i*, supposed to be equal, would carry the body at *g*, if acting singly. We thus see how the length to which a body moving under the influence of two forces striking it simultaneously is dependent upon the relation or position of the two forces or their lines of direction have to each other. Thus, in diagram fig. 9, the body *a* runs but a very short distance, as *a f*, but in first diagram fig. 12, it runs a long distance, as *c f*, the forces in both cases being equal. It will be obvious that the less oblique the lines, as *h i*, diagram fig. 12, are, the shorter will be the diagonal, as *g l*; and we can conceive of the forces approaching nearer and nearer the position of a straight line till they are exactly opposite each other, but in the same straight line, when all diagonals would be obliterated, and if the forces were equal the body would be kept at rest in a position central to the two. When we have a combination of forces

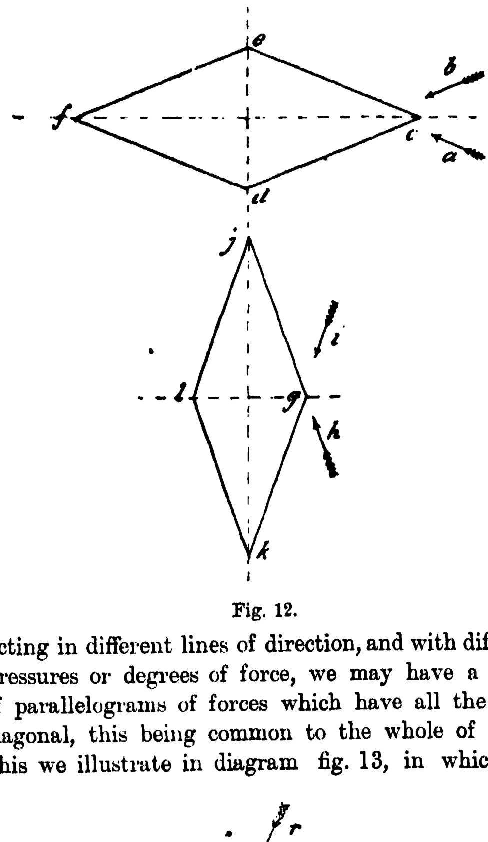


Fig. 12.

acting in different lines of direction, and with different pressures or degrees of force, we may have a series of parallelograms of forces which have all the same diagonal, this being common to the whole of them. This we illustrate in diagram fig. 13, in which the

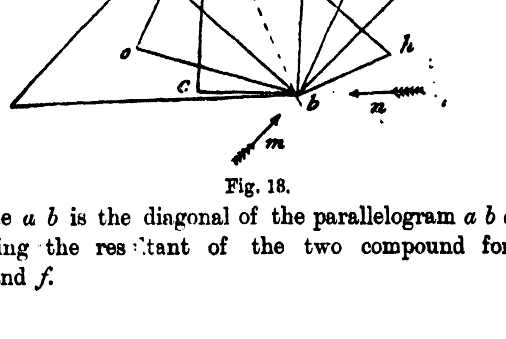


Fig. 18.

line *a b* is the diagonal of the parallelogram *a b c d*, being the resultant of the two compound forces *e* and *f*.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER VII.

IN last paragraph of preceding chapter we stated that at one time the breed of the West Highland or Scotch black cattle were scattered all over the hill-pastures of the north of Scotland. But in many of those Highland districts the breed has almost, in some wholly, disappeared. Still over the extensive pastures of the counties of Inverness and Argyle, on the exposed pastures of the islands on the coast, and throughout the uplands of Perthshire, Dumbartonshire and Stirlingshire, the breed is met with in herds, more or less numerous. By far the largest, if not indeed the finest, herds of the breed are to be met with

Fig. 6.

in the islands of Skye and Uist; but, as stated, they are to be met with throughout all the western islands. The pasturage there met with seems to suit the breed admirably; though the inland pastures, such as those of Perthshire, are said to give better bone than upland or sea-margin pastures. The moisture and the general geniality—at least, absence of extreme cold weather during the winter months—of the climate of these sea-washed islands seem also to contribute greatly to the high development of the breed. In fig. 6 we give a sketch showing the characteristics of this most interesting breed, from which will be seen its claim to be distinguished as a long-horned animal. In some cases, indeed frequently, the horns, while they have a fine curvature, branch out laterally—that is, more horizontally than those in the sketch; and this to such an extent as to make a "horned head" of a West Highland ox a meet and a striking ornament for the hall of a Highland laird, or to adorn the "shooting box" of the "rich southron," who now so frequently represents him. The following is a description of the breed, from the pen of a well-known authority on it:—

"There are perhaps few animals familiarly known to us so graceful in form, colour, and movement as a thoroughly well bred Highland ox or heifer. In form it possesses all the characteristics so much and so justly prized in the shorthorn—the straight back, the short legs, the broad chest, the breadth of loin and depth of rib, and, in short, the 'squareness' and solidity of form which always imply weight, whether in man or beast; while the noble branching horns, the fine, full, and fearless eye, the short, broad, well-bred muzzle, the shaggy coat of richest black or red or dun or brindled colour, impart a picturesqueness which is still further enhanced by that grace and deliberation of movement so distinctive of all animals reared in perfect freedom. All these characteristics of the breed are frequently found in the Highland oxen exhibited at our Christmas shows; but there the most attractive appearance does not carry the prize. The more sentimental and less earthy points, however much they may denote purity of breed, are overlooked by matter-of-fact judges of fat stock, and the prize goes—very properly perhaps—to the fattest, but not to the finest beast."

The Sussex Breed, one of the "Middle-Horn" Class.

As an example of the "middle-horn" class of English fattening cattle, we give the following illustration and description of its leading characteristics. The breed is chiefly confined to, at least is most highly esteemed in, and seems suited to the localities of the county which gives it its name. But it is one of the now many varieties of the original or native breed of England to which we have already referred. In general appearance it is somewhat like the Devon—is, like it, red in colour; but, larger and coarser, it lacks the fine qualities which make the Devon so highly prized. The Sussex breed has a high reputation as a draught beast; but animals subjected to the heavy work of plough and waggon driving, however well fed and otherwise cared for, can scarcely be expected to yield the fine quality of flesh so valued by the butcher.

Of the breeders of this class of animals the name of Mr. John Ellman, of Glynde, stands perhaps the highest. But other breeders, as Mr. H. Colgate, of Bramfield, Mr. Vittle, of East Farley—in Kent, not in Sussex, Mr. Carr, of Bidingham, and Mr. Carnegie, of Westham, should be recorded as amongst early breeders. Of the more modern ones there is a long list, all recorded in the "herd book" of the breed, amongst which stands most honourably the name of Mr. Edward Cane, of Berwick's Court, who has done much to improve the breed. The following from the pen of a high authority gives a description of the characteristics of the breed—a bull—of which the illustration in fig. 7 shows the head of an ox.

"Head rather long, muzzle fine, eyes prominent and lively; ears thin; horns fine, white, and projecting horizontally from the head, turning up a little at the points; the neck rising to a curve from the shoulder, and small where it unites with the head—top of the shoulder joining full to the chine; bosom and chest broad; legs straight and fine; broad loin, hips projecting, with round and springing ribs, quarters long and level from the rump to the hip, leaving but small space to the first rib; the tail round and thin, laying close between the wide rumps; colour a dark red—sometimes dappled with spots of lighter red, tending to yellow over the loins and rump; tip of the tail generally white. The true cow, of good shape, has a red colour; fine hair; skin soft, mellow, and thin; small head; fine horn, thin, clear, and transparent, projecting horizontally from the head, and turning up at the points; neck very thin, and clean; small bones, straight top and

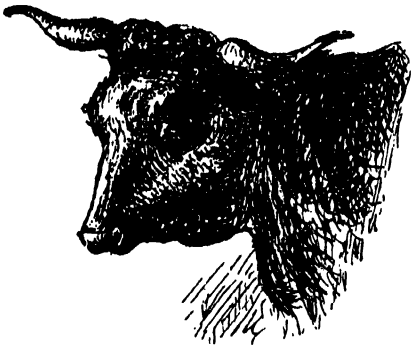


Fig. 7.

bottom, with round and springing ribs, thick chine; loin, ribs, and rump wide; a fulness in the chest and twist, added to the properties required of a dairy cow, making a complete character; but it is in Sussex as in most breeding counties,—the dairy has become a secondary consideration.

"The colour varies, like the cattle of Devonshire, from a light red, or even sandy, to a dark liver colour, with gold or flesh colour round the eyes and muzzle, the nose and horn seldom so near a light wax colour as the Devons, nor is the tip of the horn so commonly black, the whole horn being more of a mixture of red and yellow, tending to black at the tips. The length, turn, and colour of the ox-horn will often be found to take a medium character between the Hereford and Devon, from which some idea may be formed that the breed partakes of a cross between these two; and, however some individuals may resemble the best Devons so strongly as to make it difficult with the first judges to determine, yet it will be found that they have generally a larger frame than the Devons, and considerably more bone than either of those breeds."

Midway between the middle-horn and the hornless or polled breeds comes the "shorthorn," which we have fully described in preceding paragraphs, and of which, as filling up our illustrations showing the

Fig. 8.

heads of the various breeds, we give in fig. 8 a sketch.

The Polled or Hornless Breed of Fattening Cattle.

Of this class there are several varieties, the first we name being the Suffolk polled—with which are classed the Norfolk polled cattle. Of this class of hornless cattle we give in fig. 9 a sketch of a head. The two breeds now named are by some writers considered, in point of fact, but one, and that is the Norfolk. Certainly more than one herd was named as "Suffolk" when they nevertheless were in

Fig. 9.

reality "Norfolk" polled cattle, having been brought from that county. The native or original Norfolk breed of cattle are of hardy constitution, thriving under circumstances where other and finer breeds would not do so well. They are small-boned, stand short in the legs, and the loins are good and clean, thighs thin, and bodies or bowels well rounded. The flesh of the later breeds is highly esteemed by the butcher, and under favourable circumstances the cattle fatten pretty rapidly. The favourite colour is a blood red, with a mottled, sometimes a white face. The "Suffolk" breed have much the same peculiarities; but if early history is to be trusted the colour was dun,—red, red and-white and mottled were the later colours. The breed is very hardy, and feeds well upon the thin pasture grasses of the county, where other breeds would do little more than hold their own, if they did that. The breed has been much improved of late years. It is a disputed point whether the present or modern Norfolk polled breed is not a cross breed; the cross having been taken almost wholly with the Scotch polled breed known so widely as the "Galloway." That large numbers of this Scotch breed were from a very early period in the history of the county brought into Norfolk is a well established fact. There is therefore every probability, in the face of this, that the native breeds were crossed with those animals. But whether the Norfolk native qualities dominated, or those of the Galloway, some writers hesitate to decide definitely upon. Others hold that the Norfolk and the Suffolk—for this breed also was under the same circumstances as its sister county—dominated the cross, giving its peculiarities to the breed as it now is. One point in favour of this view is that the deep blood-red shade of the Norfolk is not shared in by the Galloway, in those animals of the breed which are red, the shade of this being lighter. The following is a description by a good authority of the points of the "Suffolk polled" breed:—

"The points admitted are a clean throat, with little dewlap; a snake head; clean thin legs and short; a springing rib and large carcase; a flat loin, the hip bones to lay square and even; the tail to rise high from the rump. This is the description of some considerable dairymen. But if I were to describe the points of certain individuals which were famous for their quality of milk, it would vary in several points—and these would be such as are applicable to great numbers,—a clean throat with little dewlap; a thin clean snake head; thin legs; a very large carcase; rib tolerably springing from the centre of the back, but with a heavy belly; backbone ridged; chine thin and hollow; loin narrow; udder large, loose and creased when empty; milk-veins remarkably large, and rising in knotted puffs to the eye. This is so general that I scarcely ever saw amongst them a famous milker that did not possess this point. A general habit of leanness, hip-bones high and ill-covered, and scarcely any part of the carcase so formed and covered as to please an eye that is accustomed to fat beasts of the finer breeds. But something of a contradiction to this, in appearance, is that many of these beasts will fatten remarkably well; the flesh of a fine quality; and in that state will feel well enough to satisfy the touch of skilful butchers. The best milkers I have known have been either red, brindled, or yellowish cream-coloured."

Scotch Breeds of Polled or Hornless Cattle.

Galloway, the *locale* of the Scotch breed above alluded to as having probably given a cross with the Norfolk breed of polled cattle, is in the south-west coast of Scotland, and is made up of the counties of Wigtown and Kirkcudbright. The breed has long been a celebrated one, was highly esteemed as early as the beginning of the sixteenth century, and up to the beginning of the present century has held the position of the most important breed of Scotland—when its supremacy was challenged by other and now more celebrated breeds. The colour of the breed is generally black, but red is met with, especially in the herds which can boast of the highest lineage. The following is a graphic description of the Galloway polled breed, from the pen of a high authority:—

"These are less stately, less magnificent, than the Angusshire oxen, the pride of Aberdeen and the northern feeders, and with which Scotch farmers astonished the Parisians at the great International Exhibition; but they are perhaps more characteristic and more distinctly stamped by nature as an original

Fig. 10.

breed than their weightier rivals. The Galloway ox, like a good hunter, is *long and low*, having a well rounded body upon short legs. His hair is long, soft, and glossy; the ears are large and shaggy, and well supplied with hair inside, the excellent provision of nature to meet the wetness of the climate. When slaughtered, the flesh and fat are found distributed in a manner fitted to produce the most satisfactory roasts and rounds."

The other polled breeds of Scotland are the Aberdeen and the Angus—and of these the last named is perhaps that to which the greatest attention of the grazier has of late been paid. The "polled Angus" (see fig. 10) breed owed its existence to the late Hugh Watson of Keillor, as noted for his high character as a man as he was energetic and successful as a breeder. Watson, in fact, did for the polled breeds of Scotland what Colley did for the shorthorn.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

76. The Working Condition of Belts.

As we did not exhaust all the points in connection with the condition of belts as regards their pliability in our last note (No. 62, p. 338, vol. i.), we take up what remains to be said on this subject before proceeding to other and interesting points connected with this important subject of belt and pulley driving. The following is one of the somewhat elaborate softening stuffings for a belt alluded to in the last note: "Two pounds of tallow, one pound of bay-berry tallow, and one pound of beeswax, heated to the boiling point, and applied directly to both sides by a brush—after which the belts are held close to a red-hot plate to soak the beeswax in, which does not enter the pores of the leather from the brush." Before applying this mixture—which ordinary good tallow and beeswax would represent very well, as the other ingredient is not easily or generally obtainable—the leather must be perfectly dry, otherwise there is a chance of burning it during the process. The engineer who recommends this mixture to render the belts pliable states that while a piece of belting, thoroughly dry, was boiled for nearly an hour in the very hot composition, without sustaining injury; another piece, but which was damp, by being subjected to the same process, was burnt up or made quite crisp, immediately on immersion in the hot fluid. We confess to feeling that in the hands of some careless workmen and apprentices we have had from time to time to deal with in our work, the chances of loss or injury from this cause would prompt us to be cautious in trying to gain what advantages there may be in this special application, seeing they were to be gained at a certain amount of risk—what, indeed, some would pronounce to be great risk. If belts are to be treated specially at all—which, as we have seen, some seriously object to, and do not consider necessary—certainly a mode of treatment should be adopted which is likely to change the condition of the leather as little as possible; and not to introduce more than the ordinary amount of risk run by treating it on any method. For all methods are distinctly stated by some authorities to carry risks with them. The whole subject is indeed surrounded with the uncertainty which is the result of numerous systems or methods having been carried out, without any attempt even—so far as we know—to conduct the trials in a systematic way, in order to arrive at some definite trustworthy result. The points certainly seem to be very definite indeed, just as they are as contradictory in principle as they can well be. When one class says belts (*i.e.* the leather) should never be "doctored"—that is, subjected to any application which, if used at all, is generally greasy or oily in composition, but should be left in the natural or normal condition—and when another class takes precisely the opposite ground, a third class may well be pardoned if its members say, "Well, those two views are totally irreconcilable: which of the two is the right one?—both cannot be right, unless indeed a new law is found to exist, so that in place of six and six being twelve, they may with perfect truth at one time be nine, and at another with equal veracity be eight or ten." What can the tyro in machine and belt and pulley gearing do when he hears one practical man say—as practical men have said—"Frequent application of neat's-foot oil promotes regularity of speed, durability of leather, economy of use," and on the other side listens to another practical man—"The application of neat's-foot oil to belts opens the pores of the leather and destroys the adhesion of its parts, and in a very short time renders it flaccid and rotten,"—in brief terms, ruins it? At the same time the young and inexperienced machinist may have this ground of hope opened up to him,—that such remarkable discrepancies of opinion may be reconciled if it be remembered, what in scientific investigations is but too frequently forgotten, that the *conditions* of the trials may make all the difference in the practical result. Have the results of the so-called comparative observations been obtained by using the same materials? For comparison can only be made when the case is the same. Now, as there are faggots and faggots, so there is leather and leather, and neat's-foot oil and neat's-foot oil; and, though these may be assumed to be the same in both trials, they may be vastly different in composition, and this will make a great difference in the value of the so-called experiments. Now, many of the somewhat startling discrepancies which are found to exist between the results of experiments *said* to be conducted in the *same* way, may be accounted for in this. They have not been the same—quite different, indeed, in reality. As the habit of making experiments is a very useful one, and should be cultivated and carefully trained, we would counsel the young machinist to try some experiments himself to test this much disputed question of dressing of belts or the non-dressing of them with softening oily or greasy unguents.

Let him obtain from the same piece of leather two belts—or two belts the leather of which is pronounced by competent judges to be as alike in quality as can possibly be obtained; and let him try one belt in driving without any preparation, and the other dressed or stuffed with some dressing of which he is inclined to think favourably, or which is highly recommended. The experiment would be all the more valuable if he could have more than two belts, so as to test more than one dressing. The young experimenter must keep strictly in mind what has been said as to the "conditions" in which the relative trials are to be made, and that these affect all the circumstances. If, for example, the pulleys were of different diameter—one much less than the other, in one of the trials—the results would be quite fallacious. The young machinist will see how this is so if he remembers what was said in one of our early notes on pulley and belt gearing as to the greater wear and tear on a belt running on a small pulley or on small pulleys compared with a belt running on larger-diametered pulleys.

A point which must not be lost sight of in considering the condition of belts is the circumstances under which they are working. We know what may be called the climatic effects on the working of belts; and this is much more marked in the case of rope or round or cylindrical band driving with grooved pulleys than in the case of leather belts. But a belt which works habitually in a dry and comparatively hot atmosphere will obviously work under different conditions from another belt running habitually in a moist and hot atmosphere; while one subject to positive damp or wet will still more clearly be placed in conditions very different from the others. And yet such conditions are by many not taken into account at all, although they must and do exercise a marked influence on the working results. And it is only where there is something very striking and palpable in the relative circumstances under which belts work—as, for example, where a belt is subjected to a positive drip or spray, or an atmosphere of unmistakable dampness—that the point receives serious attention, at the hands of some. In the latter case indiarubber belting will have to be substituted for leather, which would give most unsatisfactory results,—even although there might be a prejudice against indiarubber, as some have a prejudice, in fact. The materials also of which the driving belt is made other than leather, must or should dictate the way in which it should be treated, or prepared if some preparation be considered necessary. Thus, cotton belts have been lately introduced, and even for driving where great power is to be transmitted; and these have been used with such success that their makers , it is said, sanguine enough to believe that they ultimately, if not completely yet very extensively, supplant the old and still general favourite leather belting. Be this as it may, it is obvious that the condition of working cotton as a material for the making up of a broad surface, and this comparatively thin—very thin indeed in relation to the breadth in some belts—is very different from that of leather. Cotton is a material greatly subjected to atmospheric influences. A condition of the atmosphere of the room in which it regularly works, either as regards its relative dryness or humidity, which would affect leather in no appreciable degree, will affect cotton—which consequently gives and takes within considerable ranges. The inquiry, therefore, is practical enough in its outcomes which takes up the points connected with the preparation, or the reverse, of cotton belts which will enable them to work as uniformly and economically as possible within the usual range of ordinary atmospheres in working rooms. Hence some insist upon cotton belts being varnished, and recommend linseed oil for this purpose. This, as most know, is a very drying oil, and is employed with singularly good effect in cases where it is important to guard against the effects of damp. And those who advocate the use of linseed oil for the varnishing of cotton belts maintain that it will make them practically so free from atmospheric changes that they will neither give nor take, neither stretch nor contract. The linseed oil is to be applied with a brush till the cotton fibres will take in or absorb no more. The belt may be put on and driven at once, without waiting for the drying of the oil; and greater flexibility will be given to the belt by starting when the oil is wet or moist,—it will then harden equally all over. After the belt has run for some time another application should be given of the linseed oil. Before concluding the present note—which is by no means the last of our series of notes on this most important subject—we may refer, as bearing on the point of "conditions" under which experiments or trials should be made, that while some do not object to the stuffing or dressing of *leather* belts with oily or greasy substances, they maintain that the success of the operation depends altogether on the way in which the dressing is applied. Thus they insist upon applying the dressing to the flesh, not the hair side of the leather; others maintain the contrary; while those who go in for a thorough soaking of the whole belt put both of these out of court altogether, as they have then both sides or surfaces of the leather dressed, and the solid part between them as well. If the young machinist is, in view of this and of other points we have stated, apt to ask the old, old question, "Who can decide where doctors disagree?" he may perhaps, in such cautions as we have given him, be able to find a better way of deciding for himself.

77. To find the Weight of a Bar of Square Iron.

Take the square of the side of the bar in inches or in fractions of an inch, and multiply it by the length in the same factors. Divide the result by the constant 3·6, and the quotient is the weight in pounds of the given bar.

78. To find the Weight per Square Foot of Cast Iron.

Take the thickness of the plate or piece of uniform thickness throughout, and multiply it by 144, the number of square inches in a square foot; divide the product by the constant 3·84, and the result is the weight in pounds.

79. Rule to find the Weight per Square Foot of Plates of Wrought Iron.

The rule is the same as the above, the divisor or constant only being different—that is, 3·6 in place of 3·84.

80. To find the Weight of Plates of Wrought Iron, Length Breadth, and Thickness being given.

Take the breadth and multiply it by the thickness, and this by the length in inches, and divide the product by the constant used above—that is, 3·6.

81. Weight in Pounds per Square Foot of Cast Iron of thicknesses from an Eighth of an Inch to an Inch and a Half.

$\frac{1}{8}$ of an inch thick = 4·61 lb.; $\frac{1}{4}''$ = 9·36; $\frac{3}{8}''$ = 14·06; $\frac{1}{2}''$ = 18·72; $\frac{5}{8}''$ = 23·43; $\frac{3}{4}''$ = 28·12; $\frac{7}{8}''$ = 32·81. One inch = 37·54 lb.; $1\frac{1}{8}''$ = 42·18; $1\frac{1}{4}''$ = 46·37; $1\frac{3}{8}''$ = 51·56; $1\frac{1}{2}''$ = 56·24 lb.

82. Cubical Contents or Solid Measurement of Flooring Joists covering a "Square."

(That is, 100 superficial feet. For example, a surface 10 feet by 10 feet, = 100 feet, is what is technically termed a "square." The term is also applicable to flooring and roofing boarding, to slates, cement flooring, etc.). In the following table the joists of which the "scantlings" or dimensions in depth or breadth on face or side, and width or thickness on edge are given, are presumed to be "set" or placed in position at distances twelve inches apart from centre to centre:—

Scantling or Dimensions of Joists.	Solid Measurement in Cubic Feet and Inches.		Scantling or Dimensions of Joists.	Solid Measurement in Cubic Feet and Inches.	
Inches.	Ft.	In.	Inches.	Ft.	In.
3 by 2	3	7	8 by 2	9	7
3 „ 3	5	0	8 „ 3	13	4
4 „ 2	4	9	9 „ 2	10	8
4 „ 3	6	8	9 „ 3	15	0
5 „ 2	6	0	10 „ 2	15	11
5 „ 3	8	4	10 „ 3	16	8
6 „ 2	7	2	11 „ 2	13	2
6 „ 3	10	0	11 „ 3	18	4
7 „ 2	8	4	12 „ 2	14	4
7 „ 3	11	8	12 „ 3	20	0

83. On some Points of Practical Art-Manufacturing Design.

In the series of papers in the text entitled "On Form and Colour as applied to Industrial Decoration," and in that under the heading of "The Ornamental Draughtsman," the reader will find the whole subject of "design" discussed. The term itself, which has got concreted into our daily language in the everywhere known title "schools of design," is one of those vague words which give rise to many misleading views. What design really means will be found explained in the text in the earlier chapters of the series of papers given under the title of "The Workman as a Technical Student—how to Study and what to Study." But by a curious perversion of a French word, or rather a misunderstanding of what *it* really meant, the word "design" is now with us so universally understood to be connected only with the ornamentation or decoration of the materials and objects of daily life, that it seems quite hopeless to attempt to divorce it from this restricted use, and to give it the infinitely wider application which it naturally possesses. This being so, it is in the narrower sense that we employ—as nearly all writers on the subject have employed—the term "design." In the new name given to that Governmental Department of Education which at one time was alone known by the term "Government Schools of Design"—namely, the "Department of Science and Art"—there is a slightly more accurate conception conveyed of what design in the restricted sense involves, and which would be best met, perhaps, by the title of "Art applied to Industry," or more tersely "Industrial Art,"—although this is also confining the term art within limits infinitely narrower than it really means, as if art were alone the delineation or depicting of natural objects, and the application of its work to the purposes and objects of daily life—whether for the gratification of what is vaguely termed "taste," the love of what is no less loosely called the "beautiful," or for the decoration or ornamentation of what are known as "objects of utility." Precision of definition of terms used by us possesses a much higher and more practical value than is generally supposed, and of this statement many illustrations will be found in various papers in the text; it is therefore to be regretted that, in so important a subject of technical or industrial art as that we are now giving a brief note upon, a lack of precision in terms used should be a very marked characteristic. There is indeed scarcely one of them on the meaning of which, and all that that meaning conveys, we find two authorities agreed. So wide is the diversity of opinion, even on what might be called the foundation of art as applied to industry, that the very term itself which we have seen to be so universally accepted as the name of this department of work —design—has given rise to discussions as numerous and earnest as they have sometimes been warmer in tone than the importance of the subject, great as that is, would seem to warrant. Seeing, then, that the term "art" is really an exceedingly wide one in its meanings, a more definite and precise signification to the term is attempted by prefixing the term fine—"fine art" being defined to be "that which affects the passions, intellect or soul pleasurably by the aid of form and colour." Unfortunately for this attempt at precision of definition, in the popular mind the term "fine art" is almost without exception associated with the work of those who, curiously enough in this present connection, are called "artists" *par excellence*, as if there were no other artists but those who were concerned in the production of what are called "pictures"—that is, representations of natural objects existing in all their wide and ever-changing diversity in the world around us. And it is with those pictures, or the practical work or results of "pictorial art," that the term "fine art" in nine cases out of every ten is always associated. In the definition of fine art as given above, it will be perceived that its agents are two in number—form and colour; and every development of these, seen singly or in combination, has its source in nature, and in nature alone. In considering those developments as apart from what the popular mind has agreed to call "pictures," the work of "artists" as alluded to above, there is another term almost invariably used, and which is known as "ornament"; and the application by form and colour as drawn or derived from natural objects is described by a name the meaning of which is known to all—"ornamentation." But while "fine art" in its popular acceptation and "ornamentation" are both dependent for their existence on precisely the same agents or elements, "form" and "colour," and both have to go to nature as the source of their inspirations, the popular mind has no difficulty in grasping, on the contrary, comes at once to a direct understanding of, the essential difference which exists between the works of "fine art" and "ornamentation." This difference may here be explained by referring to terms we have already used, as thus: that while fine art—the work of "artists"—pictures—minister to a gratification of "taste" or to the love of the "beautiful," "ornamentation" is always associated with "objects of utility." And in this distinction the popular mind is right in its conclusions. And this, while it by no means lessens the worth or lowers the dignity of fine art—that is, purely pictorial art, the work of "artists"—does not admit, what many "artists" claim for it, that it alone is true or high art, and that the work of ornamentation is *per se* a lower, if not a degraded manifestation of fine art. If it be, as we fear, that to a large extent it is true that the work of the ornamentist, or ornamental art—that is, form and colour as applied to objects of utility—is held in lower esteem than that of the artist, or pictorial art, we haveno hesitation in saying that it is the fault of the ornamental artist chiefly, if not wholly. And this simply because he has forgotten, overlooked, or what is worse, been ignorant of the true principles of his work; has formed in place of a high a low ideal or standard of excellence—indeed, as not a few have shown, been quite indifferent as to having any standard at all. With a high ideal, an accurate conception of what his work is, the more fully it is gone into the more clearly we think it will be perceived that the practical outcome, both in its material and moral aspects, of the labour of the ornamental artist, will be higher and more valuable than that of the pictorial artist. Beyond all doubt the field of labour of the ornamental is much wider than that of the pictorial artist; his work appeals to an infinitely larger class; and, when once the field is not only fully occupied, but wisely, carefully, and assiduously cultivated, we predicate for it a material and moral national influence very much higher than many seem to think it is capable of exerting. We have thus arrived at a definition which is for all practical purposes precise enough: ornament is form and colour applied to purposes of utility—and it is to its principles that the term "design," now so imbedded in the popular language as to be considered a permanent fixture, is applied. The points connected with it will be found fully discussed in the papers in the text we have already referred the reader to; in stray "notes" in this department we hope to gather up a few hints and suggestive remarks of utility to the practical designer. Claiming thus for design or for ornamental art, whichever of the two titles the reader may prefer, such a high place as in the preceding sentence we have shown it is capable of occupying, we have room here only for a notice of three leading characteristics of the art which we have seen is always associated with objects of utility, or, to use the more fashionable term, art manufactures—a term which includes them all. The first of the rules, canons or principles which are essential to be attended to in applying ornament to objects of utility is, that their usefulness be not impaired or lessened in any degree. This is simply to say, what may be thus paradoxically put, that the useful object must be so ornamented that it remains useful—that is, affords the highest degree of convenience in use. Some of our young readers, new to the subject, or having given no real earnest thought to it, may at first sight be disposed to think it, if not an impossible, at least a very unlikely thing for an ornamentist to do, this rendering a useful thing not useful, or greatly impairing the convenience of its use, by the way he may ornament it, either by the ornament being given to it by the mere form of the object, or by the way in which he attaches extraneous ornament to it. But those who know the past history of art manufacture—and not a few phases of its present condition—know how numerous have been the examples of objects so ornamented as to have lost all their practical utility. The second canon or principle is, that the materials used in ornamentation shall so be dealt with, or treated in a way so consistent with their nature or character, that constructive truth shall not be sacrificed. The third canon or principle is, that the style and amount of ornamentation be subordinate to the object to be ornamented, thus securing what is called, for lack of a better term, artistic truth. Those three, if they do not embrace within their limits all the rules of ornamentation of objects of utility, go far at least towards a contribution to rules or canons which, as yet at least, have not been formulated and generally accepted as standards to which all could refer. And although not thus absolutely comprehensive, they will, if thought well out, be seen to underlie all good and sound ornamentation. There are, of course, what may be called sub-rules or divisions branching out from the three rules named, and these again have a variety of details which together make up a pretty full supply of material aids or helps to the ornamental artist. Those, or the most important of them, will be found treated in the text in the papers we have referred to; but in connection with them we may find in the present department space to give occasional notes useful as supplementing them.

84. Reducing a Stiff, Obdurate Clay to a Fine Garden Tilth or Soil.

Those who have had, or have the misfortune now to have, a soil so well known as "stiff," know well how difficult a thing it is to work it for garden produce; and how its hard lumps or clods in dry, or its bird-limy adhesive masses in wet weather, are so well calculated to "vex the soul of the husbandman." And they will be all the more vexed and inclined to grumble if they have formerly had to deal with that soft yielding and crumbling earth known as the "best of garden soils," the cropping and culture of which is as much a delight as that of the clay soil is a dilemma to the gardener. He knows, however, that when once, by patient toil and careful cultivation and treatment, he gets a clay soil into good heart and tilth, how valuable it is as a rich crop-bearing one. To reduce quickly a stiff obdurate clay soil to a fine clayey loam, we know of no substance so valuable as coal ashes. A great deal has been written and said as to the value of these as a manure, and some high authorities have stated that in point of fact this phrase is quite a misnomer, as they possess no value at all. Practical men not a few deny this, and appeal to a wide and successful experience in proof of their belief that coal ashes are valuable as a manurial agent. But be this as it may—and we may hereafter give a "note" on the subject—no one has as yet disputed the high value of coal ashes as an agent in reducing hard stiff clays to that fine, loose, open and "crumbly" condition which all gardeners like to work with. The action of the ashes may be mechanical only, as dividing and opening up the clay masses; but if the many practical men above alluded to are correct in their estimate of the manurial value of the ashes, we by their use in clay soils gain a two-fold advantage. The rapidity, indeed, with which a rich and comparatively easily worked garden soil is obtained from hard, close, adhesive clays—otherwise to a large extent unworkable—would seem to favour the idea that the coal ashes exercise, and that powerfully, a favourable action otherwise than one purely mechanical. The student in agriculture and horticulture should never forget that it is exceedingly difficult to decide what is or will be the result of certain operations or experiments. The experimenter may decide that he is using only certain substances, and that his soil is only of a certain character; but there may be present other substances of which he is quite ignorant, which may bring about an action of a kind wholly or greatly different from that anticipated. There may, moreover, be an action brought about by the mere mixture of certain substances placed in the manure, for example, and those present naturally in the soil, of which the experimenter has had no knowledge, and which he cannot trace. The very seasonal characteristics may bring about changes of which no prevision is possible. We could cite numerous instances in proof of the extremely varying results of trials made, so far as could be seen and provided for, under precisely the same circumstances. It is dangerous to dogmatise in matters connected with the treatment and uses of soils and manures. The best way of using the coal ashes in bringing clay soils into good tilth and heart will be obvious to the practical gardener—the great point is to get them mixed with the soil, and they should not be spared. One point is essential: that in the autumn the land should be thrown up into deep ridges, to get all the benefit possible of a good wintering. In bringing a piece of land so stiff that it often resembled a "bricky" surface and substance into good tilth we spread the ashes between the drills, and in spring they got mixed up with the wintered soil in digging and preparing the surface.

85. Average Yield of the Cereals or Corn Crops, in Grain and Straw, per Acre.

"Wheat," 5 to 6 quarters, 25 to 30 bushels; weight per bushel, 60 lb. Weight of straw may be calculated at twice that of the grain, so that a thirty-bushel to the acre crop will give 3600 lb. of straw. Botanical name of wheat — *Triticum Sativum.* "Barley," 45 to 50 bushels; weight per bushel, 53 to 55 lb. Averaging the weight of straw at one-fifth more than that of the grain per acre, we have for a fifty-bushel crop at 55 lb. to the bushel a weight of 3300 lb. of straw. Botanical name—*Hordeum.* "Oats," 48 bushels; 62 lb. to the bushel; straw, calculated at half as much weight as the grain, will give 3024 lb. Botanical name—*Avena Sativa.* "Rye," 25 to 30 bushels per acre; weight per bushel, 54 lb.; weight of straw, 4000 to 4800 lb. Botanical name—*Secale Cereale.*

86. Cements, Varnishes, Enamels.

We purpose under this head to give a number of notes and recipes, selected without any great regard to any particular order of classification. The principle of this would not be easy to define, or if defined could not be followed with a due regard to the wants and wishes of so wide and varied a class of readers, who for widely different purposes will consult the various paragraphs which under the above general head we purpose to give. To serve, in some fashion, the purposes of a ready reference to the different recipes and notes, each of which will be given under a specific number, we have it in contemplation, at the expiry of certain definite periods—say every six or twelve months, or shorter if need be—a generally classified catalogue. The collection we have at command is very extensive, as additions have been made to it from time to time, extending over a period of many years. Nevertheless, we shall be pleased to consider the giving a place to such notes and recipes as any of our readers may think worthy of being recorded. With this help we may thus be able to give to the series a completeness and comprehensiveness of a very practical and useful character.

(1) "Fluid" or "Liquid Glue."—This, which will be found useful for the wide variety of purposes for which ordinary melted glue is used, is also well adapted for joining together the pieces of earthenware or glass vessels, etc., which are large, and where the colour of the glue is no objection. Keeping dissolved or liquid or "fluid," it is always ready for use, unlike glue made in the ordinary way. Take of the best glue three parts (the weight of each part will be determined by the quantity of fluid glue required), and place them in eight parts of water, allowing them to soak or melt for some hours. Take then half a part of hydrochloric (muriatic) acid; and three-fourths of a part of sulphate of zinc; add these to the dissolved or partially dissolved glue, and keep the whole at a moderately high temperature for a length of time sufficient to reduce it to the required degree of fluidity.

(2) "Cement for uniting glass, china, etc., etc." An exceedingly strong, easily applied, and very cheaply made cement, useful for a variety of purposes so wide that we have not as yet, in the course of many years, exhausted its adaptations—is made with ordinary gum arabic by melting it in the ordinary simple fashion, in any conveniently sized vessel or bottle, taking care, for obvious reasons of cleanliness and facility in using it, that it have a wide, not a contracted mouth-piece, such as that possessed by ordinary phials or domestic medicine bottles. In place of using water, as ordinarily done, acetic acid is the liquid adopted for melting the gum arabic. This is all; nevertheless there is good reason to believe that some of the cements sold in the shops with high sounding names, such as "Oriental," "Diamond," or the like, but at very high prices, are made in this cheap and simple way. Cheap, for a large quantity may be made at a mere tithe of the cost of a small bottle,—some which in years gone by we have purchased containing, for sixpence, scarcely a teaspoonful. Simple, for there is no nicety in proportioning or weighing or measuring out quantities; all that is necessary to be done is to secure a melted product, neither too thick nor too thin—one, in short, easily spread or applied over the surfaces of parts to be joined, without being so thin as to run off. By adding a portion either of the gum or a small quantity of the acetic acid, and by a little practice in its use, the maker will soon hit upon the right thickness to make and use. One caution only is necessary. The gum must be melted in a hottish place: the most conveniently applicable is the fire-grate hob, or the oven of a kitchen range, or the hot plate of the same. And while on this point of the necessity of a warm, if not a positively hot melting of the gum and the acetic acid, it may be worth the while of some of our readers to know that this is the secret of making the strongest gum liquid or mucilage, which is now sold by all stationers, and in some of the weakest, distinguished more by the absence than the presence of gum. Let the reader, by one or two simple experiments, test the adhesive strength of a gum or mucilage made by dissolving gum arabic in *cold water*, and another quality made by dissolving the gum under the influence of a moderately high heat, and he will soon be convinced of the advantages to be obtained by the latter method. Generally the temperature of an ordinary kitchen-range oven—that is, its normal temperature when not heated specially high for baking, roasting, etc.—will be quite sufficient to give the warm or hot melting required. Where superior articles of glass or crystal have to be mended or pieced by means of this cement, a light colour, so desirable, will be obtained by using the finest quality of sheet gelatine—the modern and cheap substitute for the old-fashioned and dear isinglass. Although this gelatine is dearer than gum, it can be had at such a price as will give a large quantity of the cement for a moderate sum. We have said that it is difficult to limit the uses to which this cement can be put.

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY.

(31) In Note No. 26 we gave an explanation of the terms "saturated" and "supersaturated" in relation to "solutions" of substances which are capable of being what is called "melted" or dissolved. The youngest student in applied science knows that substances are more readily dissolved, "solutions" of them more easily made, when the dissolving or melting liquid is heated or warm, than when it is cold. As most phenomena of physical bodies generally follow or are regulated by certain definite laws, it has been found by M. Poggiale—a Continental chemist who has experimented extensively upon the saturation of liquids or the melting of solid substances capable of being dissolved—that there is a fixed or determined relation between the points of "saturation" and "supersaturation" and the temperature at which the solution is made. Thus, taking the "boiling point," 212° of Fahrenheit, corresponding to 100° of the Centigrade scale; and "freezing point," 32° Fah., 0° or zero Centigrade, as the extremes of temperature, M. Poggiale found that if of a substance the liquid became supersaturated at the point when 357½ parts had been dissolved or taken up, at the temperature of 32° or the freezing point some 3·90 parts only were taken up. At 194° Fah. or 90° Cent. 269⅓ parts were taken up; at 176° Fah. (80° Cent.) it took 134½ parts; at 158° Fah. (70° Cent.) the number of parts taken up was over 90½; at a temperature of 140° Fah. or 60° Cent. the liquid took up 66½ parts. When the temperature was 122° Fah. or 50° Cent. the number of parts taken up was a trifle over 44. With the temperature at 104° Fah. or 40° Cent. the parts taken up amounted to nearly 31, and when the temperature was at 86° Fah. or 30° Cent. the liquid took up 22 parts. At 68° Fah. or 20° Cent., six degrees above the normal or average temperature of the air, the number of parts taken up was 15⅞. Lastly, at a temperature of 50° Fah. (10° Cent.) the number of parts taken up amounted to 9½.

(32) In extension of our notes on "Cements," we give this other of what is called a "new cement—to fasten iron to stone." If this is as good as report tells of it, it will prove of great utility in many jobs of frequent occurrence in practice. While it possesses that valuable and, of course, essential characteristic of adhesive strength, or a capability to resist forces tending to separate the bodies or tear them asunder, it exercises no deleterious influence upon the iron. The base of the cement is the cheap and readily obtained one of pieces of good brick broken into small nodules and finally pulverised or crushed into the condition of a fine dust. The binding or cohesive material is resin. This is first melted over a fire—care being taken not to allow it to catch fire—the brick powder is put gradually into the melted resin, and carefully stirred till a kind of putty-like substance is formed: the finer and more uniform the brick powder, and the more intimately mixed, the better the cement. When required for use this putty can be melted by heat, and run readily into any cavity, for example, into which the iron body is to be fixed. As soon as "set," the iron will be found firmly secured to the stone. Should the cavity be much larger than the iron body to be fixed in it, a species of concrete of the putty cement and small pieces of sharp-cornered brick may be used. This will save the putty or cement, as less of it will be required.

(33) At end of Note No. 29, on the subject of combustion of fuel, we drew attention to the importance of attending to the condition of the fuel. And it may with all truth be said that it is largely to the neglect of this principle in stoking that the steam-engine boiler furnace is such a wasteful producer of heat. Of two stokers, one will do his work so well that the cost of fuel per horse-power per hour will not be one-half of that which another stoker expends, although the circumstances are alike, quality of coal, form of furnace and boiler, etc., etc. The secret of the successful working of the one stoker lies in the fact that, whether intuitively or from superior knowledge, he attends to the condition of his fuel and to that of the furnace, etc. Some men act as if they believed that coal, as long as it gives out a certain number of increments of heat, must produce the same working effects, no matter how it is consumed. They forget the fact that coal is no more in itself and by itself a combustible than stone is: it is only when treated under certain conditions that it will burn at all, and only if burned in certain conditions that it will yield all the increments of heat in such a way that they can be usefully availed of. One may have heat enough, but whether it will be economically used or the reverse, will depend upon the way it *is* used. A man may have money enough, but if he throws half of it into the sea, from which recovery is hopeless, he can scarcely be said to have used his wealth prudently. In many of our furnaces we throw away much more than one-half of the heat increments obtained from the com-

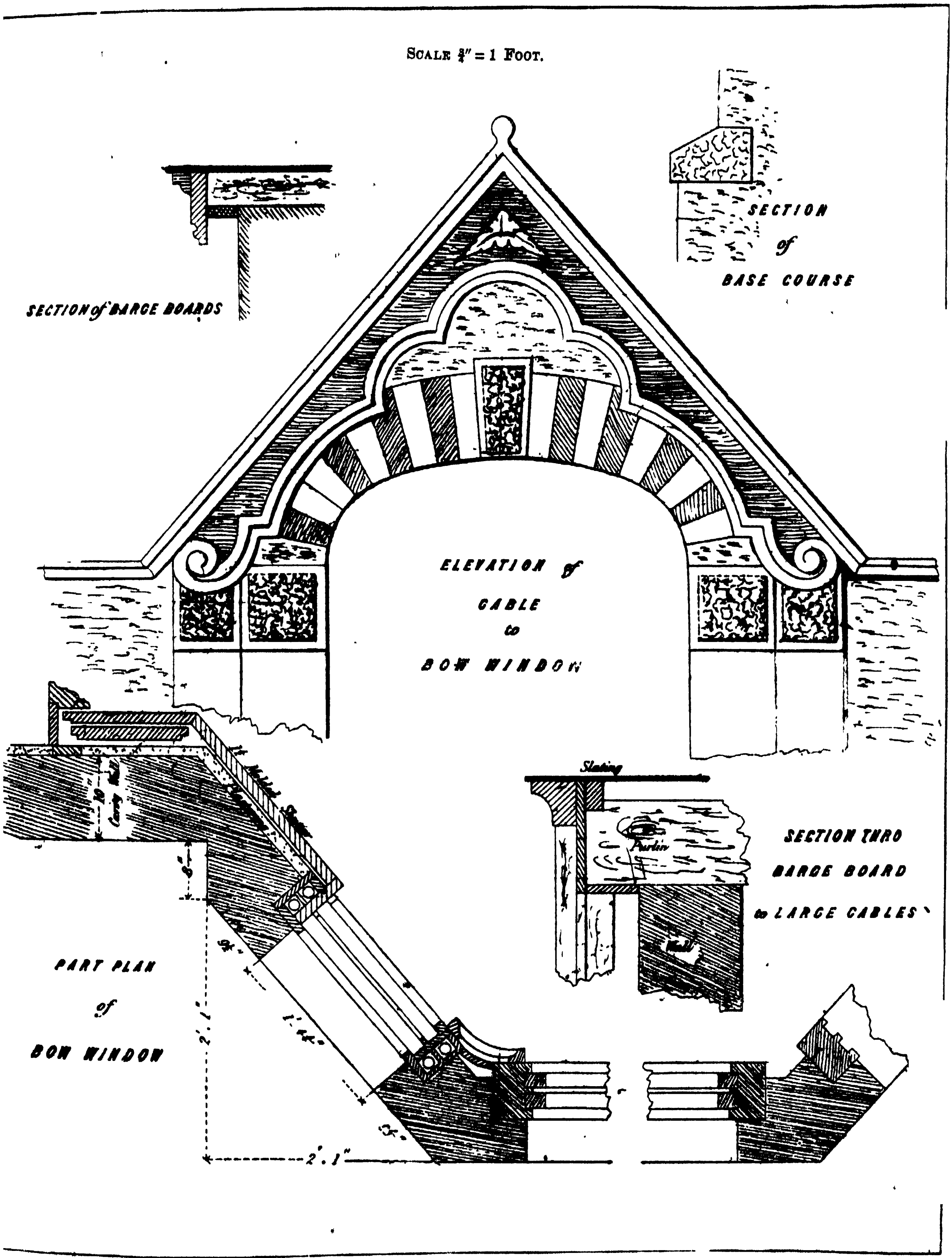
bustion of the fuel consumed in them. In order to see how far this statement is true, let us glance in the first instance at the constituents of coal, this being the form of fuel which is almost universally used for the purposes of steam raising. The coals found in different localities differ materially in heating quality, some being of a stony, slaty character, and therefore very poor in calorific value, others being rich in carbon and bituminous matter, yielding the hydrocarbons which give the illuminating or flame-producing gases; we must therefore fall back on a quality of coal which gives us the average calorific value. The amount of carbon or carbonaceous matter present in a coal determines or is the measure of its industrial value as a heat given for steam raising purposes; and the average of the best quality—as, for example, of Newcastle coal, the oldest and most valued of our coal-producing districts—yields 81·42, or say $81\frac{1}{2}$ parts of carbon out of every 100 parts of any given weight or quantity. Taking it at 80 per cent., the fifth left over is made up of the incombustible parts termed the "ash," of which there are 2·07 or $2\frac{7}{100}$ths; of sulphur $\frac{74}{100}$ths (0·74). But the greater part of the remaining fifth is composed of permanent gases, of which oxygen takes the lead in amount or percentage, being 7·04 per cent. of the bulk of coal analysed. The next largest in percentage of these permanent gases is hydrogen—equal to 5·88, or not far off 6 per cent. Nitrogen, the third of those permanent gases present in coal, amounts to 2·05 per cent., or a fraction ($\frac{5}{100}$ths) over $\frac{1}{50}$th part of the whole hundred parts analysed. As we have already said, coal—thus constituted or made up of different parts—is only a combustible when those constituents combine with oxygen, which is supplied by the ordinary air or atmosphere. But the combustion can only take place when the air and the coal are under the influence of what we call heat, the degree of temperature required varying with the quality of the coal, or with what we have already called its kindling point, or that at which it takes fire or becomes what we call "lit" or "lighted." We have in a preceding note explained how in the starting or kindling of a fire the fuel is primarily "lighted"; but in the case of a common fire or a furnace which is already lighted or in active combustion, the burning coal—incandescent, as the term is to indicate red-hot fuel—gives the necessary heat to the fresh coals we feed the fire or furnace with, and also to the oxygen of the air which passes up from the grating in which the fuel is laid, getting heated to the necessary combining or lighting temperature as it passes through the incandescent fuel. It will thus be perceived by the young student that a supply of air to the fire or furnace is just as essential to the work of heating as a supply of the fuel itself. And the "poking" of a fire, which is done to enliven it when it is dull, is simply the opening up of the fuel which has got "caked" together, thus making passages through which the air can freely pass to the point where its combination with the fuel is required. In this way also the "condition" in which the fuel is, influences its combustion, and largely decides whether that shall be active and bright or languid and dull. Some coal is so full, so to say, of bituminous matter, that when heated it to a certain extent melts and runs together, "caking" the pieces, and to a large extent preventing the passage of the air through and between its pieces. And many who are in the habit of using coals of this quality know—that is, if they have observed—how rapidly a fire made of it kindles up or flashes into a cheery flame and active combustion the moment the fuel is "poked." This breaks up the hard caked-together coal, opens up passages for the air to go through, and the bituminous parts of the coal being well heated, the combination between them and the oxygen of the air, which can now get to them in the different "condition," is quickly completed, and the bright, cheery burning of the coal in the grate is the result. On the other hand, some coals of good quality do not possess a high percentage of bituminous matter, and therefore do not cake together; and passages are therefore easily maintained between the pieces, and the fire requires less frequent poking to maintain the active combustion due to its character or constituents; for the quality, so to say, of the combustion of a coal depends much upon its constituents, even although the supply of air to it is well adjusted.

(34) Resuming our investigation of the phenomena manifested in the process of boiling water begun in a preceding Note (No. 25), the student will remember that as the water in the flask approached the point at which the whole of it was of uniform temperature, the condensation of the rising bubbles would become less and less, and on the point of uniform temperature being reached, the bubbles would rise continuously and with such velocity and force as to cause a violent agitation at the surface of the water. This is boiling—"ebullition," as it is sometimes termed—and takes place under ordinary conditions of temperature, when the barometer stands at the level of 30 inches and the thermometer indicates 212° Fah. It would require but small power of observation to notice that the boiling—that is, the passing of vapour or steam bubbles from the water—was not by any means uniform in character: in some instances the boiling would be gentle; in others violent. The principle of the process being the same in all cases, there must be some cause for the boiling in practice being at one time gentle, and the passing of the steam (watery vapour) from the mass of boiling water easy, and in

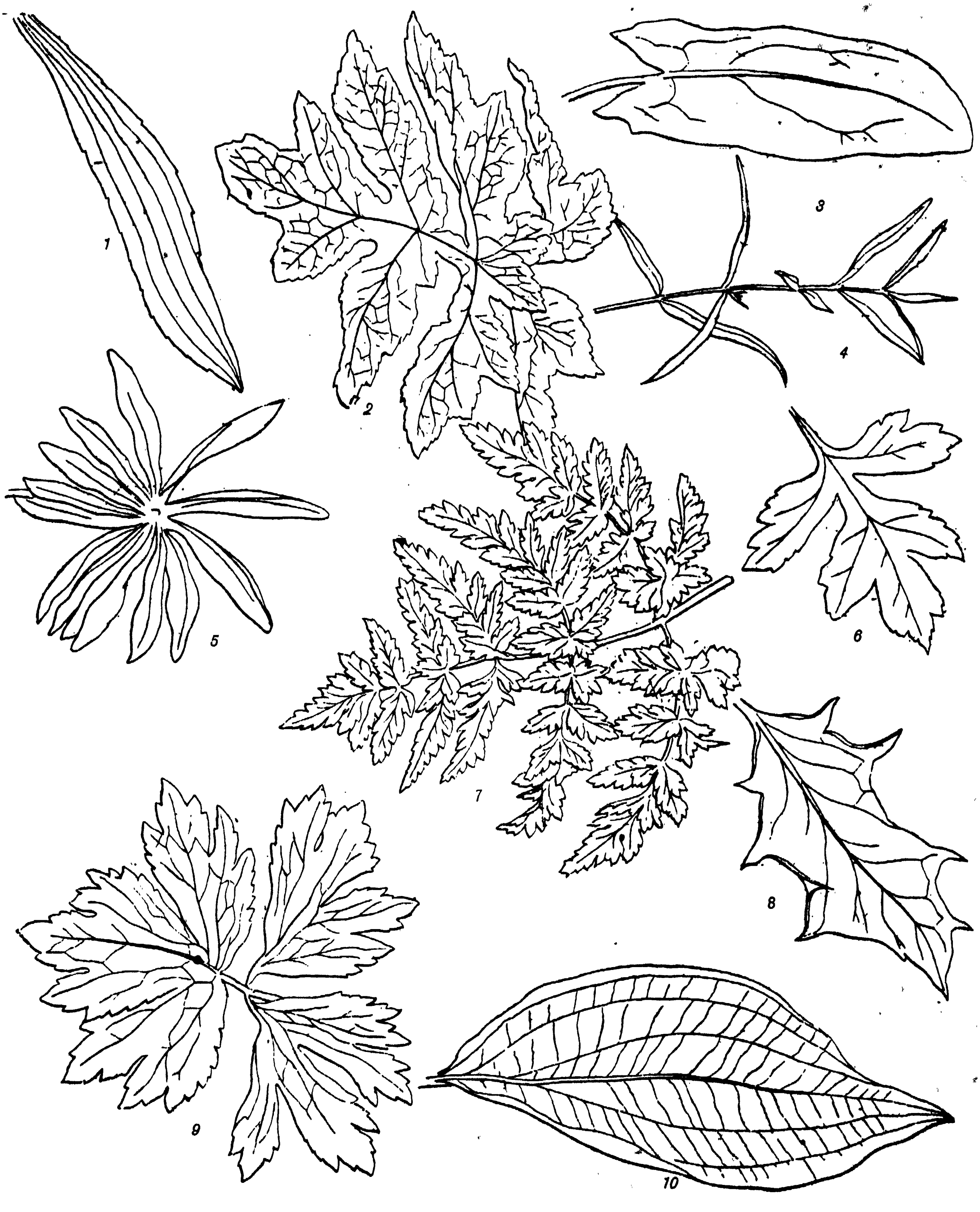
another case the reverse of this. Each abnormal phenomenon has a cause. Let us endeavour to find out the cause which makes practice so diverse. What is called the "singing" of a kettle full of water being boiled on a kitchen fire, is the series of little shocks, as they may be called, when the condensation of the earlier-formed bubbles takes place. But when a higher temperature of the water is reached, approaching the boiling point, the singing ceases; and when this temperature is arrived at, the heavy bubbling, known as boiling, causes a series of shocks, in some cases so severe as both visibly and audibly to shake the kettle, giving it a series of bumps or knocks. Still keeping the doctrine or law of the mechanical equivalent of heat in view, the student will perceive that these bumps are the manifestations of a power or force. This may be measured by carrying on the boiling in a flask or vessel suspended from the end of a delicate or sensitive balance or pressure spring, the flask being free to move up and down. Thus arranged, should the boiling be violent—that is, the passing of the vapour bubbles from the mass be constrained and difficult—a series of shocks or bumps will be caused; and each shock, reacting on the bottom of the flask, will cause it to descend with considerable force, and from being suspended or attached to the end of the balance spring, will pull it down, and its index finger will show the amount of force which the shock has, so to say, created. On the effects of the shock ceasing, the flask will rise and assume its normal position. As the boiling of the water in the flask proceeds, there will be, for the most part, a succession of risings and fallings of the flask more or less pronounced or extended, just as the shocks or bumps are more or less frequent and severe; this indicating constrained passage of the vapour from the mass of water, a steady or quiet position of the flask indicating easy boiling—that is, unconstrained passing away of the vapour from the heated water. The bumps or shocks thus given to the flasks or vessels in which the chemist carries on his experiments have long been known to him, and the results in breakages and other inconveniences have been experienced by him. So marked and pronounced has this peculiarity of boiling or evaporating been, that the French scientists have given a definite name to the bumps or shocks given to the vessels while the process is going on, designating them as *soubresauts*. Now, if quick generation of steam—the vapour or gaseous fluid of water—be the aim of an engineer, as it is or ought to be, it is obvious that the more rapid the passage of the vapour from the mass of boiling water the greater will be the saving of time and of fuel. Of time, for more vapour—steam—will be produced within a certain period if its motion or course through the water be easy and regular; of fuel, for the increments of heat produced by its combustion will not be wasted merely on the production of a force which causes bumps or shocks, and in retarding in place of expediting the free passage of the vapour from the water. And as those shocks or bumps are evidences direct and convincing of the existence of a condition of boiling anything but convenient and economical, there must be a cause for them; and if this be discovered—and further, a method of getting rid of it—a great advance will obviously be made in the art of boiling and evaporating. For most assuredly it is all based upon certain important scientific laws or principles, notwithstanding that so many seem to think, if their action be taken as evidence, that it is neither an art nor a science, but the commonest of "common things." It is so far from being this unimportant matter, this "rule of thumb," this "do in any sort of way" work, that men of eminently high scientific and practical attainments have of late been directing their attention to it; and with a result so thoroughly practical, that the art of boiling or evaporating, so useful in a wide variety of industrial work, is likely to be completely revolutionised.

(35) As explained in the Notes on "Fuel and its Combustion," in this section of the work, evaporation from liquid substances is going on at all temperatures: the higher the temperature the greater the amount of evaporation or vapour passed off; evaporation proceeds, therefore, from exposed liquids in all weathers, so that we find pools of water dry up—although, of course, slowly—in winter as well as in summer. The vapour of exposed paraffin oils is always passing away more or less in volume in proportion to the temperature. The average temperature of the atmosphere is 60° Fah.: some place it at 62°; but taking the lower temperature, it will be at once perceived how little margin there is—14° only—between this of 60° and that of 74°, the flashing point of crude paraffin oil of specific gravity 0·849. So freely do some paraffin oils give off vapour or gas, that under no very high temperature one does not even require to place the lighted match or candle at all close to the paraffin to cause it to catch fire and burst into flame; it is sufficient to place the candle above or near the vessel in which the oil is exposed. It is sometimes curious to see what may be called a train of light leading from the match or candle-flame to the surface of the oil; this is the cloud of vapour floating between candle and oil, which, under the influence of heat, has flashed into flame. Many of the accidents with paraffin lamps and with paraffin only—in greater or less bulk, dealt with in open vessels—have been called mysterious. But the mystery in more than one of them would easily have been explained, and the accidents prevented, had the parties possessed a knowledge of the peculiarities of the oils.

"THE STONE MASON" AND "THE JOINER" (see Text).



Natural Forms Applicable to Decoration.



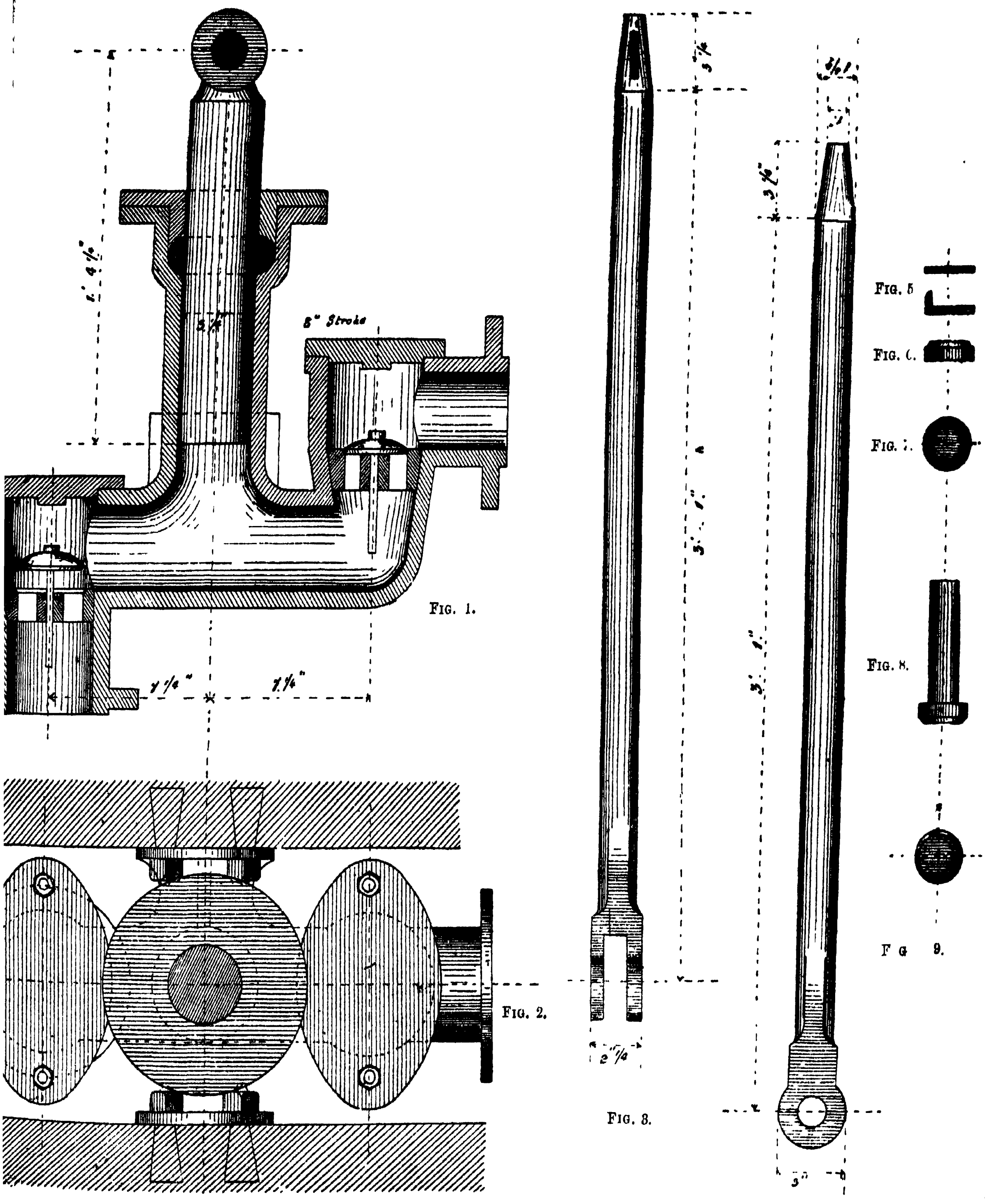
Scroll.—For Block see next Plate.

BLOCK OF SCROLL IN PLATE LXVII.

[*Plate LXVIII.*

"THE STEAM ENGINE USER" AND "THE GENERAL MACHINIST" (see Text).

DETAILS OF STEAM ENGINE—FORCE PUMP (see Plate LXIV. and Supplementary Sheet No. 2).



. Vertical Section of Force Pump. Fig. 2. Plan of Top of Force Pump. Fig. 3. End Elevation of Force Pump Rod. Fig. 4. Side levation of Force Pump Rod. Fig. 5. Key or Cottar for Pump Rod Eye. Fig. 6. Washer for Pin. Fig. 7. Top of ditto. Fig. 8. Pump od Pin. Fig. 9. End View of Pin.

THE BUILDING AND THE MACHINE DRAUGHTSMAN (see Text).

PLANS, ETC., FOR PERSPECTIVE DRAWINGS. See Plates VIII., XV., and XLVII.

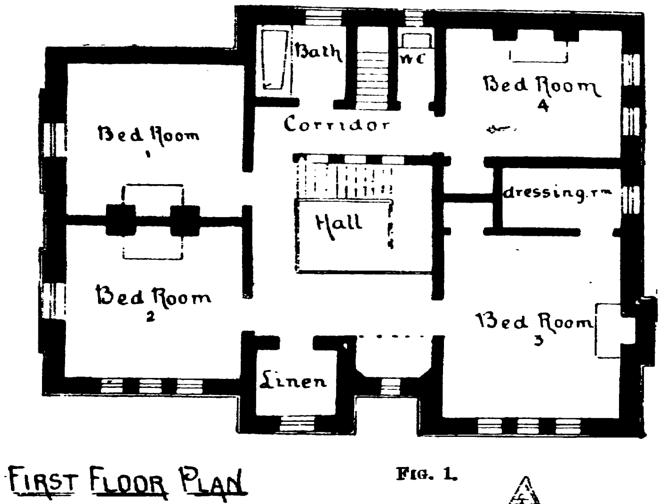


FIG. 1.

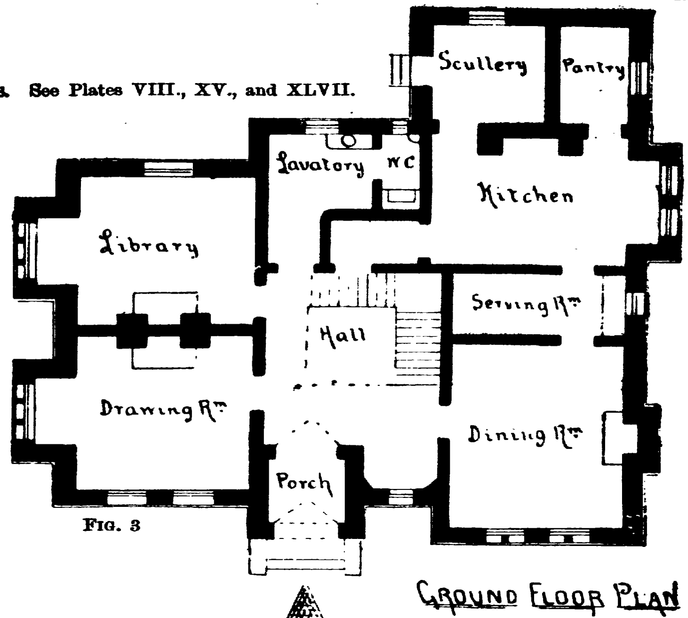


FIG. 3

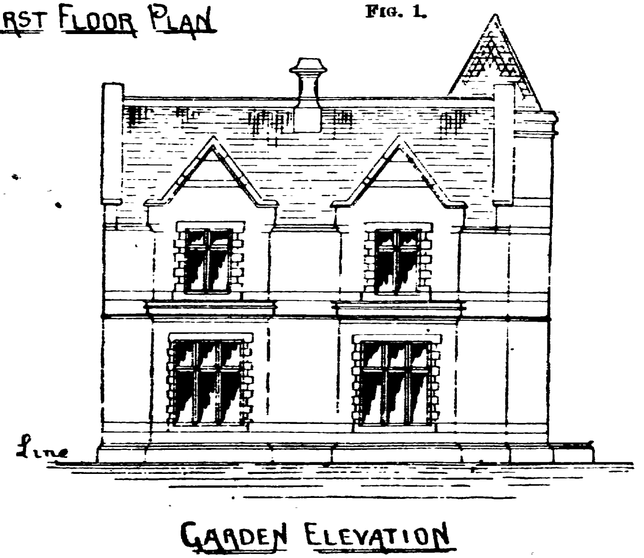


FIG. 2.

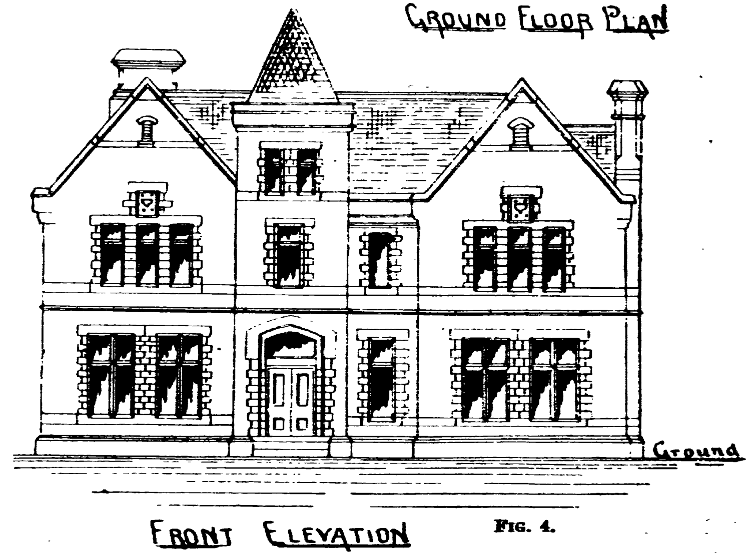
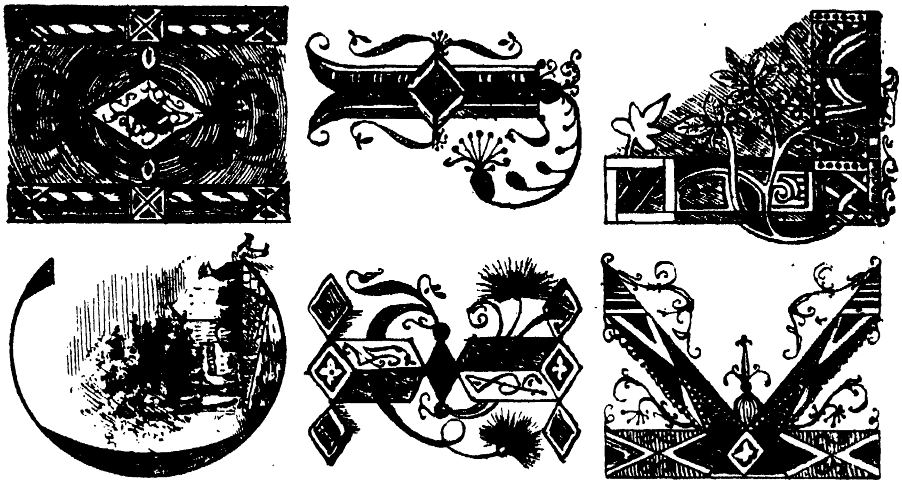
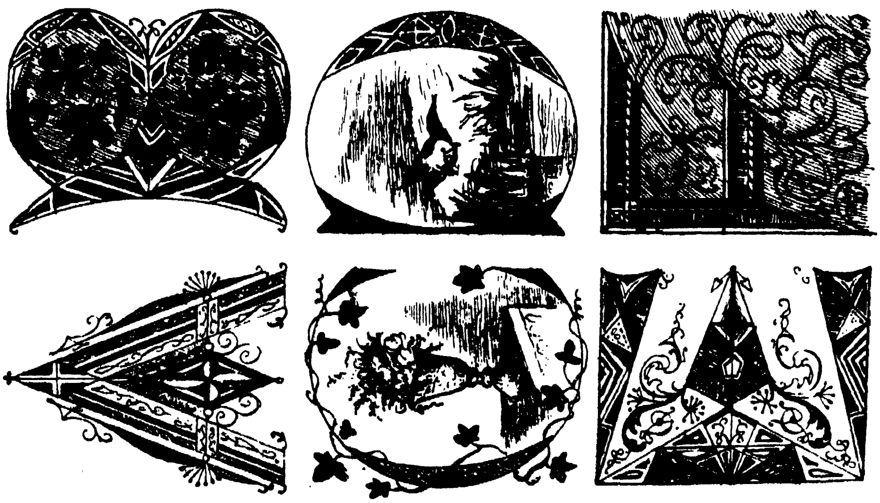


FIG. 4.

SCALE 16 FEET TO AN INCH

FORM AND COLOUR IN INDUSTRIAL DECORATION.
ELEMENTS OF DECORATIVE LETTERING OR WRITING.





fessional men would be the better if they had the education of a skilled handicraftsman added to their professional knowledge. We do not here maintain, of course, that viewed in the mere light of what each can make by his calling in a given time, the handicraftsman is placed in an equal position, has a power of moneymaking given to him equal to that in possession of the purely professional man. For as society is constituted—and divinely and wisely constituted—it will ever be that it will be divided into classes, each class having its own peculiar work to do, which brings with it its own peculiar rate of remuneration; and as the classes differ, so also does remuneration.

The Business or Remunerative Success of a Calling must be measured by its own Standard.

But the reader must be careful to observe that success in life in any calling is special and distinct; it is not relative. Success is gauged or determined by the special calling or work, the rules or laws of which define the measure or degree of success which it is capable of giving. It will not, therefore, be reasonable to measure the success of one calling, or the amount of remuneration it gives, with that of another and a higher. What in practical life—its everyday work—we have to concern ourselves with is the special class of work we have to do with; and success in it can only be measured by its own standard, and not by that of another class. This is simply a common-sense view of the matter; it would be as great folly to measure the pecuniary or other success of a "hodman," who carries, and only carries, the bricks with which the skilled bricksetter or "bricklayer" builds up a complicated structure by that of the latter, as it would be to estimate the pecuniary or other success of the bricklayer, however skilful, by that of the architect from whose brain the design of the building itself emanated—or as, keeping up the continuity of illustration, it would be to test the success of the draughtsman who puts on paper the ideas of the architect by that of the architect whose ideas he only, so to say, records by his drawing. The illustration here given, however, shows, we may remark in passing, that all classes or callings are dependent one upon the other, all being united in the common bond which unites society, and transforms a race of savages who "ran naked in the woods, feeding like swine upon the acorns, or their roots," into a civilised community, in which neighbour-help and self-help have each their value, and in which both are absolutely indispensable. But the illustration bears most closely upon the point we are now considering—namely, that each calling or class has its own standard, by which success in it is and can only be measured. And the point we draw from it, and to which we specially direct the attention of the reader, is that while, as we have said, the intellectually trained handicraftsman has this great advantage over the purely professional man that he possesses an extra power to ensure success in life, taking the handicraft class as a whole its members are distinguished by the uniform success which they obtain in their calling, or "in life," as the popular mind puts the point. It is no uncommon thing, unfortunately, to hear again and again of young men bred to some profession utterly failing to find employment even of that limited kind necessary to enable them to "pay their way" in the most limited and prudent style of living. Very rare indeed is it to hear of handicraftsmen being unable to obtain their living by their calling. We of course do not here include what are too well known as "hard times," when dulness of trade, or its positive cessation, puts it out of the power of all or any to obtain work—hard times which affect injuriously all classes, whether purely professional or not. Nor do we refer to the case of purely professional men who cannot succeed simply because they have not within them the elements of success—namely, a real knowledge of their calling. On the contrary, taking even the highly gifted, who are thoroughly able to do their work well, they yet freqnently cannot procure the work which is necessary to their existence. The purely professional classes, therefore, have fewer chances of positive success in life than have handicraftsmen; and this we venture to say, that the handicraft industries can show a far higher proportion of men engaged in them rising to high social position and ability in their calling than can the purely professional bodies, classing those as a whole.

Intellectual Training necessary to secure the Highest Success in Work.

But let the reader carefully note that this only happens in the case of those handicraftsmen who are distinguished for their intellectual training. This may be of very limited character, and so far as it goes, even of no great value; still we shall find that all those who have made an advance in position have been more thoughtful men: no matter in what direction they did think, think they did. And for thoughtful handicraftsmen there are, we maintain, very much wider chances of success in their calling than fall to the lot of purely professional men in theirs. This necessity for intellectual training is the point which we wish to impress upon the minds of those of our readers who may as yet have given little or no attention to what, in reality, is their true position as members of the working community, and which all our remarks and illustrations have tended to enforce.

THE BRICKLAYER OR BRICKSETTER.

The Principles and Practical Details of his Work.

CHAPTER IV.

We stated at the end of preceding chapter that the result of experience would seem to show that the notion that stone is less liable to decay than brick might be fairly challenged; for we have instances in all countries where both brick and stone have been used for building, showing that while the structures of stone have decayed and crumbled away more or less, but in some instances so completely as to destroy the original integrity of the structure, those built of brick have remained sound and complete. This is not unknown to, or not denied by, those who have investigated the subject, coming to its study with no preconceived notion in favour of one material, to the exclusion of all points in favour of another, but only impressed with the value of an opinion based upon the actual facts of the case. We have examples of buildings erected by the Romans so long ago as two thousand years and upwards, composed of brick, which remain as sound to-day almost as the year they were built in—while, on the other hand, contemporaneous buildings constructed of stone have crumbled long ago into decay. And the Romans were too practical a people, and too good builders withal —knowing more of construction, and doing a wider range, and an amount of finer examples of it, than we even give them credit for, much as we esteem them in this direction—to warrant us in concluding that in those stone buildings so gone to decay they used stone of poor quality. From what we know of the Romans as a people, and specially as builders, we may safely assume that they in those very instances used stones of the best quality they could obtain. If, indeed, we do not know for certain, we have every reason to conclude, that in some instances at least, if the locality itself in which a stone building was to be erected did not yield stone of good quality, they transported it from another locality which gave it.

Brick and Stone as Building Materials, considered from an Æsthetic Point of View.—Their Relative "Beauty."

We are not considering here the relative claims of stone and brick as materials giving beauty to, as best pleasing the eye, or as giving claims for the buildings in which they are individually employed to be considered the most valuable, as being the most costly. There seems, no doubt, to be an almost universal consensus of opinion that for public buildings of any importance stone is the only material which should be used. Even in localities where brick is the material universally used for dwelling-houses and the like, if a church or town-hall or museum is to be constructed, no one ever dreams of using other material than stone. It would appear as if the use of brick would be a desecration of the purpose for which the public building was to be erected. We have, however, shown that there is good reason for supposing that in some countries, specially and markedly our own, this arises from an ignorance of what can be done with brick as a material for giving ornamental or decorative effects; and in public buildings these attributes are always aimed at. Although we have unfortunately but too many examples amongst us of public buildings built in a costly way of stone in which their architects have not quite succeeded in obtaining those valuable qualities. We have seen also, from the allusion we made in the first chapter to the fact, that public buildings have in some Continental countries been built with brick wholly, which, in point of ornamental and decorative effect, will bear comparison with structures of the like kind built of stone.

Claims of Brick to be considered as the Best Material for the Building of Domestic Structures or Houses.

But looking upon the two materials simply from the point of view of their lasting qualities or durability, a close examination of structures as they actually exist amongst us will, we think, very clearly prove that brick has at least equal claims to be considered a durable building material as stone. We are inclined to go further and maintain that the more closely the examination into the two kinds of structures, those of stone and those of brick, is gone into, the more clearly will it be shown that brick is the more valuable of the two. This, at all events, when they are examined in connection with domestic structures, or our dwelling-houses, the term they are better and more widely known by. In this class of buildings we have primarily to consider the purpose which they are designed to serve, and secondarily the condition under which, in this island home of ours, they exist; and how these conditions affect the primary purpose for which our dwelling-houses are erected. The first essential in our houses, then, is that they shall minister to the comfort and the health of their inhabitants; if health, indeed, be secured by them, in so far as any external circumstance in man's life can secure health, it may be concluded that comfort will be secured. Although to some of our readers it may appear a somewhat strange statement to make, durability and strength in a dwelling-house are considerations purely secondary to health. A house must be built of very bad materials, and those put together in as careless and defective a manner, if it does not outlast the life of the occupant who may have built it, or if it be not strong enough to support the weight of his goods and chattels, or resist the fury of the winds which may blow around the walls, or the pressure of the snow which may settle upon its roof. Not but what in these days of cheap—or as it is in some districts called "jerry"—construction, houses are built, not a few of which, if they, from being built in rows, did not receive a support and strength, would, if left alone—possessing individually but little strength—stand a good chance of giving way. Instances, in truth, are not wanting to prove that building in some localities is but a name, so little of a reality that the structures cannot support even the weight of their own materials.

Brick claimed to be a better "Damp" or Wet-resisting Material than the Ordinary Classes of Stone used in the Building of Domestic Structures or Houses.

Now, in this climate of ours, if it be asked what is the attribute or quality in a domestic building or dwelling-house which secures that health to its inhabitants which we have seen, and all know, to be its primary purpose, we find the reply readily enough—freedom from damp. We do not require here to enter into any disquisition upon the importance of this point; the reader will find it fully discussed in the series of papers entitled "The Sanitary Builder." Now, it is in securing this freedom, or let us say this comparative freedom, from damp, that we claim a high, if not the highest, place for brick as a material to be used in the erection of our dwelling-houses, in which this is a prime necessity. And in making this claim we base it upon the fact of observation. To secure this one would require two fields: a locality or a district in which stone was the material chiefly or wholly used for dwelling-house construction; and another in which the use of brick was the like rule. We have such localities in Scotland and in England. And in referring to those, the writer of these lines has to note that he does not draw his conclusions on the point now under notice from the evidence of those resident relatively in those localities,—he happens to have had personal experience of the building characteristics of both. Taking, then, the average of the materials used in those two localities, the stone on the one hand and the brick on the other, the result of a very wide and, as the writer hopes, a very honest and fair examination of houses built with the two materials, is the conclusion that there are a much greater number of houses built of stone damp than of houses built of brick. Of course, it scarcely requires to be said that, to make this conclusion of any value, strict regard must have been paid to the similarity of the local, or, as we should rather say, the ground or site peculiarities of the several houses examined and compared. This regard was strictly paid in the cases alluded to.

Another Point in favour of Bricks as a Damp or Wet-resisting Material.

Nor need this conclusion be wondered at, however much many accustomed to stone building only may be disposed to doubt its accuracy, if we closely examine the physical characteristics of stone and brick. We here assume that those materials, so examined, if not of the best or highest quality in each, are in each case of fair or of average good quality. We think that an examination, given free from prejudice on either side, would show, almost at the first glance, that a well-made brick has at all events the look of a material more fully impervious to damp or moisture than stone. In lack of a wide and a carefully conducted set of experiments, we cannot lay before our readers any authoritative statement as to the relative powers of stone and brick to absorb or take in water or moisture. But even if we admit that the average quality of bricks take in more water in a given time and for a given bulk than the average quality of stone—which, however, we do not admit—we can, on the other hand, claim for brick this quality of utility, considered as a material for the construction of dwelling-houses—that it gets rid of such water or moisture as it may take up much more quickly than stone does. Many stones, if they once get thoroughly well wetted, scarcely ever get dry thoroughly; while those well acquainted with brick as a building material for houses have had abundant opportunities to see that such moisture as it may have taken up is got rid of, not only effectually, but quickly.

The Durability of Brick as a Building Material.—Practical Considerations connected with this Feature.

A word or two on the points of durability and strength. As regards the first of those qualities we have given some evidence; abundance of it is to be met with amongst us now. While a good brick of average quality is less impervious to moisture, or takes up a less amount of it in proportion to its bulk, than the stones usually employed in building, also of an average quality, brick seems less liable to be prejudicially influenced by the atmosphere than stone. Granting that the bricks have not in the first instance been soft, as also that the stones when set up have been sound, we think a close examination of old buildings in both materials will show that a greater number of houses built of brick have remained in good sound condition than those built of stone. The brick builders of olden times, and even those who flourished but two, or say three generations ago, used good brick only. Their principle was, beyond all doubt, to give the best work possible, and to use the best materials within their reach. This says much for the integrity of workmen of former times, just as the fact that it is lost sight of by so many nowadays says but little for those of modern times. The same honesty in work characterised the builders in stone. So that each gave to their work the highest characteristics they could command, and thus it may safely be predicated that in each case the best brick and the best stone was used, and the best work given in using them. Of course, in such comparative observations it is essential that the circumstances in which the houses are placed should be alike, or as nearly alike as possible. It would not be an accurate comparison between a brick house and stone-built one, in so far as their respective ability to to resist the deteriorating influence of the atmosphere was concerned, if a brick house built in a rural and therefore a comparatively, if not quite, pure air were compared with a stone house built in a town in which the air was largely impregnated with smoke and the gaseous emanations from various furnaces used in manufactures. The observance of this rule, we may note in passing, is of great importance in all technical experiments, no matter in what branch of work, where comparisons are to be made between two processes in two materials; and the neglect of it, common-sense as the rule is, is the reason why so many so-called comparative observations have been and are still practically valueless. Now, in such observations as we have made in connection with the point here under consideration, and from what we know of the examinations of others, we have noticed, almost as an invariable rule, that the brick-built houses had the bricks almost untouched by those atmospheric influences of the locality, while the stone-built structures presented surfaces more or less, and in some cases very greatly, injured. Brick may, and in certain atmospheres does, get greatly discoloured, being even more blackened than stone; but save this, no other deteriorating influence is observable. But in stone the surfaces become exfoliated, and in some instances blocks have even largely crumbled away, while as regards damp it was always in a worse condition than the brick. Many stones used in the present day seem to have so little capacity to resist the deteriorating influences of certain atmospheres, such as those prevalent to too great an extent—for it is largely preventable—in our manufacturing districts, that decay often begins to set in before the buildings in which they are used are many years old. Some stones, indeed, are so liable to attack that decay begins to set in almost as soon as erected. A very fair index indeed of the relative value of brick and stone, in point of durability, is to be met with in this—namely, that all the compositions brought out of recent years, and the methods of treatment for preventing the decay of building materials, and enabling them to resist atmospheric influences, have been designed almost exclusively for application to stone. One rarely hears of their intended application to brickwork. It may be said by some that this arises chiefly from the circumstance that, as stone is the more expensive, and much nobler, in popular estimation at least, of the two materials, it is only in the case of stone that the expense of such preserving compositions, etc., and the trouble of applying them, is gone to and incurred. But this is not the true position of the case: it simply arises from the fact that brick is found *per se* to resist the chemical action —for it is this, almost entirely—of the gases of impure or smoky atmospheres much better—in many cases completely—than stone. Costly enough houses are built of brick to justify their owners in going to the expense—and the expense in such cases would, as a rule, be cheerfully incurred—of applying compositions to prevent or to arrest decay, if decay had set in. But they are not so applied; and for the distinct and special reason that brick to a large, if not to a complete degree, possesses an immunity from atmospheric attack not enjoyed, in at least anything like an equal measure, and by many qualities not possessed at all, or if so, to a very slight extent, by stone.

The Strength of Bricks as a Building Material.

As regards the strength of bricks compared with stone, we have not data to assist us in making a proper comparison. While numerous experiments have been made from time to time to test the strength of various building stones, it might almost be said with perfect truth that none have been made to ascertain the strength of different varieties of bricks—that is, considered as individual masses. And to make such comparative observations of any value practically, it would be necessary to experiment upon blocks of stone, of different kinds and qualities, of the same dimensions as the standard dimensions of bricks. Such experiments, so far as we know, have not been made; those made relating to stones have been instituted to compare one quality and kind of stone with another, but not with bricks. But so far as regards the strength of bricks in mass—that is, when put together in building—we have a wide enough range of experience open to us to enable us to decide that brick is capable of giving a structure as strong as a like structure built of stone, and at a much cheaper rate. For while the very number of the individual pieces in a brick building gives of structural necessity a strong building, by virtue of the "bond" secured, the pieces being of determinate size, are ready at once to be handled and put in place; whereas the stone, in important structures, where great resisting strength is demanded, have to be cut into the various shapes, chiselled or trimmed to secure bond, and are costly, in so far as their handling, so to call it, demands special and often costly appliances and machinery. The railways of the kingdom give numerous examples of brickwork which are evidence enough that it is capable of resisting almost any pressure to which built structures are liable.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANIZATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER V.

CONTINUING our description of the cotton "scutcher" or "beater," we have to notice that the second beater, *b*, in fig. 2 (p. 371, vol. i.), makes 1200 to 1900 revolutions, and consequently its arms give twice that number of blows per minute. The first endless apron, *c*, conveys the cotton to the grooved feeding-rollers with a certain velocity per minute, and the second band, *d*, to the second pair of feeding-rollers, *f*, at an increased velocity, or nearly double the amount. Such a machine, one yard wide, can clean from 600 to 900 lb. of cotton in twelve hours, and requires a driving power of say two-horse power. To the first scutching machine there is a second or a similar one attached. This machine, which also has a beater, a perforated drum and an endless band, is called a lap machine, because it rolls up a certain weight of cotton on wooden rollers, in the form of a sheet of cotton wadding. The beater makes 1100 to 1400 revolutions per minute, and has about the same diameter as those in the first machine. In twelve hours it can work up about 800 lb. of cotton.

Practical Points connected with the "Scutching" and "Lap Machines."

The "lap machine" derives its name from the fact that it gives the cotton, which is fed to it at one end and brought out at the other end, the form of a continuous "lap,"—that is, the cotton comes out from the beaters in the form of a fleece, passes under "calender rollers," and so is continued in motion till it arrives at what is called the "lap roller," and is wound round it until it is so large in diameter that it has as many coils or laps round the roller as is required. A "lap machine" is the finishing machine in the blowing room. In many mills only an "opener" and a "lap machine" are used.

In other mills the "scutcher" or "beater" follows the "opener," and then the "lap machine," which in this method of working is called the "finishing lap machine," because it has received laps from the scutcher, and no more opening, scutching, or lap machining is given to the cotton. Scutching simply means cleaning or dressing. Now, where very dirty cotton is used the scutcher as well as the lap machine is employed. This is the case more especially where a very common grade of cotton is used, such as Surat. Before describing more particularly the operation of the cotton scutcher, we deem it desirable to refer again to the last or vertical "opener" we have alluded to, so that the reader may be furnished with the latest method or style of working in this department. We know that it is a good system which is coming into use. We cannot at present say it is very general, but it is fast gaining the attention of practical spinners, is adopted by some of them and carried out through their concerns, and is spoken of as being very satisfactory. The opener we allude to is the one last described, which has a conical beater, and where the cotton is fed through a funnel and not through a pair of feed rollers which hold the cotton fast until the beater has given a series of blows from steel blades, but where it is drawn in and treated with comparative gentleness until it is opened and then allowed to pass or rise up to the top, where it is conducted by creepers or endless aprons to a cage, and then through plain calender rollers, and from the calender rollers to the point where it is taken up and wound round another roller called a lap roller, and when the lap is sufficiently large it is taken conveniently to the next process. This method is carried out where the cotton is not so very dirty. Where cotton requires more opening and cleaning an additional opener is joined to the first, similar in make, but which receives its cotton not from feeding through a funnel, as in the first instance, but from the first machine through an opening, that is, a communication from one to the other, and by this means is operated upon a second time, and with the same mildness we before alluded to. But the cotton being in a better condition to cleanse, on account of its having gone through the first operation of opening and being partly cleansed, the lumps will be opened very readily.

Advantages of the Gentle Method of Opening Cotton, as by the Conical Opener or Beater.

We feel assured that this mild way of treating the fibres of cotton will in time draw the attention of spinners generally to the fact that the fibres of the cotton are and must be much freer from breakage by this simple and gentle treatment than by any other kind of "opener" we have had under our own superintendence, or have had the opportunity of witnessing; and we have been favoured by seeing all, or nearly all of them—those used in this country as well as those in the United States. We must, in view of the practical elucidation of the point, again say, as we have before said, that if cotton is in the least degree damaged in the first operation, and the damage be not detected at the first machine immediately it occurs, it is impossible to rectify the mistake or misfortune in any or all of the after processes it has to go through. This conical and vertical cotton opener promises well to become the most favourite machine in the trade. We know that prejudices in all ages have had to be overcome; and the machines now, and such as have been for a series of years in use, will linger long in the favour of some men, who may be very intelligent too, but are of that class who do not follow fashion at the outset, but often wait until the fashion is nearly dying out. If we wait for every one to accept a new style, be it ever so superior to any other that has before been used, we shall wait in vain. The fact of a machine of any kind not having the praise of everybody, must not stand in the way of progress. As far, at present, as the facts of this principle of opening cotton present themselves to us, we have tried to point out some, at least, of its advantages which we know from experience. And others who have had much practice in the different opening machines corroborate our views. We have, in truth, believed for long that great injury is done to the fibres of cotton by the rough and harsh treatment which it receives from the ordinary beater and feed-roller style of working; and knowing this, that more cotton is damaged in the "blowing room," where openers and lap machines of the beater style are used, we feel it our duty to treat this part of the operation to which cotton is subjected more at length than otherwise would have been requisite. We do not desire our readers to conclude that if the cotton in this department escape damage, no injury can be done to it in any of the future operations. We know, to the contrary, that in all the processes to which cotton is subjected before the yarn is sent into the warehouse, damage may be done to it, and when once damaged, at whatever stage it may be, it is impossible for it to be thoroughly rectified; though it may not be so easy to detect, nevertheless its defect must exist, and in some future operation it may be discovered. We may repeat the assertion already made before we conclude, and that is, that with all the care and watchfulness which can be bestowed upon it by the most eminent of the leading men concerned in the management of a mill, and with the advantage of having careful workpeople, mishaps cannot at all times be avoided in some part of the "preparation" of cotton, or in the "finishing" department—namely, spinning. Though we know this, it should rather cause us to be more watchful, not only knowing the possibility but the probability of accidents in the different departments.

As we have stated, the vertical cotton opener, or machine not only opens and cleans the cotton as it comes from the bale, but it also is now used as a lap machine—*i.e.*, it delivers the cotton to a cage in a loose and open condition, just in the same way as a scutching or lap machine does, and this without being transferred to another machine as in the ordinary way of lap-making. It then only requires the lap mechanism to be added—*i.e.*, that part which is used in the common lap machine—and then the lap is ready for the carding engine without any further manipulation.

For these reasons we feel assured that the lap machine as now made will either have to undergo some considerable change, or the opener above alluded to will take its place, especially where cotton is moderately clean, and possibly where cotton is not so clean; knowing or believing that in all cases where one machine can do the work of two,—and to be done equally as well, probably in some cases better, and at the same time to be done with half the labour, half the outlay, half the room, half the power, half the repairs, in short the half of everything in relation to cost,—it is not more costly or difficult to work with this kind of machine than it would be with any other which would give similar results. We had thought at first, when we were so well satisfied with this machine, of which we have stated some of its advantages at length, that it would have been almost useless to say more on the opening of cotton, but more particularly of the scutcher and lap machine. But as ordinary scutchers and lap machines are now largely in use, and probably will remain in use for years to come, it is necessary that we should treat fully upon them, as to their general utility and mode of working.

The "Scutcher" or "Beater," a Machine more suited for Coarse than Fine Yarn Cotton—The Principle and Details of its Operation—The "Feeding Apron," its Mechanism and Operation—Practical Management of the Important Work of "feeding" or supplying the Machine with Material.

The scutcher is a machine which is in general use where short-stapled and dirty cotton has to be treated. This will at once point out to the reader that its services are more required where coarse spinning is carried on than where fine spinning, or even medium spinning, is carried on. This machine is well known by the name of a "scutcher." Its name is appropriate, for it does scutch, whip, and scutch and whip again. Before describing the way in which the cotton is treated by the scutcher, it may be as well to give an idea of the machine in its mechanism, in addition to what has been already illustrated in fig. 2. The scutcher is of necessity a long machine. It must be understood that this is generally the second machine which operates upon the cotton after it has been mixed. First the opener; second the scutcher.

When the cotton has been "opened" it is in a light fleecy condition, and can then be spread upon a table or any other similar surface with considerable evenness. The first part of the scutcher is what is termed an endless apron, and is carried or drawn regularly round by a roller, which is driven by what is called a tooth and pinion—that is, positively driven by wheels—and it moves at a very slow pace. When the other part of the scutcher is working, it is also travelling at its regular pace; and when the scutcher is not working, it is not moving. Like most other machines, its motion is in connection with the other working parts. The object of this endless apron will be manifest to the reader from the fact that it is the bearer or carrier of the cotton. On this apron the cotton as it comes from the opener is taken to the scutcher. We will add before going any further that in the case of the opener and scutcher they are so arranged that as the cotton leaves the opener it is cast out as near as possible to the scutcher, so that labour may be economised in carrying it from one machine to the other. This machine requires in most instances two men or women to serve it, in order that it can be kept regularly fed, or otherwise the work would be spoiled. This endless apron is the first part of the machine, and the part from which the material is carried to those parts where the cotton is scutched or beaten. The apron is made of thin laths of wood, placed close to each other to allow of their going round the rollers which guide and drive. Two or more straps (leather), 2 to 2¼ inches wide, are used, and are fixed at certain distances. If the frame is wide, three straps will be used, placed at certain distances so as to insure their keeping on pulleys which are on the driving shaft, and which are 3½ inches in diameter. The thin laths being screwed to the leather strips, and the two ends pieced, it then becomes an endless apron.

On this endless apron is spread the open cotton. The apron is divided into equal lengths of say 24, 28, or 30 inches in length, and at each distance one of the laths will be painted either white or black according to taste, or it may depend on the kind of paint nearest at hand. And on each division a weighing of cotton is spread upon it with as much accuracy as can be fairly expected, even from the accustomed hand. A pair of scales is used called cotton scales, though much like scales which are in use everywhere, save and except the end where the weights are kept. No loose weights are allowed; they are put in a tin box and then locked up, and the key kept in the office. The end where the cotton is put to be weighed is in a kind of scoop, made in the best form for holding a bulky material. The weight of cotton at a weighing in one mill may differ from the weight used in another mill,—both, of course, for the same purpose; still the variation is not much. This system of weighing and spreading is the same almost everywhere, and it is done so as to insure regularity in the delivery of the cotton to the scutcher.

It must be kept in mind that regularity in weighing and spreading is indispensable in the preparing-room, and is therefore never lost sight of by thoroughly well trained cotton spinners; and to insure this the weights of the scales are always locked up in a box at the scale end. We shall see shortly how this weighing is tested. When the cotton is spread upon the "creeper" or "apron," it is carried on until it reaches two iron fluted rollers. The fluted rollers are from 2½ to 3 inches in diameter; they are so large in diameter, and consequently strong, that the cotton as it passes through may not cause them to spring, and thus allow the cotton from the creeper to be snatched from them. The object of the two rollers called "feed rollers" is to feed the cotton at a uniform rate, so that it cannot be thick at one time and thin at another. They are driven by tooth and pinion, so as to insure the certainty and regularity of their motion. We must not forget that every part of the machine must be so arranged as to do its work with the greatest amount of regularity; any hitch in one part of the machine would damage the whole where the cotton has to pass; *i.e.*, if one part of the machine were to change in speed during the working, the variation in the thickness would be observed in the following machine, and hence the importance of such a method to insure uniformity of motion throughout all the machine. As the cotton passes through the feed rollers,—but, as we said before, at a very slow speed,—the beater then operates upon it for removing any sand, motes, or other useless particles which may be in the cotton, and to further open out the fibres (separate them). Cotton is sometimes so matted together that it is with great difficulty that the fibres can be again detached from one another, or the lumps opened up. It is all-important that cotton should be well opened and freed from all superfluous matter, so that it can be the more perfectly treated in the next process.

Principle and Details of the Operation of the "Scutcher" or "Beater."—The "Beater" or Opener-up of the Cotton passed through the Machine.—Beater Cage.

The beater takes the cotton from the feed rollers by knocking it off, or separating it into small particles. Let us here examine a little closely the whipping or scutching which the cotton is subjected to as it is passed from between the two iron fluted rollers. Let the reader bear in mind the slow motion of the feed rollers, say three or four revolutions per minute. The beater has two arms, and in some cases, indeed in many instances, three arms. This means, that for every revolution the beater makes it gives three blows to the cotton as it passes out and comes from between the rollers. Now, such a beater will make no fewer than say 1100 to 1200 revolutions per minute.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

IV.

We have at the conclusion of last chapter stated that a right angle is always one of 90°, and a set-square to give this angle, as the angle *a b c*, fig. 8 (*ante*), must have its two sides or edges of equal length, as *a b* = *b c*. This is, in point of fact, the half of a square all the sides of which are equal to *a b* or *b c*. It follows that the sloping side, *a c*, of the set-square, termed geometrically the "hypothenuse" (*a b* being the "base" and *b c* the "perpendicular"), gives an angle one-half of that formed by the sides *a b*, *b c*, or the angle *a b c*: that is, the angle *b a c* or *c a b* is one of 45°. This side *a c* is then always the "diagonal" of a square the sides of which are equal to *a b* or *b c*. Set-squares are, however, formed with other angles than those of 90° and 45°. Thus one very largely used in various geometrical constructions, and in architectural and engineering drawings, is that giving the angles of 60° and 30°; this is illustrated at *o p q*, the angle *q o p* being one of 30°, and the angle *o p q* one of 60°. Another set-square is shown at *r s t*, in which the angle *r t s* is one of $67\frac{1}{2}$°. In all cases of triangles the sum of the two angles is equal to 90°. Thus the two angles at *a* and *c* being each 45°, those added together give 90°, as *a b c* or *c b a*; or the angle *o* 30°, and that of *p* 60°, the two together = 90°, *p q o*. And the angle at *s* being $67\frac{1}{2}$° (67° 30′), that of *t* 22° 30′ ($22\frac{1}{2}$°), these two together make 90°, *s r p*. In the two set-squares last referred to, and illustrated in fig. 8, the perpendiculars *q p*, *s t*, are at right angles to the base *o q*, *r s*, and giving angles of 90°, as *o q p*, *s r t*, are thus useful for drawing lines perpendicular to another in the same way as by the set-square *a b c* used as at *g h i* and at *n m*.

Testing of Set-squares.

The set-square is an instrument the principal use of which is to draw perpendicular lines in the way we have shown at *g h i*, *m n*, fig. 8, but may obviously, however, be used for the practical drawing of parallel lines.

It is, of course, absolutely essential that the instrument be correct. Set-squares cut out of one piece are liable to become warped and bent, either in consequence of heat or damp. Those in three parts, with a vacant space in the centre, are more difficult to make, but last longer in a correct condition. Great care must be taken, however, not to let them fall. Set-squares are tested in the following manner. A straight line is drawn with a good ruler; then, without moving the ruler, a perpendicular line is drawn with the set-square; then the set-square, in the position as at *g h i*, fig. 8, is reversed in position, and a new perpendicular line drawn, which should exactly coincide with the first. If these two straight lines cover or coincide with each other exactly, the instrument is correctly made or adjusted.

Varieties of Angles and their Peculiarities.—Acute and Obtuse Angles.

When an angle is less than a right angle, we say that it is "acute," as the angle *c a b* or *e f d*, fig. 9.

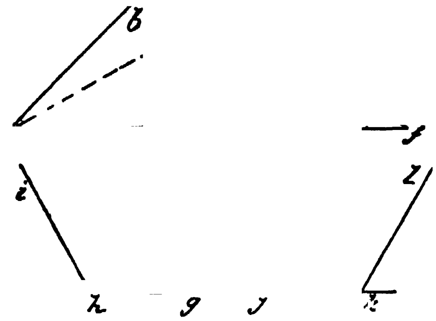


Fig. 9.

An obtuse angle is one which is larger—that is to say, gives a more open or more extended space between the lines, than a right angle, as *g h i*, *j k l*, fig. 9. When two lines intersect, the angles *a a*, *b b*, fig. 10, which are formed by their apices or points at

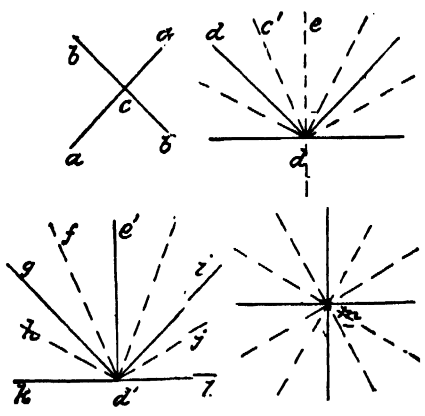


Fig. 10.

c, are equal. When the lines are not perpendicular, there are always two acute angles and two obtuse angles, the sum of which is equal to that of four right angles. If the lines do not intersect, but meet so as to form only two angles, these two angles would make, together, two right angles. The sum of all the angles formed round a point, as *d*, fig. 10, on one side of a line, *d e*, is equal to that of two right angles. This is easily understood by merely inspecting the diagram and summing up the angles formed by the lines *d f*, *d g*, *d h*, *d i*, *d j*, as the angles *e′ d′ f*, *j d′ e′*, etc. The angles formed round a point, as *m*, fig. 10 are equal to four right angles.

The angles, the sides of which are parallel and inclined in the same direction, are equal, as the angles formed by the lines *a b*, *c d*, with the lines *e e*, *f f*, fig. 11. The pupil should consider this point in connection with the use of the set-square in fig. 8. The angles, as *d a b*, *d a c*, fig. 12, or *e f g*, *h f g*, are said to be "adjacent," as they have lines, as *a d*, *e h*,

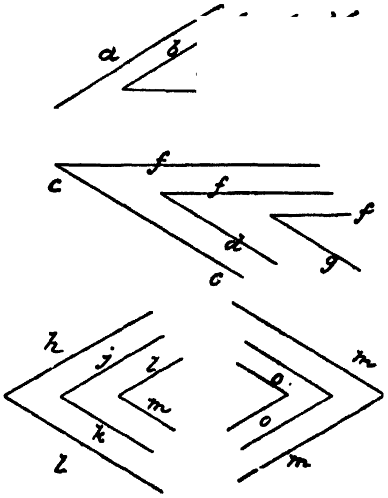


Fig. 11.

"common" to both: that is, the line *a d* belongs as much to the one angle, *d a b*, as to the angle *d a c*. *k i j*, *k i l*, *o m n*, *m o p*, *s q r*, and *q s t*, are adjacent angles.

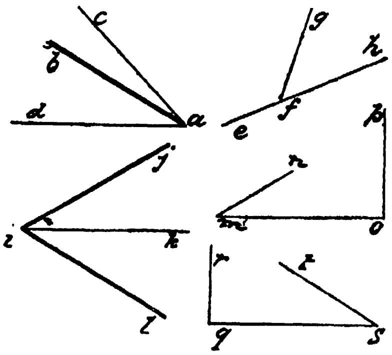


Fig. 12.

The Circle.—Various Points connected with it.—The Diameter—Radius.

We now come to consider various points connected with the circle. The feature of this is the line called the "circumference," the characteristic of which is that any one point taken in the line is, from a certain *given* point, equidistant from any other point. Every point, therefore, is equidistant from the *given* point, and that point is called the "centre." As every schoolboy knows, the circle is formed, or "described"—to use the geometrical term—by means of a pair of compasses, one leg or point of which is retained in one point, while the other leg—which is extended or pulled outwards—is swept round, the point of it tracing the line called the circumference, or, as it is popularly termed, the "circle." In certain forms one of the legs carries either a pencil or a drawing pen at its extremity.

The "diameter" of a circumference is a straight line, as *a b* or *c d* or *e f*, fig. 13, which joins two points in the circumference, as *a b*, *c d*, *e f*, passing through the centre, *g*. Every diameter divides the circumference into two equal parts, each of which is called a semicircle, as *c a d*, *e h f*. All diameters drawn with the same circumference, or in any number of circles of equal circumference, are equal. The "radius" of a circle is a line which starts from the centre, as *i*, fig. 13, and joins the circumference, as at *j*. A horizontal section, as *i l*, and a vertical, as *i j*, cuts off one width of the complete circle; and the part, as *i j l*, is called a "quadrant." In the same circle all the radii are equal. The measurement of the radius

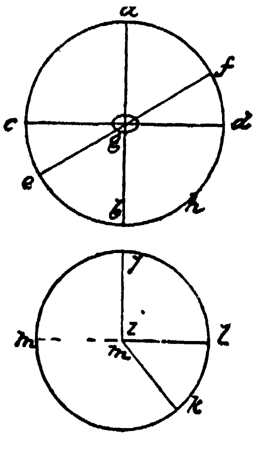


Fig. 13.

is exactly the distance between the two points of the compass which has served to draw the circumferential line or describe the circle. Two radii, as *m i*, *i l*, placed on the same straight line, form a diameter, as *m l*; each diameter, then, is equal to twice the radius, *i m* or *i l*. The radius of a circle is generally indicated by the letters "Rad," or simply by the letter R. The measurement of the circumference is the diameter, or twice the radius multiplied by the constant number 3·14, or extended, 3·1416. A circle the diameter of which is a "mètre" (French or Decimal Measurement*), would measure 3m. 14c. In other words, the ratio of the diameter of two radii to the circumference is as follows: 2 R : circumference :: 1 : 3·14, which gives as measurement of the circumference 2 R × 3m. 14c. Example: A circumference the radius of which is 6 mètres would measure 2 × 6 × 3·14 = 37m. 68c.

* See Technical Facts and Figures (p. 388, vol. i.) for French Weights and Measures.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER IX.

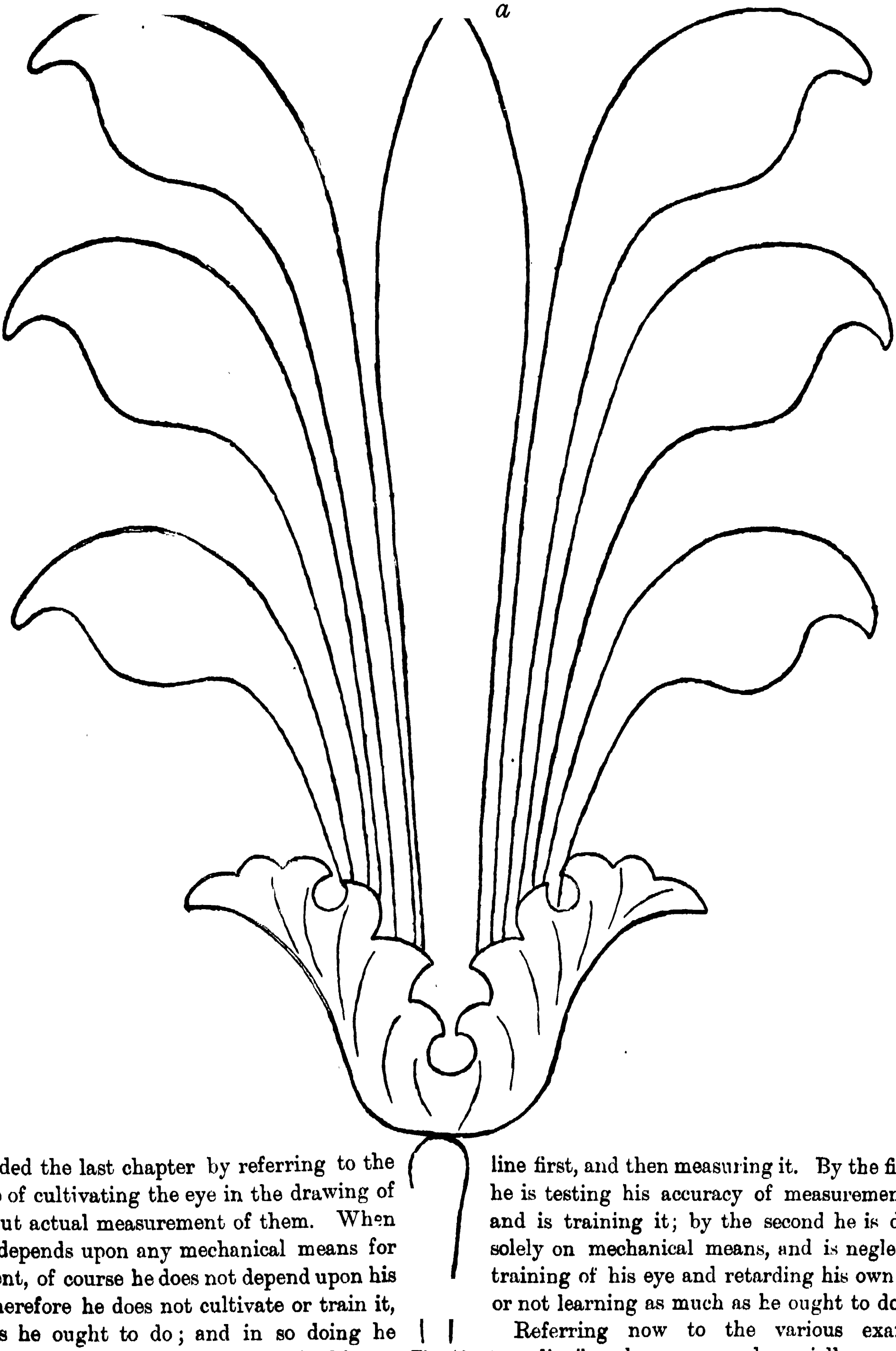


Fig. 46.

We concluded the last chapter by referring to the importance of cultivating the eye in the drawing of lines without actual measurement of them. When a student depends upon any mechanical means for measurement, of course he does not depend upon his eye, and therefore he does not cultivate or train it, or use it as he ought to do; and in so doing he is neglecting a very important element in his art education—namely, the cultivation of his eye. We hope the student sees the importance of adopting the course recommended—that is, of drawing the line first, and then measuring it. By the first means he is testing his accuracy of measurement by eye, and is training it; by the second he is depending solely on mechanical means, and is neglecting the training of his eye and retarding his own progress, or not learning as much as he ought to do.

Referring now to the various examples or "studies" we have prepared specially, as guides to the student in the acquirement of his art, we proceed to describe them in their order. The figure next in consecutive order is fig. 41 (see p. 17). This is the leaf called *mauve* in France, and with us known as a mallow leaf. The varieties of mallows are very nu-

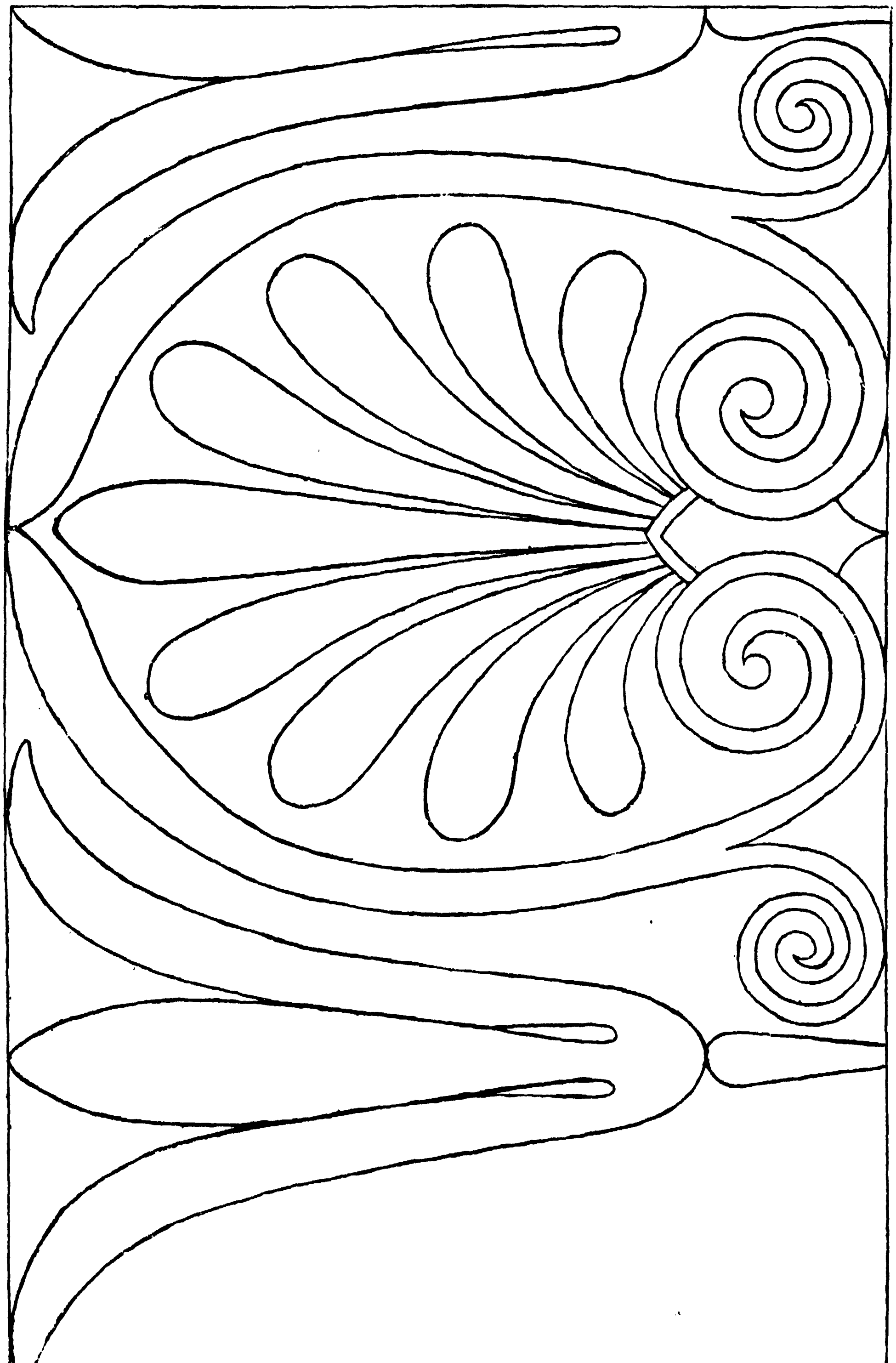


Fig. 47.

merous, and the student will observe that the shape is not unlike the geranium leaf. Now we come to a leaf that very much resembles the acanthus leaf (the chrysanthemum, figs. 3 and 4, Plate XVI.): the student will observe the divisions of the leaf and the "loops," and very carefully draw them, as he will have a shape somewhat similar very frequently in his practice. When we come to describe the "acanthus" we shall point out the different treatment of the leaf.

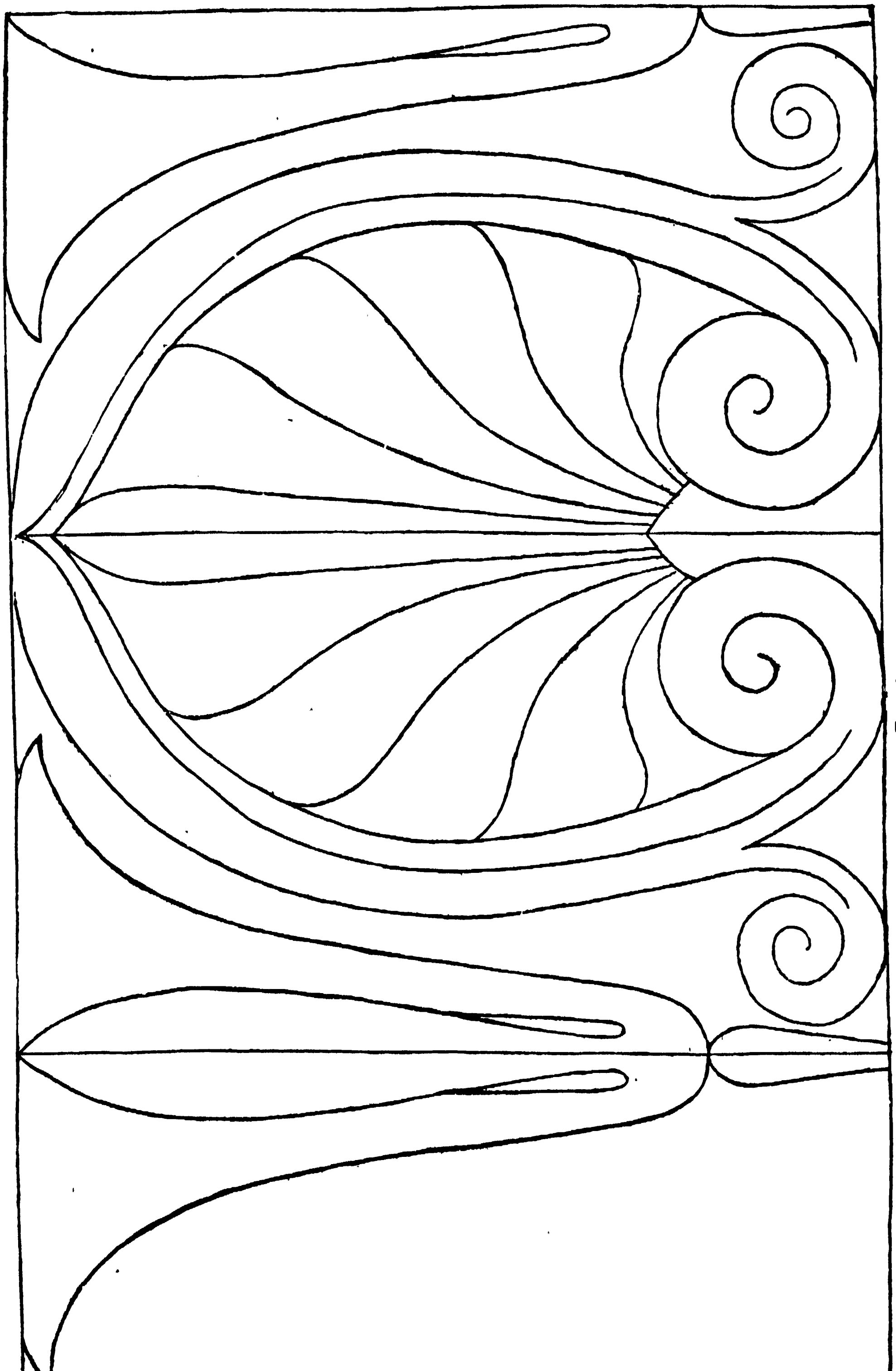


Fig. 43.

In fig. 42 we give a drawing of a "vine" leaf, with the blocking in at two stages, *b* and *c* in figs. 42, 43.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER VIII.

BUT the comparison named in our last chapter of a body in motion, is not always made relative to another at rest, for rest itself is relative. Thus, if one is sitting on the deck of a steamer coasting along the shore, he is at rest relative to the ship, but in motion relative to the shore; for the motion he has which is derived from the ship is said to be "common" with the ship, while the motion relatively to the shore is common to both. But if we suppose that he is walking to and fro in place of sitting on the deck, he then has motion "relative" to the ship; and if he walks along the deck in the opposite direction to that in which the steamer is going, and at the same rate per hour—say three miles —he is, relatively to the shore, at rest, for he is walking just as fast in one direction as the steamer is moving in the opposite. We thus see that it may be true that a man, as in this example, may at the same time be in motion and yet at rest. Thus, in walking on the deck he is in motion, as he changes his place from one part of it to the other in relation to the ship; but at rest in relation to the shore. For the "force," whatever it may be, which would take him from one point to another as measured along the shore, is counteracted, so to say, by another and an equal force—namely, that of the motion of the steamer in another direction. So that the sum of two forces, each of which is capable of producing motion, may produce rest; hence is deduced this definition of the terms motion and rest. A point is said to be in motion or at rest according as its position in space is or is not changing or being changed.

Motion and Force.—Some further Points connected with them.

If the reader will turn to the paragraph (in p. 280), giving the generally received definitions of the term "force," and to the paragraph (in p. 306) entitled "some considerations connected with the last-named definition of force-pressure," he will find under those heads a good deal which bears on the statement made above—namely, that generally force is considered to be a cause of motion. We shall have yet much to give on the subject of motion—and in its relation to force we have yet to explain the laws of motion as generally received—and we have many points to which we have yet to draw the attention of the reader in connection with the phenomena of motion under different circumstances or mechanical conditions, all of which have the closest bearing on the practical work of the mechanic. We for the present, therefore, add to what we have already given on the subject of motion a few general statements respecting it, which it will be necessary for the young student reader at present to have some fair conception of. A further and fuller one will yet be had as we proceed. From what we have said in preceding paragraphs, the young reader will have perceived that there are other definitions of force than those we have given in p. 280; and that much of the uncertainty which arises in his mind as to this point of force, and what it is, is owing to the obviously different character of the definitions given—differences not easily, if at all reconcilable. Hence it is that we have recommended as his best course of action, at least at the beginning of his study, not to take up time by trying to reconcile—or to understand—the difficulties caused by opposing, contradicting, or confusing definitions. Whatever may be said—and a good deal has been said—of Newton's definition of force, this at all events may be said of it: that it (the definition) conveys the idea in a way which so appeals to our common sense or every-day experience that no one will have a difficulty, as we have already said, in understanding its manifestations. Whatever that force may be, in every-day life we have no end of practical facts to prove that if we have a force, we can and do get by it motion. We can push against an object, or we can pull at it, or draw it, to use a very common phrase; and with the push or pull or draw we can, if the force we exercise or the energy we put forth be great enough, cause the body to move, that is, change its position—or if it be a body like a pulley hung upon a shaft, we can cause it to rotate, *i.e.* turn round or partially round on its shaft as a centre. In succeeding paragraphs we have much to give on the peculiarities of motion under different mechanical conditions. If we think of moving a body along a surface we almost intuitively conclude that it is done either by pushing or pulling or drawing it. The word "push" is derived directly from the French *pousser*, to drive or propel by pressure—to push against, as by the force of the arm or the weight of the body. And this French term is derived from the Latin *pulsare*, to beat or knock or push against. The word "pull" is Old English in derivation—*pullian*, to draw or drag a body towards one, to haul. The word "draw" is also Old English in derivation—*dragen*, or it is from the Ger. *tragen*, and this from the Latin *trahere*. Both these mean primarily the causing of a body to move or approach towards oneself by the exertion of a force—there being a connexion between the body to be drawn and the force, as the arm or body, which draws it. The word "drive," so frequently met with in mechanical definitions, is synonymous with "push," and is derived from the Old English *drifan*, to push; so that driving is like pushing—the action of a force behind the body, moving it along by pushing against it. That Newton considered force as an effort—a physical effort—and that he associated with it the ideas of pulling or drawing, and of pushing, is beyond any doubt. Now, an effort, derived directly from the French word *effort*—*e*, out of, and *fort*, strong—is an exertion of power or of strength, in other words the manifestation of energy. This method of considering a force as the cause of motion does not exclude, but includes, a strain or stress, a pressure (see a preceding paragraph, p. 306, for some remarks on pressure). In the case of moving a body by a pull or draw, a connexion being between the body and the force pulling or drawing, the connexion—as a rope—is said to be "strained." The word "strain" is derived from the French *étreindre*—to draw tightly or with force, or to test the strength of by pulling or drawing. The word "stress" is simply an abbreviated form of the word "distress," and means that which bears on a body with force, weight, or pressure. From all this, and from what has already been said, the youthful reader will perceive that force—whatever it is—is always exerted, or seen to be exerted, in relation between two bodies, and the action as between the two bodies is not completed, cannot indeed be said to be begun, till the force is exerted. Force considered as a push or pull or a draw, or an effort or strain, cannot of itself produce or cause motion till the effort be made, the push given, or the pull or draw put on. This the young reader will see to be true if he thinks it out. He may put his hand on a ball, and yet, although he knows full well that he has only to exercise his will—volition, and the force of his arm—to use the general form of expression—will be put forth, still, though the force exists, there is no motion on the ball, that is, it is not pushed forward so as to be moved from him, till the will is exercised and the push given. The same holds true in the case of a pull or draw: there is no movement of the ball towards the person till the force—pulling or drawing force—of the arm or body is put in exercise. And no matter what the force or power might be, it is obvious that it (the force) and the body would remain in the same position to each other as at first, and there would be no motion in the ball till the force gave the push, or made the pull or draw or effort. And when the push is given, the pull, draw or effort made, and the motion of the ball takes place as the result, we say in general terms that it is the force which causes the motion. This is quite true, but it does not go far enough; something has to be added to make the truth complete. And this follows from what we have said above. For the force—say the hand—may be in actual contact with the ball, and yet no motion take place till the will acts in the hand, the push is made, and the ball moves. But the existence of the mere force would never have caused the motion; unless the force—represented by the hand and arm acted on by the muscular force of the body under volition—itself had moved, the ball would not have moved either. In the case of the hand giving the push, the volition or the mere will creates, so to say, the force; but this is exercised through the medium of the muscles of the arm, which themselves moving give motion to the hand, which in turn gives motion to the ball. So that while it is in one sense quite true that it is the force which is the cause of motion, that force has, so to say, itself to move before the body it acts upon will move; so that it is equally true in another sense that force alone is not, and cannot be, the cause of motion. And this is true, whatever be the character or nature of the force, or to give it its other name, power, employed. We shall have many exemplifications of this important truth or aspect of motion and force as we proceed in future paragraphs to explain the different classes of motions. As we have said, all force is an action between two bodies, and all force may be said to be a means or mode of giving out motion, which is imparted to or taken up by another—which is thus moved. And in proportion as this body moved takes up the motion given out by the other body, so that which is or represents the force in like proportion loses it. We have not at this stage of our papers referred to certain considerations flowing out from what are accepted as the laws of motion, inasmuch as these will naturally come up for description and illustration in due course in succeeding paragraphs. Such considerations as these just alluded to would very much complicate to some of our readers the general subject of force and motion considered in their simplest elements and relations; and it is only some of the more general considerations we desire the reader at present to examine, and to gather up one or two leading features which may be of service to him when he comes to consider the more special and detailed points.

Velocity of Matter in Motion, related to or dependent upon the Elements of Time and Space.

So far as the machinist is concerned, as it is with movements he has chiefly to do, force is generally, we may say always, considered to be a "cause of motion." Motion has the two conditions of common and relative, and can never from the nature of things be said to be absolute, for that can only be ascertained by a knowledge of the universe to which absolute motion is relative. Motion has other conditions, to which we apply such terms as rapid and slow, accelerated and retarded.

What these terms imply we know almost intuitively, but direct exemplifications of them we shall meet with as we proceed. But with all of them the condition to which we give the name "velocity" is invariably associated. Velocity and motion are often confounded as synonymous terms, for we find the expression "his motion was very rapid," used as if it meant the same thing as "his velocity was very great." Now, velocity, or the magnitude or amount of motion, gives us the means of measuring or estimating the rapidity or the slowness of motion, and is constant or invariable. But the element or condition of motion known as velocity would from the latter circumstance be of no practical value to us, unless we took along with it the elements of space and *time*. For the measure of the velocity of any body is the space it describes or passes through in a given time. Velocity may therefore be defined as the relation which motion has to time and space. It is derived from the Latin word *velocitas*, and this from the root *velox*, swift. The terms swift or slow motion or speed—to employ the term used by machinists—are therefore purely relative to some point or amount determined on as a standard, and in all statements or calculations as to velocity time must be included. In mechanics the "units" of time used are "seconds" and "minutes"; generally the "speed" of a machine or parts of a machine is stated in "minutes," the unit of "space" passed through usually adopted is the "foot": thus in stating "velocities" in mechanism we say that such and such a part has a "speed" of so many "feet" per "minute." A simple statement of velocity or its measure is in mechanical papers generally understood to be the space passed through or over in a "second." Where the spaces are proportional to the times occupied or taken up in passing through them, in the case of uniform velocity, the spaces passed through are always uniform. The term "speed" is often used, as we see above, in place of velocity. In practical mechanics it is, indeed, the term which is generally used in relation to the movements of the different parts, as shafts, wheels, pulleys, etc. The word "speed" is derived from the Old English *spedan*, to make haste, to hurry on, to despatch quickly; or from the German *spediren*, to hasten, to despatch.

Varieties of Motion.—Uniform—Accelerated—Retarded.

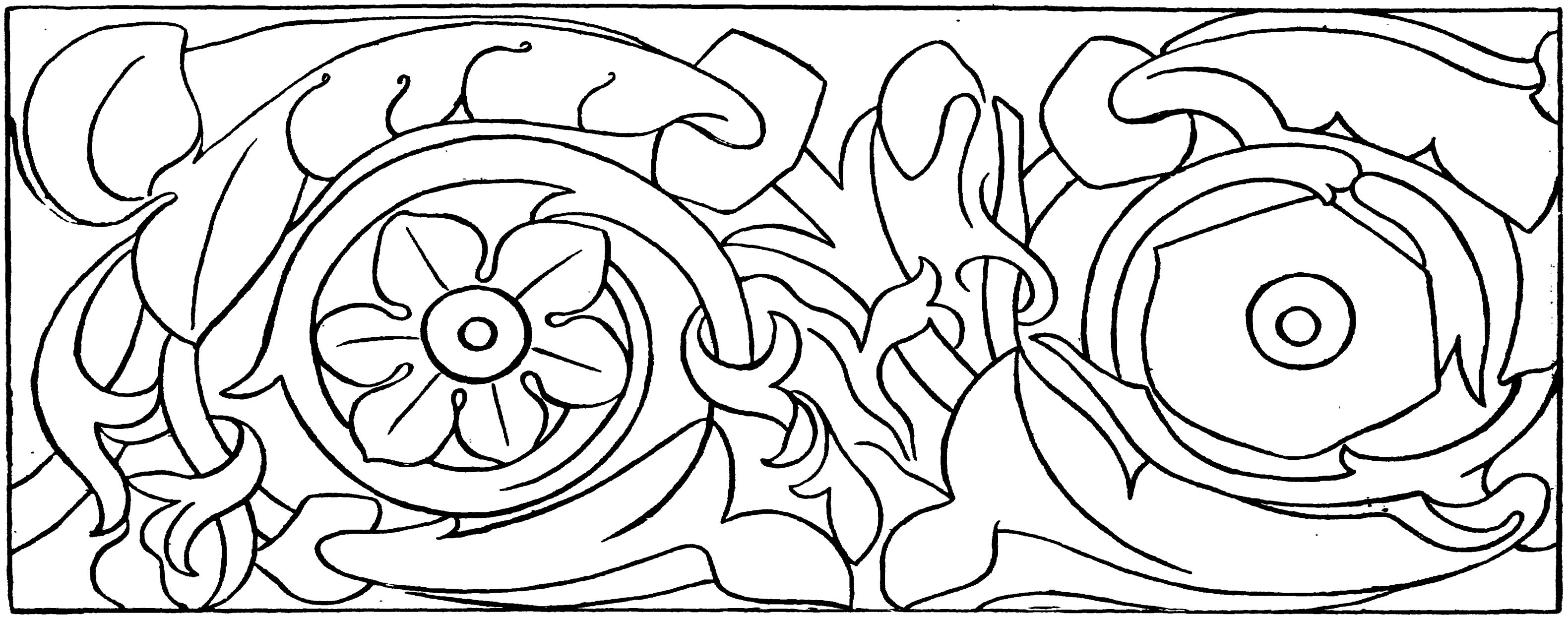
When a "body" passes through equal spaces or over certain lengths or distances in equal units of time, the motion is said to be "uniform." When the spaces or lengths and the times or units are in different proportions or relations to each other, the motion of the body is said to be "variable." If the spaces or distances passed through in equal units of time are constantly increasing at a rate greater than the times, the motion is said to be "accelerated." When the case is the converse of this, that is, when the spaces passed through in equal times decrease at a faster or greater rate than the times, the motion is said to be "retarded." Motion is defined as "periodic" or "intervallic," or at intervals, when the spaces or distances passed through or over, and the times occupied in passing through them, are in certain proportions to each other at certain defined intervals only. Motion is said to be "continuous" when it goes on during a certain time without ceasing. Continuous motion must not, however, by the reader be considered synonymous, as many consider it to be, with "uniform" motion. A motion may be slow at one part of the whole period of time during which it exists, quick at another, it may have accelerated velocity during one of the periods, retarded velocity at another period; and yet, with all their variations in velocity, which together constitute a condition the very opposite of uniform, the motion, as such, of one kind or another is always going on, that is, does not altogether cease even when the retardation is the greatest of the whole period of time during which the motion as such lasts. The motion, however varying in its character, is continuous. As above stated, we have much to give yet upon motion and its manifestations under different mechanical conditions.

Matter.

We have hitherto been considering motion and its opposite condition of rest chiefly as mental conceptions, without special reference to material considerations. But the machinist has to deal with facts, and the substances he has to do with are very solid and practical facts indeed. The reader cannot take up alike the most simple or the most elaborate treatise on physics, or on the special branch of this general science of natural circumstances or conditions known as mechanics, without continually coming across the words "matter," a "body" or "bodies," "mass," "weight," "motion" or "movements," "momentum." The last five of these terms are all conditions dependent upon the first—namely, "matter." In some of the more elaborate treatises above referred to are definitions and explanations of what matter is, or rather what the writers conceive it still somewhat dogmatically to be. But, as before, with such abstruse and metaphysical speculations we would counsel the student not—for the early stages of his study at least—to concern himself. He will have not the slightest necessity in his future work for more information as to what "matter" is than what his own sense informs him it is—namely, something which can by our senses, that is, by seeing, feeling, etc., be perceived and known to exist. What the reader can see, can handle, and in point of fact deal or do with, he knows at once is a something to which is given the name of "matter." He has no difficulty whatever in knowing that anything mental is essentially different from what is called material. The derivation of the word itself will give, as usual, a clear, at least a suggestive clue to what matter is. It is derived from the Latin word *materia*, and the root of this same word, some of our readers will be surprised to learn, is the Latin word *mater*, signifying a "mother," a maker or producer, a cause of something which bodily exists.

Plate LXXIII.

Block of Subject in Plate LXXIII.

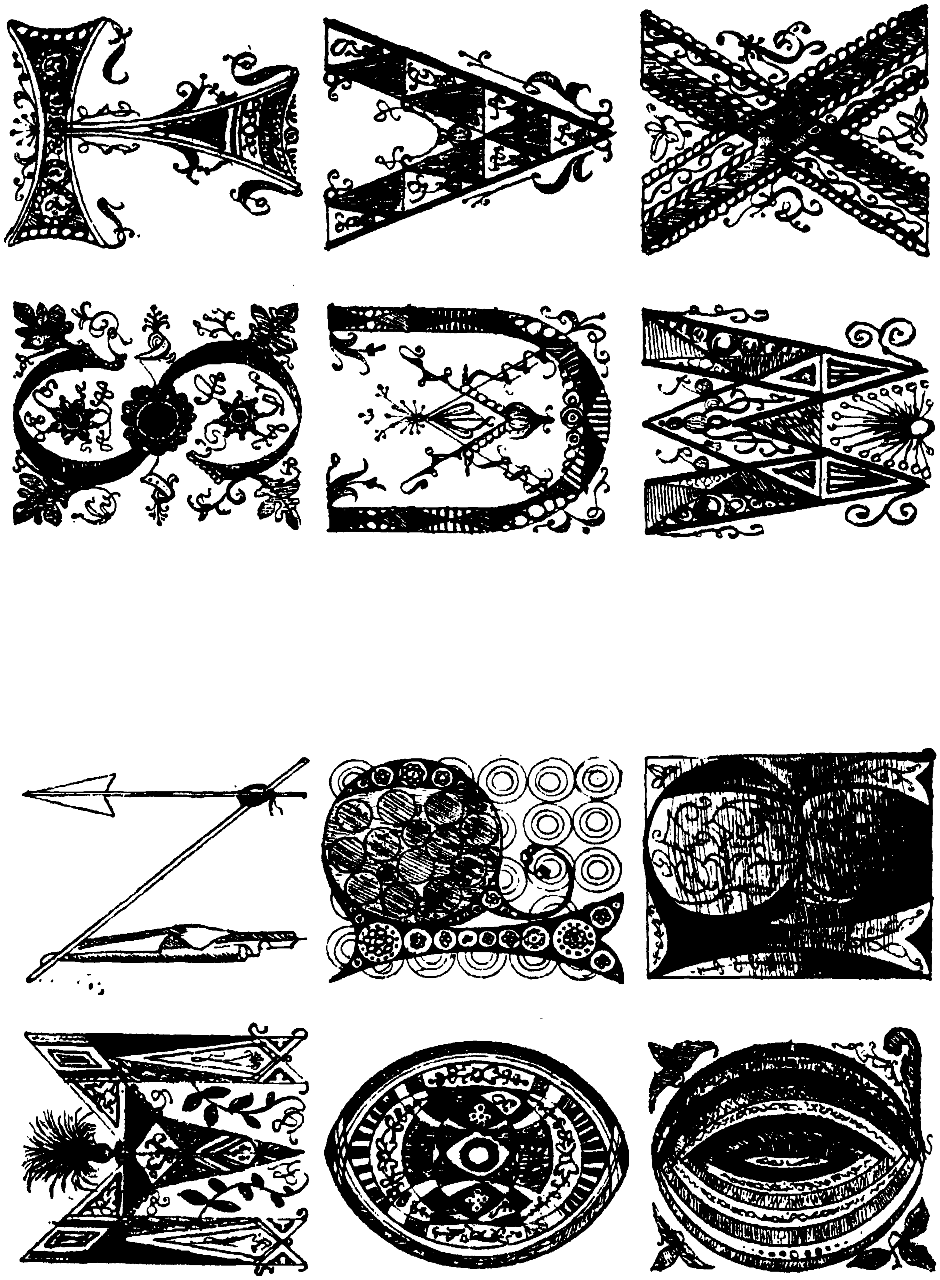


POTTERY AND GLASS-WARE DECORATION.

FIG. 1.

FIG. 2.

FORM AND COLOUR IN INDUSTRIAL DECORATION.
ELEMENTS OF DECORATIVE LETTERING OR WRITING.



FORM AND COLOUR IN INDUSTRIAL DECORATION (*see Text*).

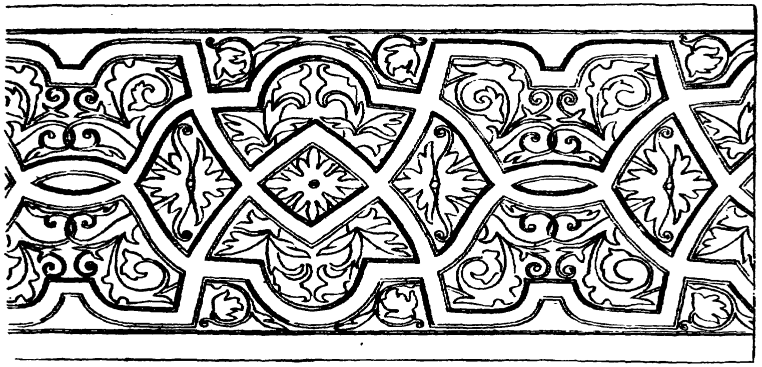


FIG. 1.

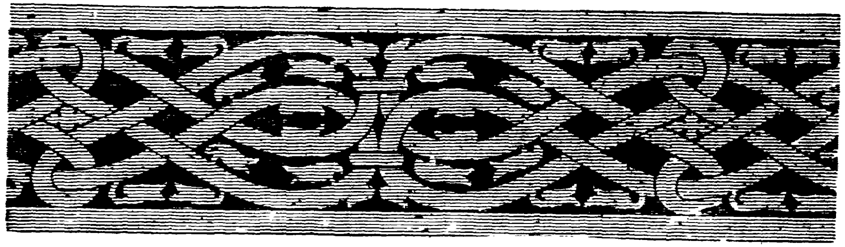


FIG. 2.

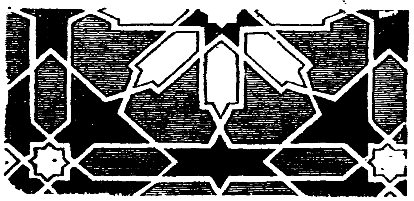


FIG. 3.

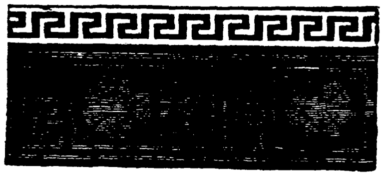


FIG. 4.

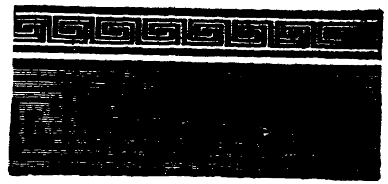


FIG. 5.

FIG. 6.

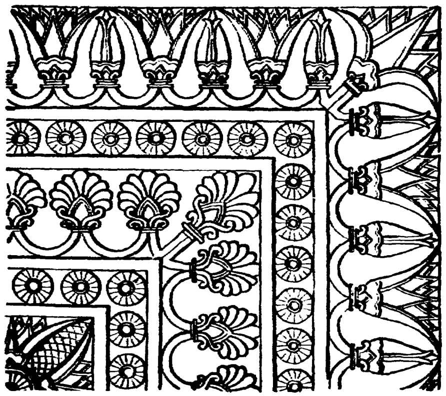


FIG. 7.

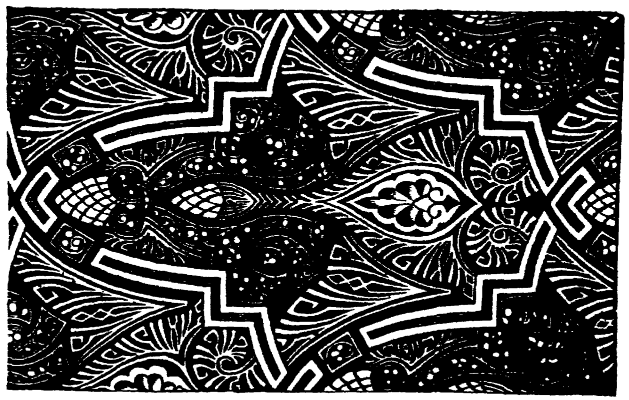


FIG. 8.

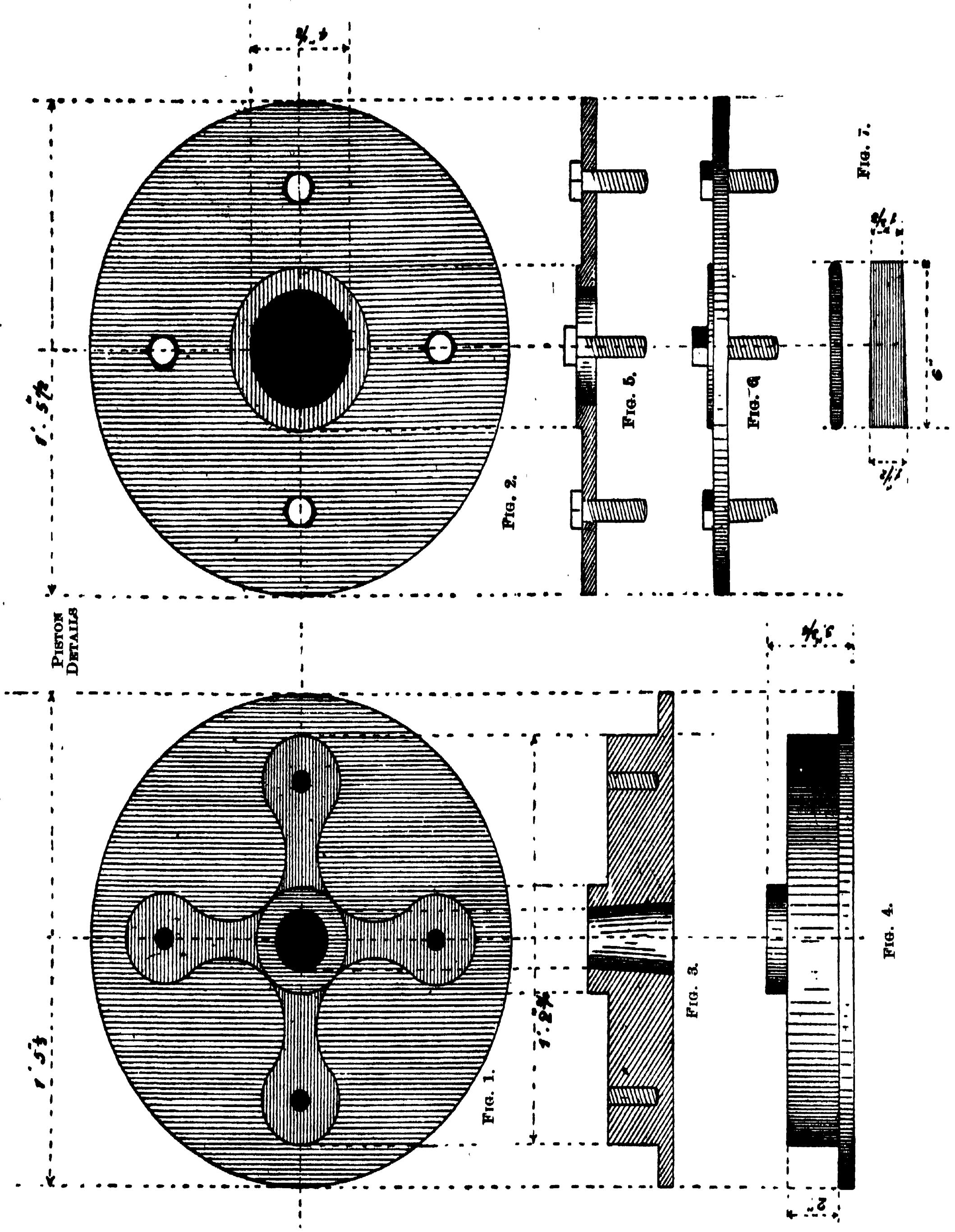


FIG. 1. INSIDE PLAN OF PISTON.—FIG. 2. PLAN OF TOP (OUTSIDE).—FIG. 3. VERTICAL SECTION OF PISTON.—FIG. 4. SIDE ELEVATION OF DITTO.—FIG. 5. SECTION OF PISTON COVER.—FIG. 6. SIDE ELEVATION OF DITTO.—FIG. 7. KEY OR COTTAR FOR PISTON ROD.

SCALE 2" = 1 FOOT.

"THE JOINER" AND "THE STONE MASON" (see Text).

GOTHIC MOULDINGS—STYLE "PERPENDICULAR."

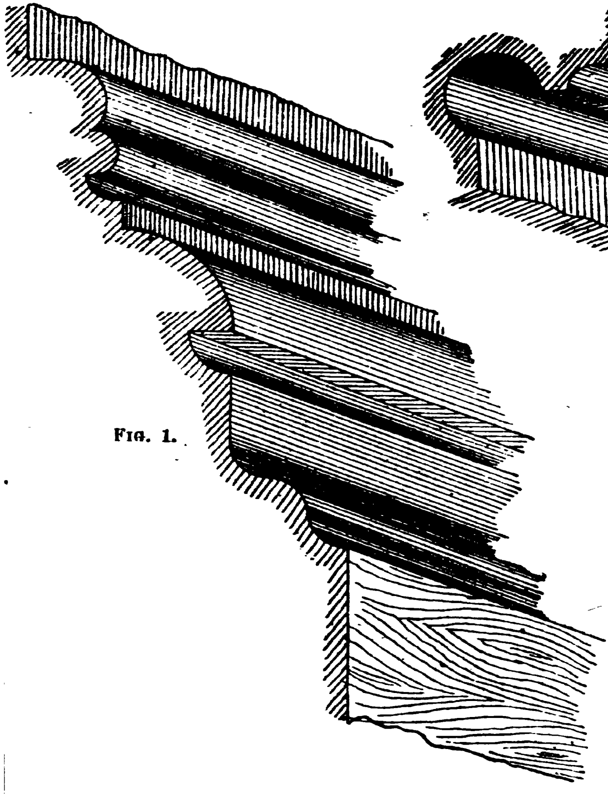


FIG. 1.

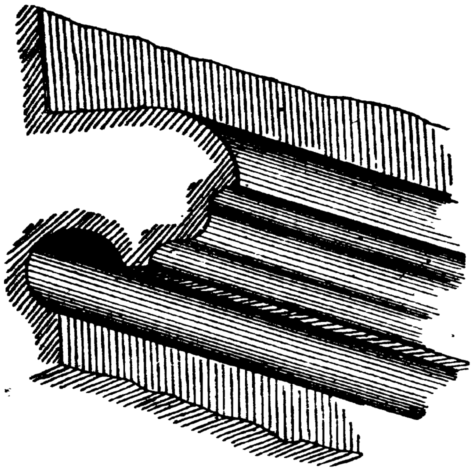


FIG. 2.

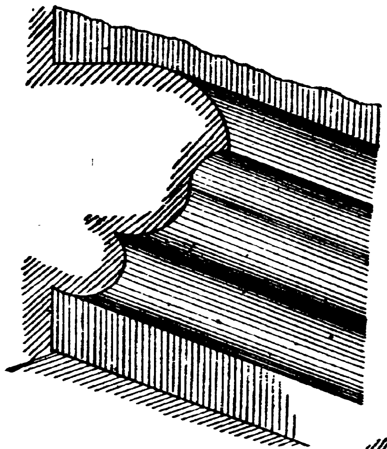


FIG. 3.

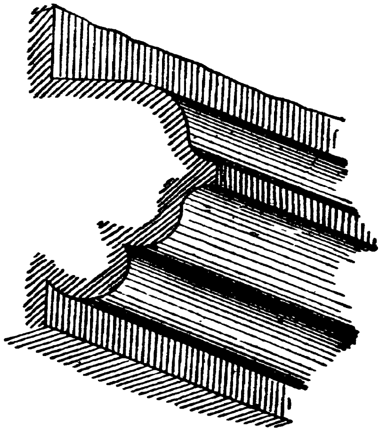


FIG. 4.

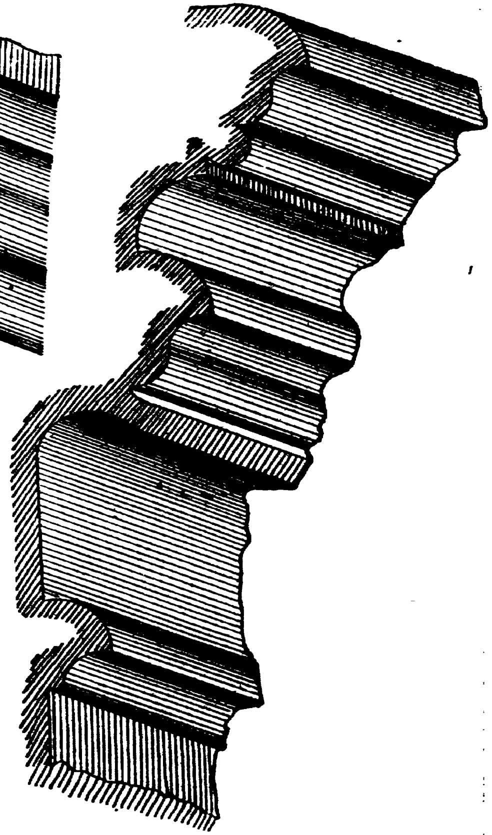


FIG. 5

FIG. 1.—BASE MOULDINGS. FIGS. 2, 3, and 4.—"STRING COURSES." FIG. 5.—CORNICE, OR "CAP" MOULDINGS.

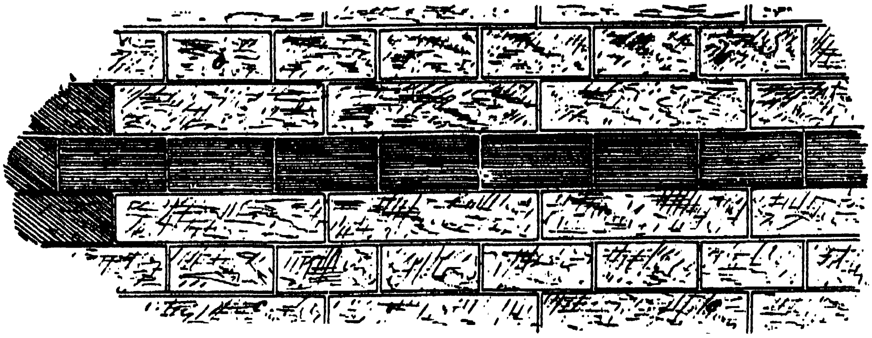


Fig. 1.

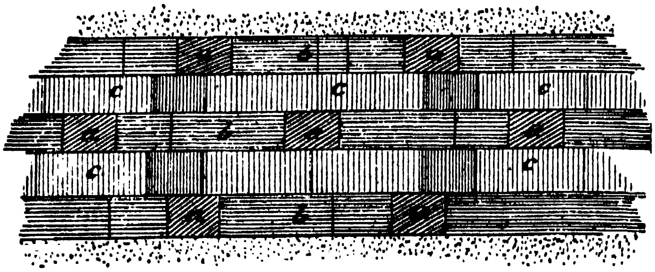


Fig. 2.

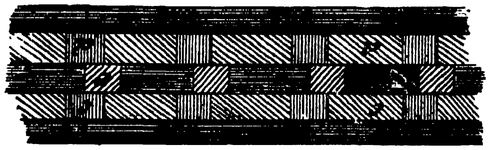


Fig. 8.

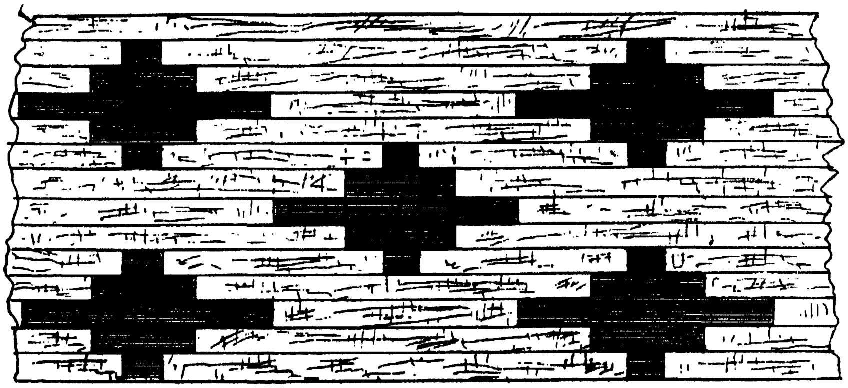


Fig. 4.

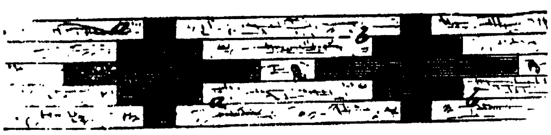


Fig. 5.

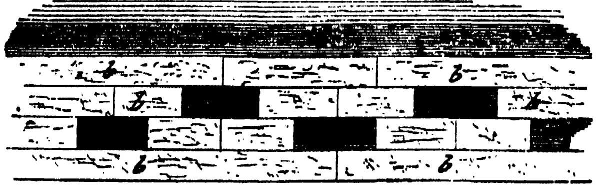


Fig. 6.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER VI.

The Drawing of Lines continued.—The Use of the T-square and the "Set-square."

BUT simple as this change of the square from the side of the board to the end, and *vice versâ*, may be in the drawing of lines perpendicular to each other, as compared with the geometrical way of drawing lines in this relationship to each other (see "The Geometrical Draughtsman"), it is an operation which takes time, and is not always convenient to be carried out. But it is readily done by the use of the appliance known as the "set-square," as illustrated in fig. 5. This

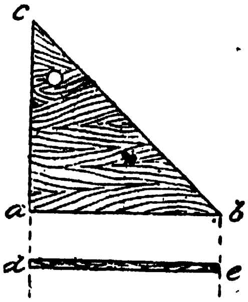


Fig. 5.

is made of thin wood—generally of pear tree or of apple tree, although sycamore or plane is well fitted for the making of a good set-square. In form it is simply the exact half of a given square, the side of which is equal to the side *a b* or *a c*. These sides are, therefore, at right angles to each other, so that if a line be drawn along the side *a b*, and another along *a c*, the line on *a c* will be perpendicular to *a b*. If, then, the blade of the square is placed to lie along the length *a b*, fig. 1, of the drawing board, as at *a b* in fig. 6, and the set-square (as in fig. 5) is placed in the

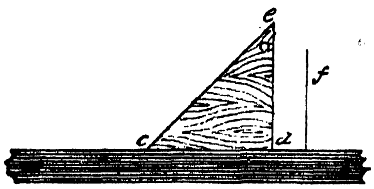


Fig. 6.

position shown in fig. 6, as at *c d e*, lines can be drawn in any number required parallel to *f* by simply sliding the set-square upon the blade *a b* of the T-square to any point required. And if we suppose a line to be drawn along *a b*, all lines, as *f*, will be perpendicular to this line. Of course, in drawing the lines, as *f*, with the set-square, it is necessary to slide it carefully along, so that its edge *c d* shall remain closely in contact with that of the T-square blade; and this again must be kept steadily in one position or place of adjustment. This is very easily done after a little practice; the T-square lies along the length of the board, or parallel to side *a b*, fig. 1. It is not so readily and conveniently done when the blade of the T-square lies across the breadth of the drawing board or parallel to one of the sides, as *a d*, fig. 1. Hence, although the set-square can still be used, as *i j*, fig. 7, to draw lines at

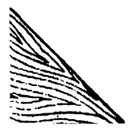


Fig. 7.

right angles to the T-square as *i j*, and all parallel to *l*, the set-square and T-square are comparatively seldom used in this relation, that in fig. 6 being the one generally used. The young draughtsman will soon find out the practical reason why this is so.

In the set-square in fig. 5 the line *c b* is at an angle of 45°, the sides *a b*, *a c* being equal (see Angles in "The Geometrical Draughtsman"). But set-squares are made with other angles, as in fig. 8, where

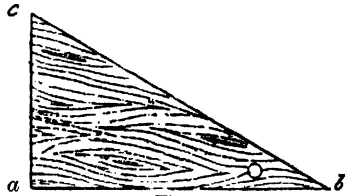


Fig. 8.

the angle *a b c* or *c b a* is one of 30°; the other, or the "complement," as *a c b* or *b a c*, being that of 60°. Another set-square—to be had, like the two already described, ready made at the mathematical instrument maker's—is shown in fig. 9; in this the angle *e d f*

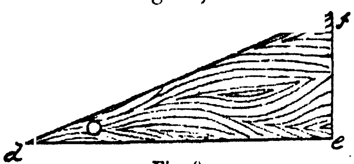


Fig. 9.

or *f d e* is one of 37° 30′, the other and complementary angle, *e f d*, being 52° 30′.

The Varieties of "Set-squares"—Their Practical Working.

The set-squares of 45° and 60°, as in figs. 5 and 8, are useful for a variety of work. Fig. 10 illustrates a method of using the set-square of 45° (fig. 5) in forming a diagonal square within a circle or otherwise, the line *a b* being horizontal or along the length of the board, and drawn along the edge of the T-square. The set-square is placed as *c d e*, its edge *c d* coinciding or lying upon the point *a*, along which is drawn the line *c d*; by moving the T-square further down the board the corresponding line *b g* is put in, and by reversing the set-square so that it will assume the position of *b e d*, the sides *b d*, *f e* can be drawn, which completes the diagonal, or lozenge square,

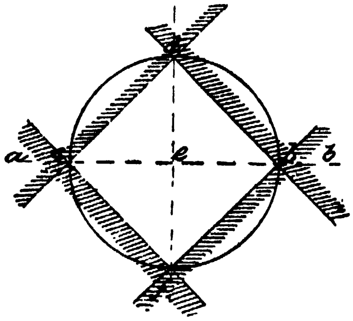


Fig. 10.

as it is sometimes called. The set-square of 45°, as in fig. 5, may also be used in drawing an octagon within a circle or otherwise, as in fig. 11. In this the

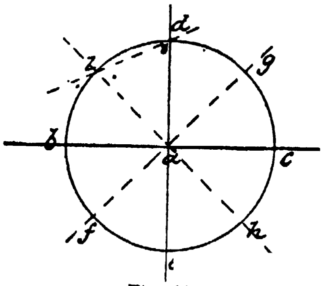


Fig. 11.

diameters, as *b c*, *d e*, are drawn through the centre *a*, the extremities of which, as at *b*, *e*, *c*, *d*, give four points of the octagon; the fifth and sixth are found at *f* and *g* by placing the set-square as in fig. 5, so that its side *c b*, placed to the left hand, passes through or coincides with the centre *a*, and a line is drawn cutting the circle in the points *f* and *g*; or these points may be indicated by simply drawing the pencil along the side of the set-square at or near the circle till it cuts this at *f* and *g*. The seventh and eighth

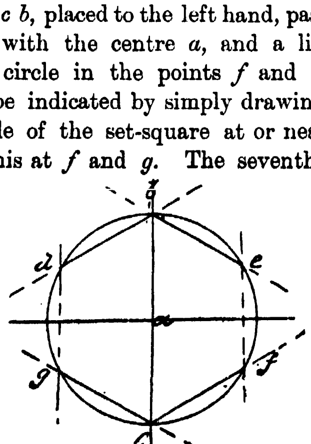


Fig. 12.

points, as *h* and *i*, are found by reversing the position of the set-square, so that the side corresponding to *b c* in fig. 5 shall be to the right hand and coincide with centre *a*. In fig. 12 we show how the set-square in fig. 8 of 60° and 30°, or to use the shorter term generally employed, of "60" only, can be used for describing a hexagon—the usual form of a "nut" for a screw-bolt—which has more than four sides (see a succeeding chapter in the present series of papers for methods of delineating screws, bolts, nuts, rivets, etc.) The hexagon is divided in a circle, as shown in fig. 12, but the set-square is available for the delineation of the figure if only one point, as *c*, be given. Through the centre, *a*, of the circle the diameter *b a c* is drawn. Placing the T-square so that its edge is at right angles to this line *b a c*, the set-square of 60°, as in fig. 8, is placed so that the side corresponding to *c b* coincides with the point *b*, and is to the right hand; the line *b e* is drawn to cut the circle in the point *e*, which is one of the sides of the hexagon; and by moving the T-square further down the board the corresponding and parallel side, as *c g*, is drawn from point *c*. By reversing the set-square so that the side corresponding to *b c*, fig. 8, lies to the left, the other sides, as *c f* and *b d*, are drawn; and finally, parallel to *a b c*, the sides *g d* and *f e* are drawn. Should only one point be given, as *c*, the lines *g c*, *c f* are drawn with the set-square (fig. 8) along its side *c b*; and the length of the side of the hexagon being known; it is set off from the point *c* to the points *f* and *g*, and from these, lines at right angles to the T-square are drawn along the edge of the set-square corresponding to *a c* (fig. 8), and *f e*, *g d* made equal to *c g* or *c f*. From *d* and *c* lines parallel to *c f* and *c g* are drawn, meeting or cutting in point *b*, when the hexagon is completed.

We have shown in these illustrations how useful the set-squares are in conjunction with the T-square in drawing various lines in relation to each other. When lines are to be drawn at angles other than those given by the set-squares in figs. 5, 8 and 9, the angles must be found by the methods illustrated and described in the paper entitled "The Geometrical Draughtsman," and when the line is drawn, other lines parallel to it may be put in by the parallel ruler (see paper named above). But the drawing of a number of angular lines parallel to one another is greatly facilitated by having a jointed T-square. In this the blade, as *b b*, fig. 2, is jointed with a set-screw joint or stud, so that its relation to the head or stock *a a* can be adjusted to form any angle required, and when so adjusted can be firmly secured in this position by the set-screw.

The "Straight-edge" or Flat "Ruler."

Straight lines other than those which can be put in by means of the appliances already described are drawn by the appliance known as the "straight-edge," popularly described as a flat ruler. This is illustrated in fig. 13, in plan or face view at *a b*, in edge view at *c d*. The edges of this are best made square, as at *e*; sometimes bevelled off at various angles, as *f*, *g* and *h*. As both varieties of edges are useful, one edge of the straight-edge should be made as at *e*, the other as at *e f g*, or by preference as at *h*. When both edges are bevelled as at *g* or *h*, and the lines of the drawing are to be inked-in, the straight-edge must be reversed, as at *i*, to prevent the ink flowing from the pen to the paper and smudging it, which is apt to take place when the edge is used as at *h*. The square

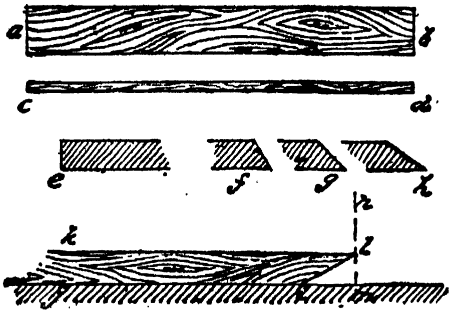


Fig. 13.

edge as at *e* does not cause the ink to run, as the edge at *h*.

Matter given in the Present Series has an Application to Technical Work generally, other than that connected with Building and Engineering Construction.

After what has been already stated, it would seem scarcely necessary to say that the important subject which in succeeding chapters in the present series of papers is to engage our attention has a wider application than the two classes of work embraced in its title. Although the illustrations and descriptions which we purpose to present to the notice of the reader will of necessity have special reference to and the closest bearing on the practical work of the draughtsman engaged in the arts and sciences of architecture and engineering, they will have, if not so closely, a direct application to the work of other technical pursuits. It may indeed be said that the species of drawing with which we are now concerned is useful to every one engaged in an industrial work in which mechanical, or (as we may give it a wider and yet a more distinctive title) constructive work is concerned; and this feature is possessed by a large proportion of our national technical pursuits. It is unnecessary further to dilate upon the practical value of a knowledge of what is so widely known as mechanical drawing to those classes of industrial workers here generally referred to. The point will be obvious to those who have perused and carefully thought over what we have in preceding paragraphs presented for consideration. It may, however, to some receive further illustration and corroboration by what will be given in succeeding paragraphs, and perhaps more pointedly by the following *vidimus*, or general view of the various subjects which will form the matter of our series of papers now in preceding paragraphs begun.

Although we here name those subjects in a certain order, the reservation must now be made that we do not engage to maintain that order strictly in the chapters yet to follow; for good reasons may yet be found for varying it in greater or less degree. Further, it may yet be deemed editorially advisable to include in the present series certain subjects which are not at present proposed to form part of it. In addition to what we have already given on the subject of the "appliances" required by the architectural and engineering draughtsman, such as the drawing board, T-square, and set-squares, we shall in the next chapter give some remarks on the "instruments" useful in their practice—how to use and how to keep them in working order. In these remarks various points bearing on preliminary and general practice will be incidentally given. Following these, the subject next taken up will be a description of the general principles upon which what are called working drawings—that is, those which take the form of and are in technical practice known as "plans," "elevations," "sections," and "detailed drawings"—are based. This principle, which admits of measurements being laid down in drawings about to be, and taken from those already executed, is generally known as plane projection, or the method of showing or delineating the different views of the same object which are required before that object can be made or constructed in strict adherence at once to its form or configuration, and to the measurements of the parts or lines making up that form or configuration. And all those views are drawn upon plane surfaces, such as the paper fixed to the drawing board when small-scale drawings are required, or in the flat surface of a drawing floor or a large boarded surface when full-sized drawings are required. In all cases, as above stated, the measurements connected with the object to be delineated in plan, elevation and section are all capable of being taken from or referred to in the ordinary or English standard of feet and inches.

Principles of Plane Projection as applied to the Delineation of Constructive Objects from which Measurements can be taken.

The drawings or delineations of an object thus drawn on the principles of plane projection, give only what are purely conventional views of the object, and do not give what would be the appearance or look which the object would assume or present when looked at as a whole, and from any one point of view. The principle upon which plane projection, as giving different views of one object in plan, elevation and section, is based, may be broadly or generally stated here.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER V.

AT the conclusion of last chapter, in describing the adjustment of the indicator to the working engine, we pointed out that the cord or string working the drum should be free from anything that would retard its free motion. When the indicator is fixed on the engine, and the string is attached to it from the radius bar or rod, it is necessary to see that the string works steadily before an attempt is made to take a diagram. The drum of the indicator has a stop fixed to it like the stop on a gas tap. The motion of the drum must be regulated so that it does not touch the stop on either side: if it touches in the least, by drawing it too far round, or by letting it touch when the spring which is in the drum draws it back, either of these movements would mar the diagram, and prevent the operator from judging accurately as to its indications. The diagram would also mislead in calculating the power which the engine was exerting. Let the traverse be as long as it can be without being interfered with. If the drum is allowed to be drawn round by the spring too far, it would catch the pencil and break off the end. The string should therefore be properly adjusted to give the exact length of traverse or turn-round of the drum required. A noose on the string should be made, to hang on the hook. After being satisfied that all is so far right, unhook the string from the indicator. Open the tap on the engine cylinder which the indicator is affixed to, and then the steam will get to the piston, etc., and it will be seen whether it works freely or not. When all appears in working condition, close the tap, and then put the paper on the drum. When the string is affixed to the hook of the indicator, the pencil is then turned against the drum, and it (the drum) is allowed to traverse two or three times backwards and forwards, a line being made upon the paper by the pencil. This line is called the atmospheric line. This means a line which is drawn upon the drum when there is neither steam to press it up nor a vacuum to draw it down. This line should always be drawn first. The tap of the cylinder and indicator is then opened. Should the pencil rise above the line, the operator would say that the steam in the cylinder was above atmospheric pressure. Should the steam in the cylinder not be strong enough to raise the line up to the atmospheric line, then it would be said, "steam below atmospheric pressure." When the pencil has made the impression on the paper, draw it back, and unhook the string from the indicator. The paper can then be removed. All indicators are provided with a scale, which corresponds to that which is screwed to the upper part of the indicator.

Some Points connected with Vacuum of a Low-Pressure Condensing Engine pertaining to the Further Consideration of Indicator Diagrams.

Before giving illustrations of the mode of working out the diagrams, it is desirable to give a few words on the vacuum, though we have before referred to it. When the steam is on the top side of the piston in the main cylinder and the indicator is on the top side of it, the indicator piston rises up to a corresponding height with the steam which is in the main cylinder, and the pencil mark on the diagram indicates it. When the piston in the engine cylinder is coming up there is a vacuum in it on the top side of it; this vacuum helps to draw up, so to say, the piston, and it also acts on the piston of the indicator, only this drawn in the opposite direction or down; and by looking at the scale on the indicator it shows the number of pounds of vacuum. When the diagram is taken from the scale which is provided, the steam and vacuum can be measured. It is frequently measured by the scale, when the operator does not require to calculate it,—he simply measures the average steam vacuum, and this measurement often answers the purpose to one who is accustomed to the same diagram. The action in the bottom part or under side of the piston of the engine cylinder acts upon the indicator in precisely the same way as we have just described in connection with the upper part of cylinder of the engine; the indicator piston being as before in the opposite direction.

Further Points connected with the Working of the Indicator.—The Action and Adjustment of the Pencil tracing the Diagram on the Drum.

In the application of the pencil which is used to the paper on the drum, we would direct the attention of our readers to one point which is of some importance. Our knowledge of this was derived partly from our own experience, partly from "thinking the matter out," and partly from a dispute which arose as to our indication of a steam engine and that of a gentleman who had taken one immediately before us, the difference in the diagrams being considerable. The diagram by the gentleman produced much less power than the one which was taken by us. This matter had to be defended and proved as far as it could be. We were challenged and desired to show how such an occurrence could be, both of us being confident that our own instrument was correct. No doubt but both indicators were quite correct. We repaired to the engine-house, and the proprietor along with us. We put the indicator on, and ventured to say that we could make two different diagrams when all was regularly going in the works. We first took one on the same principle as we had before done. That was examined along with the diagram taken by us, and found to correspond,—which was so far satisfactory. Next was to be seen how the gentleman's figure should differ from ours. The proprietor still remaining in the engine-house, a change was made in his presence, and an explanation given at the same time by us as to what the result would be. Another diagram was then taken by us, which very nearly represented that taken by the gentleman. The difference in the diagram taken arose solely through the action of the "pencil" as arranged. The proprietor was quite satisfied that our plan of operation was the correct one. We have mentioned the above circumstance, and could have referred to others of the like nature, but it will be sufficient to convince those who will allow themselves to think out the difference between doing business in a way to show what is right, or to do it in a way haphazard. We hope the explanation which we are now giving will put the true principle of applying and working the indicator beyond a doubt. Those using the indicator must keep in mind that a very little matter will impede the movement of so delicate a machine. The piston of the indicator being only about half an inch in diameter, the least friction in connection with the piston will impede its movement, and that will not allow the diagram to lie as large as it otherwise would lie. Before the pencil is applied to the paper it should have a good point. The lead of the pencil should be rather soft—sufficiently so to mark the paper with the least pressure possible. The difference between the diagrams which we have referred to above arose simply, as just stated, from the difference in the way in which the pencil was applied. In our case the pencil point was cut fine, and the pressure of the pencil was barely enough to give a faint line; in the case of the other diagram the pencil was pressed on the paper much more than in our operation. A small screw is used to give pressure more or less to the pencil. Any unnecessary pressure on the pencil will cause friction, and friction will check freedom of motion in the piston, which cannot move so freely, thus preventing the pencil from rising so high when the steam is acting, and it also affects it in going down when the vacuum is operating, and thus it will be understood that the extreme of the lines which are on the diagram will be proportionately less as the friction is increased. We consider this to be one of the important things to be observed in working the indicator. It is very possible for any one unaccustomed to taking diagrams to overlook an important matter like this, of allowing the pencil to press hard upon the paper in order that a good, clear impression can be made upon it. It is only the thoughtful, or those who have had their attention drawn to the importance of the matter, that would be aware of the consequence which would result from so small a matter. It might under one circumstance or another amount to a fault in the diagram given by the indicator which might lead to additional machinery being put down where the engine was in reality giving the full amount of power it was calculated at. In other ways it might cause a great loss to one who was letting off turning (*i.e.* turning machinery) at a rent for so much a machine, or so much per spindle of a mule, etc., etc. Any degree of pressure of the pencil, acting so as to show a smaller diagram than the true one, would be detrimental to his actual interests as a provider of steam power. Those accustomed to use the indicator might readily condemn us for treating upon so small a matter, and at such a length. Those, however, who are unacquainted with it, and have not had experience in the manipulation of it, will find our remarks of considerable value.

Some Points connected with Steam in relation to the Working of the Indicator.—Importance of the Vacuum in Condensing a Low-Pressure Steam Engine.

Every one knows less or more about the power of steam, from various facts of everyday experience. Steam is raised in the boiler by the use of coal, just in the same way as it is raised from the water in and passes out at the spout of the kettle on the household fire. When steam is bottled up, so to use a graphic expression, in a steam boiler, a continual firing up increases the pressure far above the steam of a boiling kettle, which pressure is said to be that of "the atmosphere" or "atmospheric pressure." Each steam-engine boiler is provided with what is called a safety valve. It only acts as a warning to the fireman, by intimating to him that so many pounds of steam are pressing on the plates of the boiler. The safety valve is an application to warn the attendant that the steam is as high or as strong as the plates are capable of withstanding with safety. The regulation of the weight on the lever is calculated for a certain pressure, so that it shall not go beyond that danger point. Sometimes safety valves are differently arranged, and have no levers. In such cases dead weights are applied. In the case of the locomotive boiler a spring is used, as weights would not there be applicable. The weight on a lever is, as will be understood by even the tyro in mechanics, much lighter than the weights used on the "dead weight" valves. Condensing engines are so arranged that other help than that of the steam proper is availed of to assist the engine. This extra help, so to call it, is the vacuum produced by the condensation of the steam as it passes from the cylinder into the condenser. Before giving any illustration of diagrams of indicator, as this point is one of the weighty matters in the economy of steam engine management, we have a few remarks to make on it. Those who have witnessed the scientific experiment with two cups from the interior of which the air is extracted by an air pump, will remember the difficulty there was to separate them. This arose from the fact that the inner part of the cups is in the condition known as vacuous or empty—hence the term vacuum is applied to it. In this condition there is no inner pressure equal to the pressure without, tending to equalise this pressure; so that, the pressure being wholly from the outside, the two cups, so to say, adhere to each other. A perfect vacuum is equal to taking away fifteen pounds pressure per inch. Thus the pressure of fifteen pounds is upon every inch of the cups outside, all pressing in one direction, and therefore the difficulty of rending them asunder. If there was any air left in the cups the reverse would be the case. The term vacuum indicates that there is a space unoccupied. It will be seen how valuable this unoccupied space is in connection with the condensing steam engine, as we proceed in explaining the diagrams and working them out to show the power, etc., that is performed by the steam and vacuum combined; and how the cost of working an engine is increased where the advantage of a vacuum cannot be obtained, or where it is deficient from whatever cause. The indications or diagrams of a steam engine are most important to proprietors of condensing engines, as by them they can know whether the vacuum is kept up to the highest point of efficiency. This may appear to those who have not had experience in looking after steam engines as engine drivers to be of little moment. But we wish this to be well understood: that in case the vacuum is deficient, from whatever cause, a larger consumption of fuel must take place. By taking a diagram it will show either that the engine is drawing air or steam is passing the piston in the cylinder. Drawing air in any part from bad joints, or by any means permitting air to be drawn into the condenser, would diminish the vacuum. It often happens that a little steam may pass the valves, they not being well packed, or else requiring grinding. Grinding-in is a term used very generally where valves are working metal to metal. Sometimes valves or the valve rods require packing in the box commonly called the stuffing box, and then it has to be repacked, and then they require to be screwed down to make them tight. Either steam passing any part which can get to the condenser, or air which can find its way to it, will destroy the vacuum, in proportion to the amount which finds its way to it. The indicator in this way becomes of great value. Every step we move in this direction will show the use of it.

Special Remarks on the Forms of Diagrams.

It may be of interest to our readers if we make a few remarks respecting diagrams. Two diagrams cannot be alike in form if both engines were performing the same amount of work. Supposing that two engines are coupled together working at right angles—both made by the same engineer, and in every respect the same, as near as hands could make them. Perhaps one may be more favourably situated than the other to receive the steam, or more favourably arranged for the condenser. Again, the difference in the opening of the ports to the cylinder or the condenser may vary a trifle, and hence a difference in the shape of the diagram would appear. An approximate diagram may be aimed at and may be attained. We have found it advisable under some circumstances, in order to help to more uniformity in the working of the engine, to have a little more steam on one side of the piston than on the other; but in most cases such a deviation is unnecessary. Many little defects in the diagram present themselves, and are often such as to puzzle even those of experience. Such little irregularities in forms are often unworthy of further notice, so long as the general principle is carried out.

The diagrams shown hereafter will be so drawn that some or most of the defects will be treated and explained, and thus little or no difficulty will be felt by the reader to comprehend them, and also how to remedy them. At any rate, he can so understand the cause that he may give instructions to those who can do the practical work.

The indicator shows to the performer, in addition to what we have before alluded to, whether the valves have too much "lead," or they are too late, both as regards the steam side and the vacuum side of the diagram. It also points to defects of this kind, both at the beginning and at the end of the stroke of the engine. If steam be allowed to go into the cylinder before the piston is completely at the top or bottom, a jarring is sure to be felt on the connecting rod or at the top of the piston rod—which is not only a loss in the power of the engine, by being admitted on to the piston before it is ready to return, but is the cause of much trembling of the different parts of the engine. The same is found of the exhaust side—*i.e.*, if the valve which opens to let out the steam into the condenser, so that it can be freed from the cylinder, and thus be the means of creating a vacuum as perfect as possible, is open too long, this also is an evil. The indicator exhibits the above faults.

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART

CHAPTER VI.

At the end of last chapter we gave a diagram (fig. 13) illustrating the result of a combination of forces on a number of parallelograms, all having the same resultant. In this diagram the line *a b* is the diagonal of the parallelogram *a g b h*, the compound forces giving this resultant *a b* being represented by the arrows *i* and *j*, while the two compound forces *q* and *r* give as a resultant the same diagonal line *a b* of the parallelogram *a o b p*. This method of making diagrams, showing the result of a combination of forces acting in different directions and with varying pressures, is of great value to the mechanic, illustrations of which will be found in appropriate papers.

Those illustrations of the parallelogram of forces have had reference to what is known as the "composition of forces"—by which when we have the amount of two forces, as the forces represented by the arrows *b* and *d* in diagram fig. 10 (*ante*), and wish to ascertain the force of the resultant *a f* of those two component forces, we can ascertain this graphically by drawing the lines *a c*, *a e*, coincident with the direction of the two component forces *b* and *d*, and knowing the amount of each of these two forces, stated in pounds, say *b* 50 and *d* 30, we take from a scale of equal parts the distances 50 and 30, and set them off from the point *a* on the lines *a c* and *a e* respectively. We then complete the parallelograms by drawing lines from points *c*, *e*, parallel to *a e*, *a c*, and prolong them till they cut in the point *f*. We then draw the diagonal *a f*, which is the resultant of the two component forces *b* and *d*, and by taking *its* distance *a f* in the compasses, and applying it to the same scale of equal parts with which we measured the distances 50 and 30, representing the forces of *d* and *b*, we can read off the proportion which the force of the resultant *a f* bears to the two component forces. The principle of the "composition of forces" is applied with great utility in the mechanics of rigid matter at rest, such as beams submitted to the pressure of heavy weights. This does not concern us here, as it comes within the province of the engineer or carpenter, and will be treated of in the paper on "Framing."

What is called the "resolution of forces" is an application of the principles of the parallelogram of forces, the converse of the "composition of forces." And by this latter we find a direct force, as *f a*, fig. 10, to balance or be equivalent to two given forces, *d a c*, *b a c*. By the "resolution of forces," if we have a given force we can find two forces which will be equivalent to, or will balance it, so to say. Thus, suppose we have a force represented by the oblique or diagonal line *a f*, fig. 10, the resultant of two component forces, and we desire to know the proportion of this force which acts in a direction, say, as *a c*, and that acting in the direction *a e*, we draw lines from the terminating points, *a* and *f*, of the resulting force *a f*, parallel to the axis of direction we have assumed, namely *b a c*, *d a c*. The forces we wish to know the amount of are acting as parallel to the lines *a c* and *a e*; those lines drawn from the point *f* will cut in the point *c*, completing the parallelogram of forces *a e*, *f c*. If we measure from any scale of equal parts the line *a f*, we can, by measuring the distances *a c* and *a e* from the same scale, read off the proportions which those two component forces bear to the resultant *a f*.

The Action of Forces on Oblique Surfaces.—Rowing of Boats.—Oars.—Helms of Boats and Ships.—Oblique Action of the Wind on the Sails of Ships.—Propelling Boats by Oars.—Feathering of Oars.

These two principles, the composition and the resolution of forces, or simply the one single principle from which the parallelograms of forces both flow, is illustrated in a great variety of mechanical subjects and work in which oblique action is the marked feature, this oblique action being the result of two forces. And this oblique or diagonal direction must in all cases be in a line at some point between them, no matter what the angle may be at which the lines of direction of those forces would, if continued, cut or intersect each other. This the reader will have gathered from the statements we have already given; and will have it further illustrated in those yet to be made. A very familiar illustration is met with in the act of rowing in a boat propelled with oars. If we take the *a* in fig. 14 to represent either a man rowing or a boat propelled, we have the first force applied to send *a* in the direction of arrow *b*, the second to cause it to go in the direction of arrow *c*; but these forces being equal on each side, the body takes the straight course, as *d*, between them. And although in the case of a boat rowed by one man the two oars would appear to be moved not only simultaneously but precisely in the same way, and that therefore the boat must go straight, the oblique direction in which the oars strike the water is practically always changing; still because those changes are equal on each side the boat takes the course midway between the changing forces. And this is the case with a skilful rower, who practically handles his two oars equally the same; but with an unskilled rower, the movement of the hand being by no means similar and alike to that of the other, the result is what we call a wobbling or veering course of the boat through the water. When the boat is propelled by the operation known as "sculling," in which the oar *f* of boat *g* in fig. 14 is used at the stern, we have a good illustration of two oblique and opposing forces, one of which, as *f*, itself gives the boat's hull a movement to the right, as at dotted line *h*, the other movement of the oar, as *i*, to the left, as at *j*, yet the boat goes straight on in the line *g k*, midway between them; the two opposing forces acting obliquely being equally balanced on each side. Sculling, or by whatever other name it may be called, however, affords an example of oblique action in another way; for one oar, while it is being worked laterally from side to side, is at the same time as it is pressed through the water from any one side, turned or twisted round by the wrists of the oarsman so that its blade is pointed—that is, it acts on the water at an angle, pushing the water back in an oblique direction, and acting much

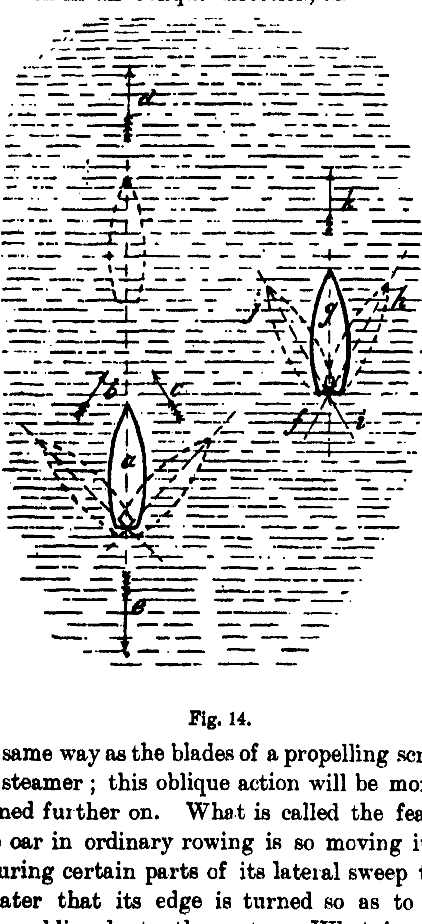


Fig. 14.

in the same way as the blades of a propelling screw of a screw steamer; this oblique action will be more fully explained further on. What is called the feathering of the oar in ordinary rowing is so moving it on its axis during certain parts of its lateral sweep through the water that its edge is turned so as to present its face obliquely to the water. What is called a "feathering paddle wheel" of a paddle-wheel steam-vessel is one with its float or paddles hung on centres or studs at their ends, so that by appropriate mechanism, as eccentrics or levers, they can, from the motion of the main shaft, be changed in position on entering, while passing through, and on leaving the water. When fixed rigidly, the floats or paddles radiating from the centre are on entering the water in the position *a*, fig. 15. Its action on the water in no way promotes the propulsion of the vessel—in fact, it tends more to lift it up out of the water, pressing as it does directly on the surface of the water in the direction of the arrow *b*, and consequently to raise the centre shaft in the direction of the arrow *d*. On leaving the water, or when about to leave it, as in position *e*, its tendency is to lift the water in direction of arrow *f*. The points where the paddles become really operative in giving their full propelling power to the vessel is at the lowest point *g*, where, as the paddle wheel revolves, the paddles *f* push the water directly back in the direction of the arrow *h*, and this pushes, so to say, the centre *c*, and through it the vessel, through the water in the direction of arrow *i*. It is only at this point *g*, when the radial paddle is vertically in the water and at a short distance from

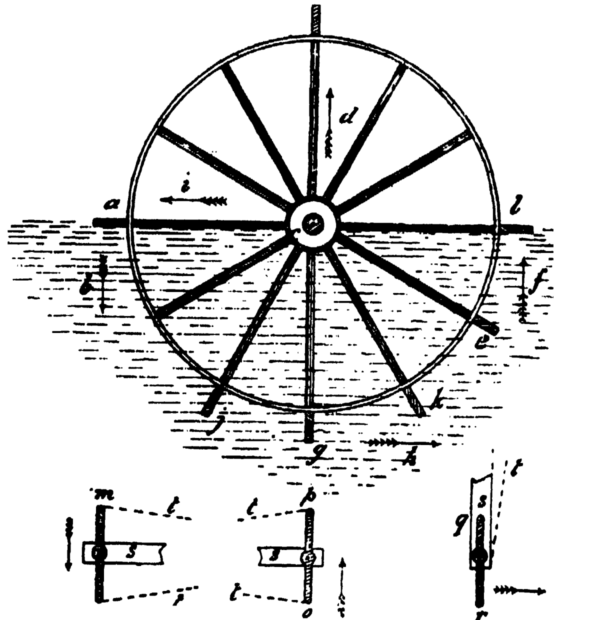


Fig. 15.

either side of it, as at *j* and *k*, that the paddle is efficient; losing its propulsive power in proportion as it reaches the positions as at *a*, *e*, and *l*. By feathering the paddles, or hanging them so that they can be moved round on their axis, the positions at *a* and *l* can be altered, as at *m n* and *o p*—*q r* being, as before, the normal position of greatest propulsive effect. In those diagrams the letter *s* represents part of the arms of the paddle wheels, which carry along with the outer rings the "floats" (or paddles), which are centred as shown, *t t* representing the eccentric rods by which the "floats," as *m*, *n*, are moved in the centre into the different positions required.

Further Illustrations of Oblique Action.—Crossing of Rivers by Ferry Boats anchored by Chain to a Central Point in the Stream, and Influenced by the Helm.—Tacking.

We have a curious and instructive example of oblique action from two forces in the method of crossing rivers by ferry boats anchored to a post in the centre of the stream—a method which travellers on the Continent have opportunities to see examples of in the broad rivers there met with: a method which has puzzled many a one to account for. In this we have the stream, *a b c d*, fig. 16, flowing in the direction *e* to *f*, fig. 16, and the post *g*, to which the ferry boat *h* is anchored by the chain *i i*, is placed in the centre of the river: so that normally, when free to act, the boat would occupy the centre of the stream or river. Presuming that it has been brought-to and moored at the bank *c d*, on the mooring rope being let go, the tendency of the current from *e* to *f* is simply to carry the boat down the stream towards *f*. But the helm is put up so that its surface is presented to the downward flow of the water in an oblique direction; therefore a force acting obliquely is created, and which tends to drive the boat up the stream; the resultant of those two component forces is just as in the case of the parallelogram of forces in diagram fig. 9 (*ante*)—only as the boat is anchored at the anchor post *g*, the resultant, in place of being a straight line, as *a f* in fig. 9, takes, or is compelled to take, the form of a curve, the centre of which is at *g*, fig. 16, and the boat is carried to a point *j* on the opposite bank, *a b*. The ferry boat is made to return from *j* to *k* by the same action. This diagram illustrates partly also the result of the two forces in crossing a river by a boat sailing across. The force of the descending stream, acting directly in direction *e f* to push the vessel downwards, is converted into an oblique force by the action of the helm and by the trimming of the sails, set so that the wind acts obliquely on their surfaces. Thus, if we suppose the boat *k* was desired to be taken across from bank *c d* to bank *a b*, and that the wind was blowing directly across the river in the direction of arrow *l* to *j*, if there were no current whatever from *e* to *f*, the boat would be propelled by the force of the wind acting in the sails right across from *k* to *j*. But the stream is flowing strongly from *e* to *f*, tending to carry the boat down the river directly it is let loose from its moorings. By the action of the helm and the trimming of the sails, the force of the wind acting on the sails in the direction of *l j*, and that of the stream acting in direction *e f*, the "resultant" of the two forces is that the boat takes the diagonal *k m* of the parallelogram *k j m n*, and arrives at a point *m* lower down than *k*. By a repetition of this process, by only partly crossing the river, not going very close to the banks, the sailing boat can "beat" up against the force of the river flowing downward, aided by a wind so that she can sail up the stream; and on the same principle a sailing ship can tack, beating up against a contrary wind. The details of this will be more clearly seen when we come to inquire into the oblique action of the wind in sailing ships. Much of the principle here described is illustrated by the action of a boat rowed by hand. Suppose the boatman in boat *j* wished to cross to the opposite bank to reach some point near the point *k*: the boat would be rowed close in shore, along bank *a b*, creeping *up* the stream in the direction of arrow *o*, the action of the current being so weak at this point that the strength of the rowers would be able easily to move the boat up—say till it reached the point *p*; they would then strike out into the body of the stream. There meeting the full force of the current, they would row, keeping by the helm the boat's head pointing up the river, in the direction of *p q*. The result of the force—singly considered, apart from the force of the current—executed by the rowers acting in direction of arrow *r*, would be to take the boat across to the point *d*, but the force of the current acting in direction *e*, the "resultant" of the two forces would be the diagonal *p k* of the parallelogram *p d k j*, which would land the boat at point *k*. By knowledge of the currents, boatmen can so "hit" the point *p*—up to which they should creep close to the bank in shallow water, having small force of current downwards—that they are able to arrive at any point, as *k*, they may desire.

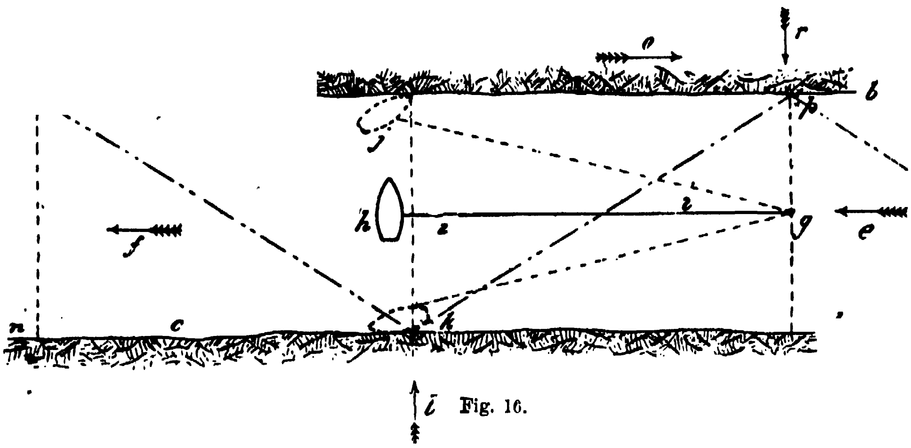


Fig. 16.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER IV.

OTHER recipes than that given in the last paragraph in the preceding chapter are followed in making vermilion by this method; but they do not differ in essential points,—in each case the mercury sulphur and caustic alkali are ground together so as to form the black sulphide, and are then cautiously heated until the mixture assumes the brightest scarlet colour.

The "Dry" Method of making Vermilion.

The elements of vermilion may be made to combine to form the red sulphide by dry treatment as well as by wet. The proportions of materials and method of their treatment generally adopted are as follows: For each pound weight of mercury from four to six ounces of sublimed sulphur are taken, and are ground together until it is converted into a black powder, which is termed the ethiop, and is generally stored in vessels of about a pint capacity. The next operation is the sublimation, which is effected in a large specially constructed furnace, on the floor of which are arranged a series of large clay pots or crucibles provided with closely fitting lids of polished iron. The pots are first raised to a dull red heat, the flame being so arranged as to reach nearly to the top of the pots; about three pints of ethiop are then thrown in, which causes a violent combustion to ensue, the uncombined sulphur being ignited and burning with a flame several feet high; as this subsides, the iron cover is put on, and the mass is stirred with an iron rod through a hole in the cover. The sublimation is continued for thirty to forty hours, every five or six hours the lid being removed and more ethiop added. The pots are then cooled, removed from the furnace and broken, and the sublimed vermilion, which is mostly found on the upper sides of the pots, is removed, ground in a mill, levigated and dried for the market. By this method a pigment of almost unrivalled beauty may be obtained; but great experience and skill are required in the management of the sublimation, upon which depends, more than anything else, the quality of the vermilion produced.

Antimony Vermilion.

Antimony, like mercury, unites with sulphur to form an insoluble sulphide of a brilliant scarlet colour. This latter compound possesses many of those properties which render any insoluble coloured compound suitable as a pigment, and hence the *scarlet sulphide of Antimony* is extensively used as a red pigment under the name of "Antimony or Mock Vermilion," and possesses the advantage of greater cheapness. Antimony forms two sulphides (antimonious sulphide, Sb_2S_3, and antimonic sulphide, Sb_2S_5), corresponding respectively to the oxides, Sb_2O_3 and Sb_2O_5. Probably a third sulphide exists intermediate between these two—namely, Sb_2S_4, and corresponding to the other oxide, namely, Sb_2O_4. The commercial product, antimony vermilion, is probably a mixture of antimonic pentasulphide, Sb_2S_5, with the tetrasulphide, Sb_2O_4. It is produced by heating solutions of chloride of antimony and hyposulphite of soda.

Antimonic chloride (Sb_2Cl_6) is employed as the source of the antimony; this is prepared by dissolving the natural trisulphide mineral, stibite, in strong hydrochloric acid by heating together—sulphuretted hydrogen (H_2S) is given off, and the solution of the chloride obtained is evaporated down to a thick syrup, in order to eliminate the excess of acid. The resulting neutral chloride of antimony, on cooling, thickens considerably. The evaporation should not be carried further than produces a syrup whilst hot. The mass is introduced into a retort, and distilled at a gentle heat—the pure chloride of antimony volatilising completely, leaving, of course, impurities behind. Any arsenic present in the native stibite used in producing the chloride volatilises as chloride of arsenic at a lower temperature than the antimony compound, and escapes when the excess of acid is being eliminated. The distillate of antimonic chloride, on cooling, solidifies into a crystalline white mass, and is known as "butter of antimony," owing to its fat-like appearance; the formula is $SbCl_3$, or Sb_2Cl_6. On mixing water with this compound, oxychloride or *basic* chloride of antimony is formed as a white, powdery precipitate. The composition of this body is not fully understood, but, according to Johnston, it is represented by the formula $4SbCl_3 \cdot 9Sb_2O_3$. The exact composition, however, varies greatly with the details of preparation, according to the quantity and temperature of the water. On the addition of a concentrated solution of hyposulphite of soda or of lime to this mixture of oxychloride and water, it dissolves. This solution is now transferred to the water bath, and the temperature slowly raised, when on reaching 35° C. a copious orange precipitate forms, and when 60° C. has been reached and maintained for a short time, the whole of the antimony is precipitated as the scarlet powder. It is true in the case of the preparation of this pigment, no less than in the case of true vermilion, that the precise shade of colour of the precipitate is entirely dependent upon the *minutiæ* or details of manufacture, such as temperature and rate of heating, etc., which are quite beyond the scope of these papers to treat of. The scarlet precipitate is now subjected to the usual washing by decantation with water, preceded usually by treatment once with water containing a little hydrochloric acid. Such are the outlines of the manufacture of antimony vermilion—a pigment which, when skilfully prepared, may in many instances take the place of real vermilion. It is, however, though of bright scarlet colour, of good covering power, and not readily affected by prolonged exposure to light and air, nevertheless inferior in brilliance and purity of shade to vermilion. Experience has shown that antimony vermilion does in course of time turn brown by exposure to moist and impure atmosphere.

Mineral Kermes.

This pigment is an impure sulphide of antimony. It varies in shade and composition; in general it consists of a mixture of amorphous trisulphide, with smaller quantities of the trioxide and other antimony compounds. It may be prepared in several ways; that usually employed commercially consists in dissolving the grey native sulphide in solution of soda ash, and allowing to cool, when a red precipitate falls down, which is collected and dried. *Liebig's* procedure is thus described:—" One part of the pulverised grey sulphide is boiled for half an hour with one part of solid caustic potash and thirty parts of water, and the filtered liquid is mixed with dilute sulphuric acid, whereby amorphous sulphide of antimony is precipitated. The thickish mixture is then divided into three parts, and covered with water in three separate vessels; the precipitate is left to settle; the water is decanted and fresh water added till the precipitates are well washed: they are then placed upon three separate filters. One part of anhydrous or 2·7 parts of crystallised carbonate of sodium is next dissolved in 34 parts of water; the precipitate from the first of the three filters is introduced into the filtered solution; the liquid is boiled for an hour; and the solution, which has taken up all the sulphide of antimony, is left to cool, whereupon it deposits kermes. The supernatant liquid is now brought to the boiling heat, the second precipitate is added to it and treated in the same manner, and finally the same processes are repeated with the third. The finest coloured kermes is deposited from the second boiling. The precipitates are washed with cold water; their weight, after drying, amounts to nearly half of the grey sulphide used."

When excess of sulphuretted hydrogen, H_2S, is passed into an acid solution of an antimony salt such as tartar emetic, and the mixture heated to about 60° C., the whole of the antimony is thrown down as a bright red-orange-coloured precipitate, antimonious sulphide, Sb_2O_3. This, when washed, collected, and dried, forms a pigment of some brilliance, but it is now seldom met with.

Red Lakes.

Most vegetable and artificial dyes may be made to combine with bases such as *alumina* and *tin* to form insoluble bodies which are found to be more stable than the dyes themselves; upon this fact depends the art of dyeing. It is these insoluble compounds that really form the colouring material in nearly all cloth decorations. These insoluble bodies, or precipitates, or pigments, when prepared from the dye and a base such as alum, are termed "lakes." They are, of course, as truly pigments as vermilion, obtained by the union of mercury and sulphur; but the distinctive name of "lake" is convenient to indicate that the pigment so designated contains a "dye" rendered insoluble by means of mineral salts, etc. Lakes are not so extensively employed in the arts as might be expected, judging alone from the theory of their manufacture and application; but many difficulties are in the way of their superseding dyes and pigments. As a rule, lakes are not so durable as pigments; they deteriorate more readily, as a rule, upon prolonged exposure to light and air, and for ordinary decorative purposes are comparatively little known. In oil- and water-colour painting they are admirably and extensively used—especially the red lakes, which in beauty are unsurpassed by any other red pigments—even vermilion. In calico printing and paper staining they are used in limited quantity, and only for special purposes, as they are generally more expensive than other pigments.

Brazil-wood Lake.

This beautiful red colour is prepared in the following manner:—3½ lb. of the best Brazil-wood is steeped in 10 gallons of water, to which about 1 oz. of powdered chalk has been added; it is then boiled, allowed to settle, and the clear liquor decanted from the woody fibre. 5½ lb. powdered alum is next dissolved in 2 gallons hot water and added to the Brazil-wood liquor; 12 oz. of tin crystals dissolved in ½ gallon of water are then added. The mixture is well stirred, and allowed to stand until perfectly clear; if this does not take place, the liquid must be filtered through flannel. To the clear filtrate a *hot* solution of 1 lb. carbonate of soda per gallon of water is slowly poured in, with constant and violent stirring, until a portion of the mixture taken out and filtered yields a filtrate of neutral reaction, and which gives only a very trifling precipitate with very dilute carbonate of soda, and no precipitate with dilute solution of alum. The proper quantity of soda having been added, the whole is violently stirred and allowed to settle. The clear liquor, which should be almost colourless, is run off, care being taken not to disturb or stir up the fine red precipitate at the bottom. Hot water is then run in, and the mixture well agitated, allowed to settle, run off, collected on a flannel-filter, well washed on the filter, and is then ready for use as an aqueous pulp, or may be dried carefully at not too high a temperature, and if required, ground in a mill.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFAC- [illegible] MATTERS—MISCELLANEOUS.

87. How to Detect Arsenic in Wall Papers.

ALL the apparatus that is necessary consists of pure zinc, dilute vitriol, a glass test tube, a solution of sugar of lead, and a solution of nitrate of silver—all of which may be purchased for a few pence. We first ascertain whether the materials are free from arsenic, as follows:—A piece of the zinc is introduced into the test tube, dilute vitriol added, and the mouth of the test tube lightly plugged with cotton-wool moistened with solution of sugar of lead. A piece of paper moistened with solution of nitrate of silver is now held over the mouth of the test tube: if the materials contain the least trace of arsenic a dark [illegible]

however, no such stain is produced, the cotton plug is removed, and the wall-paper to be tested cut into small bits, which are introduced into the tube, the plug replaced, and the gas issuing from the mouth of the test tube tested as before with silver paper. It is now advisable to heat the test tube over a lamp. The presence of arsenic in the paper is now revealed at once by the production of a large stain of metallic arsenic on the silver paper.

88. Table showing the Scantlings or Dimensions in Depth and Thickness of the Various Parts of the Two Classes of Timber Roof Trusses: 1st. The "Queen Post" Roof Truss (see Fig. 10, Plate VII.), **and 2nd, The "King Post" Roof Truss** (see Fig. 9, Plate VII.):—

Class of Roof.	Span of Roof, or Distance between Bearing Walls.	Tie Beams.	Wall Plates.	Pole Plates.	Principal Rafters.	King Posts.	Queen Posts.	Struts.	Straining Piece.	Sill Piece.	Purlins.	Common Rafters.
		in. in.	in. in.	in. in.	in. in.	in. in.	in in.	in, in.	in. in.	in. in.	n. in	in. in.
Queen Post Roof Truss.	36	10 by 5	6 by 4	5 by 4	6½ by 4½	... ...	5½ by 4½	5 by 3½	8 by 4	5 by 4½	8 by 4½	5 by 2½
	34	10 „ 4½	5 „ 4	4 „ 4	6½ „ 4	... ...	5½ „ 4	4½ „ 3½	8 „ 4	5 „ 4	8 „ 4	4½ „ 2½
	32	9½ „ 4	5 „ 4	4 „ 4	6 „ 4	... ...	5 „ 4	4 „ 3½	7½ „ 4	4½ „ 4	7½ „ 3½	4 „ 2½
	30	9 „ 4	5 „ 3	4 „ 4	5½ „ 4	... ...	4½ „ 4	4 „ 3	7 „ 4	4 „ 4	7 „ 3½	4 „ 2
King Post Roof Truss.	30	10½ „ 4½	5 „ 3	4 „ 4	7 „ 4	5½ „ 4	... ...	5 „ 3½	... ...	... ...	8½ „ 4½	5 „ 2
	28	10 „ 4	5 „ 3	4 „ 4	6½ „ 4	5 „ 4	... ...	4½ „ 3½	... ...	... ...	8½ „ 4	4½ „ 2
	26	9½ „ 4	5 „ 3	4 „ 4	6½ „ 3½	5 „ 3½	... ...	4½ „ 3	... ...	... ...	8 „ 4	4½ „ 2
	24	9 „ 3½	4½ „ 3	4 „ 4	6 „ 3½	4½ „ 3½	... ...	4 „ 3	... ...	... ...	7½ „ 3½	4 „ 2
	22	8½ „ 3½	4½ „ 3	4 „ 4	6 „ 3	4 „ 3½	... ...	3½ „ 3	... ...	... ...	7 „ 3½	4 „ 2
	20	8 „ 3	4 „ 3	4 „ 4	5½ „ 3	4½ „ 3	... ...	3½ „ 2½	... ...	... ...	6½ „ 3½	3½ „ 2
	18	7½ „ 3	4 „ 3	4 „ 4	5 „ 3	4 „ 3	... ...	3 „ 2½	... ...	... ...	6 „ 3½	3½ „ 2

' The Scantlings in the different columns are those required for the pieces or members, according to the width between the bearings, or length in feet from wall to wall, which is technically called the "span of the roof." The table may be taken as giving the requirements of the best practice, as it has received the official sanction of, and is accepted by, the "Inclosure Commissioners."

89. Ensilage.

In Note No. 21, p. 137, we gave a general description of the principle upon which ensilage is based. The methods of forming the "silo pits" are somewhat numerous, but vary chiefly in constructive details, the principle being in all the same. To the bricklayer, the mason, or the carpenter, some of those methods will readily be suggested; but as many of our readers are not concerned technically with building construction, we purpose glancing briefly at the best of them, such as brick- or stone-lined pits, set in cement or pointed with it, or pits lined with concrete. Silos are sometimes constructed above ground, and of various materials—as brick, stone, or concrete, and in some of the more recently introduced systems of iron plates, either plain or corrugated. In other cases old buildings, such as barns not in use, are requisitioned. If the barn is large, one corner only may be utilised, the walls meeting in one of the corners obviously giving two ready made of the four retaining walls forming the silo or receptacle for the produce. Or, if one end of the barn be used, a cross wall only will be required, forming the fourth of the enclosing walls, the end wall and parts of the two side walls forming the other three. On each of the methods now named of constructing silos we shall, in the course of our papers on the subject of ensilage generally, have some practical details to offer our readers. Before giving them, it has been suggested to us that many, if not the great majority, of our readers would like to have something told them as to how the system, about which so very much has been given in the journals of the day, originated—something, in fact, about its history, and of the special purpose which the system is likely to subserve. This is quite a legitimate desire, and probably it may be gratified sufficiently by the few sentences now to follow which the demands upon our space can afford room for. For the last few years so much in the way of disaster and consequent distress has befallen farmers—and this arising from a variety of causes, of which a constant succession of bad seasons has not been the least potent—that proposals without end have been made by which they could be relieved. Of these proposals which have from time to time been made for their benefit, some have been received with a species of *furore*, or at least great enthusiasm, by farmers; but the great majority of them have died out, having no real backbone of practicality to insure continuous and healthy life. With this new scheme or proposal of "ensilage," however, the case has been very different, for it may be said of it that with the exception of two subjects there has been none which has met with such a great degree of practical interest, such a wide-spread and thoroughly earnest desire to put its merits to the test of practice, and none which really promises to do so much for the farmer in the way of giving him a help of thorough practical value to overcome some of the difficulties arising from the depression under which the business of farming has so long laboured, and under which it still suffers. Every one knows —even that wonderful "schoolboy" who owed his existence to the genius of Macaulay, and who has had such a number of descendants—that of the crops upon which the farmer depends for the feeding of his live stock one of the chief is that of hay. And every one has had experience enough of the uncertainties of this "weeping," rainy climate of ours, to tell him how equally and in virtue of them uncertain it is that the farmer shall get his "hay crop" well harvested and secured. Those of our readers not acquainted with practical farming would be surprised at some of the statistics of farm losses arising through untoward weather, and specially of the hay crop. Taking one year with another, the average yearly loss from bad weather in failing to get in the hay crop may be safely put down as very large indeed, amounting to many hundreds of thousands of pounds. The system of ensilage proposes to save much of this loss. But it promises to do more, as we shall presently see, its capabilities taking a wider range than merely the work connected with the hay crop. We have incidentally said of this system that it is one of the new schemes which are introduced from time to time to the notice of farmers. But it is really the revival of an old scheme, it having been first proposed, and, better than that, actually carried out, and with marked success, by a clever agriculturist of the Continent—from which, by the way, British farming has received more good things than many are disposed to admit or may indeed know of. This far-seeing farmer — M. Auguste Goffart — was not, however, the originator of the principle upon which ensilage depends: that he borrowed from a practice of Continental farmers so old that we have no record of the date of its introduction. But, though not the discoverer of a new principle, M. Goffart took the no less high—in some respects the much higher—position of taking advantage of an old and comparatively worthless—in a practical point of view—idea, and working it out in such a way as to make it a matter of the highest practical value. Time out of mind it has been the practice in certain parts of the continent of Europe blessed with warm and dry climates to store up wheat and grain in pits dug in the earth. In connection with this there are some curious points of so great practical suggestiveness in certain technical work that we may in a future paragraph again advert to it. This practice of storing up corn or grain had evidently given the idea to other farmers living in less favoured districts of storing up green cut produce in pits dug in the soil. The green crop—chiefly, but not always, grass—was put into the pit dug in the soil, firmly compressed together layer after layer by stamping with the feet or otherwise compressing the material so that all the layers would lie closely together. On each layer a little salt was sprinkled previous to the next layer being put in. When the pit was filled with a succession of salted layers of the grass or green crop, the whole was covered carefully over with soil, which was in turn stamped or pressed closely down. When the contents were required for food the pit was opened, or partially opened, and as much only taken or cut out as was required for the time being, leaving the general mass undisturbed, which was gradually cut down until the whole was used, and the pit emptied ready for another filling. What M. Goffart really did was this. He took up the principle of storage of green-cut farm food here presented to him, and, by thinking the matter out, looking at it as some say "all round," he kept working at it till he at last succeeded in giving it not merely the characteristics of a well devised practical system, so far as the nature and construction of the pit itself was concerned, but by a much wider development of its principle made it applicable to a variety of crops other than grass. M. Goffart's efforts to give to the principle all the advantages of a well thought-out system were thoroughly successful—so much so that he gave them a record in the form of a small brochure or pamphlet, believing that a wide knowledge of what it was capable would be of real service to the agricultural world. The pit in the old system was known in certain districts by the name of "silo." This was retained, and it has given to the process of preservation of green-cut food the name by which it is now universally known—"ensilage." A further diversion in the nomenclature of the system is adopted by Mr. Jenkins, the ever active secretary of the Royal Agricultural Society of England, and the able editor of its *Journal*, and who has collected more information on the subject than any other agricultural authority. This is the term "silage," by which Mr. Jenkins denotes the substance or crop preserved by the system. We have thus the "silo," or receptacle in which the crop—the "silage"—is preserved; and "ensilage," the general or distinctive name by which the system as a whole is recognised. We have stated in the most general of ways that to the Continent of Europe the farming of Great Britain has been greatly indebted, not merely for methods of working but for not a few of its crops. But although the systematic development of the old principle of ensilage was due to the energy and ability of a Continental agriculturist, it so happens that we owe the impetus which has made ensilage a practical scheme not to the efforts of a European but to an American continentalist. A farmer of the United States of America, while travelling on the continent of Europe—our Continent—happened to fall in with the pamphlet of M. Goffart to which we have alluded, which, sharing the fate of many like productions equally valuable, had, so to say, fallen still-born from the press, and was virtually altogether unknown to the agricultural world. Struck with what he read, this American farmer resolved to try the system on his return to the United States. He did so, and with such practically striking success that he deemed it right to publish a work drawing special attention to its advantages to the farmer. It was to this work, and to the numerous papers and communications it called forth, that the various journals and magazines of the United States gave an exceedingly wide publicity. This attracted attention on this side of the Atlantic, and it is thus that to American sources we owe the system of ensilage in its modern development. The title of the work which drew such marked attention to it is "The Book of Ensilage; or, the New Dispensation for Farmers." By John M. Bailey. New York, Orange Trade Company. 1881. And this was followed up by an "Essay on Ensilage" by the same author.

90. Bessemer Steel Castings.

In our last note under this heading, we gave a description of the new mechanical agitator for stirring molten metal previous to casting it, and promised that in a future note we would take up the leading points connected with the use of this stirred or mixed steel in castings for various constructive purposes. That promise we now set ourselves to redeem. And here at the outset we would direct the attention of the reader to one point of the stirring process. Its object is not alone fulfilled when the mere mixing of the alloy materials, such as spiegeleisen, with the molten mass is completed. Another very important object is gained by it—namely, the setting free of the occluded or hidden gases locked up, so to say, within the mass. Under the operation of the agitator those gases are set free, and have by the agitation of the masses, passages (so to call them) made in the metal, by which they are set at liberty, or free to pass upwards and out. Mr. Allen states that these occluded gases, which are apparently always present in all masses of molten steel in the ladles, pass out freely in large volumes—giving a solidity and freedom from blow holes or honeycombed cells, to which, Mr. Adamson—who has had large experience in the practical use of Bessemer steel, and to some of whose opinions we shall hereafter refer—calls "vacuous cavities." So far as at present known, there seems to be no other method available by which those gases present in the interior of the contents of the ladle can be got rid of. Steel well mixed or agitated in the ladle before being poured into the ingot, when poured passes or flows into the ingot mould in a quiet steady manner somewhat like that of thick viscous fluid such as treacle, which, as Mr. Allen says, is "supposed to be the exclusive characteristic of dead-melted crucible steel" (for this see "The Steel Maker"). We have said that, important as is the new process of agitating with reference to the thorough amalgamation of the several constituents of the mass, this liberation of the occluded gases is, if not more, at least equally important. Of these occluded gases the one which exercises the deleterious influence on the constructive quality of the metal is oxygen; and in referring to a method sometimes adopted in the Bessemer steel trade of turning up, or partially turning up, the converter-vessel just after the spiegeleisen is added to the mass of molten material, and this in order to effect the complete mixing, or amalgamation of it, Mr. Allen has the following:—"It does no doubt, to some extent, secure that object, but it has serious disadvantages. It oxidises some of the carbon and manganese contained in the spiegeleisen; and what is far more serious, it recharges the steel with a large quantity of oxygen, which at this stage of the process it is all-important should be got rid of as far as possible." The importance of the whole subject is such in connection with the use of Bessemer steel for constructive purposes, in articles cast, not forged—and though in another direction not less important in regard to the latter—that it will be in the interests of readers who are not well, if at all, acquainted with its different phases, to glance as briefly as may be at some of the points to which reference has been made, and at some of the most recent experiments in connection with steel castings; bearing specially on the question of the action of occluded gases in steel, and likewise on the method adopted by Mr. Allen for not only getting rid of these, but also for securing, as a resulting consequence, the absence of blow holes or vacuous cavities in the mass of the casting or of the ingots. And it may here be well for our young readers to show the derivation of the word "occluded," as it may give them a clearer conception of what the condition involves. The term is derived from the Latin word or verb *claudo*, I hide or conceal. Occluded gases, therefore, are those simply which are concealed, hidden, or as we may say, shut up or enclosed within the mass of the fluid steel, and which if they cannot be, or are not, placed in such conditions that they can escape, remain present within the mass, and being present form vacuities, or recesses, so to call them, in which they are contained and retained, and into which the solid metal cannot, in virtue of their presence, pass—as no two bodies can exist in the same space —a principle in physics, or what may be called the mechanics of matter, of great importance. Of these occluded or shut up gases, oxygen, if not the only or chief gas, is one which plays the most important part in deteriorating the constructive value of the steel ingot or casting. In a paper recently read before the "Institution of Naval Architects," by Mr. J. F. Hall, on "Cast Steel as a Material for Crank Shafts," attention is drawn to the influence of "blow holes," or, as Mr. Adamson calls them, "vacuous cavities," even in cases of the metal used for *forged*, that is, hammered work, in which "welding" plays an important part. Mr. Hall, on the connection of those blow holes with the process of welding, states that it is well known that a number of these blow holes have an oxidised surface; and oxygen is but too well known to be "a foe to successful welding." In the employment of small-dimensioned ingots this difficulty may be, and is got over in practice in several ways. But the case is different when large ingots are used; and in the work done with them, welding, though apparently done, is in reality not done at all. We say apparently, for although to the eye the junction of the pieces may be so close as to induce the belief that welding has taken place, the condition is such that they are not really stuck together. Mr. Hall, to show how this is, bent a a piece of steel boiler-plate in the *cold* condition, so that one face simply rested upon the other face; the piece was then subjected to a close and powerful hammering—and the edge, or face, where the two pieces joined was then smoothed and polished so as to show, if at all visible, the lines of junction. So closely were the two surfaces hammered together, that one might have concluded that the two parts were welded together, inasmuch as the line of junction was only partially visible, parts showing all the appearance of solidity, as if actually welded. Yet, from the circumstance that the pieces had been placed together while *cold*, and hammered in that condition, it was impossible that welding could have taken place. We have referred to this point specially in regard to the influence of oxygen, which is generally present in the interior of ingots or of castings, in which blow holes are formed, and which, along with other gases, are, in fact, themselves the cause of the existence of these blow holes; and to show the importance of getting rid of the occluded gases. But not only in regard to the effect of the oxidation of the surface of blow holes, in being antagonistic to a good welding property; to this also may be due the presence of especially hard veins, sometimes met with in steel casting. Sir Henry Bessemer mentions one instance in which, in the boring out of an hydraulic cylinder cast in steel made by his process, a vein was met with so "exceedingly hard" that the tool would not cut it. And although Sir Henry states that a fault of this very abnormal kind is not likely often to be met with, we should not forget that what has happened once may happen again; and that under the ordinary circumstances of making Bessemer steel ingots, illustrations of the old saying that "it is always the unexpected which does happen," may be met with. And it certainly is the fact which, with a commendable candour, not by any means frequently met with amongst inventors of new processes, Sir Henry Bessemer himself mentions, that there was the greatest difficulty in introducing his steel for the making of that high class of steel goods for which Sheffield is famous, and for the manufacture of which the best crucible steel only was employed. And this Sir Henry admits was owing to the want of homogeneity in his steel, which is essential in the making of the steel articles, such as cutting tools, and instruments in which the processes of hardening and of tempering had to be gone through. For through lack of this equality in Bessemer steel hard veins might be met with; and however small a vein of this kind might be in the ingot, still when the ingot was drawn out and worked up till but a small part of it was used, as in the making of a cutting tool, as a knife, the processes of hardening and of tempering would, in place of getting rid of this hard vein primarily present in the ingot, on the contrary increase the hardness; and in proportion as this hardness was present even in the smallest vein in a cutting tool or instrument, its efficiency would be lessened, and in the majority of cases the tools might be of little value. Much stress has been laid on the value of chemical analysis in tracing the presence of such unequal veins in Bessemer steel ingots; but valuable as chemical analysis is in ascertaining the quality of the steel presented by any special ingot tested, it is well to remember what Sir Henry Bessemer points out—that chemical analysis would be valueless in detecting those unequal veins. For the information of the youthful reader we may say that the method of ascertaining the quality of steel ingots is by making borings at different points of the ingot, and testing the product of each—that is, the metal resulting from the boring—the average of these chemical tests giving, or being assumed as, the average quality of the whole ingot or piece. But Sir Henry Bessemer points out that it would be impossible thus to detect the hard veins in an ingot; for though the chemical analysis of twenty borings might be made, giving a mean average of the different qualities at the place of boring, still the presence or position of the faulty vein could not be ascertained definitely. This condition of matters would at first sight open up a hopeless prospect for Bessemer steel being available, not only for the making of high-class steel goods, such as cutting tools and instruments, but of castings of a more or less bulky character for the varied purposes of mechanical work; as also indeed for the making of such important material as steel plates used for boiler and shipbuilding plates—in all of which homogeneity or equality of the metal is absolutely required where trustworthy constructive material is to be made. Fortunately, however, for the interests of those engaged in trades requiring steel for various purposes, we have the assurance that in the agitating or mixing process introduced by Mr. Allen, to which we have drawn special attention in this series of technical notes, we have a process which gives steel ingots and castings of almost perfect, at least of practically valuable homogeneity or equality of the metal. As we have seen, every class of goods, from a penknife up to the largest crank shaft—and in the "behaviour" of the latter we have no higher crucial test of the quality of the metal—is now being made of Bessemer steel which has passed through the stirring or agitating process. Indeed, Sir Henry Bessemer himself states that even in Sheffield—the seat *par excellence* of steel goods—no small weight or mass of steel is produced, to which is given all the value which the name of the "best *crucible* steel" carries with it, which is no other, more or less, than Bessemer steel well stirred or agitated by Mr. Allen's method. As the whole question of Bessemer steel cast *versus* Bessemer steel forged work for various bodies required in mechanical construction turns on the value of the ingot or steel in relation to its homogeneity or equality of constitution, the point as to how this can best and most economically be obtained has given rise to more than one important discussion amongst experts in metallurgy; and we need scarcely say more than one view has been taken of the point. And as, in view of this diversity of opinion, in which even the value of Mr. Allen's method has been questioned, it is necessary at least for the youthful reader or the student coming newly to the consideration of this important department of constructive work which gives the title to our series of notes, to know as much of the subject as may be possible for him. We shall therefore next glance at the position in which the discussion stands; from which glance the readers will, if not able to decide as to which view is correct, at least be able to derive a great amount of information, which cannot fail to be useful to them in the pursuit of those technical callings in which they may be interested, in which metals play an important part. This glance will thus occupy our attention in the succeeding note under present heading.

91. Driving Belt and Pulley Gearing—Points connected with Speed or Velocity in Working.

In Notes in pp. 39-41, 84, 135-6, 182-4, 292-4, 338-9, in the first, and in pp. 32-3 of the present volume, we have explained various points connected with this department of practical mechanism, which has so largely superseded toothed-wheel gearing (spur, mitre and bevel wheels) that by far the larger number of machines are now driven by its aid; although, as we have already stated, and as we shall hereafter see, in more or less complete detail, it has a rival in rope-and-pulley gearing, but which itself may, however, be considered, in one sense, as a mere modification, inasmuch as the rope may be looked upon as the flat belt made circular. The two systems are, at all events, so much alike that they represent what may be called the "flexible" system of communicating "motion" from one part to another, or of transmitting power from the prime mover, as the steam engine, to the machinery which it is designed to work or drive; and both are, in this feature of flexibility, different from what may be called the "rigid" system of machine driving of toothed-wheel gearing in its varied forms of spur and bevel and mitre wheels and pinions. This latter is also and more generally known as "positive" gearing; inasmuch as while the wheels and pinions remain in contact or gear, and are not broken, this rigidity insures that the motion of the "driven" wheel or pinion shall be positively secured by gearing with the "driving" wheel or pinion. Both belt and rope-and-pulley gearing, on the contrary, as compared with toothed-wheel gearing, are not positive—in the sense of certain—methods of driving machinery. For while toothed spur-and-bevel "driving" wheels *must* communicate power to the "driven" wheels so long as they are in gear or working contact with each other, and so long as they remain in their original integrity or completeness, and are not broken—as toothed wheels and pinions often break up, or "break down" as the technical phrase has it—the belt or rope *may* not communicate power from the "driving" to the "driven" pulley. This lack of positive or certain driving possessed by belt and rope gearing arises from that feature which has in previous notes been described —namely, their "slipping" on the pulley surfaces, or what may be more accurately described as the driving pulley revolving and slipping within the belt without carrying it round with it. But while "slip" is prejudicial, and a necessary waste of driving power, and as we have seen various methods have been proposed and some adopted to prevent it, it must not be overlooked that though this slip or slipping is a loss of power, and in so far as this is concerned constitutes a practical defect in belt-and-pulley gearing, it is, on the other hand, a positive advantage. And this arises from the fact that when any undue or excessive strain is thrown upon the gearing, or when the speed becomes so excessive that, in the technical language of machinists, the machine "runs away," the belt not being able to communicate the excess of power, slips, or, as it is better put, the "driving" pulley revolves within the belt without dragging round the belt, or the belt slips round the "driven" pulley without, or only partially, moving it; the result in either case, or through both actions, being, that a "break-down" of the gearing itself, or of the machine which it drives, is prevented. In this way the slip of the belt may be said to be a safeguard against accidents or break-downs: in consequence of the slip the excess of power or of speed is not communicated to the machine—acting precisely in the same way as the safety-valve of a steam boiler acts by opening under excess of pressure, and relieving the boiler from strains or stresses which, if allowed to act, might cause an "explosion" or a rupture of its parts. But in the case of toothed-wheel gearing, while the "positive" character of its power-transmitting characteristics is an advantage, and in certain classes of machinery an absolute necessity, where certain driving must be obtained, this has its dangerous side; for, being rigid, the wheels cannot "give" or yield to excess of strain or speed, but must continue to take up this until it becomes greater than the strength of the parts are able to meet, so that a "break-down" of greater or less extent takes place. But much of the efficiency of belt-and-pulley gearing is dependent upon the dimensions of the pulleys, irrespective of other considerations, to which we have drawn, and may yet draw, the attention of the reader. One cause of inefficient working and loss of power is making the diameters of the pulleys too small. In the case of a small pulley the compressive strain on the lower side of the belt puts the fibres in a condition tending rapidly to destroy their integrity, whereas when the belt passes over a large pulley periphery its line of contact approaches more to that of a straight line—that is, a flat belt—in which position, when strained, the fibres are placed in that best calculated to enable them to resist wear and tear, both surfaces being stretched alike when the belt is strained in a horizontal or flat position. When the diameter of pulleys is small, not only is an undue strain thrown upon the belt, but the belt must be put on very tight in order to communicate the motion and transmit the power from the driver to the driven pulleys. Now, tightly stretched they never work satisfactorily; they throw of necessity great strains upon the shafts and their bearings—in the case of the shafts pulling them down, so to say, or causing them to have undue pressure on the journals and brasses or bushes, and on the other hand putting an upward strain upon the pedestals or plummet blocks which carry the bushes in which the journals of the shafts revolve, tending to pull them up. All this not only uses up needlessly part of the transmitting power of the belt, but worse than needlessly, for it rapidly puts the shafts and bearings out of repair, in addition to the extra consumption of lubricating oil. But the loss arising from the condition of pulley gearing above noticed does not end here: undue strains upon the belts give rise to breakages or loosening of the belt junctures, whether these be made by lacing or by riveting: this is a perpetual cause of loss of time in tightening up the belts, and in re-splicing or re-riveting, and more than that, a loss of money. Where the pulleys are of proper diameter, the belt runs slack, and thus lasts much longer—very much longer—than when it is tight. The proportioning of the speeds of the pulleys placed on the machines to be driven in relation to the driving pulleys should be carefully studied. One frequently sees subsidiary pulleys so badly proportioned that their speed—generally denominated by the symbol F. s. p. m. (that is, "foot-space passed through per minute")—is but an eighth or a ninth of that of the main driving pulley; and it certainly seems to be scarcely a common-sense mode of proceeding to take all pains to secure the high speed of driving belt which we have seen to be so essential for economical working, and thereafter fail to take advantage of it. In this case the advantage of high speed is merely nominal; to make it absolute the speed of subsidiary pulleys should be increased in due proportion to that of the main driving pulleys. Another point to be attended to is the mode of taking off the power of the engine and distributing it to the different parts of the building in which the machinery to be driven is placed. This we shall hereafter refer specially to, meanwhile gathering and presenting here a variety of details in relation to the speed of pulleys. We have already said in one of our notes that when a determinate relation of the speed of the driven to that of the driver pulley is required, positive gearing must be used, and this is what is known as toothed-wheel gearing; by its use we can always secure a fixed and an unvarying relation of the speed of the driven and driver shafts. This is not so in the case of belt-and-pulley gearing, and the inequality or uncertainty of the related speeds does not arise merely from what may be called the normal or ordinary slipping to which all belts are more or less liable, and this dependent upon the conditions under which they work; it also arises from another peculiarity of belt-and-pulley gearing, known as the speed variation. In a succeeding note we purpose giving rules or calculations showing how the speeds of pulleys are proportioned according to the relative rate required for work; but practically the calculated speeds will not be precisely obtained, for it is found, when the belts and pulleys are working properly—apart from any abnormal slip of the former which may arise from defective arrangement—that there is a loss of pulley revolution amounting, as a wide variety of experiments show, to one-fiftieth, or two revolutions per hundred. This loss, where there is but a single pair—driver and driven—working is so slight that in ordinary working it is scarcely worthy of notice, although independently of ordinary slipping of the belt it shows that no positive gearing can be obtained by belt and pulley. Neither does this loss from speed variation matter much, so small as it is, when even two or three, or what may be called a small train of shaft speeds is combined; but it becomes a very serious item of loss in working when a great number of connected speeds has to be dealt with; as they have in a large factory or workshop, when widely varying classes of machinery are used, each class having its own normal speed or speeds. Taking the loss from variation in revolutions of one pair at two revolutions per minute, or with a coefficient for the variation of ·98, we have with two pairs the coefficient increased to ·96, or four revolutions per minute, with three pairs ·94, and so on; thus with a train or succession say of six speeds we have a loss of $2 \times 6 = 12$ revolutions; with ten of 20 revolutions, equal to one-fifth of the normal number—an ultimate speed or velocity of the last driven pulley or shaft which is very serious. This must, in the designing of belt-and-pulley gearing, be allowed for, either by increasing the calculated diameter of the driver pulley, which gives the theoretical speed, one-fiftieth part—or by decreasing in like ratio the diameter of the driven. From what we have said on the subject of large diameters for pulleys, the young reader will see that it will be best to increase the diameter of the driver pulley. In connection with the transmission of power by belt-and-pulley gearing, there are many points to be considered, such as the distribution and adjustment of the belts in relation to the different parts of the building and the localities of the mechanics in them. This arrangement of belting embraces the question of the relative advantages of taking off the power and giving it out to the different lines of driving shafting by the continuous belt running on the main driving pulley, or by having a number of belts conveying power to different parts, the main driving pulley being in this case broad in its rim or driving periphery, and so divided that each belt can work truly and independently of all the others. This arrangement of the belting also includes, or ought to include, the distribution of the shafts and their necessary driving pulleys and belts, so that the strain or pull exercised by one belt or set of belts in one direction shall be met or counterbalanced, so to say, by the strain or pull exercised by another belt or set of belts acting in the opposite direction. This last point will necessitate the exercise of some care in planning the works in which the machinery is to be placed; but the advantages gained by what may be called the balancing of opposing strains will amply repay any expenditure of time and trouble in this direction. In connection with the speeds of pulleys come up considerations in regard to the power transmitted by belts; and this relates again to their dimensions, and to points connected with single-substance belts or to double belts or many-plied belts. Again, the speed and the driving power of belts bring up points connected with the diameter of pulleys in relation to the arc of contact, or the proportion of the pulley periphery which is embraced by the belt, or with which it comes in contact. Other details, which spring naturally from the points here named, will in addition fall to be glanced at in notes yet to be given in this department.

92. Mixture for Cleaning Brass.

Crush down some bichromate of potash into a fine condition, then pour over it about twice the bulk of sulphuric acid, mixing this with an equal quantity of water. Rub the brass well over with the mixture, when it will be instantly cleaned. Wash immediately in plenty of water, wipe it, and rub perfectly dry.

93. To give Zinc a Fine Black Surface.

The usual method of giving a polish to the surface with rotten stone or emery is well known. Clean first the surface with very fine sand and sulphuric acid; immerse for a very short time in a mixture of four parts of ammonia-sulphate of copper in forty parts of water, acidulated with one part of sulphuric acid. When taken out, wash well with pure water, and carefully dry the article. The normal black colour may be changed to a fine bronze surface by burnishing it.

THE PRACTICAL NOTE-BOOK
OF
INDUSTRIAL SCIENCE FOR HOME STUDY.

(36) In our last note on the "combustion of fuel" (see Note No. 33) we gave a brief description of the constituents of coal, and the percentage of each in one hundred parts of an average quality. Of these constituents the permanent gases, oxygen, hydrogen, and nitrogen, are locked up or occluded within the mass of fuel (the scientific term "occluded" coming from the Latin verb *claudo*, I inclose or lock up), but they are also combined with the carbon. Under the influence of heat the combination gives rise to very important elements in the combustion of coal. There are the "hydrocarbons" and ammonia, all of which are volatile. When fresh fuel is added to or thrown over a mass of red-hot or incandescent coal, the process which is set up is virtually one of distillation, so far as the permanent gases, oxygen and hydrogen, forming the hydro-carbons, are concerned. In the distillation of coal in a closed vessel, known as a "retort" in the manufacture of lighting or town gas, those elements of coal, being volatile, are passed away from the retort as a gaseous fluid combined with a portion of watery vapour or steam. This gaseous fluid is in proper appliances partly condensed, yielding tar and what is technically known as ammoniacal liquor, while the gaseous fluid so far purified is still further so by being passed through a series of appliances of a more or less costly and complicated character, and is finally sent to the "gasometer," from which it is taken for use as required. Very much the same process goes on in the open fireplace or furnace, with such differences in the final results of the combustion of the fuel as arise from the difference between a closed and an open place in which the combustion, largely one of distillation of the fuel, is carried on. In the free or open distillation of coal in an ordinary furnace or in a fire grate, the volatile elements of the coal are set free by the heat arising from the portion of incandescent or burning fuel lying in the furnace or grate bars; in the primary starting of a fire the heat necessary for this is supplied by the kindling material, such as wood—a combustible much more easily set fire to than coal. The volatile elements of the coal being thus set free, pass off from the mass, and under favourable conditions as to the supply of air are flashed into flame, which adds to the supply of heat obtained from the other source—namely, the combination of the carbon and the hydrogen with certain respective atoms, bulks, or increments of heat. The proportions of each to promote proper and complete combustion will be given in a future note. In the distillation—otherwise called combustion—of coal in a closed retort or vessel, as in gas making, as well as in the improved ovens for the making of coke for iron ore smelting purposes—which in one way may be looked upon as huge gas-making retorts—what are called the "bye products" are an important result of the two methods. These, the tar and ammoniacal liquor, are utilised, and by passing through certain processes yield highly valuable products, in place of being, as at one and for a long time they were, nuisances with which it was very difficult for gas companies to deal, as there was little or no use for them. In the old-fashioned or open coke ovens these "bye products" were passed off into the atmosphere, forming part of the general results of combustion. In the closed retort, when the process of active combustion is completed, and the residuum withdrawn to give place to fresh coal, that residuum taken from the retort is known as "coke," which may be looked upon practically as pure carbon. This, as it is formed in our open fireplaces, is that which in the shape of red-hot or incandescent lumps or masses of coal, emitting no light or causing no flame, yields that radiant heat which, acting upon our bodies as we sit or stand near an open fireplace, feels so pleasant, and is beyond all doubt the most healthy form in which heat can be communicated to the body. The English love for, and intense attachment to, the domestic open fireplace is thus justified, and in part largely explained and accounted for. A fire made in a grate with good coke, almost a pure carbon, gives forth no flame, and is therefore considered generally to be, as it is in fact, a cheerless fire; this arising from the fact that the hydrocarbons, the volatile part of the coal, have been expelled by a previous part of the process of combustion. What slight lambent flame there is in a pure coke fire arises from the ignition of such portions as are formed of carbonic oxide, which is a combustible gas. Pure or good *coke* made in a closed or gas-making retort is in amount equal to 13 parts (twentieths) of the 20 parts (cwts.) in each ton of coal put into the retort. The other products of the distillation in amount are $1\frac{1}{8}$ part of tar, $1\frac{3}{4}$ part of ammoniacal liquor, $3\frac{1}{6}$ parts of illuminating gas, $18\frac{1}{10}$ parts of carbonic acid gas, $30\frac{1}{100}$ parts of sulphur; and the original amount of 20 parts or cwts. is made up of the allowance for loss, which is equal to $12\frac{1}{100}$ parts. Deducting the earthy incombustible ash from it, 100 lb. of coal yield only 60 lb. of coke in the ordinary or open coke oven, or admitting the ash

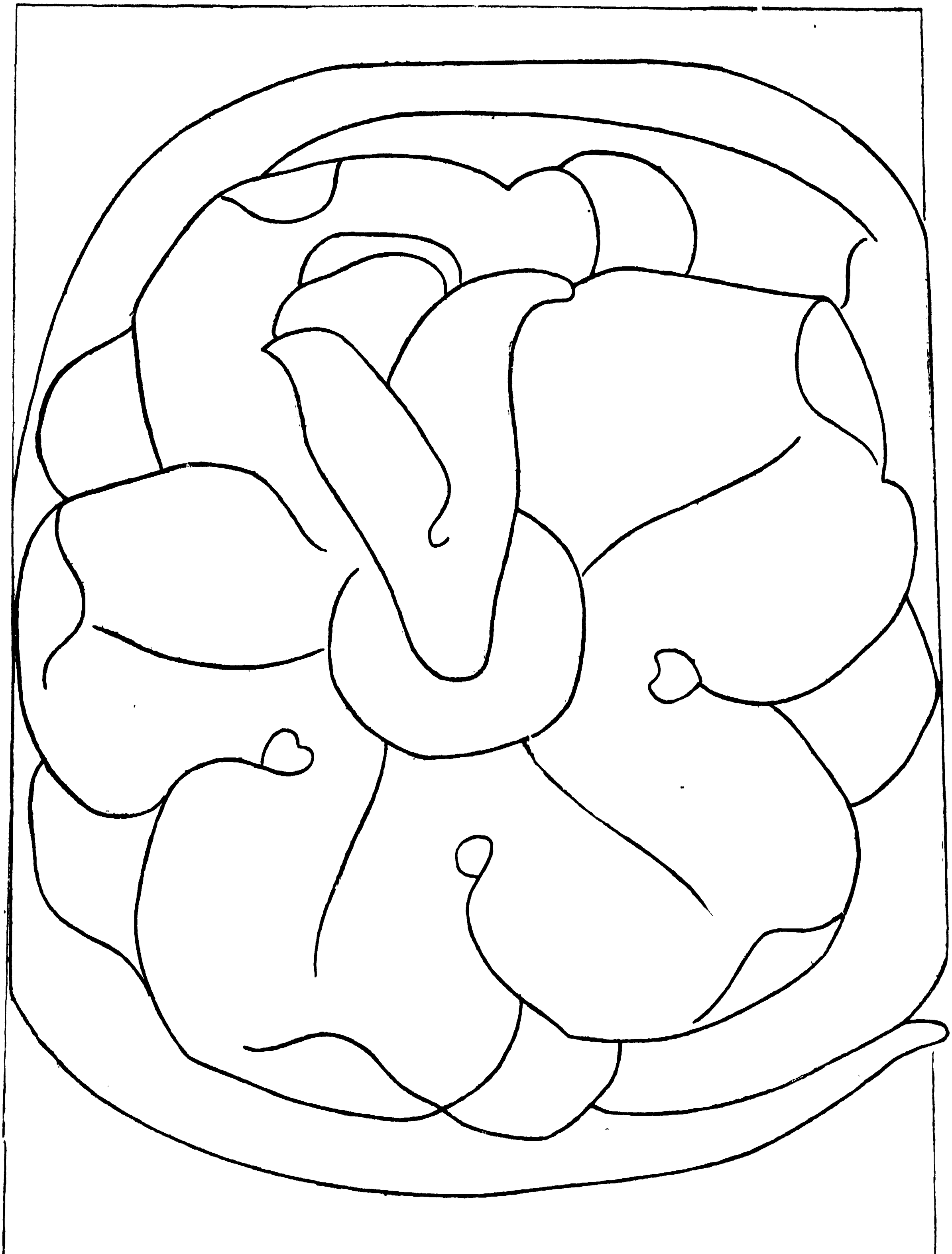
66 lb. The 3 or 4 lb. of volatile constituents are driven off in the atmosphere, and are lost. And the heat required for their combustion must be accounted for in estimating the calorific value of coal; and allowance must also be made for the heat required to make the coke incandescent or red-hot, the temperature of which condition may be put down at 1000° Fah., or nearly five times the heat of boiling water with the barometer at 80 inches.

(37) In Note No. 35 we stated, while considering the subject of the combustion of fuel, that the product of coke made in an ordinary coke oven obtained from each 100 lb. of coal was 60 lb. This weight of coke produces by its combustion 870,000 units of heat. But before we can arrive at the calorific or heat-producing value of the 100 lb. weight of coal, which produces the 60 lb. of coke, we have to add the heat or calorific value of the 16 per cent. or pounds of illuminating or combustible gas, which is yielded by or is the product of the distillation of the volatile or bituminous portion of the coal. The calorific value of those parts of the coal is equal to 350,000 heat units. Theoretically the number of heat units due to or obtained by the combustion of one pound of coal is equal to 12,200. But from this must be made certain deductions which we have already named, to which must be added a deduction made from the circumstance that the average or ordinary quality of coal is in heating or calorific value considerably below that of the quality of coal used in the experiments from which the data we have given were obtained. These deductions bring down the calorific or heat-producing value of one pound weight of average quality of coal to 10,500 heat units. The steam-engine is generally, almost universally, the mechanism by which what is called "motive power" is obtained; or is, to use another expression, the agent by which we convert units of heat into mechanical force or power. Let us briefly glance, then, at the actual amount of heat obtained by the combustion of coal used in the raising of steam in the engine boiler. The best steam-engine practice gives a consumption of coal of from 1½ lb. to 2½ lb. of coal per hour per horse-power, or let us say 2 lb. It is scarcely necessary to remark that a vast number of steam-engines and boilers are made and worked so badly and carelessly that the consumption of coal per horse-power per hour is largely in excess of the weight above named. But assuming the lower weight of 2 lb., and taking 33,000 foot-pounds raised per minute as the unit of a horse-power, this multiplied by 60, the number of minutes in an hour, gives us 1,980,000 foot-pounds as the amount of mechanical power obtained from the combustion of 2 lb. weight of coal. But to obtain the mechanical equivalent of the heat obtained from the combustion of 1 lb. of coal we have to divide the above number of foot-pounds by 2. This gives us 900,000, or nearly a million of foot-pounds. For every unit of heat we have, as we have already seen in a former paragraph, a mechanical equivalent of 772 foot-pounds. Dividing the 990,000 heat units above named by this 772, we have 1282 units of heat as the number expended in getting one horse-power of mechanical effect from one pound of coal. But bearing in mind that the units of heat actually due to the combustion of coal are equal to 10,500, the young student will be in a position now to see whether we had any reason to put the question we did in a former paragraph, and which question was to the effect—Do we avail ourselves wisely and well of the units of heat obtainable by the combustion of every pound of coal? or do we, on the contrary, spendthrift fashion, lose, *somehow*, the best part of the wealth of heat thus placed at our command? If out of the 10,500 units of heat available from the combustion of one pound of coal we get one horse-power of mechanical effect, which takes only 1282 units, what becomes of, what use do we make of, what return do we get for, the 9218 units of heat remaining? Where do they go? How are they lost? Perhaps we may get some answer to these questions from what we have yet to give.

(38) In Note No. 17 we stated that the temperature of the air which was requisite to enable the oxygen present in it to combine with the combustible constituents of a liquid fuel which paraffin is, or with a gaseous fuel which ordinary house-lighting gas is, and by the combination to create combustion, which is manifested by flame and the development of high temperatures—that this necessary heat to be given to the air and its oxygen was very low. This necessary rise in the temperature of the air can be obtained by almost merest touch, in the case of paraffin oils of a lighted match or candle, the flashing of the oil into flame being almost instantaneous; in the case of domestic illuminating gas the combustible constituents of which are in a state of still finer division than the paraffin oil, the flashing into flame is literally instantaneous. The flashing point of the illuminating oils varies with their characteristic qualities: by the term flashing point is meant the temperature at which the vapour always rising from the surface of the oil —which vapour conveys the odour or smell—flashes or bursts into flame, or, to use the popular expression, "catches or takes fire" from the heat given out by a candle placed at a given distance, which in all experiments, to test the relative flashing points of different oils, is always kept definite and constant.

THE ORNAMENTAL DRAUGHTSMAN (*see Text*).

BLOCK OF SUBJECT IN PLATE LXXXI.



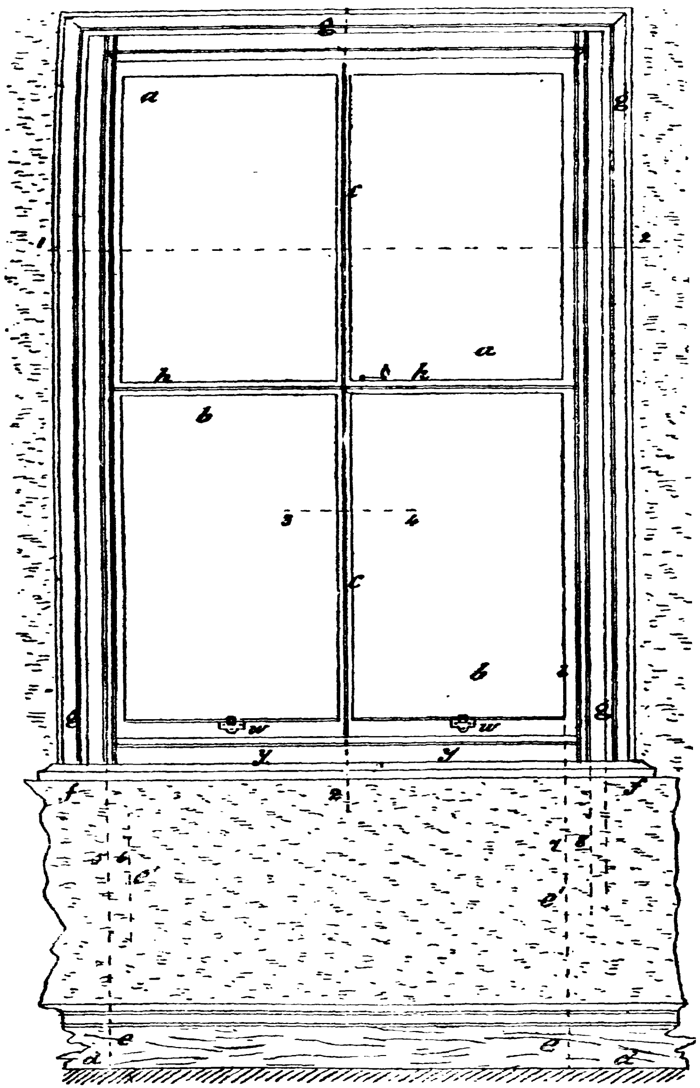


FIG 1.

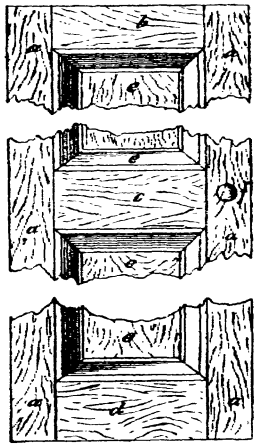


FIG 2.

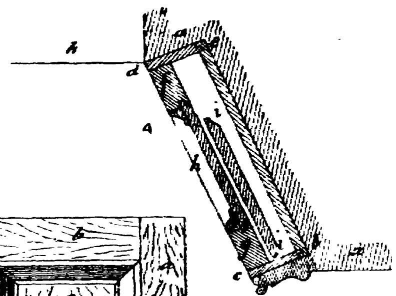


FIG 3.

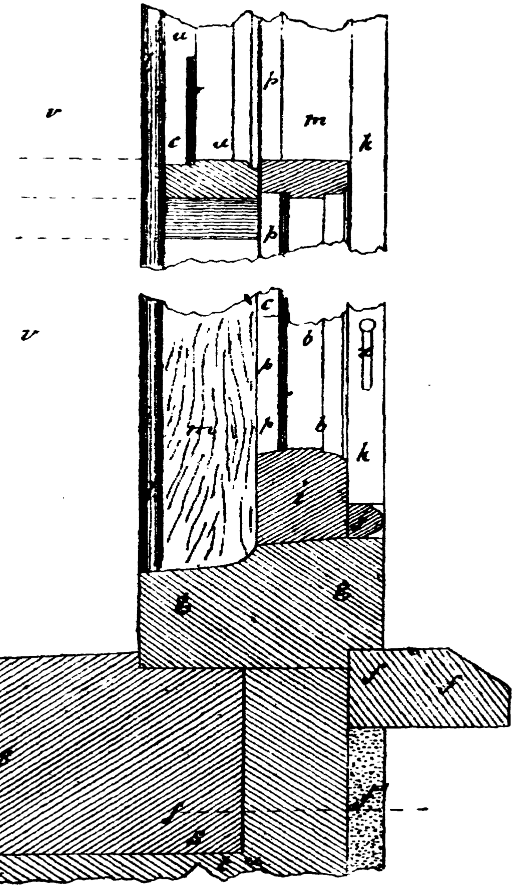
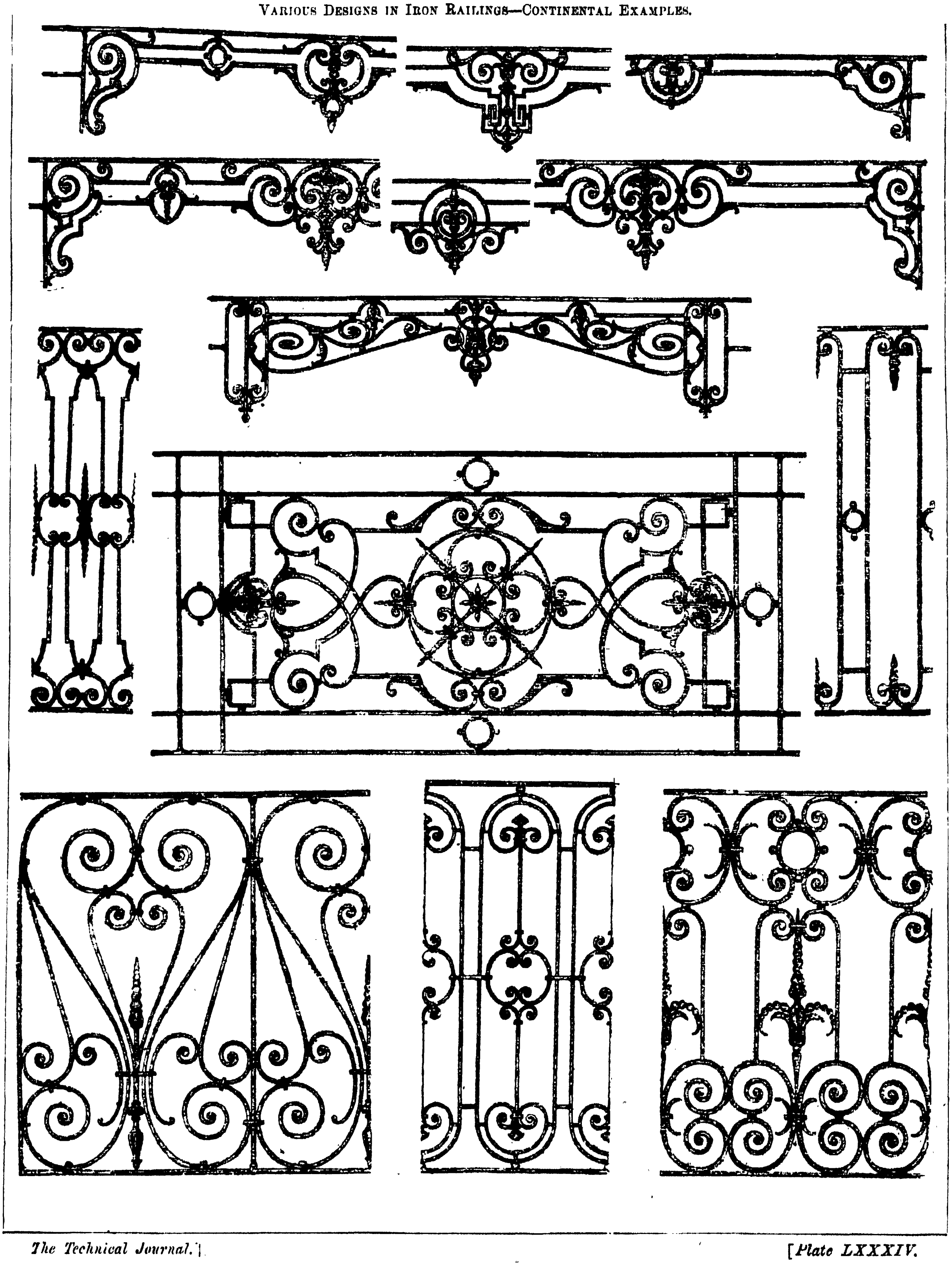
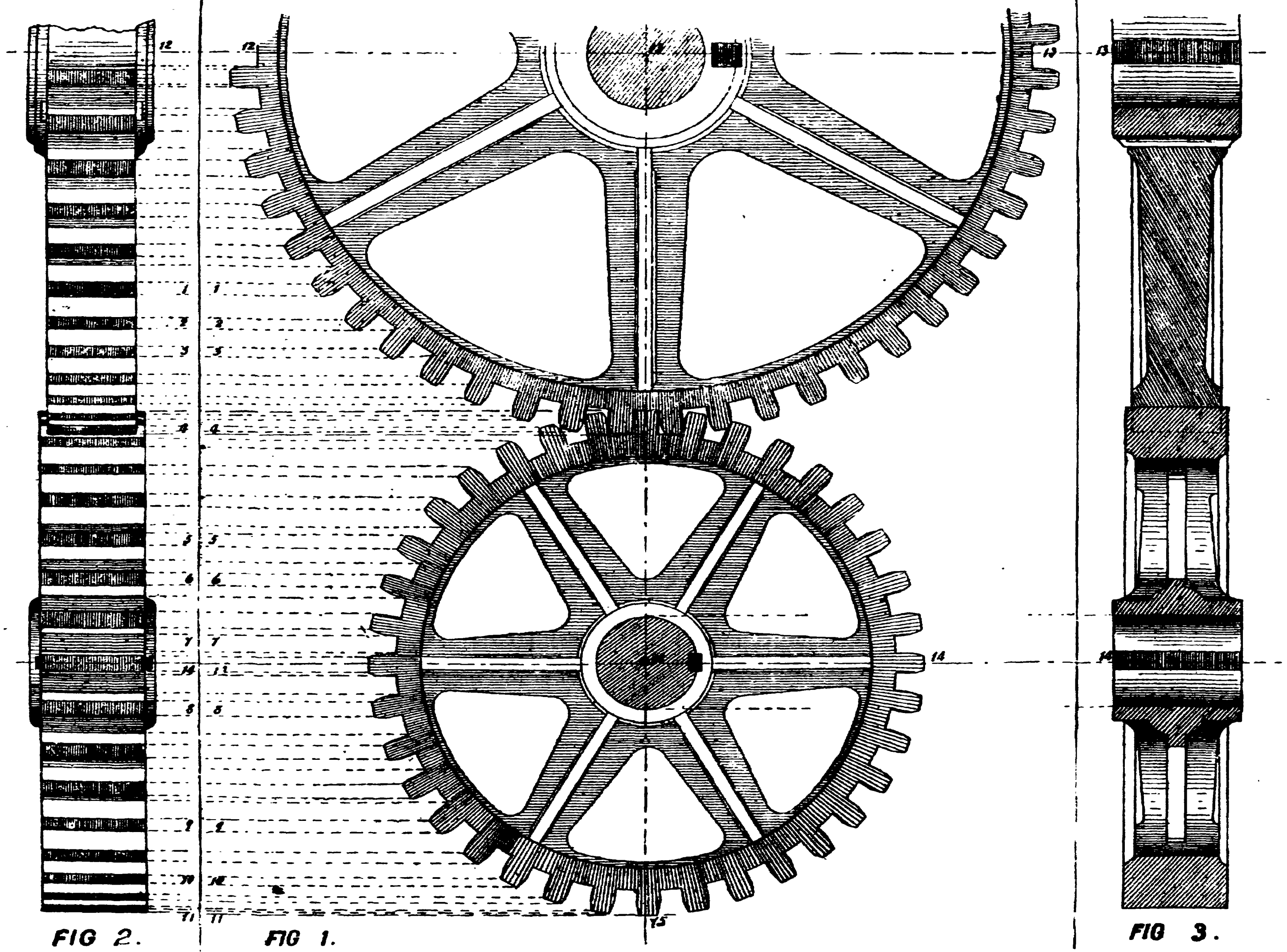


FIG 4

Various Designs in Iron Railings—Continental Examples.

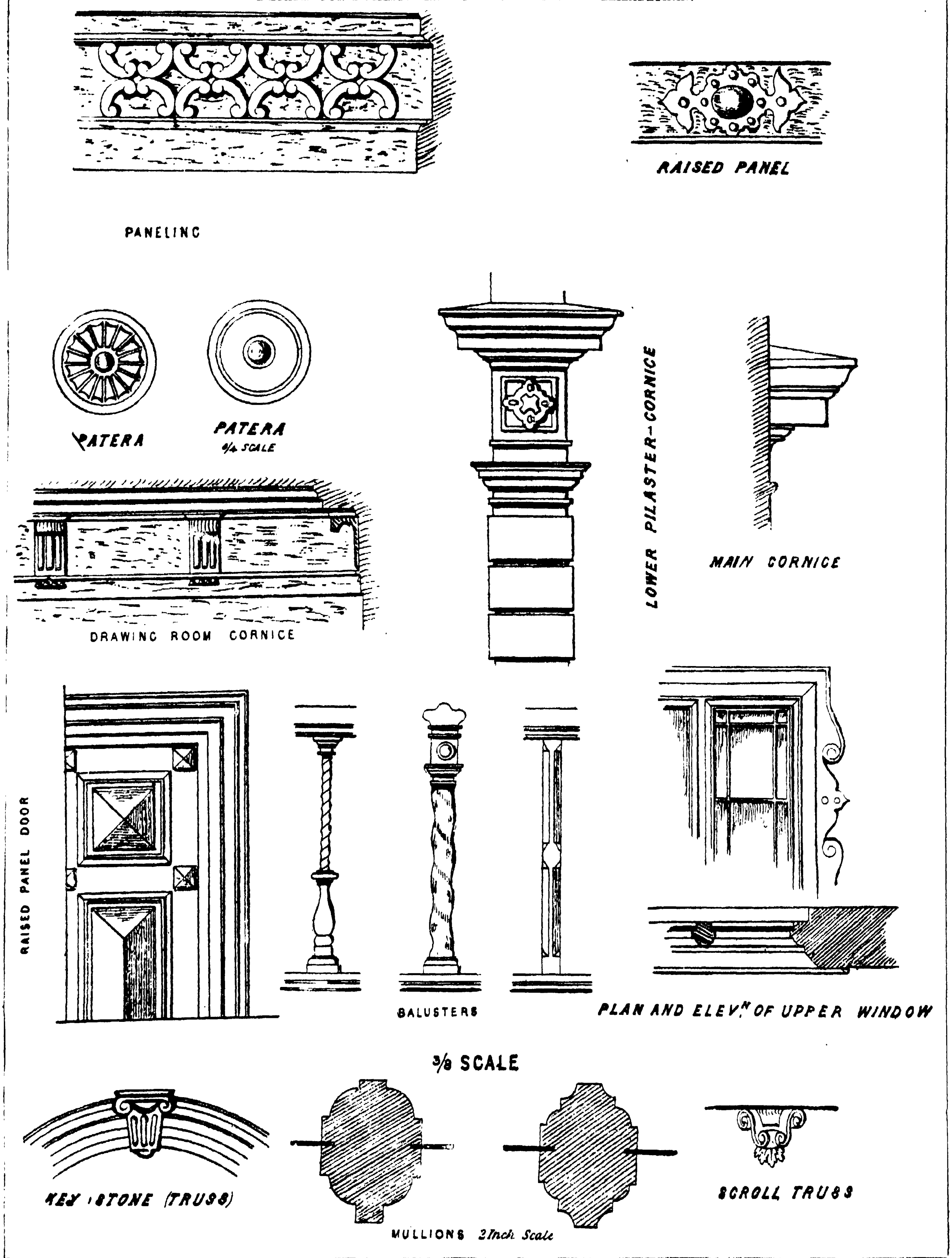


TOOTHED-WHEEL GEARING—SPUR WHEEL AND PINION.

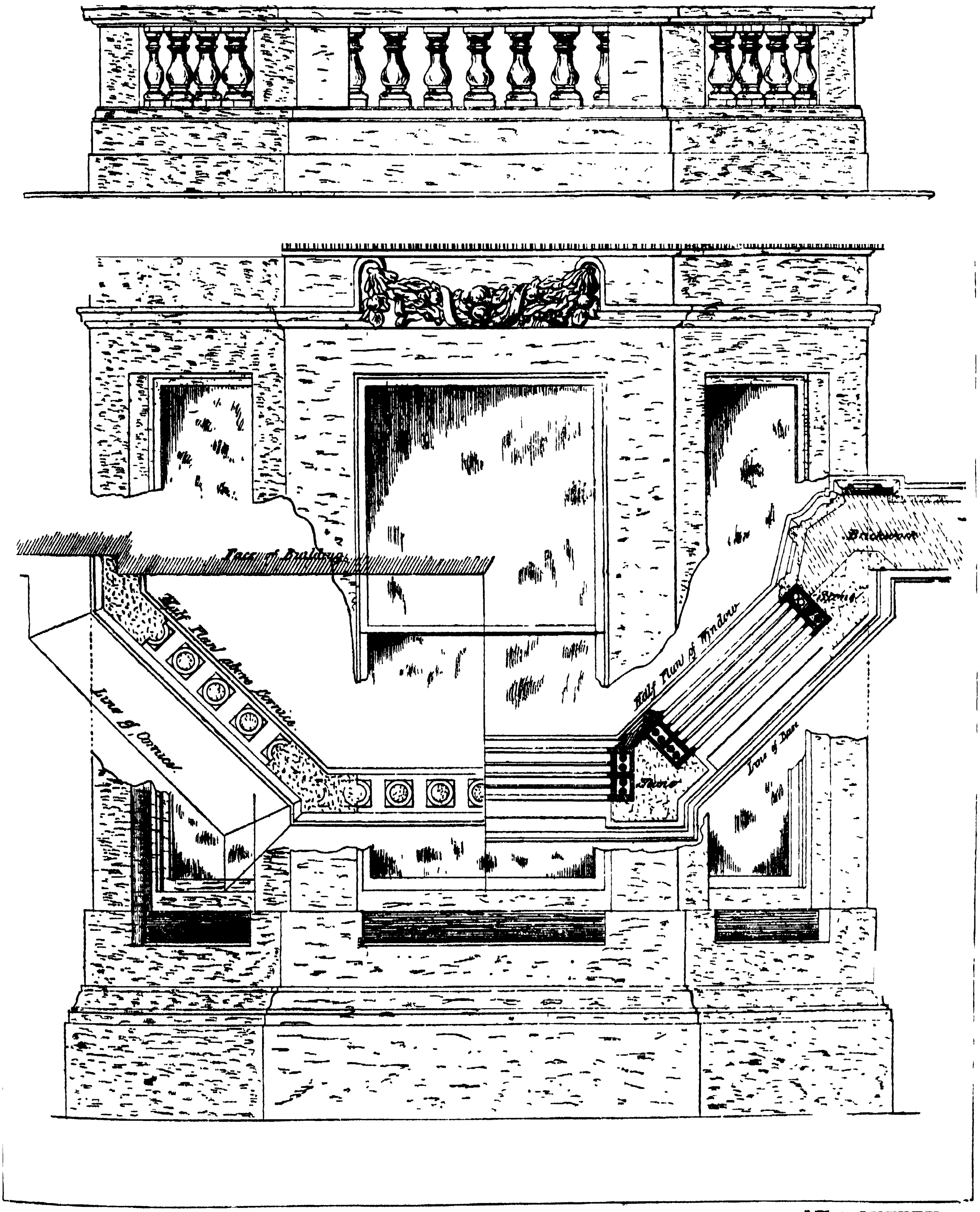


"THE STONE MASON," "THE CABINET MAKER," AND "THE JOINER" (see Text).

DETAILS FOR DOMESTIC ARCHITECTURE—STYLE "ELIZABETHAN."



DESIGN FOR A BAY WINDOW.—PART ELEVATION AND PLAN.



SUGGESTIONS FOR VILLA ELEVATIONS.

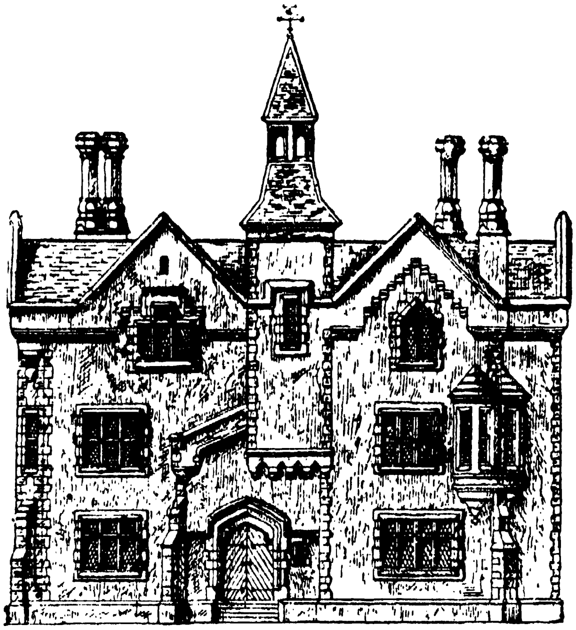


FIG 1.

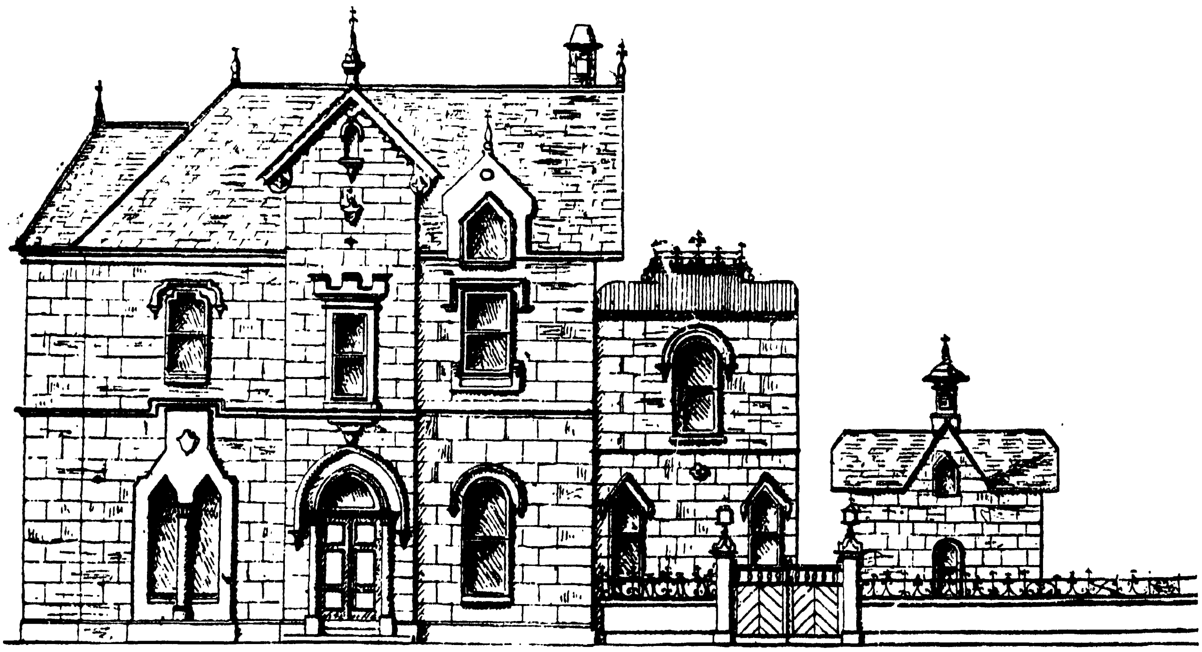


FIG 2.

THE LAND DRAINER.

DRAINAGE OF LANDS OR SOILS SUITABLE FOR THE CROPS AND LIVE STOCK OF THE FARMER.—ITS HISTORY, PRINCIPLES, AND PRACTICE.

CHAPTER III.

AT the conclusion of preceding chapter we pointed out certain evidence which goes to prove that arable culture was carried on in this country to a very wide extent, and that long and long before the land which has been for so long grazed was placed under pasture. In looking for those who had carried out this extensive system of arable culture or tillage, we are perforce, then, driven to account for its establishment by the occupation of the country by the Romans, extending over a space so long as four hundred years; we then alight on a state of affairs that at once admits of it and of wants that called for it.

The Rise and Progress of Practical Drainage.—The Origin of Drains.—Practical Lessons to be derived from the Investigation.—Surface Drainage.

Whether the art of tillage or arable land culture, which the Romans had carried to such comparative perfection in this country, that Britain ranked high as one of the provinces which paid corn tribute to them, was so completely lost after their departure that none of its details descended to later times—and amongst others those of drainage, such as we find it explained in Roman writings—is now almost impossible to say. Certain it is that we have to come down to within a comparatively short (in the life of nations) period of our own times, before we meet with any record of drainage as an essential part of farming,—certainly before we meet with anything like the principle which constitutes the chief feature of drainage as now practised—namely, the depth in the soil at which drains are placed, and the frequency of the intervals in the sense of the extent of its surface or area drained. For long before this first notice—made some two hundred and forty years ago—appeared, it is certain that farmers had become convinced of the necessity to get rid of superfluous water from their soils, the presence of which, they could not be but too painfully aware, was the cause of great deterioration in the value of the wheat crop — the only corn crop then grown. Some effort was therefore made, somewhat after the manner of the Romans, to get rid of it. This was chiefly, indeed, so far as we know, only done by so treating the land that much of it would rise above the general surrounding or natural surface of the soil. And this would naturally be done in the most ready of ways,—by dividing the field surface into spaces, all parallel more or less to each other, rounding or raising up the central part to form what has been called a hog, or saddle-back, gradually dropping to the outer edges. There would thus be formed, between each two contiguous raised parts, hollow spaces or narrow channels. The rain-water falling on the surface of the rounded parts would be shed downwards on each side, delivered to the wide channels, and by them conveyed from the field to its ultimate place of destination, or what is technically called the "outfall."

This, the simplest method of drainage introduced amongst us, had its effect as a drain; though it was equivalent to the lifting up of the land from the water, rather than the freeing of the land from it. This would indeed be only a mechanical result of the arrangement, and would have no reference to what course the water would take after it had settled in the channels formed by the hollows between the contiguous raised portions of land or soil. The water might descend below the surface, but this in its normal condition being either hardened or compressed, or naturally of a close relative character, might not allow the water to pass through to the soil beneath. And this under soil might, and at parts in many instances would, be so waterlogged that it could receive no more, being in a supersaturated condition. In this case the water would only stagnate in the channels between the raised portions of the field to which the name of "ridges" was early given, as also in some districts "stetches"—which is evidently a corruption of the word stretches. And the stagnation would be more complete and permanent, the more level the land was; it being only when the land or surface of the field had a natural "lie" or inclination in one direction, that the water would have a tendency to run more or less rapidly away to a lower level.

The Diversity in the Practical Details of Surface Drainage caused by Diversity of Soils.

The width of the raised up or saddle-backed strips of the field, ridges or stetches, would vary in different parts of the country, and indeed in different parts of the same district. For it would not be long before it was discovered that soils have different absorptive and retentive qualities; some soils—as heavy, close and retentive clays, would be more difficult to keep dug than others, such as what are known as loams; while in some districts soils would be so light and porous—as the sandy and chalky soils—that in many cases it would be more the object of the farmer to keep the water on or in the soil, than to get rid of it. We shall see how it is that the deep drain system of modern times is as beneficial in its way to light as to heavy soils. But meanwhile we proceed to say that this diversity of soils would early introduce a diversity in the practice of the earliest form of land drainage, now being considered—namely, that which concerned itself with the surface only of the land. This diversity of practice could only show itself in two ways: first in making the breadth of the ridges or narrow divisions, and correspondingly the widths or distances between the channels formed by contiguous ridges, less or greater; and second, by raising the centre of the ridge or division more or less above its edges, where they cropped into the midway channel or space. And it will, on consideration, be seen that the natural tendency would be to make the broadest divisions or ridges in light and porous, and therefore as a rule dry soils, and the narrowest in heavy and retentive, and consequently the wettest soils. And in proportion as the breadth and consequent width or distance between the channels or water-ways increased, so would the rise or convexity of the ridge in and towards the centre decrease, and the converse of this would be the case in the heavy soils.

That this would be the ultimate result of the purely surface land or soil drainage system, is proved by innumerable fields throughout the country which have been at one time all under arable culture, although many are and have for very long periods been under grass or pasture. In the heavy lands we find the ridges narrow in breadth, with the surface,

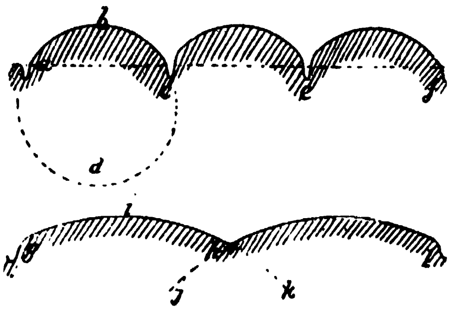


Fig. 1.

as *a b c*, fig. 1, forming part of a comparatively small circle, *a b c d*, with a short arc, as *a c*, or narrow spaces between the mid-water way or channels *a*, *c*, *e*, *f*; while in the light lands the width, as *g h*, of the ridges or stetches is much greater; the rise or convexity *g i h* much less, forming part of a comparatively large circle *j i k*, with wide arc *g h*, giving greater distances between the mid-water-ways or channels, as *g h l*. And it is a curious commentary upon the conservatism of old customs to find that this relation of the methods of carrying out the old system of securing a "high and dry" crop-bearing soil in wet fields is one which has modified and is still to some extent the practice of modern and, as we may fairly and truly call it, scientific deep drainage. For we shall see as we proceed that in the practice of modern deep drainage there is a very considerable diversity of opinion as to the widths or distances between the drains. Now, this diversity has, according to the best authorities—and they have much evidence to bear them out—arisen from, or rather been caused, by the widths or distances formed, so to say, ready to their hand by the old channels or watercourses or "furrows" midway between the ridges laid out by our ancestors long long ago.

Influence of the Old System of Surface upon the Details of the Modern System of Deep or Thorough Drainage.

In carrying out the modern deep drainage system, it would obviously be much the easiest way to accept of the positions of the old water furrows as that of the new drains, in place of laying out a new series, some of which might strike the ridges at their highest point, as *b* or *i* in fig. 1, when there would clearly be more digging required than at the point *a* or *g*. By taking the old furrow lines, the digging of the trenches for the new deep drains would start in all cases at or nearly at the same level as at *a*, *c*, *e*, or *f*, fig. 1. Moreover this retention of the old water furrows for the distances between the new deep drains was by some maintained, not because there were some economical reasons for adhering to it, or that it arose, so to say, from accident. Some farmers argued that as our ancestors had been guided to the widths or distances between the furrows for good cultural reasons—as suiting, in fact, the diversities of soils—it was wise to follow their lead, and for the same reasons. While this was no doubt true, it did not follow, because the distance might be well suited to the soil treated only for surface drainage, that it would be equally good with deep drains; surface drainage being, as we have seen, no drainage of the soil in the real sense of the term. The result of more accurate thinking, based on more scientific reasoning, is that now the old water furrows are not accepted as absolute guides for distances between deep drains, but those are decided by considerations wholly connected with the quality of the soil and the physical condition and circumstances of the field or land.

Point.

But although we have had occasion to name deep drainage, the reader must not suppose that we have, in our historical notice of the earlier forms leading up to the present system of deep drainage, reached the period in which that has to be spoken of as invented and carried out into practice. We have no means to enable us to decide how long the surface drainage system was carried out, nor by whom or at what period in our national history the first departure from it was made in the direction of improvement. All men have a natural tendency to think, to reason out a subject, as they say; some cultivate this by continued exercise, some do not cultivate at all, as they seldom or never exercise it (see chapters under the title "The Workman as a Technical Student").

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER VI.

IN stating at end of preceding chapter what were the illustrations we proposed to give for a house

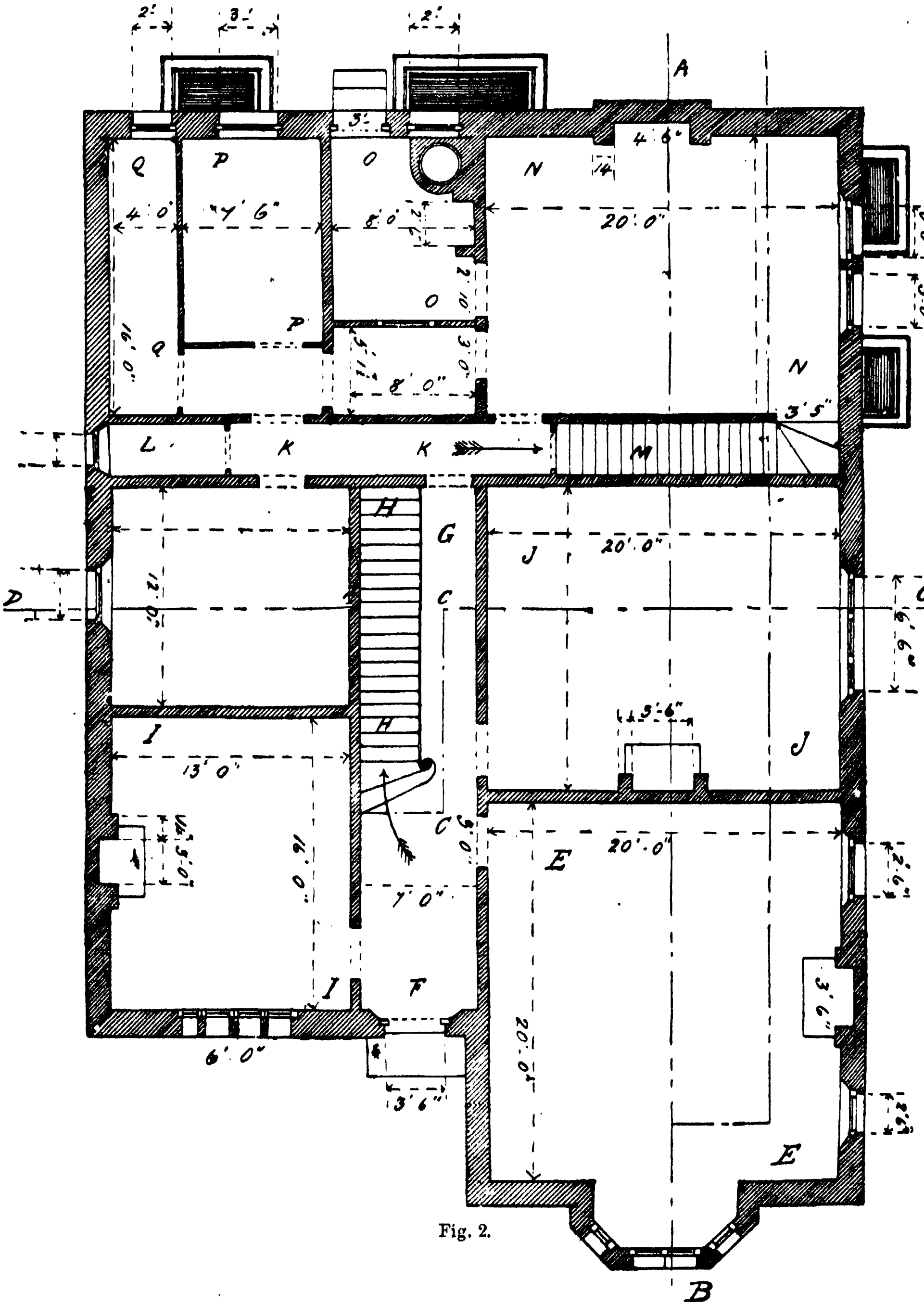


Fig. 2.

costing several hundred pounds, we named that the "details" would be given. The character of those details will be seen in certain illustrations of masonry work in the series of papers entitled "The Stone Mason," and in illustrations of floors, gutters, etc., in the paper under the head of "The Carpenter," and

The Cellar Plan of House, and Plan of Footings or Foundation.

In fig. 1 (see p. 337 *ante*) we give a plan which at its upper part shows the "plan of cellar" at A, B, C, D, E and F, and in the lower part the "plan of footings" or foundation course of walls. The "cellar" accommodation is as follows:—The floor is reached by the stairs, A A, entering from the kitchen N N, in ground plan, fig. 2; B B is the landing and passage, lighted at one end near the stair foot by a window, as shown C C is the "wine and beer cellar," D the "washhouse," E the "provision cellar," F general storehouse, or milk room if a cow or two be kept in the grounds belonging to the house. The dimensions of the walls in the "plan of footings" are given in fig. 1 (p. 337).

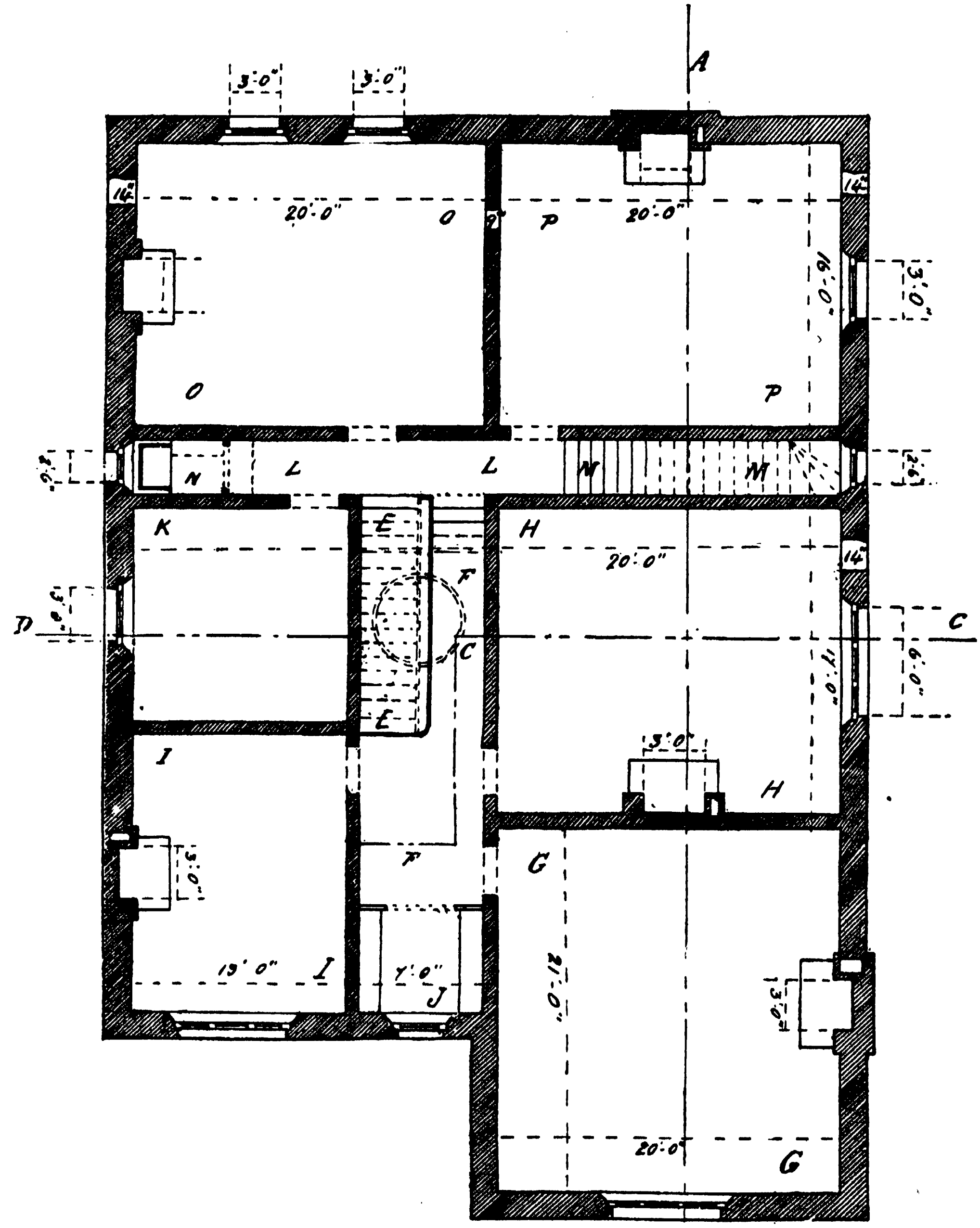


Fig. 8.

The Ground Plan of House.

In fig. 2, the "ground plan," the dimensions of the various apartments are figured. The line upon which the section in fig. 10 is taken is A B, that of fig. 9, C D; the "entrance hall" or "lobby" is at F; G G passage leading to back part of house at side of "stairs," H H, which lead to upper floor. The "drawing room" is at E E, the "dining room" at J J, the "breakfast" or "morning room" at I I, with a room to be used as a "library," "study," or "smoking room" next to it.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER IX.

Atoms—Particles—Bodies.

THIS last word, "matter," brings us to the other term named in last paragraph—"body." Matter, however caused or produced, is by nearly all scientific men considered to exist in its first or primary condition in forms of an inconceivably minute size—if the term size as involving dimensions can be applied to such infinitesimally small "somethings," quite beyond the reach of measurement. To those "somethings" the term "atoms" is applied. The name is derived from the Greek word *atomos*, signifying "uncut,"—that is, an atom is indivisible, or as it may be so expressed, it is so small that it *cannot* be cut or divided. When a number of such indivisibly small "somethings," called "atoms," come so together, the number being indefinite or unknown, what is called a "particle" is formed. The word particle is derived directly from the Latin word *particula*, and this is a diminutive from the root *pars* or *partis*, a "part"; and it means a small part of matter, or a substance. An aggregation or collection of particles massed or joined together is said to be a "body." The word body is derived from the Anglo-Saxon *bodig*, signifying the "trunk of a tree," from which the reader will perceive its applied meaning—a something large or massive, which can be handled or moved or dealt with in one way or another. The reader will obtain a good idea of these abstract statements in a concrete form by supposing a bagful or heap of dry, clean, sharp sand. Each individual grain, which is so small that to an ordinary eye it may be, and in some cases actually is, invisible, represents a "atom." Let the reader suppose that a liquid of a gluey or cementing character is sprinkled over or here and there passed through the heap of sand, and in such a way, but in such minute quantity, that it cements or binds together a *few only* of the grains of sand, and only at wide intervals or spaces in the heap. Those few grains bound or cemented together represent "particles." From some cause or other the heap may be supposed to be so stirred or moved that the particles separated from each other come together in greater or less numbers, and lie in little heaps of particles here and there throughout the general heap. Suppose now that in greater strength and quantity the cementing liquid is so sprinkled over or mixed with the general heap that it attaches, so to say, some of the little separate heaps of particles, and binds so many of each into separate and individual pieces. These pieces represent "bodies." So that ultimately the heap of fine sand originally taken in hand is composed of three divisions of matter—first the grains or atoms; second the aggregation, the going together of some of those atoms, forming particles; third the aggregation of some of those particles, forming bodies.

Further Considerations connected with Matter.—Molecules.

The term "molecule" is often used as synonymous with that of "atom." But this, arising from a confusion of ideas, if not absolutely erroneous is not strictly correct; the more accurate way is to consider the term "molecule" as synonymous with or a more scientific term for the word "particle." This is borne out by the derivation of the word molecule, which is a diminutive of the Latin word *moles*, which signifies a mass or "heap" of matter, the word molecule being thus defined as a small or minute particle of matter, a mass, a "heap," so to say, of "atoms." In this view, which we hold to be correct, a molecule possesses properties, so to say, of a much more tangible and understandable character than an atom. A molecule has properties with which the mechanic has really in practice to do; atoms scarcely—indeed, as strictly defined, cannot possibly—come within his ken. The point involved is one which carries with it so much that is of scientific, and, what is more to the purpose, of practical interest, that it is necessary to go somewhat into its consideration. From the very term employed—"atom," we have seen, from the conditions or circumstances in which atoms exist, that they are indivisible, and inasmuch as the eye aided even by the most powerful microscope fails to see the atoms, they are also invisible. For the present we merely allude to the thought, which naturally arises here in the mind of the reader, that there can be little use in saying much about what is invisible, and about which, therefore, it may be predicated at first sight that nothing can positively be known. Taking the common-sense view of the matter, he is apt to decide that there is little good practically to be got out of considering things we cannot *divide*—that is, touch and handle under their mechanical or material aspect—far more when we cannot even *see* them. But here we would remind the youthful reader that if this consideration were always acted upon, it would be disastrous to all mechanical progress, as no investigation would be made into the natural causes upon which all mechanical work depends. For the same objection could be made to inquiries about heat, light, and electricity, none of which can be seen, any more than atoms can, and about what they really are we know as little—that is, absolutely nothing—as about them. *But*—and this "but" the reader must give special heed to, for it lies at the root of or forms the basis of all scientific inquiry to which the mechanic owes so much—if we do not know what heat, for example, is, we do know—thanks to the patient observation and earnest investigation of generations of those who have lived before us—a great deal of what heat can do and does, and what is more to the purpose, what we can do with its help. All these "facts," these known things about heat, then, form, as we have already seen in preceding paragraphs, the basis of a special department of mechanics—that of "thermo-dynamics" or the "science of heat force" —of infinite value to the mechanic. And having thus a series of facts, the student will perceive that there is nothing to be lost, but that there is the chance—we prefer to put it in this way—that there will be a good deal gained by science, if there be an endeavour made by scientific men to make out a theory or create an hypothesis (the derivation of this latter word is already given) which will account for the facts. The theories in connection with laws of nature, on which all "work" depends for its existence and maintenance, may be open to the objection of this one or that one, but they form, as we shall presently see, what may be called useful working theories.

Generally Accepted Views or Theory as to the Condition of Matter.—Atoms.

It is in this way that, in considering "matter," and in endeavouring to account for the phenomena which are known respecting it when in the tangible form of what we call "bodies," scientific men have agreed to the theory—practically the great majority of them are agreed in it—which we have generally stated, —that the ultimate or primary condition of matter or of bodies is that to which the name or term atom is given, and that atoms possess the following properties, or we should rather say, are supposed to be and to exist in the following conditions. The indivisible and practically invisible atoms are separated from each other, kept apart, by the agency of heat, which prevents their ever approaching each other so as to become aggregated into that condition for which the only term here available in our language is that of a solid body or mass. The spaces are perpetually maintained which keep separate the atoms, and those spaces are in that condition known as, and only to be described by, the term vacua, or completely empty spaces, in which nothing exists. Further, that these spaces, separating what all are agreed to call atoms, are so excessively minute, that no substance we know of, even the finest air or the most subtle of gases, can pass into them and thus gain a position between two or more atoms. Atoms being thus separated by, and each of them enveloped in, a vacuous or completely empty space, the youthful student may have a difficulty to see how it is that they can in this condition go to form, or be themselves the primary elements of bodies or masses of matter. But this difficulty is got over by the hypothesis—which is in fact a common-sense one, and the general theory of atoms as so far now stated is admitted or held—that while thus floating about, so to say, in this sea of vacuity, each separate from its neighbour by the law of "heat," another law, that of "cohesion," comes into play, and it is this which brings about the condition of atoms which may be said to constitute them into a mass, or by which an infinite number of them are, so to say, held together. It will be perceived that we have used certain terms which have as yet received no special explanation. This, however, has been unavoidable, inasmuch as, we have already pointed out, we cannot describe certain conditions without using certain words which convey those ideas, and which are the only words available. But these words which denote certain conditions, such as "contact," "cohesion," "mass," will be fully explained in all their mechanical importance in their allotted places in succeeding paragraphs.

On some Speculations as to the Condition of Atoms.

It is only when this atomic condition of matter is changed, so that the aggregation of "atoms" constitutes what are called "particles," or in scientific language "molecules," that the attention of the mechanical student becomes arrested, in considering what matter is, by something which comes really within the scope of sense; inasmuch as we have seen that molecules of matter possess what are known as *physical* or *material* qualities which minister to the necessities of the mechanic in dealing with bodies, substances, or materials. Up to this point the theoretical expositions of atoms has been wholly in the region of thought or conjecture, but this has had most important outcomes, as in the atomic theory on which all modern chemistry is based. But while the value of those theoretical considerations is shown in connection with this science, they may be dismissed here, as they are, to say the least of it, too metaphysical or too subtle to be of practical service in the science of mechanics. Yet, as we have hinted at, some of those who have taken up the exposition of this science have not hesitated so to deal with this question of atoms, or the ultimate or primary condition of matter—bodies, substances, or materials—as to base upon what they conjecture or assert, theories which they maintain lie at the base or very root of the science of mechanics; dogmatically asserting that, unless those theories be accepted, nothing but errors will arise in all mechanical calculations and investigations. After what has been said—and with much, if not with all of which, such expositors of mechanical science agree—the student will perhaps be a little more than surprised to learn that those expositors of new views or of a new theory do not hesitate to attribute to the ultimate atoms of matter, which we have shown to be—or which are, for scientific purposes, assumed to be—in such a condition that they cannot be said, correctly, to have a physical condition at all, certain physical attributes. When the student comes to peruse a future paragraph on one of the properties of matter—namely, that of elasticity—he will find an example of this tendency of some writers to attribute physical properties to that which is admitted to be in a condition to which the term "physical" cannot with reason be applied, and some remarks upon that particular subject in relation to this assumption or conjecture which have a practical bearing on the subject of mechanics.

What is chiefly required of a Theory in Mechanical Points, is that it "fits in" or "squares" with the Facts of Observation and Experience.

This straining by some to know what is in itself, as we have seen, unknowable, has, we are bold enough to say, a very prejudicial effect upon technical teaching, in connection specially with mechanics; nor less those confident assertions that things are as those who assert wish them to be, when in truth they cannot possibly say what they either are or are not. In view of all those assertions, so bewildering to the student in mechanics, one is apt to be reminded of the way a celebrated reviewer put a point in relation to this assertion made by an author: That "we know that there is no such thing in existence as spirits"; to which the reviewer pithily put this question, "*How* do *you* know? did *they* tell you?" The truth is, that many of the theories advanced in connection with mechanics, or the physics of bodies, are useful in the same way as the theories, for example, of the scientific agriculturist. In connection with all the phenomena of growth of vegetables, and the action of certain substances termed manurial upon them, he knows absolutely nothing; but taking the phenomena or facts connected with them which he does know as they exist, he finds that a certain theory "fits in," so to say, so well with those phenomena, in the various phases of existence, that he adopts the theory as a basis for, or that which accounts for, the facts of practice. The theory, as a theory, is, after all, but a mere "hypothesis"; or, to use a term derived from the meaning of the word, a "supposition," or something "placed under"; nevertheless, it is a working supposition which in practical everyday work is found to be conveniently applicable to its demands and requirements. This is, indeed, all that can be said for many of the theories of physics, and it is practically saying a good deal. And all teachers of science—that is, true science, which never "assumes" anything—will take care to acquaint their pupils with this fact: that many theories are only held because they are convenient and good working suppositions, which are held for lack of a better, or of that precise and definite knowledge which, so far as we see, we are destined never to arrive at. But while all this is true with reference to speculations, points connected with atoms or the ultimate condition of matter, which is only a matter of pure supposition, and must with our present knowledge be so, it is altogether different when we come to consider what may be called—

The Molecular Condition of Matter and its General Phenomena, as exemplified in Mechanical Work.

This, as we have shown, is a region which comes under the domain of the practical mechanic. Although we have said that the subject of molecules is one which has a practical interest that mere speculations as to atoms do not possess, the student must not suppose that these conditions and characteristic phenomena, and the laws which regulate them, are thoroughly understood; the very opposite, indeed, of this is the case, as we are but groping in the dark, so to express it. Still, what man has found out respecting molecular conditions and action has been and is daily of vast practical service to him in his mechanical work. And although progress in further and fuller discovery is slow, yet it is still being pushed forward, and we are gradually accumulating such a series of facts as lead to the hope that the law which regulates the various and wonderful phenomena of the molecular condition of substances and materials may yet be discovered. So that it may reasonably be anticipated that we shall make advances in our knowledge of and modes of dealing with materials as great, compared with what we know and possess at present, as that which we know now when viewed in comparison with what was within the ken of our predecessors in mechanical work of but a generation or two ago.

It need scarcely be said that it is in connection with metals that the phenomena of molecular conditions are chiefly displayed, and in a way or rather in a variety of ways which in practical application have been of the highest service to the mechanic. Taking the most common, the cheapest, the most easily obtained, and yet to the mechanic, for the endless purposes of his work, the most valuable of all the metals—namely, iron—we find that in its three forms of cast iron, wrought or malleable iron, and steel, the phenomena of molecular condition play an important part, and it is in virtue of those that all the striking characteristics of these metals arise. Taking cast iron, for example, we find that in its manufacture from the crude ore the presence of certain substances brings about remarkable changes in the mechanical capabilities of the metal, those by which they can be made use of by the mechanic for certain classes of work. And these substances, although present in the furnace during the process of the manufacture of the cast or pig iron, exist in quantities so minute in relation to the vastly greater bulk of the material, that one would be justified, on being made aware of their presence, in deciding instantly that they could exert no appreciable influence on the metal with which they came in contact. And yet this influence, brought about by substances infinitely small, is so great that the metal may for certain practical purposes be useless or greatly reduced in value, according as those substances are dealt with. If the reader will turn to the papers entitled "The Iron Maker" and "The Steel Maker," he will find some striking examples of the effect of certain substances on the molecular condition of the metals in which they are present, and conversely in which they are absent or eliminated.

The molecular influence, as we may call it, present in all matter to which we give the name of substances or solid bodies, is seen in every department of mechanical work in which metals are used. It lies at the very base of the mechanic's work; and much as has been done, is being daily done, in the mixing of metals, in bringing about changes in their physical condition fitting them for certain classes of mechanical work, there is every prospect of our being able to bring about still greater improvements in this department of labour. In this mixing of metals, or what may be called the making of alloys, the results exhibited are singularly striking illustrations of molecular phenomena. Thus the density of a given metal may be increased to a very great degree by mixing with it a small proportion of another metal; and yet while the density is increased, and there are two metals now in the mass, the volume or bulk is not only not increased, but is actually smaller than that of the metals in their separate condition; in some cases the bulk remains the same. Here the connection of matter is evidently this: that the added metal must flow and fill up the spaces between the molecules, however those spaces are caused or created and maintained. A very good, although familiar illustration of this condition may be had in a barrel full of large stones, which we may consider as representing molecules. We find that by taking a number of smaller stones we can find space for them by shaking them into the spaces between the large stones, for the shape of them prevents them from lying closely together. The smaller stones may now in turn be considered as molecules, and by taking a number of pebbles we can by shaking the barrel get a large number to pass into its interior, those finding resting places in the spaces left void by the smaller stones failing to come close up to each other and to lie in contact. Looking now upon the pebbles as molecules, we can take sand, and by shaking it into the barrel we find that we can pass into it a very large bulk of this new material, sand, which represents what we call "atoms." Here we have within a definite space or volume, represented by the barrel, added bulks of three different materials, giving a new material, a conglomeration or concrete, and which we may, keeping up our illustration of the mixing of metals, call an alloy, of consequently much greater density, but of no greater volume or bulk, for the barrel still contains the same cubic space. It is on the same principle, or in virtue of the same law, that the mechanic can enlarge a small hole in a metal casting by using a tool of larger diameter passed forcibly into the hole, the molecules of the metal being crushed inwards, towards the direction of the exterior surface of the casting; and that those solid molecules must be made to occupy the void spaces between molecules, beyond the range of the enlarged hole, is evident from the fact that while the interior hole is enlarged or increased in diameter, the exterior diameter is not so, but remains the same. This law is taken advantage of in an infinite variety of ways in the mechanical and industrial arts. We have never yet reached the limit of density, or the point beyond which molecules cannot be compressed so as to occupy new positions or fill up new spaces. So far from this, that it has sometimes been jocularly said that it is possible to compress all the incalculable molecules of the globe into the bulk of a nutshell. This is, so far as we know, theoretically true, but, like all illustrations of natural laws, pushed to an extreme—such as in the case of Archimedes, who boasted that if he had a fulcrum and a lever long enough he would move the world out of its place—is only useful as expressing a law in the most striking way.

Further Illustrations of Molecular Disposition of Matter.

The very melting of the metals, in the arts of founding and alloy making, is a process dependent upon the laws regulating molecular phenomena; the flowing property imparted to the molecules by the accession of heat of a much higher temperature than that of their normal or familiar or ordinary condition, enabling them to be run into the finest and minutest intricacies of a mould, the shape of which when again cooled the mass of molecules will assume. When we come to consider specially what are called the "properties" of bodies or their physical or mechanical condition, we shall find that the phenomena of molecular influence are illustrated in all the properties about bodies which are known as elasticity, hardness, density, porosity, malleability, ductility; and also in all of the wide range of the actual or workshop practice of the mechanic by which he gives to his materials certain properties of which the hardening of steel may be taken as the most striking representative. In all of them *heat* plays a most essential part, for although heat may be in such a condition as that its presence is not indicated by feeling, or even by the most delicately adjusted of our thermometers, the young reader must not suppose that it does not exist.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER X.

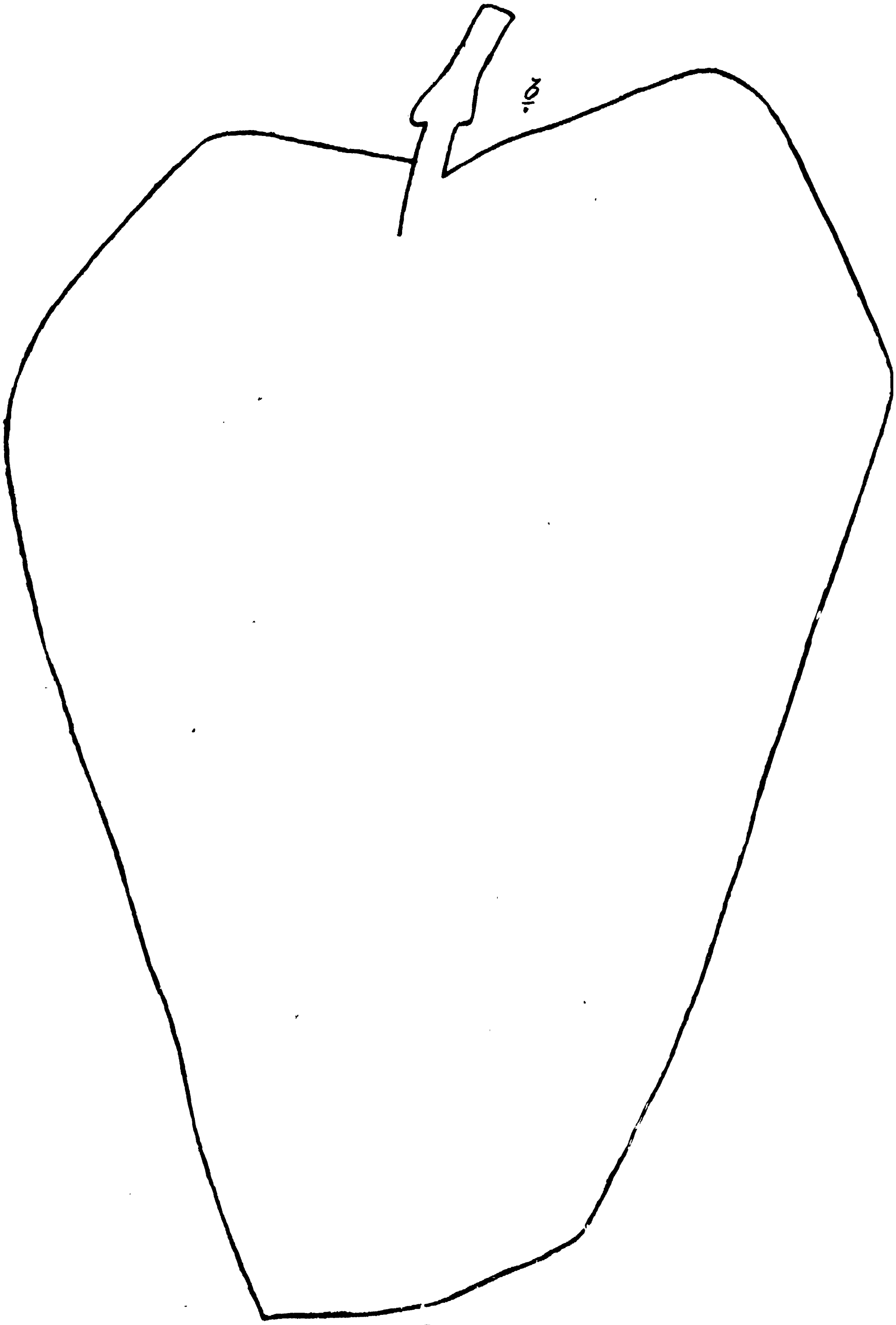


Fig. 49.

In copying *a*, fig. 42, the pupil should begin by drawing the pentagonal figure *b*, figs. 43, 44, giving the shape of the leaf with straight lines. He ought to be sure, before he draws more, that he has got the proportions of the leaf right—that is, its width as compared with its height; he will find that the height and the width are nearly equal. When he has succeeded in getting the proportions right, let him proceed to draw the curved lines into the straight

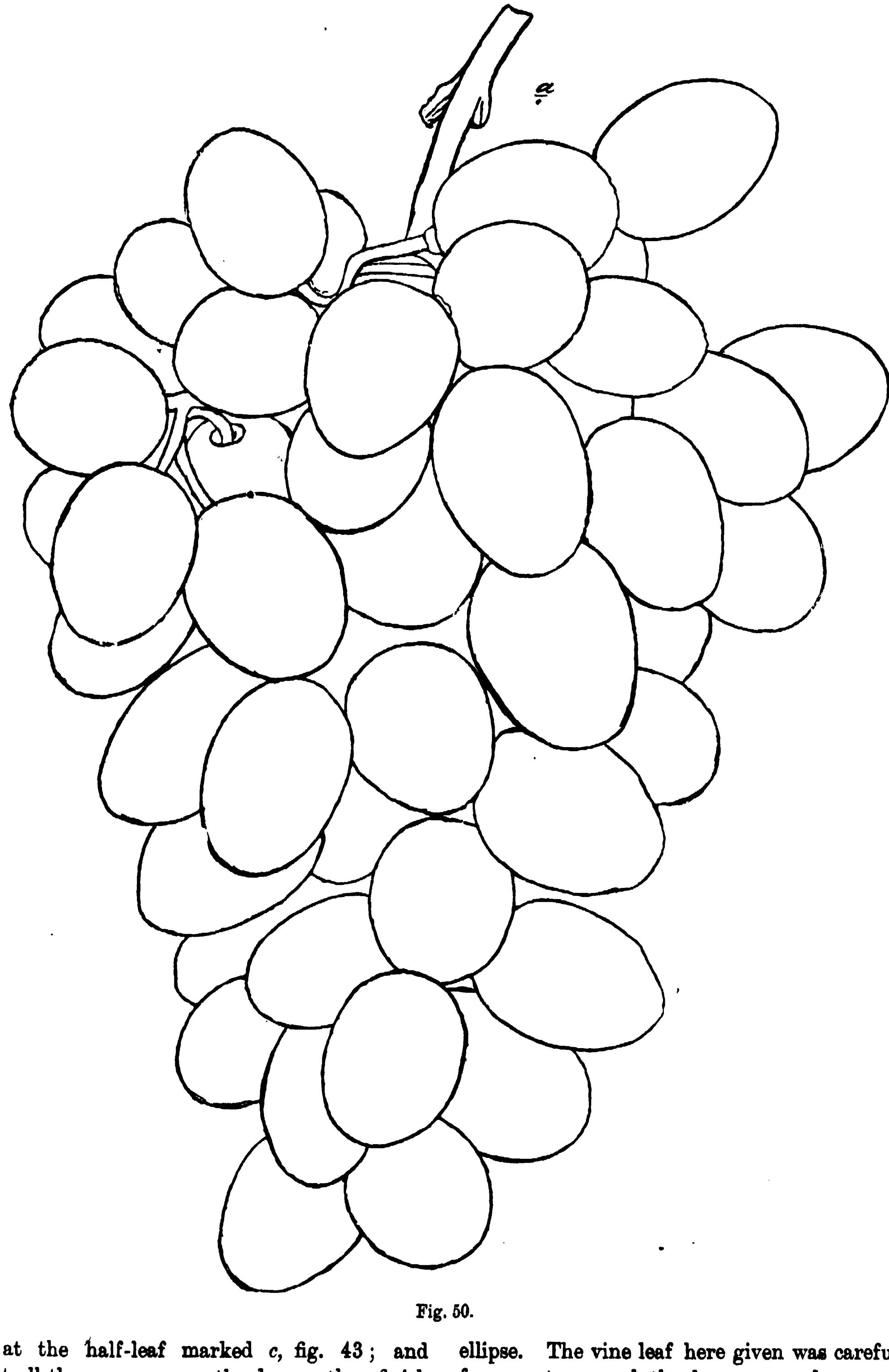


Fig. 50.

ones, as at the half-leaf marked *c*, fig. 43; and having got all the curves correctly drawn, then finish the leaf as at *a*. He will observe that at the loops of the leaf—that is, that part of the leaf where one lobe joins another—the lines go into a point above *a* in fig. 42, and do not form a part of a circle or an ellipse. The vine leaf here given was carefully drawn from nature, and the loops were drawn with great care.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER VI.

Bond secured between Stones by cutting them into Certain Forms—The Ordinary "Joggle" for Stones on the Flat.

OF the foregoing methods of this supplementary or mechanical style or class of bonding stonework, let

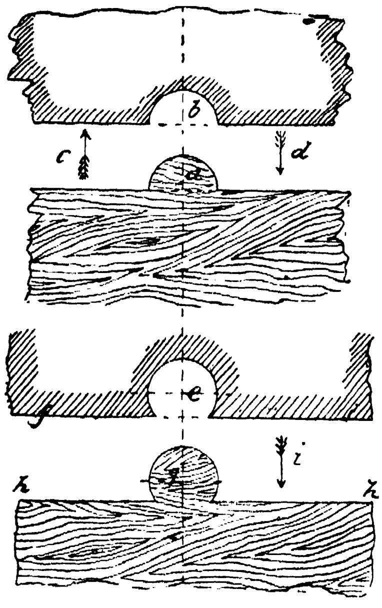


Fig. 36.

us now glance at the first—namely, that in which the stones are specially treated or cut. A simple way of keeping two stones, lying on the flat, bonded together, is by cutting a circular projection, as *a*, fig. 36, on one edge of the stone, with a corresponding indentation, *b*, on the other. But while this would

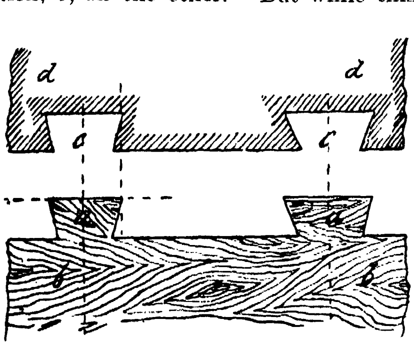


Fig. 37.

keep the stones together, pressing in the direction of arrow *d*, there would be no tendency in the joint formed by *a* passing into *b* if the pressure acted in the opposite direction, as in the arrow *c*, inasmuch as the projection *a* could easily slip out from the indentation *b*. This would be prevented by giving the indentation the form of more than a semicircle, as at *b*, such as is shown at *e*, cut in the edge of stone *f f*; the projection *g* in *h h* would be of the corresponding shape, and would of course require to be lifted and passed endways into the indentation, as it could not be passed in edgeways. This form of bonding or binding joint is called a "joggle," and the method is termed "joggling," or the stones so joined are said to be "joggled." The principle is carried out in more ways than one. Another and a more common method is illustrated in fig. 37.

The Dovetail Joggle for Joining Stones on the Flat.

The joggles *a*, *a*, are of the dovetail or fantail form, and are cut out of the solid on the edge of the stone *b b*. These pass in or are lifted into the corresponding indentations, *c*, *c*, on the edge of stone *d d*, or what may be called mortise holes, to borrow a term from the sister art of carpentry (see the papers on "The Carpenter"). Another method of joggling stones, and a simpler, is shown in fig. 38, in which the joggle

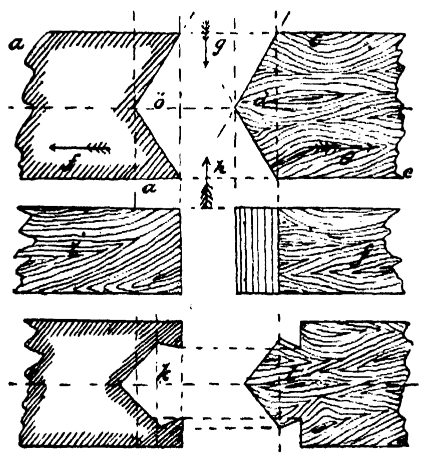


Fig. 38.

extends across the whole width of the stone *a a*, having an angular indentation, *b*, cut in its end, the stone *c c* having its projecting end similarly formed. This method affords no bond preventing the separation of the stones by pressures acting in the direction of the arrows *e*, *f*, although it provides for pressures acting in the direction of the arrows *g*, *h*. The pressure in the direction of *e f* on the stones *c c*, *a a*, is met by giving the joggle the form of *k* and *l*; *i* and *j* are side elevations of it. A modification of the joggle in *b d* in the last figure is shown in fig. 39, by which the stone *a a* is connected with a stone *b* at right angles to it by the joggle *c*. This joggle may be modified as at edge *d*, the joggle *f* having two butting shoulders at *e e*.

Joggles for Stones in Positions other than the Flat.

All these joggles are used for stones in the flat, lying in the same plane. We now illustrate joggles used for stones lying in different planes, as stones or blocks lying one upon another, and those at right angles to each other. The first of those we illustrate are joggles used to connect horizontal stones together, in which a more perfect bond is required than can be obtained by the ordinary bonds we have described in preceding paragraphs. This more perfect bond—in addition to the connecting force obtained by the use of cement between or on the beds of the stones—is often required in stonework exposed to great pressures

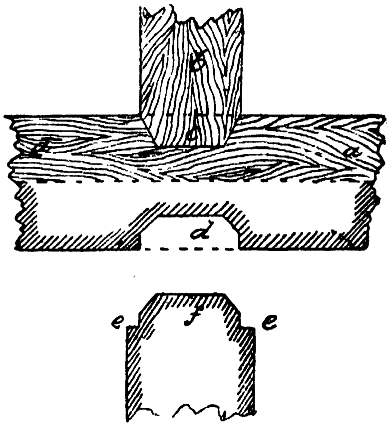


Fig. 39.

and severe shocks, as in lighthouse work, marine or harbour works, etc., etc. The principle upon which the methods proceed is that of the dovetail joint, of which we have already given an example or two in connecting stones lying on the same plane. A very celebrated example of the joggling or dovetailing of stones together lying on the same plane, but the

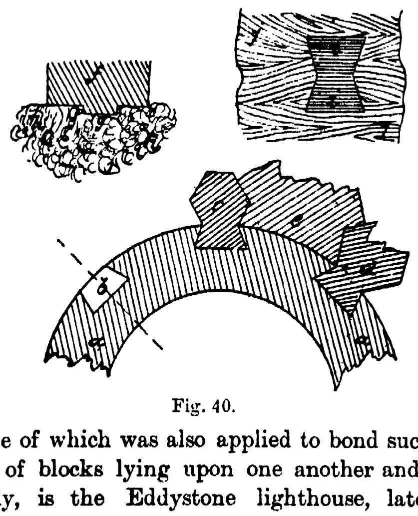


Fig. 40.

principle of which was also applied to bond successive courses of blocks lying upon one another and rising vertically, is the Eddystone lighthouse, lately in Plymouth Sound, erected from the designs of the father of modern civil engineering, Smeaton, and which has been re-erected on the ground known as The Hoe, at Plymouth, as a monument to that great engineer. This may be illustrated by fig. 40, in which blocks as *c*, *e*, *d*, are united to the central part *a a* by dovetails cut as at *b*. The relation of any two blocks, as *c* and *d*, also give rise to another dovetail joint, by which the piece *e* is firmly bonded to those and to the central part. It is obvious that by carefully adjusting the positions a series of dovetail joints can be arranged over the whole surface of the structure—which was done with admirably designed forethought by Smeaton. In the new lighthouse, recently erected as a substitute for the old one—the foundation rock of the latter giving signs of evident and dangerous decay and weakness—this principle of interlocking was carried out still more completely throughout the structure, not applied merely to the courses placed

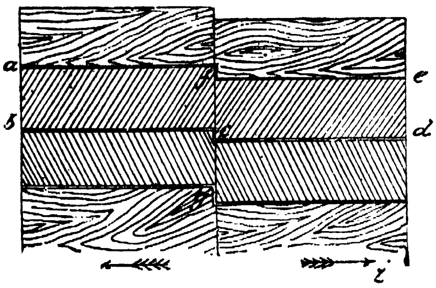


Fig. 41.

and resting upon the rock as a foundation; the first course has, we believe, been dovetailed to the rock itself. The principle of this is also illustrated in fig. 40, in which the block, as *f*, is provided on its lower surface with a projection, as *g*, which passes into a hole cut in the face of the rock *h h* itself. The form which this might assume is illustrated as *i i* in the plan of rock *j j*.

Uniting or Joining Blocks of Stones to lie in Vertical Courses.

A method of uniting blocks in successive courses is shown in fig. 41, in which the blocks are cut to a peculiar form, the outline of which is at *a b c d e f*. This shows the section or end view of the block, but the same form is maintained in the side—that is, the length running in face of structure. The pupil

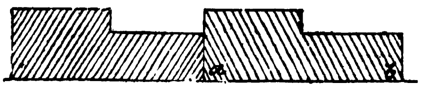


Fig. 42.

should "project" a drawing of the structure in side elevation, showing the position of the zigzag lines of courses which the peculiar shape of the stones would give. As the foundation or first-course stones would not have a fair bed if formed as in fig. 41 in section, to be used as the blocks for the length of the wall, the blocks for the first course are cut with the lower bed at *a* in straight line, as at *a b* in fig. 42, the upper bed as shown to correspond with the shoulders of the blocks formed as at fig. 41.

In examining fig. 41, the reader will perceive that a shoulder is formed at the points *f*, *c*, and *g*. In the wall of which the diagram is a cross-section, pressure put on the sides, either in the direction of the arrow *h* or *i*, would have a tendency to force the block asunder sideways. The block *g* to the left, if acted upon by a pressure in the direction of the arrow *i*, might leave the shoulder at *g*; or the block *b c d e f a* above it might be forced aside if the pressure acted in the direction of the arrow *h*. No doubt the tendency to leave the shoulder *g* would be counteracted by its coming in contact with the shoulder *c* of the block *a b c d e f*, supposing this block to be steadily secured. But it would probably be liable to the same pressure as put upon the block *g*, and in the same direction. Any pressure, in fact, acting in the direction of the arrow *i* would have little tendency to be resisted by the shoulders, at *f*, *c*, and *g*, as they all "give" in the same direction. A more perfect locking or bonding can be secured, as by the method shown in illustration, fig. 43: in this one stone, *c c*, has a part *a b* cut out, as at *g* in the stone *f f*, the stone below it being provided with a corresponding projection, as *d e* of the stone *f f*. As two shoulders are thus provided,

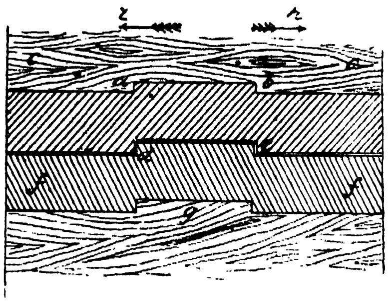


Fig. 43.

as at *a b* and *d e*, pressures in the direction of arrows *h* and *i* would be both counteracted. We do not at present go further into the subject of pressures, nor show how they can be met further than by methods connected with the bonding or interlocking of the blocks; but it is obvious that as a mere locking or bonding contrivance that in fig. 43 is of a higher class than that in fig. 41.

Another Example of the Class of Joggling described in Last Paragraph.

We now come to another example of the same class of joggling, suitable for the binding together of the various blocks in the vertical courses of a structure, this being illustrated in fig. 44. Here the blocks are flat on both beds, and have no projecting or hollow parts, as in figs. 41 and 43. The bond is secured between the blocks in any one course only, wholly by the peculiar form into which they are cut. This form has no influence in bonding a course with the next one above or below it; the connection between the several courses being obtained, as in ordinary bond, by the mortar or cement between the binding faces. Any bond between the courses vertically, other than this, must be secured, if secured at all, by the three methods of supplementary bond yet to be described—namely, "dowels," "cramps," and "bolts." As seen from fig. 44, the shape of the central block is precisely like the letter I—the web, or central part, *a a*, being finished at each end by cross pieces of equal length, as *b b′*, *c c′*. The outside blocks are, on the other hand, shaped like the letter E without the central projection, or like part of a central block with the projecting parts *b′ c′* cut off. The space between the "lugs" or "ears" of the outside blocks, as *d e f*, is such as admits the easy insertion of the ends, as *c c′*, *h h′*, of two central, or I, blocks placed in contact, as shown in diagram. Those ends are embraced or locked by the hollow parts of two outside, or E, blocks, as *d e f*, *g i j*, one on each side. The breadths

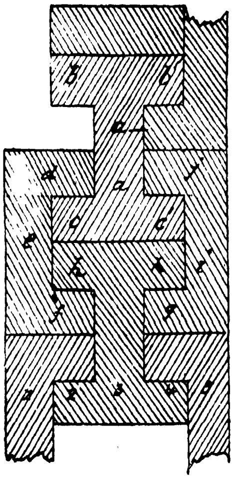


Fig. 44.

of all the parts are equal,
placed in position, or *in situ*, [illegible]
is, the thickness of the wall is made up by them
as by the five parts 1, 2, 3, 4, 5, all of which are equal in breadth or width. The pupil will see how completely interlocking this somewhat elaborate method of preparing stones or blocks is. Fig. 45

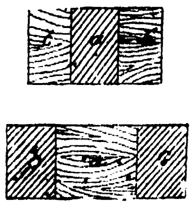


Fig. 45.

gives at top a section of the I or central block in fig. 44, through a line at *a a*, *a* being the section of centre part or web, *a a*, fig. 44; *b b*, fig. 45, being the inner sides of the corresponding parts in fig. 44. In the lower sketch, fig. 45 is a section through the points *b c* or *b′ c′*, fig. 44, as is elevation of inside of block; *a a*, *b c*, being sections of parts *b* and *c*, fig. 44.

THE JOINER.

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER VI.

IN fig. 47 we give a modification of the form of joint illustrated in fig. 46, where one piece, as a horizontal one, *h h*, joins another, as a vertical, *a a*, and that not in the centre of its edge or thickness, but at one side, so that the surfaces of the two pieces are flush, while there is a projecting part behind, as shown in side view of *a a*, at *l l*, *m m*, *n n*. The horizontal part may be simply let in by a mitre joint, and secured by a pin in the centre of the cut-out part *b c d* at *e e*. The work will be more secure if a tenon or tongue, as at *g g*, be cut in the end of the piece *h h*—this taking into a mortise or groove, as *m m*, cut in the mitre joint *l n*. The edge view of *g g h h*, looked at in the direction of arrow 3, is shown at *g′ g′ h′ h′*; *l l m m n n* being a side view of *a a*, looked at in the direction of the arrow 1. If the part cut out at *b c d* on a piece *a a*—edge view immediately below—had a tongue or tenon in its centre, as *e′e′*, the horizontal part joining it in elevation to the immediate right of *a a* at top, would have a mortise or groove cut out in it, as shown at *f f*, which is the plan of top or upper edge of horizontal piece, as looked down upon in the direction of the arrow 2. The diagram marked *k k i i j j* is a cross section of the piece *a a* on the line *b c*, when the joint is made with a tenon or tongue, as at *g g* on the horizontal piece. In those three last illustrated forms of joints the tenon or tongue, in place of being formed out of the solid, may in some cases be more easily formed by cutting or "squaring" off the mitre or angular face right across, and then cutting in its proper position a groove a little less in width than the thickness of the tenon or tongue, then driving this cut to its proper dimensions into the groove, leaving as much projecting from the mitre face as gives the required length of the tenon.

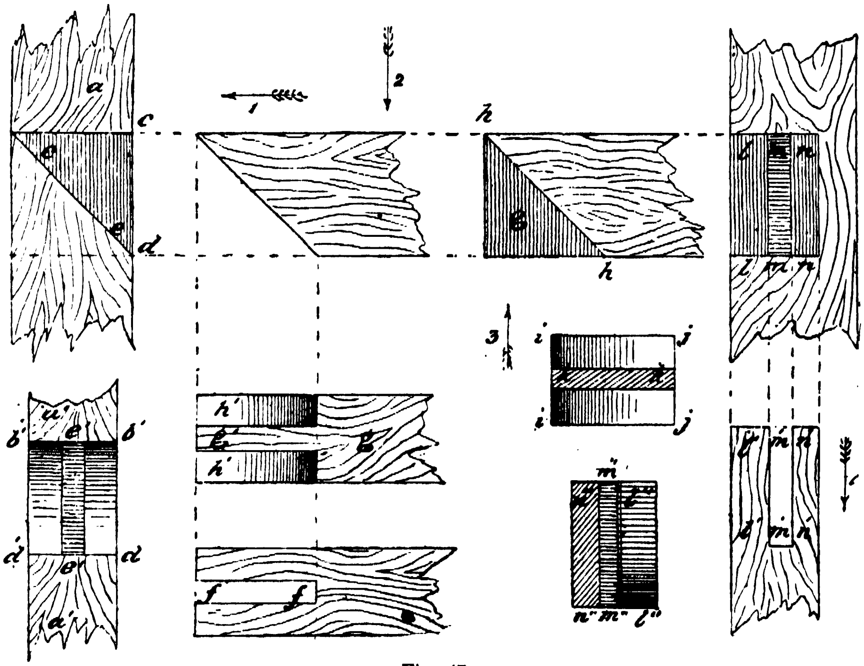


Fig. 47.

Joints finished off with Beads.—Quirked Beads.

The corners of pieces joined in the manner illustrated as in figs. 41 and 43 (*ante*), are sometimes finished off as "beads," of the class known as "quirked beads" (see the series of papers under the title of "Ornamental Work in Stone, Timber, and Metals," in the division treating of Mouldings). Fig. 48 illustrates a method of joining two pieces at right angles, with a double quirked bead *b* at the end of one of the pieces, as *d d*. The bead proper is the rounded part at *b* forming part of a circle in section; the "quirk" is the recess or part *c*, one side of which is formed by the square end of the piece *d d*. The bead *b* is formed at its upper side with a projection 2, shown at 2″ in the lower diagram to the right; this projection is carried down so as to form an indentation, as at 1″, into which the part 1′—corresponding to 1 in lower diagram to the left—passes or is inserted. When the two pieces are joined together, as in the upper diagram, the upper "quirk" corresponding to *c* is formed by the square end of the piece *a a*. In fig. 49 both pieces have beads at their ends, as at *b* and *d*; but those are single quirks, as at *e* and *f*. The junction is effected by a shouldered tenon *a* passing into a corresponding mortise in *c c*, as at *a′* and *a″*.

Joints for Angles other than Right Angles.—Beaded.

In fig. 50 we illustrate pieces joined at angles other than at right angles, provided at the meeting point or

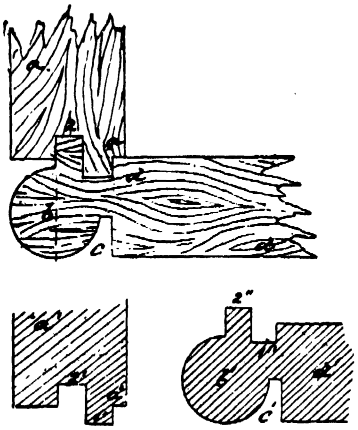


Fig. 48.

corner with a "bead" finishing; in this case a double quirked bead, the two quirks being at 4 and 5, the bead proper being at *b*. The lower diagrams show the method of cutting the ends of the two pieces, corresponding letters accented showing corresponding

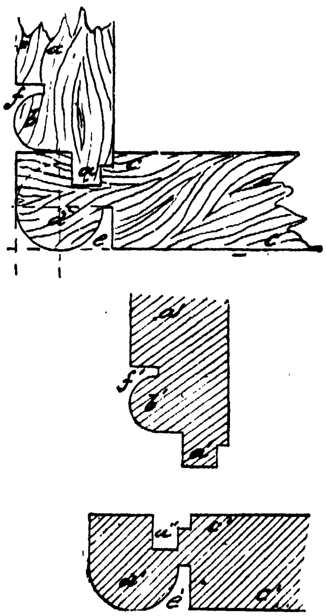


Fig. 49.

parts in upper diagram. In fig. 51 we illustrate another joint of this kind, in which the circular bead *b* has curved quirks 4 and 5, the ends of the two pieces being curved in place of being left square. The upper and lower diagrams show the pieces *a a* and *c c* separately, the corresponding letters accented showing the corresponding parts in the middle or complete diagram.

Joints for Pieces Circular or Round in Section.

In figs. 52 and 53 we illustrate methods of joining

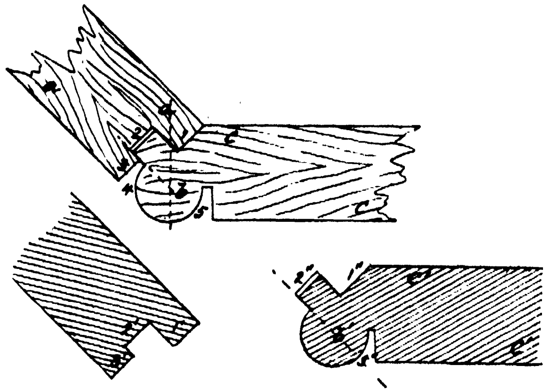


Fig. 50.

round pieces of wood together. In fig. 52 the one piece at *a b* has simply a part cut out of an angular form, as at *h i j*, in vertical section at one side; the

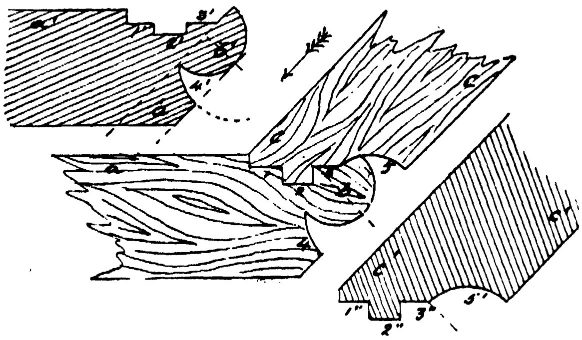


Fig. 51.

end of the other piece *c d*, *f e* is cut to the same angle and with the same length of face as *h i j* and inserted. The two are kept together by glue, or are nailed.

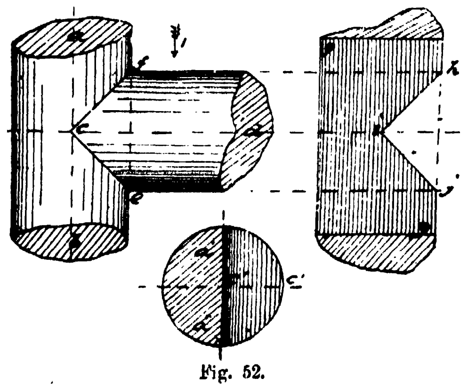


Fig. 52.

The lower diagram gives an inside view or plan view of the part *c e f* cut out in *a b*.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER VI.

Essential Importance, nevertheless, of attending to the External Design or Style of the House.

BUT while the plan should dictate the external form of the house, and in this way influence its architectural character—and although that may be given to it through the medium of one "style," such as Domestic Gothic, in one case—through the medium of another, such as "Italian" or "Elizabethan," in another—the external design must ever be a most important point for the young architect or builder to consider. We have no sympathy whatever with those who hold that if only a house be well arranged in the interior, or "planned," it is quite a matter of indifference whether it be so "designed" that externally it may be ugly, or positively hideous. Those, indeed, who take this view can scarcely be said to be merely indifferent as to whether the house may be beautiful or otherwise,—this is not a point of indifference with them,—rather is it a decided preference for the plain and ugly. They seem to be, in fact, incapable of appreciating the beautiful, and, indeed, ignorant of what is the difference between this and the opposite. With such we have no sympathy; and so far as they are concerned, it would be but lost time to endeavour to convince them of the great loss they sustain by holding the views they do. We refer here only to, and concern ourselves only with, the happier class who *do* believe that to possess an object pleasing to the eye, gratifying to the higher intellectual tastes, is a real gain in life—to those, indeed, who believe that "a thing of beauty is a joy for ever." And a beautiful house is not wholly, if it be, indeed, much of a selfish gain, for it may be made, and indeed is, a joy to the passers-by, to all in the neighbourhood, who, like the owner, believe in beauty.

Study of Style, or the Design, of Building essential to the Young Builder.

Hence the necessity for the youthful builder who lays himself out for the planning and erection of houses—and in so far acts as and attains to what is supposed to be the higher dignity of an architect—to add to his labours that of the study of design, By this study he becomes intimately acquainted with the peculiar characteristics of what are called the "styles" of architecture, and thus is enabled to adapt them to the external decoration of the houses he may be called upon to erect. It is a matter greatly to be regretted that so many of our builders who are not only ambitious to be planners as well as erectors of domestic structures, but who do a large business in the actual work of construction, should have deemed a knowledge of architectural style a matter which did not concern them. This no doubt arises from the fact that the clients or general public for whom they act as constructors or builders make no demand upon them for external style or architectural beauty of form and decoration. It seems to be quite enough for this class of the public—unfortunately comprising a vast number of people—if they get houses which are said to be fit and convenient to live in. If they get this—or think they get it, for we have seen that the chances are pretty numerous that they will not obtain it—they are utterly regardless, or at all events practically are so, of any claims which the beautiful or that which is pleasing to the eye has upon their attention. And so long as this public apathy exists, there will be found but too many builders ready to minister to and perpetuate it. It is only to a wider-spread knowledge of what *art* in all its departments really is, and how it can minister to a better and higher civilisation, that we can look as a means of altering the present state of things in regard to the design or style of the great proportion of domestic buildings, which from almost any point of view may be said to be deplorable. We have hundreds of acres of land covered by buildings of which the best that can be said of them is that they are honestly ugly—that is, they make no pretension to be even moderately pleasing to the educated eye.

Points which influence some Builders in their Relation to the Work of Design or Style of their Houses.

Much might be said in favour of the view that builders of houses have not much concern with design, looking upon that, as many do, as the work of the architect—a profession to which they, or at least many of them, make no pretensions to assume. It may be said, for example, that all they lay claim to is this—that they can give houses convenient and healthy to live in. As to how far the claims of health are met, something may be said by the author of the paper entitled "The Sanitary Architect and Engineer," to which therefore the reader interested in the matter is referred. And from what has already been said on the other of the two points above named, it does not follow that because a builder claims that the houses he does build are—at all events from *his* point of view—convenient, that they are in truth well planned. Unfortunately but too many are now in existence, and more we fear will yet be, which have scarcely any claim to be considered even moderately well and carefully planned. Some indeed, more captious critics, would say many are as badly or carelessly planned as they can well be. Builders who are careless as to their possessing a knowledge of architectural design should at least take every pains to make their plans good, so as to give what they do claim to be able to give—namely, houses convenient to live in (the other point, houses healthy to live in, will receive separate treatment in the paper we have already noted, "The Sanitary Architect and Engineer"). But if the choice between two evils in the matter of a house had to be made, we frankly confess that we should choose the work of an architect who, while he thought less of the internal plan than of the external design, would at least give us something pleasant for us and our neighbours to look upon. We should also in this case have the chance, moreover, that his plan would possess some good features in respect to convenience. For it would be at least an odd thing if he, who had the ability to give a good design, overlooked altogether his work in regard to the plan. Rather this than decide upon employing one to erect a house for us who, while he claimed only to be a builder and to give a good plan, was not after all able or was careless to give it, and who, confessedly or professedly having no knowledge of design, would thus give us neither a good plan nor a good design. In this case we should be wholly the losers; in the other case we should get something for our money, and something even at the worst worth having, and it might be something highly valuable as an artistic design—with, as said, the chance of getting a moderately, perhaps a very good plan.

Added or "Stuck-on" Ornament not True Design in House Construction.

We shall see as we proceed that the beauty of a house, or those attributes to which this term is applied, do not consist in the mere elaboration of the external decoration with which it may be ornamented. We are far from ignoring the value of such decoration when the means of the owner admits of their being more or less lavishly employed. On the contrary, we deem it to be a public duty that those possessed of means should make their houses in every way "things of beauty." Still we wish to impress upon the minds of our young readers that a house may be made very beautiful to look upon, and quite competent to gratify educated taste, without, or at all events with very little of, what is purely decorative or added ornamental details. A house may be of the very plainest, so far as regards what may be termed "added decoration," and yet it may be "beautiful exceedingly" considered as an architectural design. No doubt this can only be attained by a skilful architect, who knows what mere form or external outline can do for him in securing what will be beautiful to the eye; and this by *natural* aids, which are so prolific in creating lovely forms and giving no less lovely colour. How all this is to be effected, and what are the leading principles upon which house design is based, will be duly considered in a future chapter. Meanwhile we have put before the youthful reader what we deem to be essential points which should be considered by him in commencing his career as a designer of domestic structures.

General Features of the Plans of Domestic Structures given in this Paper.

The feature of this series of papers being the planning of houses according to the style or class to which they belong, "plans" of various structures must of necessity be given in considerable numbers. And with regard to those we desire the reader to take careful note of the fact that we in no wise give them as model plans—that is, plans which are so good or so well designed that they may be followed as positive guides as to what should be done in planning a house in the particular class or classes of houses to which they refer. At the best they must be looked upon as purely representative plans, showing the style and the extent of accommodation required in particular classes of houses. On this point we can fully endorse what a well-known writer has said. "Practically," he remarks, "there can be no such thing as a plan which can be designed to suit the always-varying requirements of different families and different circumstances of living. It may be that now and then a plan which has been designed to meet the necessities of one will be found suitable for another, but the cases will be few—so few that practically there is no such thing as a model plan. Each house must be planned to meet the requirements of the family which is to inhabit it; we know of no other rule for guidance in this case. Still certain accommodation is required in *every* case, and cannot be dispensed with, such as the kitchen and working apartments, and the living or entertaining rooms and the bedrooms." It will be perceived, from what we have said and quoted on this important point, that we condemn what may be called the stereotype system of planning adopted by so many builders and speculators in house property. They seem to be thoroughly alive to the fact that in our crowded towns, and no less indeed in our large villages and hamlets, the necessities of an increased and always-increasing population, the demands of growing trades, and the thousand-and-one exigencies of daily life, bring numbers of people who *must* have houses to live in. And as they are there ready built for them, they must take them. With them it is "Hobson's choice—this or none." They do not find the houses all they wish in point of conveniences; too often they find that scarcely one of their wishes in this respect can be gratified. But what can they do?—if they had been consulted they could have shown how the plan of the house could have been so arranged as to meet not merely their individual requirements, but very likely also those those of other families in the same class of society to which they belong.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER VII.

We concluded our last chapter by stating that we should explain broadly the principle of plane projection. This is a method of cutting up, so to say, the object viewed as a whole into several parts, those parts having a direct and special relation one to another; and which when considered in this relation afford—known by the designations we have above named, plans, elevations and sections—data, or in other words forms or configurations and measurements, by which the workman can construct, or, in popular language, make the object. Those plane projections in plan, elevation and section, to those ignorant of the principle upon which they are made, afford, even at the best, but a very vague conception of what the object in its various parts will be when it is constructed or made, and as looked at from any one special point of view. The plane projections or working drawings give little or no idea to those uninitiated in this principle of the look of the completed object. A box, for example, longer than broad, and of less depth than either its length or breadth, when placed upon a table, gives different aspects or looks, so to say, when viewed from different points. But no matter what the point of view is from which the box is looked at, the spectator has no doubt in his mind as to what the peculiarities of construction of the box are. He can at once, from what he sees, describe its shape, the relation which its length has to its breadth and its depth to both. But if a series of drawings were presented to him which gave in plane projection the working drawings from which a workman could construct the box, with all its measurements accurately given, the spectator would have some difficulty to make out from them what the object precisely would be when constructed in accordance with them. He can take in at a glance what the peculiarities of the construction would be when it is placed on the table before him; but it would take more than a glance—some considerable amount of study—before he could form a conception of what the object would be from the data afforded by the working drawings before him. And if the object were much more complicated in its parts than the simple box we have taken for illustration, the almost certainty would be that the working drawings of it in plan, elevation, section, and details would give him no clue, certainly no ready clue, to what the object would be when looked at in the ordinary way after it was constructed in strict adherence to the form and measurements which the drawings would give to the workman making it. It is to the explanation of all the points involved in the terms plan, elevation, section, and detailed drawings, that the first part of our paper will be devoted.

Distinction between Drawings constructed on the Principles of Plane Projection, and those sketched and aided by the Eye only.

But in many cases, in addition to those drawings in plane projection, or, to use the popular, yet strictly technical terms we have more than once above named—the plan, elevation and section—views of the object to be constructed or made more or less pictorial in character are required. This is more specially applicable to the work of the architectural draughtsman. Reverting to our simple illustration of the box when seen by the spectator as placed upon a table before him, while able to take in at a glance its constructive peculiarities, he might be puzzled if he were asked to give upon paper his conception of what those were—that is, to make a drawing of it. If possessed of artistic ability, he would give a representation of it which would be very accurate; if not, the almost certainty would be that his drawing would give a very inaccurate view of what the object really was; although, be it remarked here, his drawing of it would be *his* way or method of showing what he conceived he was looking at. If possessed of artistic ability, so as to be able to give a drawing or sketch of the object which would at once, by all who examined it, be seen to give what would be called, and indeed would be, a faithful representation of it—"so like," to use the popular phrase—still, while giving this sketch or view of the object, the artist or draughtsman might have no conception of the principles upon which that drawing was based, or indeed any notion that such principles existed. If the reader will peruse the matter to be given presently, in a succeeding paragraph, he will find there stated fully, what is now here merely in the most general way—the reasons why different artists would give sketches or views of the same object which would all in one or another respect vary the one from the other—some two or three out of, say half a dozen views, done by six different artists, varying, indeed, very much the one from the other. Now, here the pupil might ask the question, Is there no method of drawing or delineation which will give an idea of the look or appearance of an object constructed from drawings in plane projection—that is, in plan, elevation and section—which is based upon a principle or upon principles, and being so, if those are followed, will give a drawing, sketch, or view which, while presenting the appearance of the object as looked at from a certain point of view, will be precisely the same in a number of sketches or views taken or made by different draughtsmen? The question here put is a very natural one, and has a close practical bearing upon the general subject of the present series of papers. There is such a method of delineating on fixed principles an object which will give a fairly accurate notion of how the object will look when viewed in its completed state from a certain point of view. This method is popularly known as that of drawing an object in perspective; and the data of this drawing are obtained from the plans, elevation and section, the preparation of which must in all cases precede that of perspective drawing. Hence this method of delineation of a completed or constructed object may be called the projection in perspective of its plane projections. In other words, this conventional method of giving a view or sketch of an object is a drawing perspectively projected. We have said that drawings giving the appearance of the completed object constructed from the plans, elevations and sections are most frequently required by the architect. In explaining the principles of perspective projection, then, we purpose applying them to architectural subjects; but it is scarcely necessary to say that what we give will apply also to the work of the engineering draughtsman. At the same time it must be observed here, that there is another method than this here named—and which we may call conventional perspective—of preparing drawings which will give the appearance or look of the object as seen in a certain way. This other method is more directly applicable to the purposes of the engineering draughtsman; and this therefore we shall also illustrate and explain under the head of isometrical projection or perspective. This method presents some features of great practical utility applicable to the work of the architectural, as well as to that of the engineering draughtsman. This section will follow that which we have designated as conventional perspective, or projection in perspective.

Brief Statement of Subjects to be Illustrated in the Present Series.

Having thus briefly explained the subject of Projection in its three branches as above named, the next series of illustrations embraced within the proposed limits of our papers will come under the head of "Special Departments of Architectural and Engineering Drawing." Some of these will necessarily be directly applicable to one only of those two branches of drawing, some will be common and directly useful to both. Without committing ourselves to the precise order in which these special departments of architectural and engineering drawing will be ultimately given, we may here name them in the general sequence in which they will be presented to the reader. The first section will concern itself with various constructions or problems connected with curved and eccentric lines: these will be applicable to the work both of the architectural and engineering draughtsman. Based upon and following these will come the special constructions under each head—as, for example, the methods of delineating or constructing "volutes" and "scrolls," "spiral staircases," describing the curves of "arches," all of which we meet with in architectural or building construction. In this section are embraced also the various constructions useful to the engineer and mechanic in the setting out of "eccentrics" and "curves," "helices," "springs," and "screws" of different kinds.

Following upon these will come the important section of construction connected with the section and development of solid bodies, which are applicable to the work of setting out forms of building work in "arches," "bridges," and the finding of the forms for the construction and covering of different kinds of "roofs." The application of this principle of development of solids to the work of the mechanic in the finding of surfaces in the construction of such work as tubes or pipes, boilers, etc., etc., will also at this stage be illustrated and described. Finally, various points connected with the preparation of working drawings will be amply considered. The whole matter of the present series of papers thus foreshadowed will, the author trusts, embrace what may with all practical propriety be termed a treatise on the work of the Architectural and Engineering Draughtsman—a guide to the principles and practice of his important art.

Detailed Statement of the Distinction between the two Classes of Drawings or the Delineation of Objects—Mechanical (Plane Projection) and Freehand.—General Conditions of Mechanical Drawing.

In an early paragraph we explained the varieties and use of the appliances employed in drawing in what is called the mechanical way, adopted alike in the delineation and setting out of subjects in architecture and engineering. And in describing the use of these the young draughtsman incidentally received what may be called "lessons" in the art. But as they were only incidental to the description of their use, they were very general, and will of necessity be again fully and specially referred to in succeeding paragraphs, in which the regular instructions as to laying down drawings are systematically given. Such drawings, although they may severally come under the special or class term of architecture or engineering, are usually described or talked of in the generic term "mechanical drawing." This term is used to denote the specific difference between those drawings connected with the constructive arts generally, whether they be connected with architecture—which again has all its departments classed under one head termed "building construction"—or with engineering, which in its turn has very frequently all its departments placed under one head—namely, mechanical—and all that wide class of drawings which come under the head of artistic or freehand.

THE STEAM ENGINE USER.

The Different Classes of Engines Used chiefly for Manufacturing and Agricultural Purposes.—The Leading Details of Steam Engines—Constructive and Operative.—Their Practical Working and Economical Management.

CHAPTER VI.

At the end of last chapter we stated that the indicator exhibits certain faults there named in the working of the engine. Further, it directs attention to the other end of the diagram—that which shows the conclusion of the steam side of it—and thus points out that the opening of the exhaust valve (that valve which opens to allow the waste steam to pass into the condenser) is either too late or too soon. The four corners, as we may term them, are all presented to the eye at once by the diagram, and show which are too late in opening or closing. The knowledge of such arrangement of the valves will so far enable those who are in charge of the engine to be skilled in producing steadiness in every part of the engine, besides giving effect to the economy of fuel.

Richards' Indicator, Kenyon's Pistonless Indicator.—General Description.

There being two classes of engines—low-pressure condensing engines and high-pressure engines—we shall give illustrations of diagrams from the first named, they being in most general use, and the form of calculating them when taken.

It will cause an investigation to be made by those using the indicator when they find at the commencement of the steam side of the diagram a series of lines made by the flirting of the spring in the indicator, and thus producing zigzag lines. This sort of figure is produced by the pressure of steam coming upon the piston too soon—*i.e.*, before the piston is ready to return; and thus the steam which enters the cylinder before the piston arrives at the end of its passage becomes compressed, or, if the steam is admitted suddenly—*i.e.*, the steam valve opening suddenly with a high pressure of steam, the same effect will be produced. The best made indicator we have met with to cope with the flirting or irregular lining in the diagram, which we have referred to, is "Richards'" indicator, hereafter illustrated in figs. 3 and 4. In no other way can we say that it is superior to McNaught's, or Hopkinson's, or that of any other maker. As there are others which have just come into use, we will refer to one or two. "Kenyon's indicator," hereafter illustrated in fig. 5, is certainly new in its construction, in the way by which the steam acts upon it, and also in the way by which it operates so as to produce the necessary result. It is ingenious in its arrangement and novel in its form. We have often found that new constructions of machines are merely applications of an arrangement which has been adapted to some other machine. This employment of the different forms by which steam can be adapted to other kinds of machinery shows the diversity and also the versatility of men's minds, and how they can apply certain portions of machine to other machines, and sometimes with great results. In the above-named form the steam is applied to the steam engine indicator in the same way as the steam is applied to the steam gauge indicator for the steam boiler.

This—Kenyon's—"indicator" claims to possess the following advantages: accuracy, absence of friction, cleanliness, handiness. Each of the claims named are of the utmost advantage for a delicate machine. As we have referred to some of the other indicators, and pointed out the part of the moving power called the "piston," this machine is in that respect termed "pistonless." The change from the principle of steam acting upon a cylinder piston, which has been the usual practice, is in this arrangement transferred to a tube of iron metal. This tube is of the form of a "sickle"—*i.e.* a semicircle. When the communication is made between the cylinder and the sickle (tube) by the opening of a tap, which is used to shut off or to let in steam from the cylinder into the indicator (sickle), it causes it to expand, and thus the change of its position is effected; and also as the steam leaves the cylinder and passes into the condenser, the contraction in the sickle takes place. When the steam enters the sickle the expansion of its metal causes the pencil to rise, and as the steam leaves the sickle it contracts, and thus the pencil falls and forms the lines on the paper in the same manner as it does where the steam acts upon the "piston indicator." The paper which is intended to receive the pencil impression is fixed on a barrel or drum. The drum receives its motion from the radius rod of the engine, or from any other part of it where a convenient motion can be obtained, as is the case with any other indicator. Thus the steam causes the pencil to rise, and as the steam leaves the expanding and contracting sickle the vacuum acts in drawing the pencil down below the atmospheric line. The atmospheric line is that where the pencil rests when it is free from any action of either steam or vacuum—*i.e.*, when the communication between the cylinder of the steam engine and that of the indicator is cut off. This alternate operation of rising and falling of the pencil takes place at every stroke of the engine when the opening between the cylinder of the steam engine and that of the indicator is clear—*i.e.*, allowing the steam and vacuum to act upon the indicator. Those acquainted with Richards' indicator will at once perceive that the action of the pencil is obtained much in the same manner by acting on a lever in this way; the diagram is freed from the flirting at the commencement, and thus the lines are more regular.

Certain Points to be attended to in the Working of Indicators.

We have warned the user of the indicator in a former paragraph of this paper as to three important parts which require continual care and attention, in order that it can work accurately and thus be a true guide. One thing is to keep the piston clean, free from grit or any kind of gummy substance, as either one or the other would lead the operator into a wrong channel. It might not only mislead the owner or operator, but might also cause a mistrust in his mind and lead him to abandon the use of the indicator without any warrant for so doing. The next point is to pay attention to the cleanliness of the spring, and in other respects to be careful that it is not in any way injured; and in the third place use all necessary precaution with the piston rod, lest it should come in contact with anything that would put it "out of truth." An injury arising to any of the three parts named would be detrimental to the production of a correct diagram. The delicacy of the machine is such that a little friction would very much mislead—in particular where the indication was intended to ascertain the number of horse-power which the steam engine was performing. Unnecessary friction would lead to the following results. The engine would not indicate the amount of horse-power that it was actually giving out, and therefore the owner might think that more machinery might be added with safety, and such addition might prove disastrous to the engine. Secondly, in case the indication was for the purpose of ascertaining the power that a tenant was consuming, the proprietor would be a sufferer.

We refer to this for two reasons. First, to show how desirable it is that the indicator should be kept in truth, and that it should be, in short, as free from all unnecessary friction as possible, allowances being already made for unavoidable friction. Secondly, by so regarding such possibilities of extra friction that correct indications may be taken, as is necessary both to the power hirer and the power letter. Kenyon's indicator claims four points of advantage over others. We shall satisfy ourselves by referring to one only of the four proposed advantages—namely, "absence of friction." In this indicator the only friction which has to be guarded against is in the pressure of the pencil which describes the diagram upon the paper. This is only what all other indicators are liable to; the same allowance being made for the moving of the pencil, and to overcome the weight of the metal to which the pencil is attached. It must be evident that it is freer from friction than any other which contains a piston. It might also be termed "frictionless" practically, as well as "pistonless."

Importance of a Certain Point in the Use of Indicators—The Kind or Class of Oil used for the Machinery driven by the Engine to be Indicated.

Before illustrating and describing the various kinds of indicators which are in use, each form having some claim for perfection over others, we shall refer to a matter which those who have steam engines should be made acquainted with. This is another very important duty which the indicator is so well calculated to bring before those who are interested in the economical working of their machinery. All business men plead that trade is so finely run that to work an establishment otherwise than with all economy consistent with efficiency would be ruin. Saving is said to be good earning, when judiciously done.

We have at different times been much surprised in our experience to find changes in the diagram, showing variation of the total indicated power of a steam engine, taking place sometimes to a very considerable extent. The first thing to be done is to ascertain that the indicator works freely, making all necessary examination of those parts that can produce extra friction. Very frequently we have found the indicator to be free from this, so as not to be the cause of such a result.

What we mean by the variation in the diagram is that it is much larger than on former occasions of trial. We at once make the necessary inquiry at headquarters. 'Have you been adding any machinery to your concern since the last indication?' The answer is sometimes, 'No!' 'Have you been "speeding" any of your machinery?' Answer again, 'No.' In regard to the latter question, the young reader must bear in mind that to run machinery at a higher speed is equal to adding more machinery, in view of the extra power being required to turn it. Finding, from the above inquiries, that no extra power is required from the steam engine, further inquiries are therefore still necessary. 'Are you using the same kind of oil now as on former occasions in your machinery, in part or throughout?' The answer to this is practically 'No!' for we have generally found that a different quality of oil was being used for the machinery. In our experience we have found a difference arising from this course, varying from 5 per cent. to 12 per cent. in power. When we have reported this fact to the proprietor it has often been disbelieved. We have been told that the class of oil now in use is of a superior quality, specially prepared. When a higher price is paid for an article, it is only natural to hope that a better article shall be obtained—at least, this is expected. This hope is not always realised. The competition in the oil trade causes all kinds of admixtures, and different processes to clarify them to be used.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER V.

Various Points connected with the Circle.—A Chord—An Arc—Tangents.

The "chord" of a circle is a line which joins two points of the circumference, as the line *a b*, fig. 14; the curved part, *a c b*, is called the "arc" of the chord. Two radii, as *d e*, *d f*, cut off a part of a circle, as *d f e g*, called a "segment." The diameter, as *h i*, is the largest "chord" which can be drawn within the circumference of a circle. Of two chords, *h i*, *j k*, fig. 14, the smaller is the one which is farther from the centre, at *l*. Every perpendicular line drawn in the middle of a "chord," as *m n*, must always pass through the centre, *l*, of the circle.

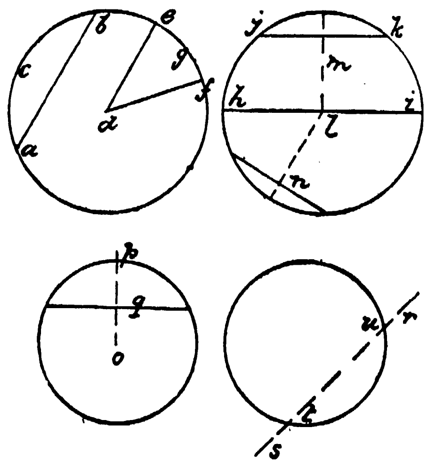


Fig. 14.

The "arc" is a part of the circle, as *c*, joining the ends, as *a b*, of the "chord." The "rise" or height of the arc is the perpendicular line, as *q p*, drawn from the centre, *o*, of the chord to the circumference, at *p*. This line prolonged, extended or continued, always passes through the centre, *o*. The measurement of the arc is the number of degrees of circumference comprised between its extremities. If the entire circumference were 37 m. 68 c., and the arc 42°, the latter would measure $\frac{42}{360}$ of 37·68, or 4 m. 39 c. The arcs comprised between two parallel spans are equal.

The "secant" of a circle is a line, as *r s*, fig. 14, which cuts the circumference in two points, as *t*, *u*.

The "tangent" is a line, as *a b*, fig. 15, which only touches the circumference externally at a point, as *c*, which is called "point of contact." The lines *d e*, *f g*, are also tangents to the circle. They are often called "tangential lines."

The perpendicular line drawn from the tangent to its point of contact always passes through the centre, as *h*. Thus every line, as *i j*, drawn perpendicular to and at the extremity, *k*, of a radius *l k*, is a tangent.

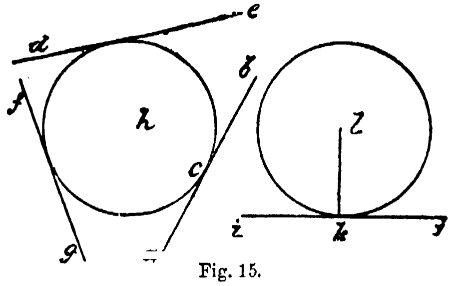


Fig. 15.

Two circles are tangential when they have only one point of contact, as at *a b c*, fig. 16, which is on a straight line with the centres, *d e*, of the two circles.

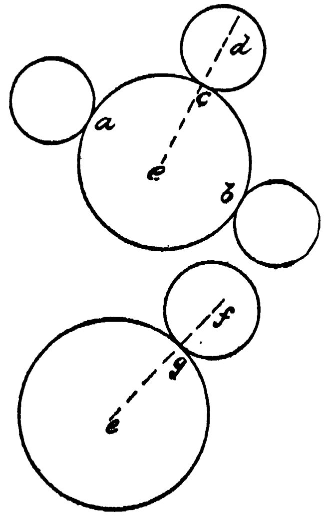


Fig. 16.

Two circles are externally tangential to each other when the line, as *e f*, which joins the two centres, *e* and *f*, is equal to the sum of their radii, *f g*, *e g*. To draw a tangent to a circle, or through a given

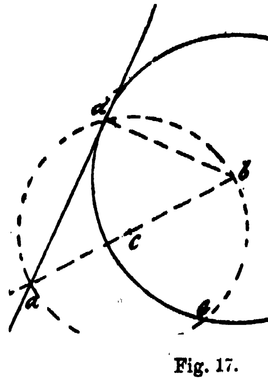


Fig. 17.

point, *a*, fig. 17, connect the point *a* with the centre, *b*, of the circle by a straight line, *a b*. Bisect this straight line at the point *c*, and with a radius equal to half of it, as $c\ b$ or $c\ a$, describe a circle $a\ d\ e$, which will cut the circle described from b in a point d—this will be the point of contact of the tangent passing through the point a.

Two circles, $a\ b\ c$, $d\ e$, fig. 18, are internally tangent to each other when the distance between the centres, f and g, is equal to the difference between the radii $f\ c$ and $g\ c$. If the distance of the centres of two circles be greater than the sum of the radii of the two circles, there will be no contact. If the distance of the centres be less than the sum of the radii, these two circles will intersect.

The drawing of various parts of machines, architectural mouldings, etc., is based on the properties of tangents and tangent circles. This forms, therefore, one of the most important parts of engineering and architectural drawing. (See paper "The Building and Machine Draughtsman.") We cannot be too careful in drawing them exactly, keeping in view,

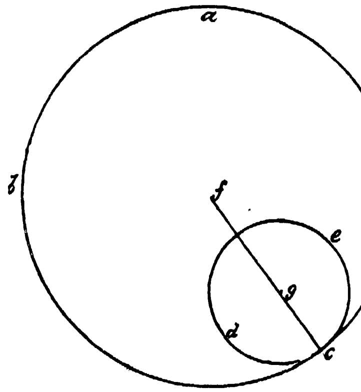


Fig. 18.

for facility of execution, that a tangent line is always perpendicular to the radius, starting from the point of contact.

The Degrees of a Circle—Degrees in a Semicircle, and in a Quadrant—The Setting out of Angles of any given Number of Degrees by the Use of the Protractor—How to Construct a Protractor.

If through the centre of a circle, fig. 19, we draw two diameters, $a\ b$, $c\ d$, resting in the centre, e, we form four right angles—the ends of each diameter dividing the circle into four equal parts. We have before said that a right angle is one of 90°, two right angles give 180°, and four 360°. Each degree is the 360th part of the whole circumference, which in practice is supposed to be divided into this number of *equal* parts. One of the "quadrants"—which, as we have said, is the name given to the fourth part of a circle, as $a\ c$—is shown divided, and when two quadrants or a semicircle is divided we obtain an instrument known as the "protractor," which is exceedingly useful in the setting out of angles of various kinds and extent in degrees. To construct a "protractor" (fig. 20—see next paragraph) proceed as follows: Draw any line $a\ b$, and from a point about the centre of it, as c, as a centre, with any convenient radius, describe the semicircle $a\ d\ b$. From c, at right angles to $a\ b$, draw the line $c\ d$, through the point of the 90th degree (90°). Starting from the right hand of the line $a\ b$, divide the arc, or part of the circle from b to d, into nine equal parts, as in the points 1, 2, 3, 4, etc., the ninth part terminating at d. Draw the inner circles, or rather semicircles, as shown in the diagram, fig. 20; and from the points 1, 2, 3, 4, etc., draw radial lines to the centre, c, cutting those semicircles, as shown in the semicircle starting from g in the point h. Divide each of the parts thus obtained in the semicircle $h\ i$ into ten equal parts, and each of the outer divisions on semicircle $b\ d\ a$ into twenty. The divisions on the semicircle $g\ i$ are "degrees," and those on the outer circle, $b\ d\ a$, are half-degrees—or 30 minutes—each

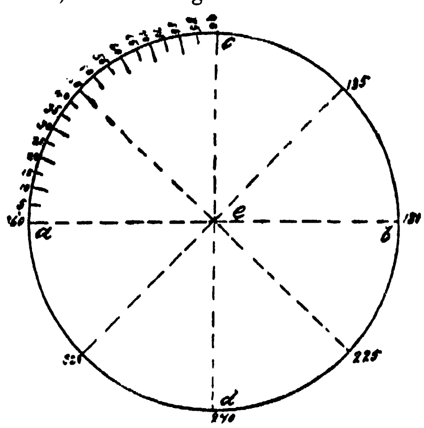


Fig. 19.

degree being again divided, or supposed to be divided, into 60 equal parts. While a "degree" is indicated by the mark or sign °, a "minute" is indicated by a single accent, ′: thus, 69° 30′ reads "sixty-nine degrees thirty minutes." The point e indicates the position of the angle of 45°, an angle much used in engineering and architectural drawing, and is that which forms the "set square" $a\ b\ c$ in fig. 8. We have, in describing this figure, stated that this "set square" is virtually half of a square; this is illustrated in fig. 20, in which the square $a\ c\ d\ f$ is completed by drawing the lines $a\ f$, $d\ b$, at right angles from the points a and d; intersecting at f, through which the line of angle of 45° at e, if continued, will pass. The inner circle, as $j\ k\ l$, gives at the points where the radial lines from points 1, 2, 3, 4, etc., cut it, the points indicating the "complementary angles." Thus the angle of 40° in the outer circles gives the angle (the "complementary angle") 140°, the two together making up 180°.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER V.

Carmine or Crimson Lake.

THIS brilliant crimson pigment, so much a favourite with artists, is a preparation from the cochineal insect (*Coccus cacti*). It is a pure bright crimson-red colour, but unfortunately is unstable—it is easily destroyed, and on exposure to light and air loses its colour. Although it has to some extent been superseded by more permanent lakes prepared from alizarine, it is yet very extensively used as an artists' colour. A variety of processes—or rather, modifications of one or two processes—are in vogue for the preparation of carmine.

The colouring principle of cochineal is named *carminic acid*, and according to Schützenger is represented by the formula $C_9H_8O_5$; it may be obtained for experimental purposes by exhausting cochineal with water; then precipitate, with slightly acid subacetate of lead not in excess; wash the precipitate with water, then decompose with sulphuretted hydrogen. The sulphide of lead formed is filtered off, the filtrate is evaporated to dryness and treated with alcohol, which extracts the *carminic acid*. It is of purple colour, soluble in water and alcohol, and dissolved by sulphuric and hydrochloric acid without alteration. It yields red lakes with alkaline earths, and acetates of lead, copper, and zinc.

Preparation of Cochineal or Crimson Lake.

3 lb. of the best cochineal is boiled in 10 gallons of water until all the colouring matter is dissolved. A solution of 3 oz. of carbonate of soda in a pint of water is then added, and the whole is boiled for an hour or two hours. It is removed from the fire and allowed to settle; the clear supernatant cochineal liquor is poured off, and 3 oz. of ground alum dissolved in a pint of water is then added, with vigorous stirring, for which purpose a long brush is well suited. The mixture is allowed to cool, and 3 oz. of egg-albumen previously dissolved in 10 oz. of water is added. The mixture is well stirred and gently heated, after which the liquid is allowed to cool, when the carmine lake settles, and may be washed by decantation and thrown on a filter, when it is ready for use. The product obtained is a pigment of great brilliance, which is completely soluble in ammonia, and which on ignition leaves a white ash containing alumina. Crimson lake may also be prepared by heating the aqueous solution of cochineal with excess of freshly precipitated hydrate of alumina, and if the latter be well washed before employing it, the lake will require very little washing to fie it for use.

Preparation of Carmine with Alum.

Introduce 1 lb. of the best powdered cochineal into a pan containing 6½ gallons of boiling water—the more free from lime and other impurities the better. Mix up well together, and boil—with stirring—for about a quarter of an hour. Add 1⅛ oz. of pure powdered alum, stir well, cease to boil, and at once filter into earthenware settling pans. After three to four days' settling a quantity of carmine lake of the finest quality deposits at the bottom; the supernatant liquor is therefore drawn off into another settling pan, and on standing several days a further deposit is obtained, which forms a lake of inferior quality to the first. The first deposit is collected, washed with hot water, and collected on a woollen filter. The carmine so obtained cannot readily be surpassed for brilliance of shade. It is not, strictly speaking, a lake—and hence is generally spoken of as "carmine"—no definite compound seems to be formed between the colouring matter and the alumina—the precipitation of the red "carmine acid" is probably due simply to coagulation of albuminous matters which carries it down. The liquor remaining after the second deposit still contains a considerable quantity of colouring matter, and may be utilised for the preparation of carmine lake by means of carbonate of soda and alum.

Testing Cochineal Lake or Carmine.

Cochineal lake is a true pigment, a compound of carminic acid and alumina, insoluble in water, alcohol, ether, and the essential and fat oil, and in acetic acid, but soluble in hydrochloric acid. In ammonia and in caustic soda it dissolves to a deep red solution, the former solvent depositing the lake unaltered on exposure to the air or neutralisation with an acid; the latter on cautious neutralisation yielding the original lake, but of impaired beauty. Any residue left undissolved by either of these alkalies may contain starch, sulphate of baryta, vermilion, or other mineral pigment. The red-woods, such as Brazil-wood, peach-wood and sapan wood, resemble cochineal in many of their properties, but differ in their behaviour with acetate of lime, which yields with them a violet solution, whereas cochineal gives a dark-purple, almost black, precipitate. From madder lake, carmine lake is readily distinguished by the reactions given hereafter when treating of the latter pigment.

Madder Lake.

Unlike carmine and brazil-wood lake, madder lake adds to its quality of beauty that of permanence. It resists the action of light and long exposure to the atmosphere. It is prepared either from the madder root, or from garancin—a preparation of madder—or from artificial alizarine. Although the last-named material is the cheapest to employ, and the cleanest, it has not yet superseded the older methods that make use of the natural root and the prepared product garancin.

Madder lake, as prepared for use in painting, or alizarine lake, is a true pigment: it consists of the brilliant scarlet or crimson precipitate of alizaric acid or purpuric acid with alumina, which is perfectly insoluble in water, and remains unaltered when exposed to the light and air for a long time. Hence madder lake is preferable to cochineal or brazilwood lakes when the shade desired can be obtained with the former. Cochineal lake may be made of a brighter, more fiery shade of red than madder lake—otherwise the latter would in nearly every case take the place of the former.

From artificial alizarine may be obtained different shades of lake by employing different qualities of alizarine. Commercial alizarine appears in the market in shades varying from a very yellow to a very blue shade—which variety in shade is due to the respective quantities of alizaric and purpuric acids of which the alizarine is composed, the former giving blue and the latter yellow shades. With madder and garancin but little variety of shade can be obtained.

Madder Lake prepared from the Root.

The following recipe for the manufacture of madder lake from madder root has been very extensively followed, and the product yielded is a lake of fine quality. 1 lb. of the best madder root is enclosed in a linen bag of fine texture, and beaten with a pestle in a large mortar, with 1½ to 2 gallons of pure water —free from lime—added in small portions at a time until nearly all the colouring matter is extracted. This muddy liquor is then made to nearly boil, and gradually poured into a boiling-hot solution of 1 lb. of pure alum in 1½ to 2 gallons of pure water. A solution consisting of 12 fluid ounces of a saturated solution of pure pearlash, or carbonate of potash, in ½ gallon of hot water is then gradually added, with constant stirring. A beautiful scarlet lake is immediately precipitated; it is allowed to stand for at least twelve hours, when the clear supernatant liquor is poured off, and the vessel filled up again with pure *boiling* water; and after settling and running off, the precipitate is thrown on a flannel filter, washed thoroughly with hot water, and, after draining, the product is carefully dried in an air bath at a temperature not exceeding 100° C.

Madder Lake prepared from Garancin.

Commercial garancin, or, as the French call it, *charbon sulphurique*—which is prepared by steeping madder in strong sulphuric acid and subsequent washing—is more suitable for the preparation of madder lake than the root itself, and is the material usually employed. 1 lb. of garancin is boiled with 2 gallons of pure water, and then 1 lb. of pure alum dissolved in a little water is added, and the boiling is continued for about 1½ or 2 hours. It is allowed to settle partially, and at once filtered, before cooling, through flannel. To the filtrate is then added ½ oz. of tin crystals, and also carbonate of potash, or soda in solution, with constant stirring of the mixture in quantity insufficient to precipitate the whole of the alumina. It is now filtered through flannel and well washed, and a beautiful lake of most brilliant hue is obtained. The first filtrate is of yellow colour, but contains a considerable amount of colouring matter, and is used in the preparation of lakes of inferior quality.

The garancin originally treated as above described also contains yet a large amount of alizaric acid, and is boiled with water and treated exactly as described, when a lake is obtained which is slightly inferior to the above in brilliance.

Testing Madder Lake.

As paints which are sold as madder lake frequently are mixtures with other less valuable lakes, or contain no madder lake at all, the method of distinguishing it may be of use to our readers. Madder lake should be completely insoluble in water, hot or cold; if a small quantity of red or purple solution comes out on treating with water, it is probably due to an excess of alkali, which is objectionable in painting; the lake should be quite neutral, or contain only a slight excess of alum. Hence a small quantity—about a drachm—of the sample is warmed in a test-tube with a little water, and allowed to stand, or filtered through thick filter paper: if the supernatant liquid or filtrate be red or purple, and it turns red litmus blue, alkali is present in excess. The precipitate remaining is now warmed with a solution of caustic soda, madder lake dissolves completely to a deep purple liquid; and on adding now excess of hydrochloric acid the colour is destroyed, and a copious orange precipitate of alizaric acid forms and falls down in flocks. If now this be collected on a filter and washed and treated with ammonia, a beautiful deep purple solution of ammonium alizarate is formed, which, on addition of alum, loses its colour and precipitates again as a red lake. The amount of pure alizaric acid contained in a sample of madder lake may be estimated by applying these reactions and weighing the orange precipitate of alizarine obtained. On igniting madder lake a white ash of alumina is obtained.

"Rose" Pigments.

Under the name of rose-pigment occur in the market a variety of products of variable composition, for use chiefly in paper staining and distemper. They are not real pigments, as repeated treatments with hot water washes out most or the whole of the colour, leaving a residue of sulphate of lime or baryta, chalk, or carbonate of baryta.

THE CARPENTER AND HIS TECHNICAL WORK.

ITS ORIGIN AND EARLY PROGRESS—THE PRINCIPLES AND DETAILS OF ITS PRACTICE.

CHAPTER V.

IN a framing thrown across—or "spanning" as the technical phrase is—a void or open space, *f f* (fig. 25, p. 359, vol. i.), as between two walls, the beam is called specifically a "tie beam." And although inclined, as at *c d*, in fig. 22, the inclined pieces *a c*, *b c* (fig. 25), are not, as in fig. 22, termed struts or braces, but "rafters." In a king-post roof truss, as in fig. 25, at *a b*, *c d*, *e e*, other members placed diagonally supporting the rafters at a certain point in their length are placed as shown at the dotted line *d*. Timbers so placed in a truss are then called struts or braces; the vertical post *c d* is called a "king post."

We trust that the reader who has done us the favour to read the foregoing matter will have obtained not a little information on the strictly technical points of the art of carpentry, and a fair idea of some of the leading principles upon which it is based. This will be all the more clearly perceived as he proceeds to the consideration of the various departments which will form the subjects of succeeding chapters.

Iron used in the Construction of Framing generally considered as belonging to the Work of the Carpenter.—Present and Future Use of Timber in his Construction.

It is scarcely necessary further to allude to the development of the art of carpentry in the later phases of its history. Suffice it to say that up till a comparatively recent period timber was the material employed in the construction of every kind of framing, and that some of the best examples were shown at periods of European history which some are disposed to think were, as they are generally called, the dark or middle ages. Of these ages, however, it may be truly said that they tended at the least to conserve or preserve arts which would otherwise have died out, and their reproducing or re-invention been necessitated. It is only within times comparatively, or, as may with truth be said, absolutely recent, that timber in the construction of a wide variety of framing has been superseded by iron. At first the form or variety of this metal chiefly used was that known as "cast iron." (See the paper entitled "The Iron Maker.") Then followed the superior material, wrought or malleable iron; and this latter, so long used and so valuable, is now being gradually, if not quickly, superseded by steel (see "The Steel Maker").

But although those metals have been largely used and are still used for the construction of framing, to the exclusion of timber, the at one time universally employed, and indeed only available material; still there remains, and will, so far as we know, long remain, a wide field for the employment of timber in the large works in which it proves so useful. As a rule, iron and steel are employed only for the large—in many instances, vast—structures or framework of civil engineering, as bridges, viaducts, in railway work, etc., etc. But for the wide variety of roofs, partition floors, etc., etc., used in civil architecture, as churches and public buildings—and in domestic architecture, as in houses, rural structures, and the like—there is still a wide field for the exercise of the skill of the carpenter, and which will long demand the use of the material in which he works. Even, indeed, in the large structures we have alluded to as coming within the domain of the civil engineer, in which he uses wrought iron or steel, he finds the services of the carpenter, with his timber, absolutely necessary. In this the heavier material possesses many advantages for what may be called the foundation framing or scaffolding by which and upon which he raises his superstructure of iron and steel.

Carpentry, then, still remains an important branch of technical work, for which there will still be a wide field in which those who follow it will be able to display their skill in execution and their ability in design. That this will be so for a long time in our own country is beyond a doubt. The uses to which timber in the large, as contrasted with it in the smaller "scantlings" or sizes used in the sister arts of joinery and cabinet making (which see under the special heads of "The Joiner" and "The Cabinet Maker"), can be put are so numerous, and the ease with which it can be adapted to various combinations of design so great, that for long time to come at least carpentry will be one of the most important branches of national industry. But if timber be less used now than it formerly was on the continent of Europe—and it is chiefly in the more gigantic works of the civil engineer that it has been superseded by iron and steel—in the continent of the New World we find it is used on the most extensive scale. Throughout the United States of America, specially, and even in our own great colonial possessions in Canada, not merely do we find it used universally in all works of the architect and builder of civil and domestic structures, but we have an almost endless variety and number of examples of the adaptation of timber to the more gigantic and complicated structures met with in public works, alike on the road, the river, the sea margin, and the railway. If this feature be less marked in our other colonies, such as on the Australian continent and in our colony of New Zealand, and our still more important possessions in India, even there timber is largely used in construction. And this is likely to be the case for long, for timber is abundant to a degree of which those who have not a personal knowledge of those countries have not even the slightest idea. And this work, in the pages of which these chapters on the art of the carpenter's work will appear, although perhaps more especially designed to meet the wants and wishes of the large and most important body of technical workers in our own island home, nevertheless addresses itself to their brothers in skill and business energy in all countries, however distant, in all our colonies, however remote, in which is spoken and read the "grand old English tongue" in which Shakespeare wrote and Milton sang. So that for these papers of ours we have a wide circle to address, a numerous *clientèle* to cater for. And although as compared with some of the branches of our technical trades and arts, the branch of technical work we in these chapters are now concerned with may not possess all the features of, shall we say, popular interest? still we can safely claim for it that of a special and a truly scientific one second to none. Apart from its practical details, always interesting and suggestive, scientific theories, or rather, as we should say, principles, are concerned and mixed up with it, which in many departments are specially applicable to other branches of technical work in which mechanical construction is a marked, if not the only distinct and special feature. While, therefore, we do not wish to overestimate the importance of the subject of those special chapters, we believe it to possess or carry along with it practical work and scientific considerations of a high value. And if, in addition to those who have a special and direct interest in its operations, as forming the work of their daily lives, we can impart to others who have not merely a general desire to add to their acquirements, but what is called a taste for mechanical work, some interest in the work of carpentry, we shall be abundantly rewarded for such labour as the preparation of our chapters has entailed upon us. It is well when the work we have to do can be claimed as a labour of utility; it adds a fresher zest to that work when it comes under the category of a labour of love.

Varieties of First Class of Joints—Square Joints.

We have in the preceding paragraphs presented some remarks and illustrations connected with the use and cutting up of timber, the representative joints by which pieces are secured one to another, and with the elementary points of framing or of framework. From these the reader will have gleaned some idea of the first principles of the art, and will be prepared now to take up the systematic consideration of its various departments, of which the first will be those of joints, beginning with that illustrated in fig. 1, which we have already given as one of the representative joints. In this the piece *a a* (fig. 1, *ante*, p. 11, Chap. I., vol. i.), supposed to be lying horizontally, as, say on the ground soil, forms what is technically called a "sill," which is very likely to be a mere corruption of the word sole, or base. This term, further and more specific illustration of which will be given hereafter, is often spelt as "cill," but if our derivation be correct this is wrong, and the other, and we may say perhaps the more usually adopted mode of spelling the word, with an *s*, is the right one. To the sill *a a* the vertical piece *b* is to be joined. The simplest method of effecting the junction would be merely to rest the end of *b* upon the face of *a a*. In this case its mere weight, on the principle of gravity, or the pressure exerted by any mass of material supported or carried by the timber (*b*), would have to be trusted to to keep the piece *b* in its position as placed in *a a*. This simple method is still often adopted in the practice of the present day, but it is needless to say only in cases where the pressure is great which is exerted on the piece (*b*), and that pressure only in a vertical direction or parallel to the axis of the piece. By the term "axis" of a piece of timber is meant an imaginary line which passes through the centre of the piece. If it were circular the axis would pass through the centre; if the two ends were square or rectangular, through the point of intersection of two diagonal lines drawn from opposite corners of the square or rectangle (see "The Geometrical Draughtsman").

If the simplest of all the methods of joining piece *b* to *a a* above described were adopted, the efficiency of the junction would obviously depend upon the condition in which the two joining surfaces were. If the surface of *a a* at the point or place of junction were uneven, or if this were the case at the surface of the end of *b*, the inequalities of surface would prevent the whole of the two surfaces touching each other. The one piece at *b* would clearly "rock" from side to side exactly as it was moved, and this evil would be all the more pronounced, not merely in proportion to the unevenness of the surface of either one or the other; if both surfaces were unequal. The joint here supposed is one in which the one piece *a b* merely presses against the surface of the other at *a a*; and the piece *b* is said technically to "butt," this term being obviously a corruption or rather a compression or shortening of the term "abutment," for which see the paper under the head of "The Stone Mason." The point of junction at *c* is technically called the "seat" of the joint, or the actual place or position which the joint end of the piece occupies in the other.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

93. Ventilation of Dwelling Houses.

VERY much is this important department of sanitation spoken of, and nearly the same things may be said of—and are, indeed, often said about—it as about drainage, a cognate branch of the art of healthy house arrangement and construction. Almost every one, when closely put to it, admits its importance as a means of helping on the maintenance of good health; and very many profess to know a good deal about it, and have schemes of their own, which they are clear would be most efficient. Notwithstanding all this, what is the actual fact in practice? We have our public buildings in most cases ventilated, or they are said to be ventilated, which seems to satisfy most people as highly as if they really were. But what of our private houses—the dining-rooms in which we partake of the necessities, the drawing-rooms of the elegancies, and, above all, the bedrooms in which we gain the repose and spend most of the time of our life? Why, not one in a thousand—a very much greater proportion than the latter term might with all safety be used—of those rooms have the slightest attempt made to ventilate them! How does this arise, that a point upon the value of which nearly all are agreed is not acted upon? Drainage stands upon a much higher platform, for it is carried out in a very large proportion of our domestic buildings; but ventilation, as we have seen, is not so.

The public are not to blame wholly for this state of matters, although they are ready enough to blame the architects and builders for not being able to ventilate their dwellings; neither, in spite of this, are the men of those professions wholly to blame for it. Probably the statement is near the truth which maintains that the blame must be pretty equally divided between them.

There is, however, more to be said in favour of the architects than of the public who employ them. In the first place, ventilation is not an easy thing to carry out, especially in our domestic structures, built and arranged as they are. In theory it seems all "plain sailing"; it is in practice quite the reverse. Plans by the score have been introduced during the last twenty or thirty years, each of which claimed on its advent to be the one which would overcome all difficulties; but, notwithstanding, we are very much in the position in which we were when those plans began to force themselves upon public attention; for one after the other has more or less failed, to be succeeded by another only to meet with the same unsatisfactory fate. This indicates what, in reality, is the truth.

Again, the public as a rule have a very considerable objection to ventilation when it *is* carried out on some plan or another. In their mind, ventilation seems to involve nothing more than this—the getting rid of the foul or used air. But it is something more, for it involves the supply of fresh air, without which, and in proportion to the withdrawing of the foul, there is and can be no ventilation—in the sense, that is, of being efficient. Now, the admission of fresh air to an apartment to supply the place of the foul seems an easy thing to provide for. In one respect it is easy; but then, seeing that the easy method is strongly objected to, because it creates currents of air more or less sensibly felt, it is very difficult, inasmuch as those currents must—at least, the public has determined that they shall—not be felt.

If the British public has a horror well defined and universally shown, it is that of "draughts." One has only to say the word to conjure up a long list of evils arising from their existence. And if fresh air be admitted, no matter how, and at any point, no matter where, the British public at once makes up its mind that there must of necessity be draughts, and that these will play all sorts of mischief upon themselves and their unfortunate families.

If architects, then—or "ventilating doctors," as they have been called, for them—can introduce into any room of any house a system of ventilation in which appliances for admitting fresh air play a part, the "system" very soon gets its quietus. Try to introduce a plan in the rooms of the poor: they soon decide the point by stuffing up all the apertures with very little ceremony, and too often with many dirty rags. In houses of the better class a little more politeness to the architect is shown,—he is at the least consulted,—with, however, a very plain hint what the result of the consultation must be: "the thing must be stopped, for it will never do, you know," so that the practical result is the same in both cases of rich and poor.

Until the public, then, can make up its mind to believe that ventilation *cannot* be effected without establishing currents of air, and these currents are *not of necessity* draughts, and that some draughts are not dangerous, ventilation will never be general; and all the talk about its importance will be seen to be what many have long known it to be, "mere talk and nothing more." We have said that currents of air are not, nor do they constitute of necessity, draughts. This of course must be taken with a reservation; that is, it will depend how and where the currents of air are admitted to the room. As on drainage, so on this subject, we do not intend to enter into any lengthened disquisition as to its principles—we merely wish to draw attention to a few of the leading points of its practice. The modes of admitting fresh air to the rooms of dwelling houses are very numerous, and various appliances more or less complicated have been introduced from time to time in order to get over the difficulties of draughts. The simplest, if it be not the most elegant, is what is known as Sheringham's ventilator, which is a valve capable of being opened and shut to any required degree by simple apparatus worked in the interior of the room. It can only be applied in cases where there is an outer wall; the air being admitted directly from the external atmosphere. It may of course be applied to an inner wall which opens into another apartment or passage, itself supplied with pure air. The valve is fixed near the ceiling, so that the entering air is mixed with the heated air at that part, and becomes so warmed that in descending it is not felt as cold by those in the room; and it is also so diffused amongst the surrounding air that the currents or draughts are if not destroyed rendered almost imperceptible. Now, we wish to draw attention here to one point in this mode of admitting fresh air; and that is, the air being generally much colder during the greater part of the year than that within the room, is felt by those sitting in it, and it is at once pronounced that there is a draught. But if that air were warmed to the same temperature as that of the room, the almost certainty is that no objection would be raised; because it would not be felt. We see, therefore, that it may be suspected that the objection is not so much to draughts as to *cold* ones. If the air were warmed they would still nevertheless be there, but not being sensibly felt, would not be suspected to exist, and not being known, would not be objected to. It is a very good exemplification of the proverb, "Where ignorance is bliss 'tis folly to be wise." Our space precludes us from giving in present note all that we have yet to say on the general features of this important question; this we propose to give in our next part.

94. Ensilage.—Crops suitable for the Process.

In Note No. 21, p. 137, vol. i., and in Note No. 89, p. 68, in the present volume, we gave some general information as to this system of preserving green food for cattle and dairy stock, a process which is every day growing in importance, and its adaptation to the working appliances of the farm steadily increasing. In view of this, and of the way in which it meets one of the most pressing difficulties of the farmer—specially of the dairy farmer and the grazier—space will not be given uselessly to a pretty full detail of all the points connected with it. This we propose to give in this and succeeding notes. We intend to first take up the consideration of the crops suitable for the system—for, like other systems, it has its special demands, which must be attended to before success can be secured. We shall then pass on to the points connected with the value of the preserved produce of the silo, or silage as it has been termed—this opening up the chemical and physiological points involved. From this we shall proceed to examine how far it is likely to meet the future necessities of the farmer, and to become a permanent part of dairy farming. Under these heads we hope to be able to present some views worthy of consideration, not only as bearing specially on the system, but of practical value in relation to feeding of farm stock generally. We propose to conclude the subject by explaining the methods of constructing and also of filling or packing the silo, so as to obtain the produce in the best form adapted for feeding and in the most economical way.

When the system of ensilage was first introduced its promoters had in view only one object—namely, the making it a readily available, economically carried out, and practically useful substitute for the process of haymaking, which, as carried out universally, was at the best an expensive one, demanding much labour, and that at a season of the year when labour was difficult to be obtained; and when, moreover, it was so much required for other work of the farm, even when it was available. This, however, was not the only objection to the process of haymaking: the chief one—and that which in some seasons operated so powerfully that the crop was practically lost, or so deteriorated that its value was reduced so that frequently the crop did not pay the cost of procuring it—was the uncertainty connected with the process, dependent as it was upon the condition of the weather when the crop was ready to be harvested. No one who has had any experience in arable land and meadow crop cultivation, but has had painful and costly experience of this element of uncertainty in connection with the hay crop. No doubt many a good crop has been, and is now every season lost, simply, at all events chiefly, through a lack of careful observation as to weather, etc., and from a positive indifference and a habit of procrastination. But with those who are not lacking in observation, and who certainly are industrious to a degree, and know nothing of the evils of procrastination, the same element of uncertainty exists. It is all very well to counsel the farmer to "make hay while the sun shines," which he is only too glad to do; but what when the sun does not only "not shine," through being cloud-obscured, but the same clouds keep pouring down showers as heavy as they are persistent; or while, if the sun does shine so long and so well that the crop is saved nearly up to the period of being ready for housing in good condition, it ceases to shine and its place is taken by such continuous rain that housing in this good condition is impossible? An "out-and-out good" haymaking time is, in this weeping climate of ours, a very rare occurrence; the weather, indeed, at its best average can only be said to be of that kind of negative goodness described by the phrase "mixed middling," or "catching."

Ensilage, then, at first was, and with many still is, looked upon as a system which offered, and still offers, an escape from the evils of ordinary haymaking, and the crop for which it is adapted is thus naturally looked upon as being one only—namely, meadow grass. Extended experience with it, and for the matter of that but a moderately complete examination of what its principle is, has shown, or will show, that the system of ensilage is adapted to a very much wider range of crops than the single crop above named. Still meadow grass may be taken as the type of farm produce best suited for ensilage preservation; a produce when cut green—that is, before it is dead ripe, and therefore practically dry—in which green condition it is succulent, or full of its juices which have not gone to ripen the seed, or been dried up by too long standing uncut. In this succulent or juicy condition the grass is lithe and its stalk and its points tender, so as to be easily crushed or made to lie close when placed in contact with other stalks, and the whole pressed down by the compression which forms the feature of ensilage. When meadow grass is in this condition, juicy inside, yet not thoroughly wetted or drenched with rain, it forms the typical farm produce best suited for the ensilage process. And taking this condition as a standard, one can judge at once whether produce proposed to be used for ensilage is really fitted for it. This standard embraces within its limits all the artificial or alternate husbandry grasses, and also all the clovers. It further includes green-cut grain crops, as rye, all oats, and also maize or Indian corn—on which latter we shall have a special word or two to say—as also spurry, well suited for growing in soils too poor to grow almost any other crop—while it takes in also tares or vetches, lucerne, and sainfoin. It is scarcely necessary to add that ensilage enables those odd plots or corners of land, or parts of plantation, orchards and the like, in which grasses more or less rough or rank, but generally luxurious, are met with, and in conditions which would make their preservation in the form of hay a work which it would not pay to do, and which grasses also grow in situations in which it is seldom convenient or proper to turn in the live stock for the purpose of eating them off. We have thus such a wide range of produce at command suitable for the ensilage process, that it is a pity to waste the time—if nothing else be lost or cared for—in trying to use under it such crops as are obviously, on due consideration, unfitted for it. Of those, the forage crop known as the "prickly comfrey," of late much lauded by some as a forage crop for live stock, is shown on all hands to be quite unfitted; and the attempt to preserve by it leaf crops, especially such as cabbage—from an altogether erroneous estimate of the cabbage as a forage crop, and from an overlooking of its habits of growth and of the methods by which it is cultivated, and of its own natural keeping properties—has proved abortive.

In naming the typical ensilage crop we have alluded to its being partially dry, or so far so that it is not drenched or thoroughly soaked with rain, as one of the elements of an ensilage crop best suited to be successfully preserved. This may seem strange to some readers, who may have hitherto been under the impression that the one general feature and great advantage possessed by the ensilage system is that grass can be saved and preserved in good condition by it, which could not be saved by the ordinary process of haymaking in an adverse season; or if saved, only in a condition greatly deteriorated by the wet to which it is exposed. But while it is quite true that ensilage can be, and is, made thoroughly successful in the preservation of grass crops under those conditions—that is, that they can be cut and siloed when they could not be made into hay under the old system—nevertheless it must be remembered that there is wet weather *and* wet weather. That condition known as "catching weather," which is most trying to the haymaker, and often so *very* catching that it spoils his crop to a large extent, need not concern the siloer, or but little. Occasional showers will not injure the grass to any appreciable extent; and it may be taken as an axiom that more harm will be done to the grass by allowing it to lie for any length of time cut than by taking it in for the silo wet. And, much as excess of wet is to be deprecated, less loss will be sustained by siloing it when wet than if it is allowed to lie too long cut, or till it is dried up and withered. Any approach to the condition we call hay is quite antagonistic to the principle of ensilage. What is really the point under this head is, that while grass thoroughly soaked with rain may be siloed, and had better be so than allowed either to remain growing so long that it loses its succulence and nutritive properties, or much of them, or allowed to lie too long after being cut—the sooner it is put into the silo after this the better—still, extra care will have to be taken in carrying out the ensilage and in its after treatment; for any excess of water may create that chemical condition which is best known by the name of "souring," and which is made known by the strong pickle or vinegar odour evolved. And this condition always lessens its value as a food for stock.

We now take a brief but yet a more systematic glance at the crops suited for the ensilage process, with a view to offering a few special remarks on one or more of them. Of the grasses, those known as "meadow," and to which the term "natural" grasses is applied, form, as we have seen, the typical ensilage crop. These natural grasses are also termed "permanent" or perennial, as distinguished from those known as "artificial," and which latter are grown in alternate husbandry practice, taking or forming part of the rotation courses of the particular course or rotation adopted. These permanent perennial natural grasses are, as their name indicates, grown year after year on the same land; the success of the crop being dependent upon the character of the grasses, the way in which good ones are restored when dying out or substituted for bad ones which might have had original possession of the soil—the value of the crop being dependent also upon the way in which the field is manured, and kept clear and free from weeds; in other words, upon its good general management. The best of the natural grasses are those which may be ranked as first-class or of the highest nutritive quality. (1) Rough cocksfoot grass, botanical name being *Dactylis glomerata*; (2) Crested dog or dogstail grass, *Cynosurus cristatus;* (3) Meadow barley, *Hordeum pratense;* (4) Soft brome grass, *Bromus mollis;* (5) Meadow catstail, *Phleum pratense;* (6) Annual meadow grass, *Poa annua;* (7) Italian ryegrass, *Lolium Italicum.* Grasses of the "second class," or of medium nutritive quality, are as follows:—(8) Sweet-scented vernal grass, *Anthoxanthum odoratum.* (Of this, although in the second or medium class, it is to be noted that, being the grass which gives by far the most decided fragrance, or what is known as the peculiar "sweet smell of first-class hay," its presence is indispensable in all meadow or hay grasses. If less productive than the first-class grasses, such as cocksfoot, it has the advantage of coming early into growth, and continues flowering far on in the autumn; it is therefore useful in permanent pastures.) (9) Meadow foxtail grass, *Alopecurus pratensis;* (10) Common oatlike grass, *Arrhenatherum avenaccum;* (11) Rye or darnel grass, *Lolium perenne;* (12) Smooth-stalked meadow grass, *Poa pratensis;* (13) Rough-stalked meadow grass, *Poa trivialis.* The "third class," or those of the lowest quality, is thus made up:—(14) Soft meadow grass, *Holcus lanatus;* (15) Hard fescue grass, *Festuca duriuscula;* (16) Upright brown grass, *Bromus erectus;* (17) Common quaking grass, *Briza media;* (18) Downy oat grass, *Avena pubescens;* (19) Yellow oatlike grass, *Avena flavescens.*

Although this classification gives, according to our highest authorities, the relative feeding value of the natural grasses of permanent pasture or meadow, still it is to be noted, as showing how strictly accurate scientific deductions or analyses require to be, or are modified in practice, that some of the grasses classed above as second and third are desirable in meadows or pastures, and are therefore ranked by practical men as good grasses. Thus the grass numbered (19), the last named of the third class, is greatly relished by cattle, and it gives an abundant feed, and also makes good hay. And, as we have occasion in another part of this work to point out the importance, in the art of cattle feeding and fattening, of attending to physiological as well as chemical considerations, in estimating the feeding value of a food,—if a grass be relished by stock, although of inferior class chemically valued, yet it is to be ranked as a desirable grass. The same remark applies to a grass of the second class, numbered (9). This grass yields largely, comes early—if not the earliest of all the grasses—into feed, and is relished by all classes of stock, sheep, and horses as well as cattle.

Of the clovers those suitable for ensilage are (1) The perennial red clover, most commonly known as cow clover, *Trifolium pratense perenne* (native perennial clover); this is most esteemed for permanent pastures, inasmuch as it is more durable than (2) the red or broad-leaved clover, *Trifolium pratense* (common red clover)—which, however, being the most esteemed of all the clovers for alternate or rotation husbandry, seems therefore the most likely to be useful in the practice of ensilage. Another clover useful for this is (3) Alsike clover, *Trifolium hybridum;* this is also known very generally as "Swedish clover," as it was introduced from Sweden into British farming some half-century ago. It is looked upon as one of the most valuable of our clovers. Another clover which may be taken into the rank of ensilage crops is (4) Crimson or Italian clover, *Trifolium incarnatum*: it is of rapid growth, and sown in autumn it gives a heavy crop for green food in May following, when it may be succeeded by rape, etc. Another clover is (5) Yellow clover, also known as the trefoil clover, *Medicago capulina.* This is not a perennial but an annual clover, but therefore well adapted, especially in cases where soils are light, for an ensilage crop. The common white or Dutch clover is *Trifolium repens.*

As a rotation or alternate husbandry crop, the following grasses and clovers may be grown, either as a mixture or separately; but for ensilage the mixture is worthy of a trial: (7) Italian rye grass, (11) Perennial rye grass, (1) Cocksfoot grass, (5) Catstail, (3) Alsike clover, (2) Red or brown clover, (5) Yellow clover. The numbers refer to those in the paragraph giving the lists of grasses and clovers, from which the botanical names can be obtained. In medium soils the weight in pounds per acre may be as follows, and as per above numbers:—(7) 5 lb. per acre, (11) 3 lb., (1) 3 lb., (5) 2 lb., (3) 1 lb., (2) 6 lb. It is right, however, in concluding this note to remind the reader that the nutritive and other properties of grasses and clovers are very much modified by the character of the soils in which they are grown and the way in which they are cultivated. In practice there are different grasses for different soils.

95. Scantlings or Dimensions of Pieces of Timber of the Thicknesses of 2, 3 and 4 Inches required to make One Cubic Foot, in Pieces of given Lengths.

Pieces of 2 inches in thickness.		Pieces of 3 inches in thickness.		Pieces of 4 inches in	
Width or breadth of the piece in inches.	Length of the piece in feet and inches.	Width or breadth of the piece in inches.	Length of the piece in feet and inches.	Width or breadth of the piece in inches.	Length of the piece in feet and inches.
2 by 2	36 0	3 by 3	16 0	4 by 4	9 0
2 „ 3	24 0	3 „ 4	12 0	4 „ 5	7 2
2 „ 4	18 0	3 „ 5	9 7	4 „ 6	6 0
2 „ 5	14 5	3 „ 6	8 0	4 „ 7	5 1
2 „ 6	12 0	3 „ 7	6 10	4 „ 8	4 6
2 „ 7	10 3	3 „ 8	6 0	4 „ 9	4 0
2 „ 8	9 0	3 „ 9	5 4	4 „ 10	3 7
2 „ 9	8 0	3 „ 10	4 10	4 „ 11	3 3
2 „ 10	7 3	3 „ 11	4 4	4 „ 12	3 0
2 „ 11	6 6	3 „ 12	4 0	—	—
2 „ 12	6 0	—	—	—	—

96. Belt-and-Pulley Gearing—Points connected with Speed or Velocity in Working.

In our last Note, No. 91, p. 72, we placed before the reader certain points for consideration affecting the most economical and efficient speed at which the gearing can be worked, and contrasted them with the points connected with positive or toothed-wheel gearing. Those considerations were of a general character, and more especially designed for our young readers who are new to the subject. We now proceed to the consideration of special points connected with this question of speed. We in our last note stated generally that high speed of light shafts with pulleys of large diameter was the characteristic of properly designed and judiciously constructed belt-and-pulley gearing. Speed in the driven pulleys, and those of course directly connected with the machine to be worked, being the object aimed at by the machinist, it is obviously desirable that the more quickly this speed is gained the better. Hence the feature of the system that the main driving pulley connected with the prime mover shaft is frequently the fly wheel of the prime mover—that is, the fly wheel is in reality a pulley, and this of dimensions, diameter, and breadth of face sufficient to take off at once the full power of the prime mover, such as the steam engine, this being especially the case where the engines are what is called speeded—that is, running at a high piston speed, as from 400 to 500 feet per minute, nearer the last than the first-named figure. The speed of the engine should be so related to the diameter, or conversely, that the surface or circumferential velocity of the fly-wheel pulley should be not less than three thousand feet lineal per minute—the abbreviated term for which, in making calculations and statements of working, may be F. l. p. m, or more simply, F. p. m., or still more so, F. m. This expression for formulæ or calculations applies, it need scarcely be said to the young reader, to the circumferential or "rim surface," velocity, or speed, of all pulleys, large and small. Another expression for formulæ of belt-and-pulley gearing, in close connection with that just given, is the number of revolutions of pulleys per minute, abbreviated thus—R. w. p. m., or more simply, R. p. m., or still more so, R. m.; the expression indicating the speed of the belt, or the number of feet lineal per minute through which any point on its surface runs, may be thus B. s. p. m., or more simply, B. s. m. We have said that the speed of the main driving pulley or fly-wheel—"drum" as it is sometimes called—should not be less than three thousand feet per minute. But this may be increased, and with advantage, some 25 to 30 per cent, giving a speed of from 3750 to 4000 F. p. m. Other things being equal—that is, with pulleys carefully balanced, so as to run as perfectly true as good workmanship can secure, with shafting and bearings well proportioned and carefully fitted—the greater the speed at which pulleys run the better. For, as the young reader should know, the efficiency of the belt as a transmitter of power is in direct proportion to its speed, or the lineal space through which it passes per minute (B. s. p. m.). It follows from this that quick running, with high-speeded belts, is cheap or economical running. For if we suppose a belt, say 6 inches wide, to transmit a certain power at a given speed, if that speed be increased it transmits more power, so that a narrower and therefore a cheaper belt driven at the higher speed will do the same work—transmit the same power—that the broader belt does running at the lower speed. Thus, for example, if we have a belt 4 inches wide and run at a speed of 4000 B. s. p. m., it will do as much work in driving machinery, or will transmit as much power, as a belt 16 inches wide running at 1000 feet only. We have said that the diameter of all pulleys, main and subsidiary alike, should be as large as is consistent with the general conditions and circumstances of the machinery to be driven. If the young reader will remember what we have said as to the strains thrown upon belts when wrapped round pulleys, he will see that this having of them of large diameter is necessary to economical working of the belt *per se*, as less strain of a highly prejudicial character is thrown upon the fibres of the leather when it is passed over a large pulley periphery than when it is wrapped round a small one; the line of contact in the case of a small pulley being so much curved that the tensile strain on the upper side and the compression on the lower side is great, tending rapidly to wear out the belt. This condition of pulleys too small in diameter involves other points, some of which have been already alluded to, and others are yet to be noticed. Much as we already in the course of these "notes" have given on the subject of belt-and-pulley gearing, from what has been more or less explicitly stated, the reader will not be surprised to learn that more has yet to be presented to him before it can be said to be completed. It would, indeed, not be right to give our readers the idea that to our notes this term last given can be applied; and in view of all that has been written on the subject, and of the records of experience of practical machinists which lie before us—an experience which ranges over a field very wide, both in point of time and of detail; facts and records which if collected in one would make a very portly and portentous-looking volume—it can scarcely be expected that within the space which with due regard to the claims of other technical subjects we can alone give to this, we should give a series of notes which would present a view of the subject which could claim to be complete. All that we can promise for the notes yet to be given is that they will present a fairly full exposition of the leading features of belt and rope and pulley gearing. Of those points yet to be noticed, the first we take up is that of "speed." In machine and building construction in which beams and girders are used, what is called a "factor of safety" is carefully looked to—that is, that the beam shall be in practice loaded with only a certain part of the load or weight which its calculated "breaking strain" would show that theoretically the beam could support or carry. So in belt-and-pulley driving, there is what may be called a factor of economical or safe speed which is necessary to be attended to. The speed at which the driving pulley revolves—which is technically designated "revolutions per minute"—or the speed at which the belt travels or traverses through the space between the driving and driven pulleys, is technically called the speed or rate of "feet per minute." If this speed be too slow, the result is a loss of efficiency in working; if it be too quick or excessive, the result is a loss of safety as well as efficiency. As the young reader will, in considering the method of communicating motion or of transmitting power by "positive," that is toothed-wheel gearing, perceive without much difficulty, the system is from its very nature, and from the construction of its members or parts, better adapted to machines slowly than to those quickly worked—in other words, to cases where low velocities or speeds than when high speeds are required. To look only at one point, it will be easily understood that in running positive gearing at high speeds a much greater degree of noise will be created than when it is run at at a low speed; and it may be accepted as a rule which has comparatively few, if indeed it has any, exceptions, that with mechanical noise there is a loss of mechanical power or efficiency. Another feature—which, indeed, is the cause of this increase of noise with increase of speed of positive or toothed-wheel gearing—is that there is almost inherently in the system a certain degree of roughness of motion which gives rise to jars or shocks, which can only be prevented, or it would be more correct to say reduced to a minimum, by extreme accuracy in designing and forming the teeth of the wheels and pinions, and in balancing them on their shafts, and in the construction and fitting up of those and of the bearings by which the shafts are carried and in which they revolve. When those essentials are not secured—and in a very wide range of work they are greatly neglected, —what may be called rough working of the gearing is sure to be the result (and this expression is but a synonym for noisy and dangerous). And this peculiarity in "positive" gearing gives rise so often to break-downs, at all times inconvenient and frequently very costly, that various mechanical contrivances are resorted to, or modifications of positive toothed-wheel gearing made, to get rid of or lessen its intensity. The most important of these will be described more or less in detail in the series of papers in this Journal entitled "The General Machinist." Now, in looking at the operation of belt-and-pulley gearing, the young reader will at once be struck with two features: first, its smoothness of motion, that is, freedom from jars and shocks; and second, its noiselessness—both of which characteristics are highly favourable to the continuity of the motion being easily maintained. Again, in contrasting positive or toothed-wheel with belt-and-pulley gearing the young reader will be struck with another feature. In positive gearing, ponderosity or weight is a characteristic, and this is noticeable both in large and small machines, being always greater than in the case of machines of corresponding power driven by belt-and-pulley gearing *properly* designed and constructed, in which lightness of parts is a clear characteristic. All those considerations now noticed point, then, to one distinguishing feature of belt-and-pulley gearing—namely, its adaptability to machine driving having high velocities. The belt and pulley give out their highest powers of efficient and economical working when driven at high speeds or velocities. To adapt it to work having the opposite characteristics is to display an utter misconception of the mechanical features of the system. When those are understood and judiciously or properly applied, we find light shafting and correspondingly light bearings, and pulleys of large diameter running at high speeds or great velocities, and running also smoothly and without noise. In connection with this special feature of belt-and-pulley gearing, quick running of shafts and pulleys, many points have to be taken into account before the maximum of economical and efficient working with the minimum of expenditure of driving power can be secured. To those points, all of which involve considerations of extreme interest and value to the general machinist, we shall draw the attention of our readers in succeeding "notes."

97. Weight in Pounds of Square Bars of Wrought Iron per Foot Lineal fom $2\frac{1}{8}$ inches on the Side up to 5 inches. (See note No. 65, p. 341, vol. i.)

$2\frac{1}{8}$ inches = 15·05 lb.; $2\frac{1}{4}''$ = 16·87; $2\frac{3}{8}''$ = 18·8; $2\frac{1}{2}''$ = 20·83; $2\frac{5}{8}''$ = 22·96; $2\frac{3}{4}''$ = 25·2; $2\frac{7}{8}$ = 27·55; 3 inches = 30·00; $3\frac{1}{8}''$ = 32·55; $3\frac{1}{4}''$ = 35·2; $3\frac{3}{8}''$ = 38; $3\frac{1}{2}''$ = 40·83; $3\frac{5}{8}''$ = 43·8; $3\frac{3}{4}''$ = 46·87; $3\frac{7}{8}$ = 50·05; 4 inches = 53·3; $4\frac{1}{8}''$ = 56·71; $4\frac{1}{4}''$ = 60·2; $4\frac{3}{8}''$ = 63·8; $4\frac{1}{2}''$ = 67·5; $4\frac{5}{8}''$ = 71·3; $4\frac{3}{4}''$ = 75·2; $4\frac{7}{8}''$ = 79·21; 5 inches = 83·3 lb.

98. To find the Length of a Wrought Iron Rod (or Circular Iron Bar) when the Diameter and the Weight are given.

Take the square of the diameter, and with the product multiply the decimal ·7854 with it, which will give a product to be used as a divisor, and which we call "D." Then take the given weight of the rod and multiply it by 3·6, and by dividing the product by "D" the quotient obtained will give the length of the rod or circular bar. (See note No. 46, p. 244, vol. i.)

99. To find the Diameter when the Length and Weight of the Rod or Circular Bar are given.

Take the weight and multiply it by 3·6; then divide the product obtained by the length of the rod in inches, and again by ·7854: the diameter required will be equal to the square root of the quotient. (See note No. 46, p. 244, vol. i.)

100. To find the Weight of Plates of Wrought Iron.

(*a*) *The Dimensions being given.*

Multiply the breadth in inches by the length in inches, and divide the product by 3·6: the quotient gives the weight in pounds.

(*b*) *When the Length of the Plates and the Thickness are given, and also the Weight, to find the Breadth, which will be in Proportion.*

Take the length and multiply it by the thickness: this will give a figure which we call "L." Then multiply the given weight of the plate by 3·6 and divide by "L": the quotient is the breadth required.

101. Weight in Pounds and in Parts of Pounds of Flat Wrought Iron Plates $\frac{1}{8}$th of an inch Thick, 1 foot Long, and of Breadth from 1 to 6 inches.

Note the first figure in the following denotes the breadth, the second figure the weight. $1''$ = ·41 lb.; $1\frac{1}{8}$ = ·46; $1\frac{1}{4}$ = ·52; $1\frac{3}{8}$ = ·57; $1\frac{1}{2}$ = ·625; $1\frac{5}{8}$ = ·67; $1\frac{3}{4}$ = ·72; $1\frac{7}{8}$ = ·78; 2 inches = ·83 lb.; $2\frac{1}{4}$ = ·93; $2\frac{1}{2}$ = 1·04; $2\frac{3}{4}$ = 1·14; 3 inches = 1·25 lb.; $3\frac{1}{4}$ = 1·35; $3\frac{1}{2}$ = 1·45; $3\frac{3}{4}$ = 1·56; 4 inches = 1·66 lb.; $4\frac{1}{4}$ = 1·77; $4\frac{1}{2}$ = 1·87; $4\frac{3}{4}$ = 1·97; 5 inches = 2·08 lb.; $5\frac{1}{4}$ = 2·18; $5\frac{1}{2}$ = 2·29; $5\frac{3}{4}$ = 2·39; 6 inches = 2·5 lb.

102. To find the Weight of a Square Bar or Body of Cast Iron.

Multiply into itself the side of the square, or, as it is termed, square the side of the bar, and multiply the product by the length in inches—divide their product by 3·84, and the quotient is the weight required.

103. Screw Threads in Use: the "English," or "Whitworth" Standard.

(1) Number of threads per inch. (2) Pitch in millimetres. (3) Diameter in inches. (4) Diameter in millimetres.

(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
24	1·058	$\frac{3}{16}$	4·7	8	3·175	1	25·4
20	1·270	$\frac{1}{4}$	6·4	7	3·629	$1\frac{1}{8}$	28·6
18	1·410	$\frac{5}{16}$	7·9	7	3·629	$1\frac{1}{4}$	31·8
16	1·585	$\frac{3}{8}$	9·5	6	4·225	$1\frac{3}{8}$	34·9
14	1·815	$\frac{7}{16}$	11·1	6	4·225	$1\frac{1}{2}$	38·1
12	2·120	$\frac{1}{2}$	12·7	5	5·080	$1\frac{5}{8}$	41·3
11	2·309	$\frac{5}{8}$	15·9	5	5·080	$1\frac{3}{4}$	44·5
10	2·54	$\frac{3}{4}$	19·1	$4\frac{1}{2}$	5·650	$1\frac{7}{8}$	47·6
9	2·820	$\frac{7}{8}$	22·2	$4\frac{1}{2}$	5·650	2	50·8

104. Fertility in Soils.

The most recent and exhaustive experiments in connection with the soil show most conclusively that those soils considered the most fertile are not inexhaustible of the fertilising constituents—that they contain only a certain amount of these, and that every plant grown on them requires at least eight different constituents to bring it to perfection. If, therefore, these be not all present, or if one or more be present only in small quantity, it follows that the plants cannot be good, and that very soon, by repeated cropping, the soil will be deprived altogether of one or more of the necessary constituents. Hence the absolute necessity to keep up the supply of these by manurial applications.

105. Mineral Constituents withdrawn from the Soil.

As connected with the above, the following results of a course of experiments will be suggestive. The crops of a "rotation" (see "The Farmer" in text) of turnips, wheat, hay, oats, potatoes and wheat carried off from the soil in which they were grown the number of pounds of constituents as follows: (1) Potash, 319 lb.; (2) Soda, 66 lb.; (3) Lime, 100 lb.; (4) Magnesia, 39 lb.; (5) Chlorine, 58 lb.; (6) Sulphuric acid, 78 lb.; (7) Phosphoric acid, 122 lb.; (8) Silica, 384 lb.; (9) Nitrogen, 274 lb.

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY.

(39) In our last Note on boiling or evaporation, we endeavoured to show that economical steam-raising depends upon the freedom with which the vapour created by the action of heat can pass away from the mass of water in the boiling vessel—in engineering termed simply a "boiler," to the free space in the upper part of the vessel—in engineering termed the "steam space," as the other part nearest the fire is called the "water space." In the change from the liquid to the vaporous or gaseous condition, a mass of water may be considered as made up of an infinite series of particles or molecules, each of which, in the first instance, expands, or, in common language, swells out, occupying more space than it did before it was heated. As a greater number of "increments of heat" are being taken up by the water, vapour or gaseous fluid is formed. This is taken up, or, so to say, absorbed by a molecule of water, or inclosed by more than one molecule. In this condition the water is said to be "saturated" with the vapour. But, as the number of increments of heat taken up by the water increases, the amount of vapour correspondingly increases, and this is continued to be taken up by the molecules of water till they become "supersaturated" with the vapour-steam—that is, the molecules cannot take up or absorb any more of the vapour; and when this point is reached, the change from the liquid form of the molecules to a vaporous or gaseous condition is completed, and the product—steam—passing upwards, flows off from the general mass of the water. Hence the definition of a boiling or steam-producing liquid is that it is a "supersaturated solution of its own vapour," the point of supersaturation being that of the change from the liquid to the gaseous or steam state. The "bubbles," already in a previous note described, are the centres, so to call them, around which the process of vaporisation goes on; and the great object in boiling—steam-raising—is to get those bubbles set free from the mass of water not yet vaporised, and this as freely and quickly as possible. But the "condition" of the mass of water may be such that in place of facilitating it retards the passage of the vapour through and away from it, the space which they occupy, and from which they are naturally disposed, so to say, to escape, being closed up all round. In scientific language, the vapour is occluded in the water. To open up this space, in which the vapour is thus locked up, is the object to be attained; and before this can be done and free spaces created, the pressure of the surrounding water must obviously be removed, or what are called free surfaces created, which lead to free spaces. The vital importance of these free spaces or surfaces to the art of economical boiling and evaporation has only been recently discovered; and it is the application of this principle which bids fair completely to revolutionise the whole art, and to make clear many of the points connected with boiling which have for so long puzzled our scientific and practical men. Seeing the importance of this point of free surfaces or free spaces, it will be well here to go somewhat into detail respecting them. We have, let us suppose, a number of granular and extremely small bodies, forming in the aggregate a mass more or less solid and compact by being inclosed or placed within the compass of a vessel which contains also a chemical liquid. The object, let us further suppose, of the arrangement is to subject each granular body to the action of the liquid, so that it shall be saturated by it, and this as rapidly as possible. It is obvious that this rapid saturation of *each* of the granular substances will depend upon the way in which the body is surrounded by or acted upon by the liquid, and has its surface exposed more or less completely to the action of this. And it is also obvious that the granular bodies most quickly acted upon by the liquid will be those in immediate contact with it, and these will be more on the outside of the mass. Those situated near the centre of the mass will clearly be less likely to be reached by the liquid—certainly more slowly. And the liquid might be altogether prevented, or nearly so, from reaching those central grains if the grains surrounding them were very closely packed together. In the normal condition of the mass of granular substances as surrounded with the liquid, those situated near its centre would be the last to be influenced by the liquid. And we can conceive that there would be such a chemical affinity between the granular substances and the liquid that, when free to do so, the one would rush, so to say, to the other, and the combination would be effected. It is obvious that the bodies nearest the centre of the mass would be prevented from doing this by the pressure or weight of other bodies surrounding them. What is wanted under the conditions we have here named is some method of changing the position of the bodies, so that the surfaces of each or all of them would be exposed to the action of the liquid. And to effect this a space would be required into which the bodies could be freely moved, and in which they

could individually be free also to move—free spaces into which and in which the bodies could move in the liquid, free surfaces all round each body, in which the liquid could act. This giving of free spaces and free surfaces to the mass of granular substances we have supposed, could be done in more ways than one. It might, for example, be effected by stirring the mass mechanically, ample space in which the movement could be efficiently done being, of course, supposed to exist. This is illustrated by stirring a mass of sugar which lies for the most part unmelted at the bottom of a vessel filled with water, and this even where the water is heated. The liquid does not act upon the great mass of granular sugar, which lies in consequence unmelted at the lower part of the vessel. This is in consequence of the absence of "free spaces" in the liquid, into which the grains of sugar can pass, and in which they can move, and of "free surfaces" on which the liquid can act. These can be created by stirring the mass, which then melts away more or less rapidly, saturating or supersaturating the liquid. This principle of free spaces and free surfaces in connection with the raising of steam, the rapid evaporation of water, is likely, as we have already said, to revolutionise the whole practice of boiling, which, apart altogether from the work of steam raising, forms an important department of practical industrial work, in which many "callings" or trades are concerned. And in connection with this principle—the result of recent investigations and experiments—there are some very striking and suggestive points in relation to the application of heat to masses of water placed either in open vessels, as mash tuns, or in closed ones, as in steam-engine boilers. On heat being applied to the lower part of the vessel which contains the water to be boiled, and the steam which is to be raised from it—we take, of course, a steam-engine boiler for illustration—certain bodies are formed to which the name of "bubbles" is given. These form the vehicles, so to say, for carrying the vapour or watery gas, into which particles or molecules of the water at the lower part of the vessel is changed by the application of heat—the water requiring to take up so many increments of heat before this vapour is formed. These bubbles, acting as vapour vehicles, pass upwards through the mass of water in the upper part of the water space of the boiler, and pass out from the surface into what is called the steam space of the boiler. When the bubbles, as they are formed in the lower strata of the water, which is constantly receiving fresh increments of heat from the fire in the furnace below, are enabled to pass freely away from the mass of surrounding water, and to pass freely through the mass of water above to the surface, and from thence to the steam space, the boiling is said to be "regular." This is owing to the boiler arrangements and construction being such that "free spaces" and "free surfaces" are created easily. But regular boiling is quite the exception, as has been long known to scientists, and also, though less markedly, to practical men interested in one or other of the many industrial processes in which boiling and evaporation are concerned.

(40) As a constructive metal, aluminium (see Note No. 28) is noted for the high degree it possesses of being worked or manipulated by the artificer in almost every variety of way. Its malleability is high, as it can be beaten or hammered out into the thinnest of plates or leaves; its ductility is great, as it can be drawn out into the form of the finest wires, or rolled out into plates of varying thicknesses. And, as we have said in a previous note, it may be classed as one of the most workable of all our metals, lending itself with the greatest facility to all the purposes of the constructive or decorative workman. It can be turned in the lathe, it can be filed in the vice, it can be squeezed in the press so as to give the impress of the finest lines of the most delicate "dies," it can be engraved, its wires can be twisted into the most intricate of convolutions without injury, it can be moulded, giving castings with the finest lines,—in brief, it can be made into forms and shapes of an almost endless variety, while, to add still more to its constructive and decorative value, it seems to be almost absolutely indifferent to that oxidising influence of the atmosphere which tarnishes and deteriorates other metals. As a metal in the making of alloys it has had a most useful application: *e.g.*, the alloy known as bituminous bronze, a rival to that well-known phosphor bronze so largely used by mechanics for brazing, etc.

(41) An alloy, which closely resembles silver in appearance, and which possesses several useful properties, has had an extensive use on the Continent. It is extremely hard, and capable of receiving a high polish. The base of the alloy is copper, of which 70 parts are used; to this is added, when melted, 4½ parts of cadmium, 5½ parts of zinc, and 20 parts of nickel.

(42) In using cements—as, for example, in the making of floors, and in pointing and facing walls, or for one or other of the many purposes for which cements are used in forming a concrete as a substitute for stone—care should be taken to avoid a mixture of cements of different kinds. Thus, with an idea that it is cheaper, Portland is sometimes used with Roman cement. Now, the resulting material can never be satisfactory in use, as the two cements have different times for setting or hardening. The more uniform the cement in quality, the more regular and trustworthy is the setting.

Ornamental Brick and Stone Work Combined.

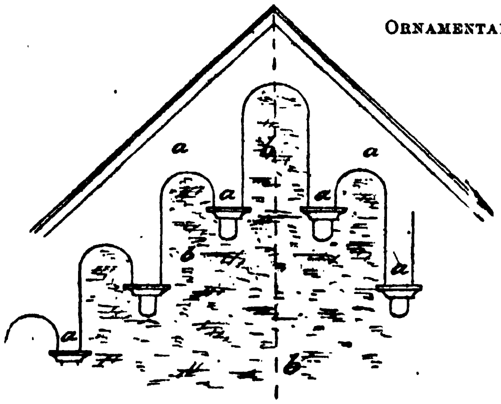


Fig. 1.

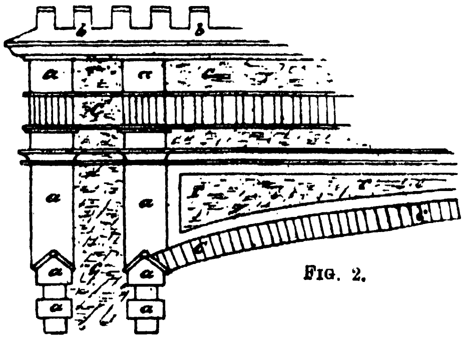


Fig. 2.

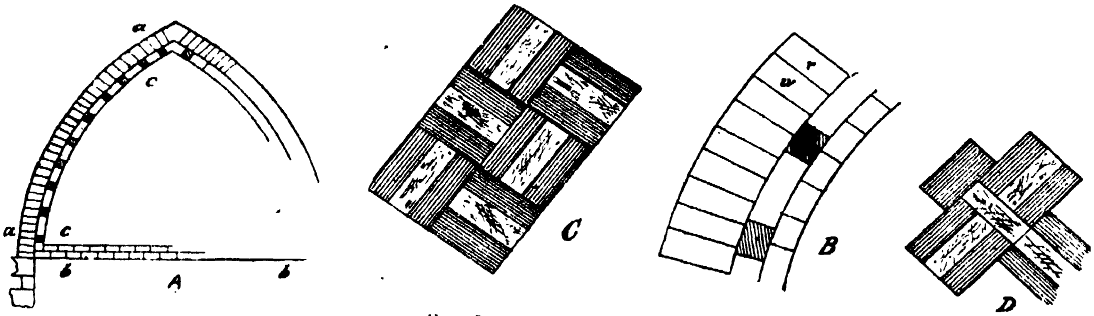


Fig. 3.

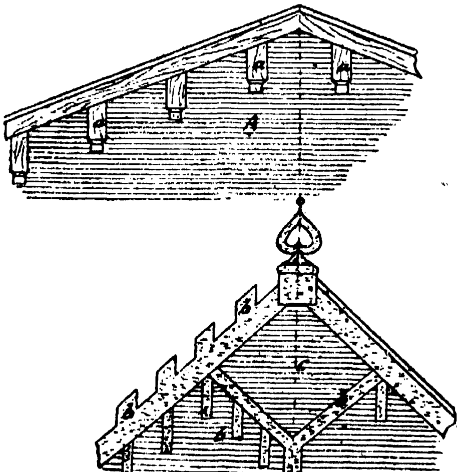
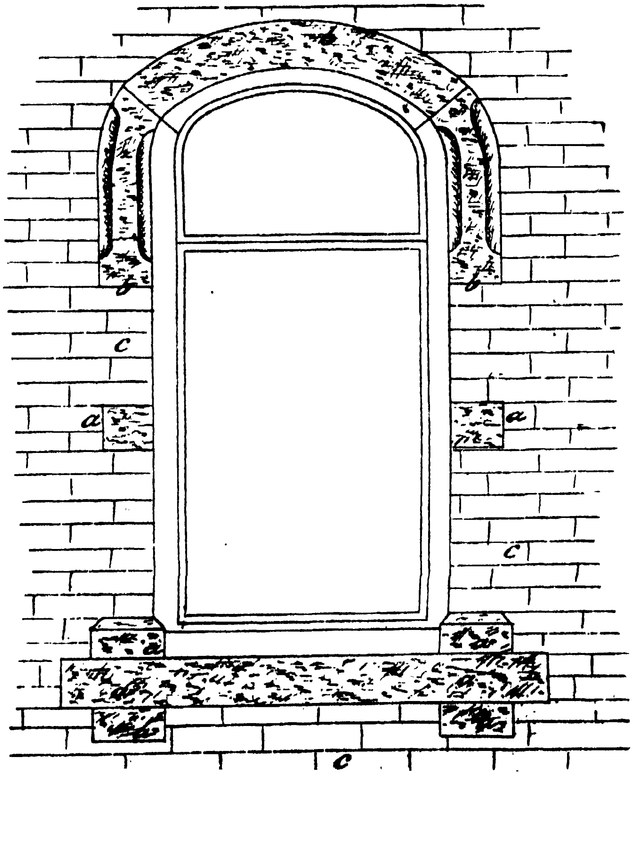


Fig. 4.



WINDOW CONSTRUCTION.

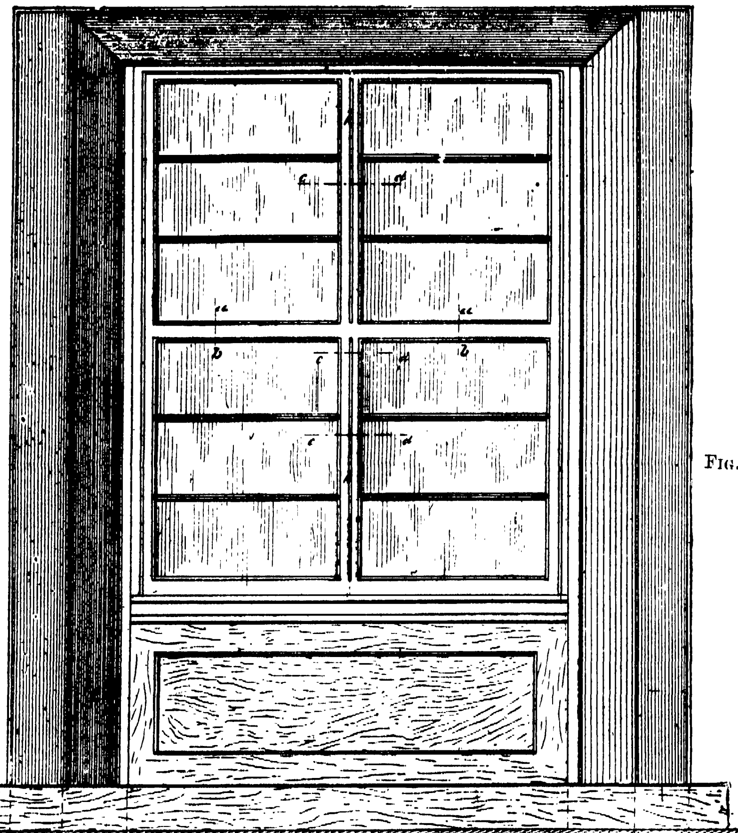


FIG. 1.

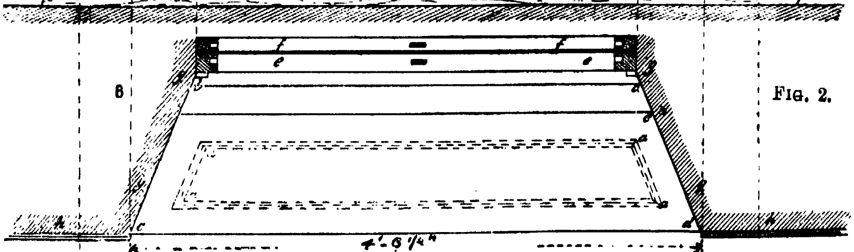


FIG. 2.

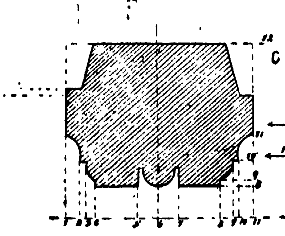


FIG. 3.

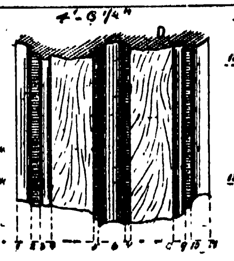


FIG. 4.

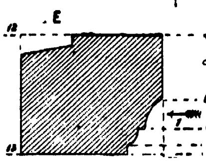


FIG. 5.

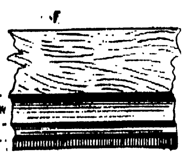
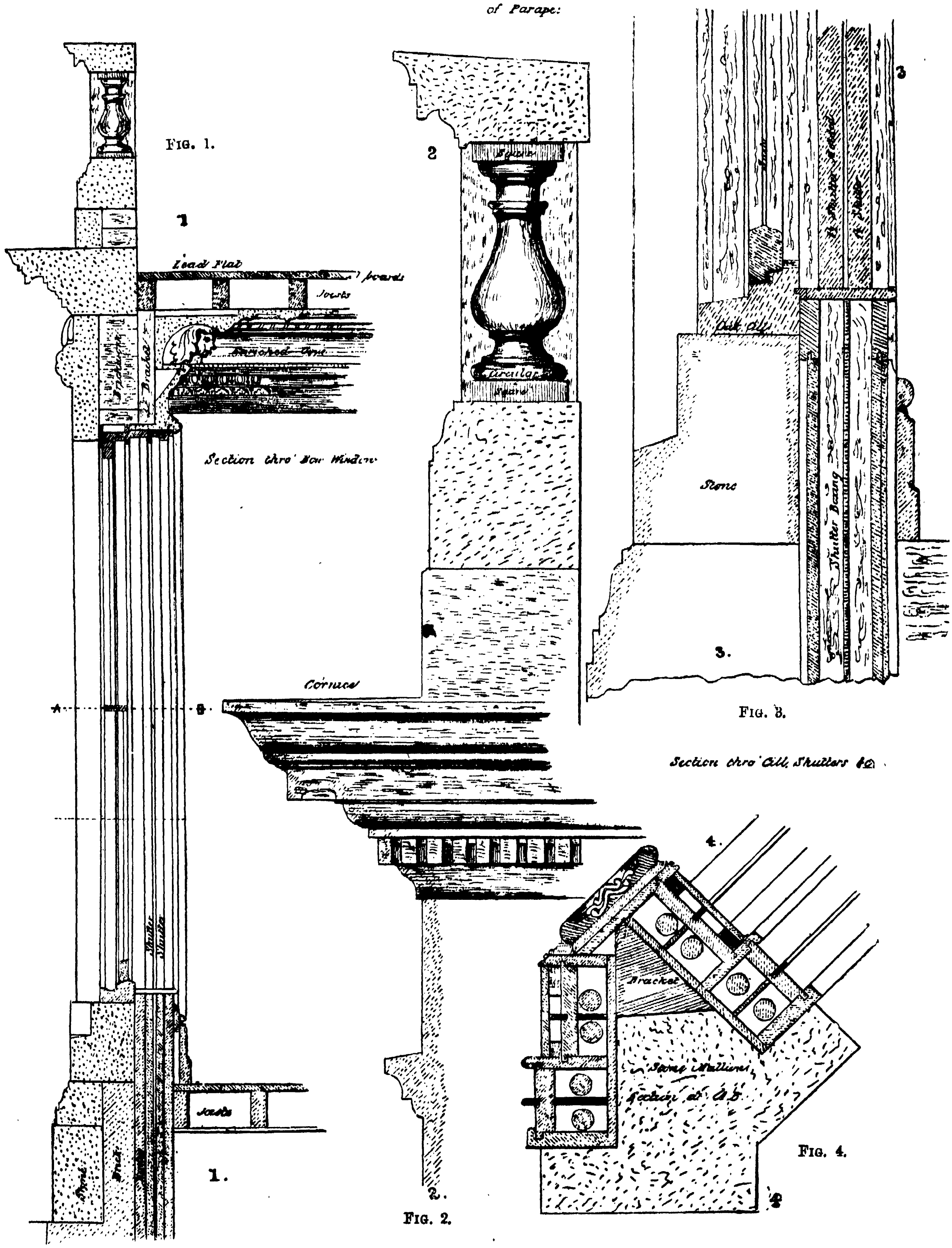


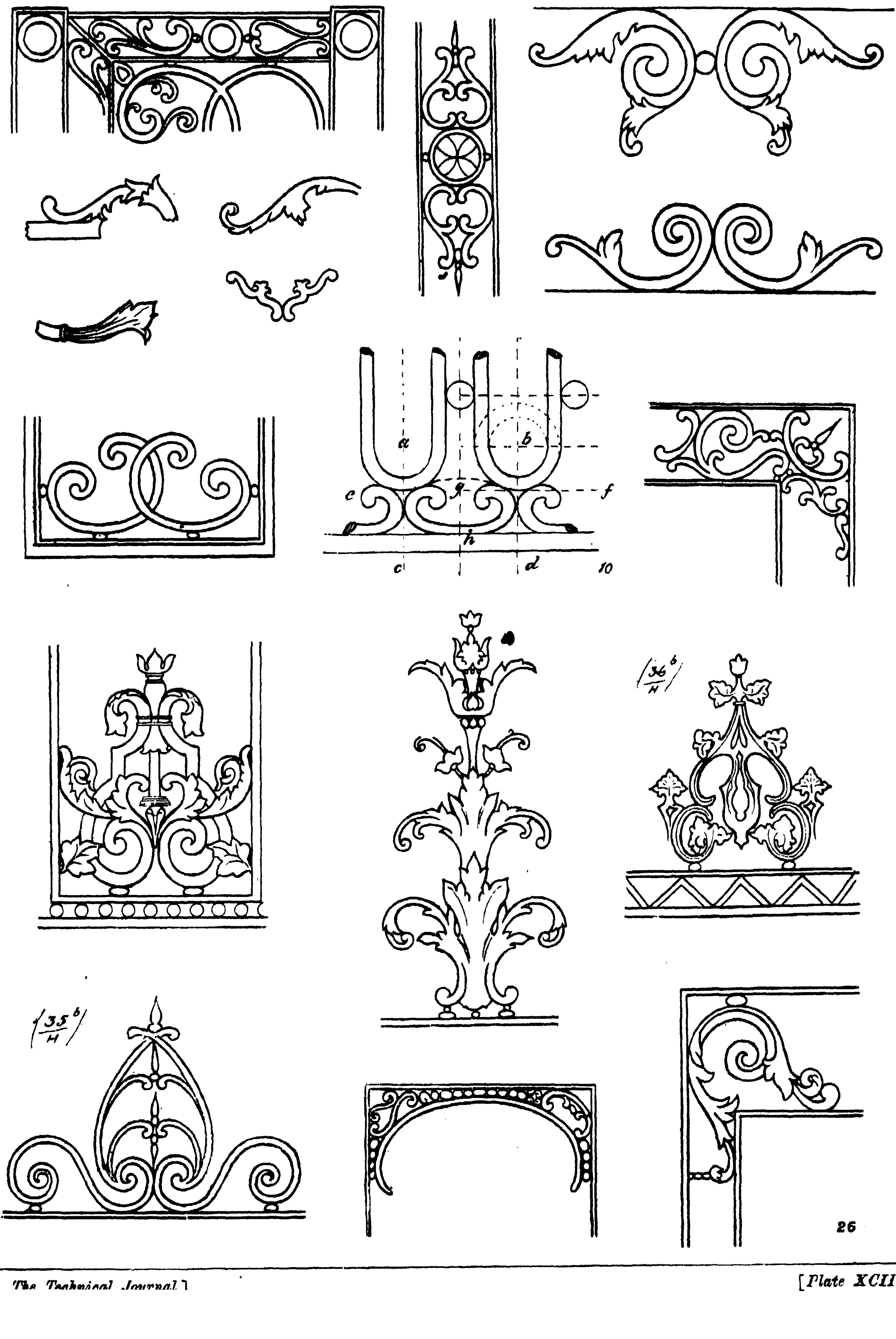
FIG. 6.

"THE MASON," "THE BRICKLAYER," AND "THE JOINER" (*see Text*).

DETAILS OF BAY WINDOW IN PLATE LXXXVII.



ELEMENTARY FORMS, ETC.



THE GENERAL MACHINIST (*see Text*).

TYPICAL OR REPRESENTATIVE MACHINE TOOLS.

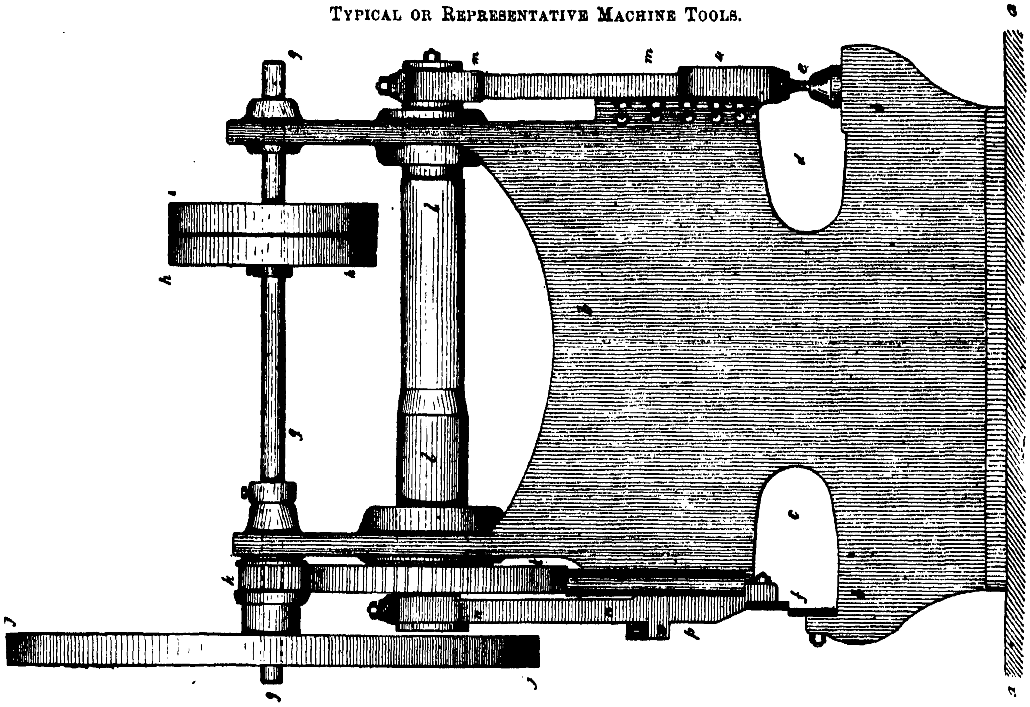


FIG. 2.—COMBINED PLATE SHEARING OR CUTTING AND PUNCHING MACHINE.

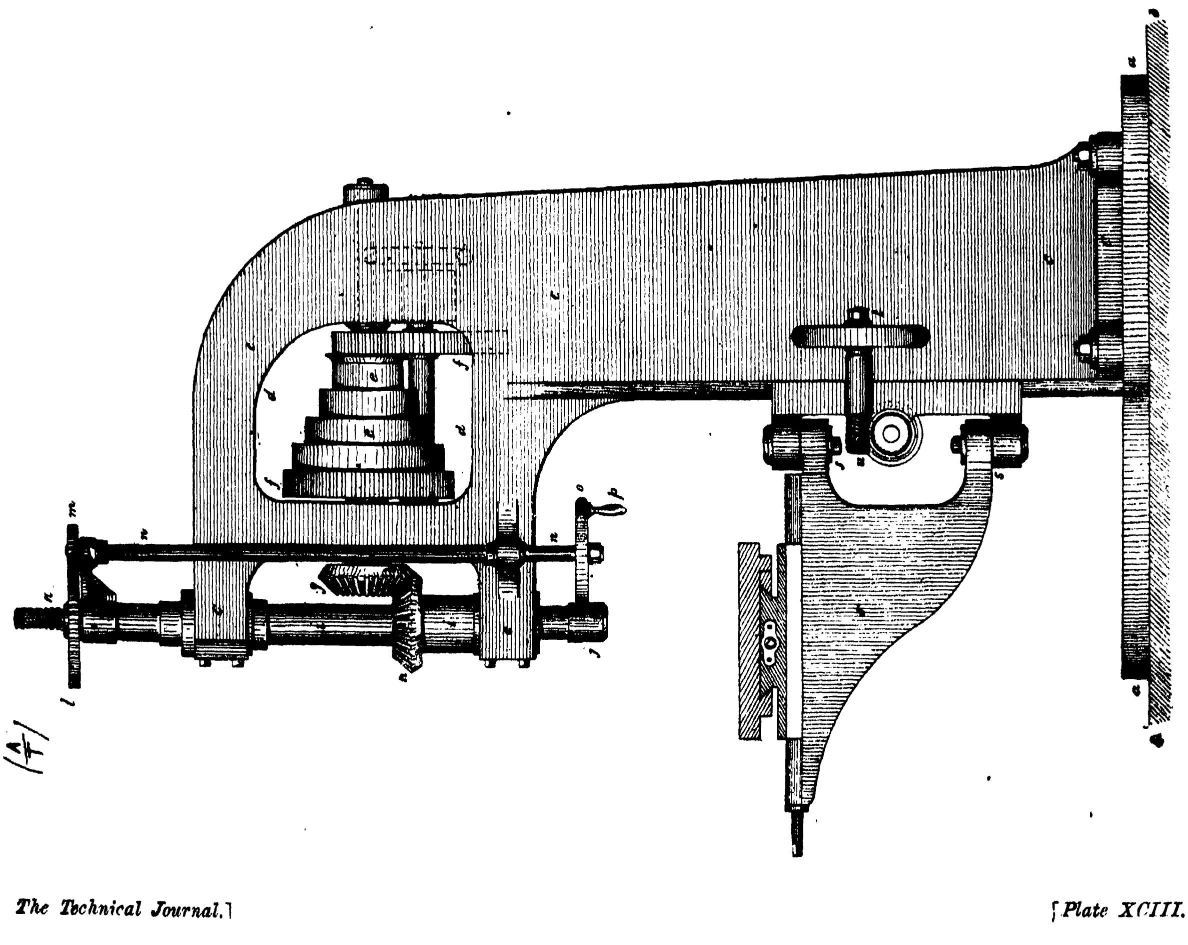


FIG. 1.—BORING OR DRILLING MACHINE.

SUGGESTIONS FOR COTTAGE FRONT ELEVATIONS.

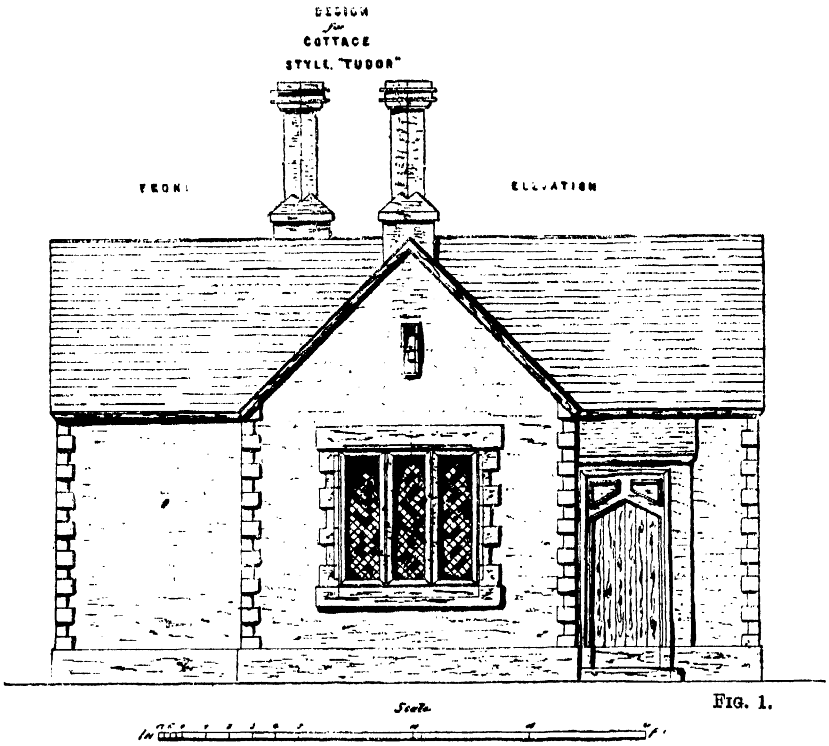


FIG. 1.

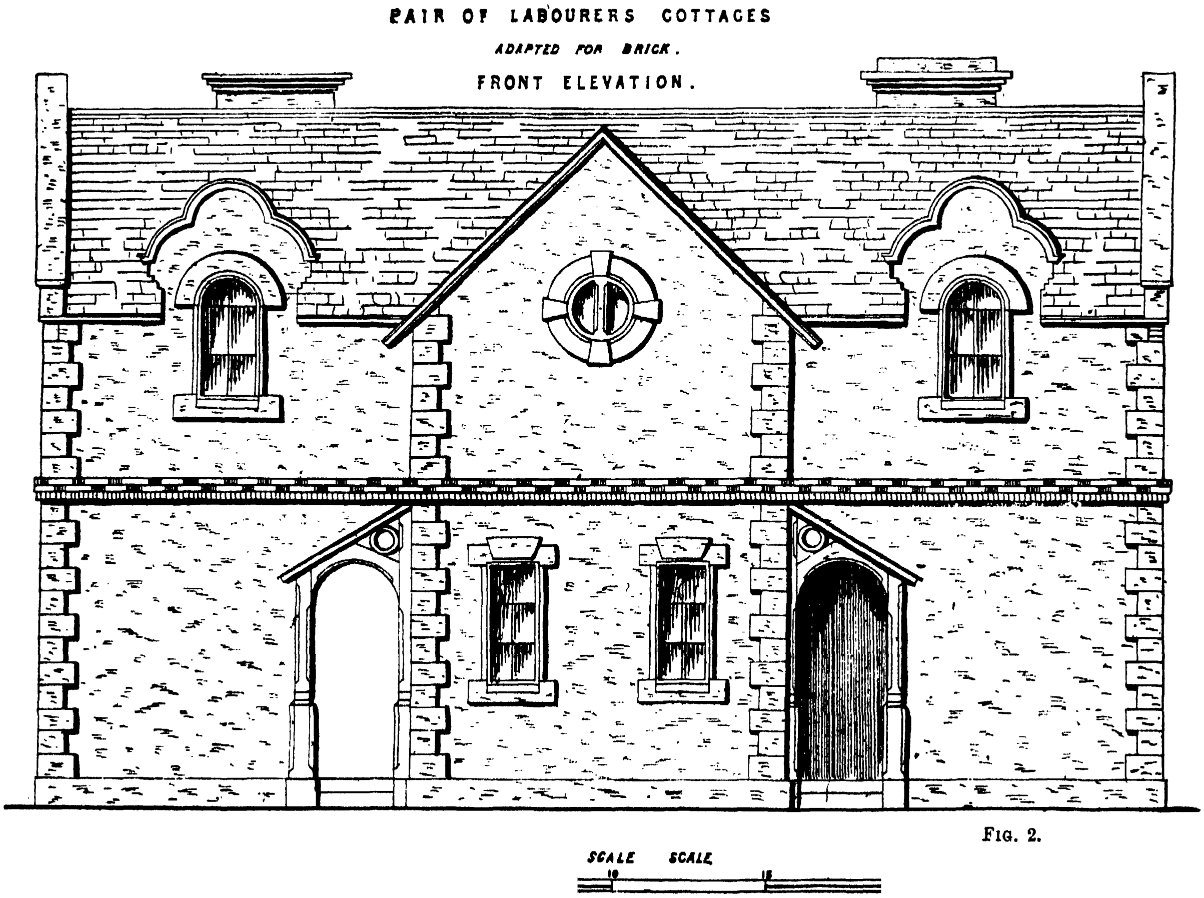


FIG. 2.

"THE CABINET MAKER," "THE ORNAMENTAL WORKER IN WOOD," AND "FORM AND COLOUR IN INDUSTRIAL DECORATION" *(see Text)*.

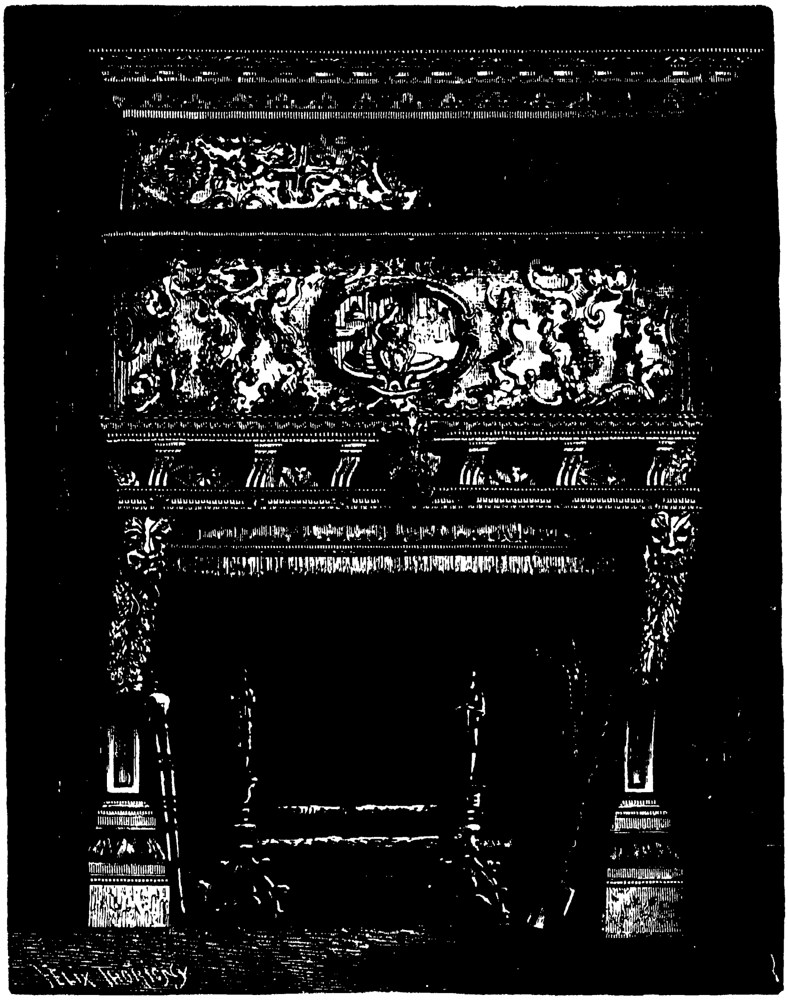


FIG. 1.

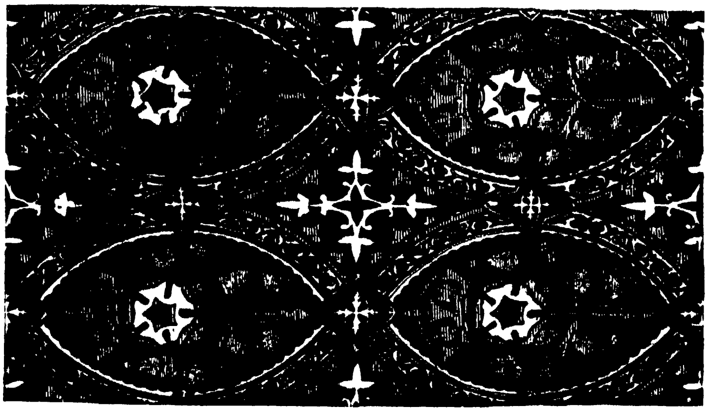


FIG. 2.

FIG. 3.

THE CARPENTER (*see Text*).

Flitched and Trussed Beams.

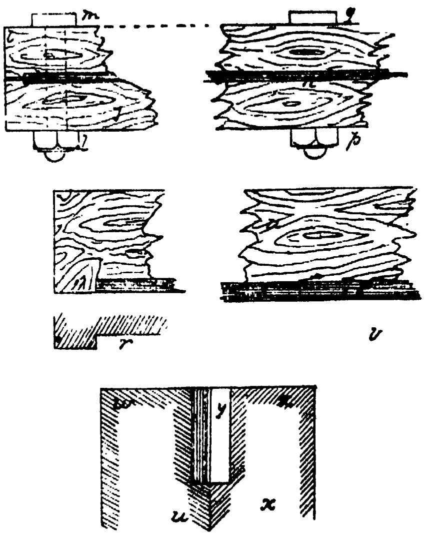
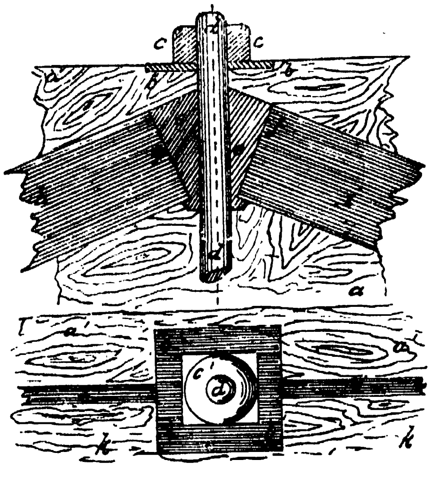


Fig. 1.



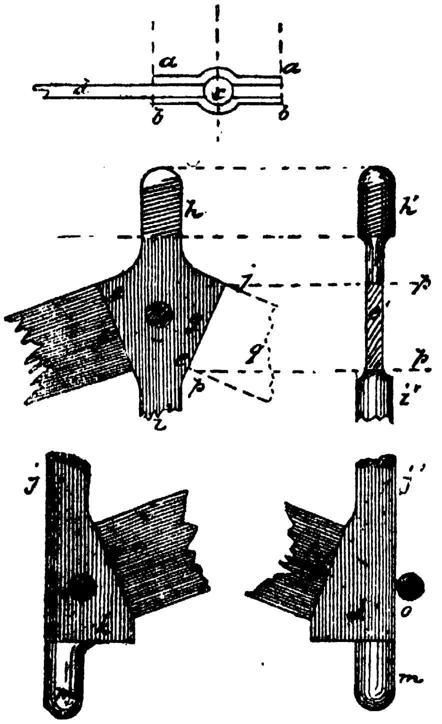


Fig. 8.

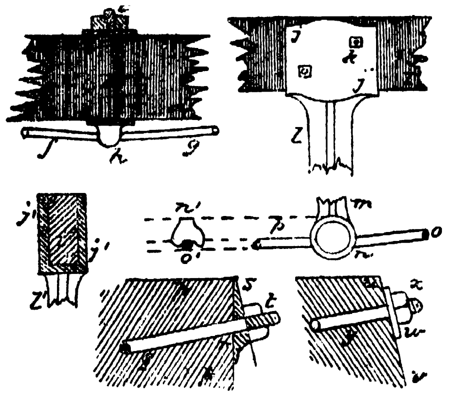
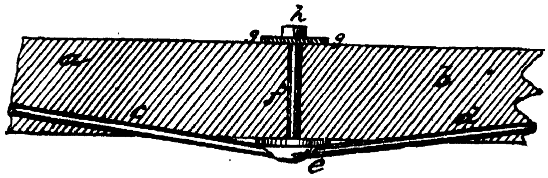


Fig. 4.



ɜ. 5.

Fig. 6.

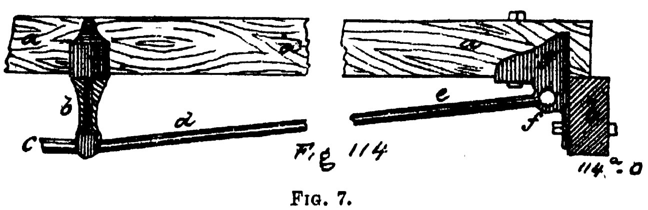


Fig. 7.

THE WORKMAN AS A TECHNICAL STUDENT.

How to Study, and What to Study.

CHAPTER VI.

Dignity of Handicraft Labour.

We have purposely avoided making reference to the ideas but too generally prevalent amongst all classes as to what is termed the "dignity" of this or that calling. This phrase is most generally applied to the professions, as if they alone comprised all that was "dignified in labour." For this phrase, or rather for the idea which it involves, let our readers cherish the profound contempt it deserves. They will comprise every, or nearly every, class of handicraftsmen; but let each and all be fully persuaded of this great truth—that no honest labour is undignified. True dignity comes from the man, not from his work; it is he who dignifies his calling.

True dignity rests in doing the "daily work lying before us" honestly, conscientiously, and truthfully, determined that we will do our best, and that simply because it is the best thing to do—the only thing which a true man can do. We can smile at the story told of one who, certainly not in the garb of a "first class" man, when asked by a railway official what *he* was doing in a "first class" waiting-room, replied, "Wherever *I* am, that is the first class!" We may smile at this, but the lesson it teaches is worth the learning. It is exemplified by what was said of one of our greatest scientific men—namely, that "if circumstances had compelled him to take to scavenging, he would have made up his mind to be the best scavenger of his day, and he *would* have been!" And it is simply the expression of a great truth, that what a man is to be in his calling depends upon himself. And when the paper entitled "The Workman at his Daily Work: his Privileges, Duties, Responsibilities and Rewards," is taken up (which see), the reader will have abundant illustration, drawn from practical life as it is not as it might or as we wish it to be—for we have to deal with facts or things as they are in this work-a-day world of ours—of the truth of this. And although it may not follow that because a man does his work in the best possible way he can do it in, he will therefore be a successful man in the sense of being a rich one, he will obtain what in a far higher sense is better than riches—the true dignity of a man, a self-respect and satisfaction which nothing else could or can give. And of this he may rest assured: that he will secure the respect and esteem of all those whose good opinion is worth having, and to obtain which every true man strives for. But although pecuniary success may not always follow upon a man's dignifying his calling by doing it well, it may be accepted as a general rule, with but few exceptions, that this pecuniary success will more or less follow. Certain beyond all doubt it is, at all events, that this will not, cannot follow, where a man does not so dignify himself and his calling.

A Thoughtful, Careful, Intellectually-trained Workman most likely to command Success in Life.

Men of the high class of mind we have here been dwelling upon are too scarce in daily life not to be valued. A man of this class is always a "marked man" in the highest and best sense of the term. Those above him take note of him, and he is sure to be advanced. We appeal to the history of all successful men who have "risen from the ranks" in support of this. It would be well if young workmen could understand how closely their conduct is watched. If they simply decide—and no decision can be more unfortunate for one beginning life—to be of the common or general run of men of their class, they will be allowed to go unheeded by those above them, as they are themselves unheeding. But the moment a young man begins to think, begins to separate himself from the mere ordinary every-day surroundings, determines to be thoroughly master of his work, and to keep on improving, educating himself, in fact—from that moment he may rest assured that those above him will take note of him, to see what manner of man he is; and as they have the power to advance him, some fine day the advancement will come. We have a duty to perform to our readers other than that connected with explaining the details of purely technical work, or expounding the principles on which correct work is based; and we should be ill performing that duty if we neglected to inculcate upon the minds of our readers those higher principles which underlie all work, and without attention to which that work cannot be in the highest sense of the term successful. When those vital principles are more fully acted upon by the various classes of intellectual workers, then, and not till then, shall we see them rise to a true conception of the dignity of their calling—a conception which will carry with it the power that will tend to raise our handicraftsmen, taking the class as a whole, to a position infinitely higher than that it now occupies.

The Status of any Particular Section or Class of Work dependent upon the Individual Workmen who make up that Class.

And as a class, however numerous, is made up of individuals, so the onward and upward progress of that class in the rank of civilising and humanising agencies is really created and promoted by the exertion of each individual. There is nothing which retards the progress of a class more hurtfully and more powerfully than the notion held by its individual members that *as* individuals they can do nothing of a valuable character. One requires but to think a minute only to see how true this statement we have just now made, in a common-sense way, is. If the work actually done by the class is done simply because each individual member does his share of the work, surely the same could be done in any movement tending to raise the quality of the work. He would be very silly who expressed surprise that there was no work done by the class as a class during a certain period, when he knew perfectly well that each individual member of the class had been idle, "playing himself," as workmen say. Now, while explaining the details and principles of the various classes of industrial work—which is, of course, the main object of our work—we hope to be able to show how, in educating himself on such points, the reader will have inculcated upon him those other principles without which special work could not be carried on, and without which he cannot hope to raise himself in the world. The workman must, therefore, take rank as a student; and to help him in the work of this the following pages are printed.

The Undue Preference given to Practice as opposed to, or as different from Theory, powerful in retarding the Progress of Intellectual Training.

Meanwhile, before entering upon various points involved in this vitally important question, we shall glance at another of the causes which so unfortunately tend to keep back the general acquirement of knowledge from so many of our workmen.

This cause is stated in the expression so often heard and read about, that "theory is all very well, but, after all, there is nothing like practice." The contest between the rival claims of theory and of practice is not a new thing in the history of technical work—using this term in its widest acceptation. It has long been maintained, and is still too often maintained with more of the worthless warmth of inconsiderate zeal than the valued coolness of calm consideration and respect for the opinions of others. But the field on which the war has been somewhat fiercely fought has of late been much narrowed in extent; while the combatants, at least on one side, have in like, if not in greater proportion, been reduced in number. And, judging from the position of matters now, as compared with what it was not so many years ago, an observer of the merely external or outside view of it would be much inclined to decide as between the combatants that of the two the theoricians have so gained the day that the practicians are, to borrow a phrase from the sporting world, "nowhere." But this decision would be as erroneous as the views upon which it is founded; for in reality there has been no decided victory on either side: if it has not been, and by common consent, a drawn battle, it has been a case of compromise, of "give and take," that sound principle of what has been called healthy business and daily life, which, more than any other, has done so much—some maintain that it has done it wholly—to make us the practical, and which has so signally succeeded in making us the prosperous people we are. This principle of compromise, which is indubitably the very foundation of all business which is carried on with mental comfort as well as with material success, in the matter of the rival claims we have referred to, will soon end, if it has not already ended, the long-carried-on dispute between them with the establishment of the best, because it is the most reasonable and practical of unions—that of "practice with science."

"Practice with Science."—Some Considerations connected with the Phrase, as bearing closely upon the Progress of Technical Education.

Let the reader who may not yet have had much experience in the ways of the practical world note the distinction between the sentence as we have put it, and the form in which it is sometimes placed—practice *and* science. The first is correct; the second correct so far as it goes, but it does not go far enough. For the *with* involves the idea that there is a willing going along with each other, a hand-in-hand progress of the theoretical man on one side, the practical man on the other. Of the high value of the work of both we have evidence around us everywhere and always. It is impossible to exaggerate the value of the service done to the nation by the theoretical men; for some, if not, indeed, all of the discoveries which have been made in the arts and sciences, have been made and based solely upon the deductions of theory. For example, one of the most recent discoveries, which, when carried out practically, seems destined to revolutionise one branch of the iron trade, has been characterised by an eminently practical man as the most striking example which the world of science has yet witnessed of a thoroughly practical and immensely valuable process being discovered wholly and altogether by the aid of scientific deduction—that is, by the aid of pure theory. And there are other exemplifications of this which could be easily named. On the other hand, not only have the practical men, by some fact which in their daily work they have noted, or by some hint derived from it which they have thrown out, suggested to the theorist a train of thought, research and deduction, which has resulted in a discovery of great value; but the extent is also notorious to which they have aided the theoretical men by the results of their practical knowledge, skill and dexterity.

THE ROAD MAKER.

HIS WORK IN THE LAYING OUT OF ROADS IN RURAL, SUBURBAN AND TOWN DISTRICTS, THEIR CONSTRUCTION, REPAIR, AND IN THE CHOICE AND USE OF THE VARIOUS MATERIALS EMPLOYED.

CHAPTER IV.

CONCLUDING our remarks on the materials used in road making begun in the last paragraph of preceding chapter, we have to note that whenever a choice can be had, the best should be selected, although the cost of the material itself may be greater, and the expense of the carriage of the better may be somewhat more than that of the inferior. The margin of advantage in using a superior material in road making should never be too narrow in considering its cost.

Preparation of the Materials for the Macadam System of Road Making.

In preparing material for covering roads, whatever stone may be used for the purpose, it should be broken into small and clean angular fragments, not exceeding two inches in their largest dimension, and without crushing or reducing it to sand. This can only be accomplished by the use of light hammers, not exceeding a pound weight in the head, the face about the size of a shilling, well steeled, and with short handles. The average size of the stones in a heap of prepared or broken material may be tested by taking several at random from the heap, and dropping or passing them through a ring two inches in internal diameter.

Placing of the Materials in the Macadam System of Road Making.

The stone having been broken to the proper size at the side of the road, it should then be spread over the prepared form or bed, by shovelful after shovelful following each other, and spreading over a considerable surface, until a uniform depth of about six inches be reached throughout the whole breadth of the road. That the stones should be spread in the manner directed, and not laid on in shovelfuls at once, is a matter of considerable importance, as by being so scattered about they alight in their places in a position the most favourable to lock together by their angles and consolidate. When the first six inches in thickness of stone has in some degree become consolidated, a further quantity may be added, by which the original convexity of the surface may be somewhat increased; but such increase should on no account be so great that the rise at the crown of a road of thirty feet in breadth should exceed six inches above the level at the extremities of the sides when the road is finished.

Thickness of the Road Metal or Material for Surface of Road in the Macadam System.

To whatever traffic a road may be subject, the thickness of the covering need never exceed nine or ten inches at the crown, and six or seven inches at the sides.

Until the surface of the covering of a newly made road has become thoroughly and perfectly consolidated throughout its entire breadth, the filling of ruts, the replacing of displaced materials, and the removal of loose stones, should be constantly and carefully attended to. The consolidation of the new covering of a road will be greatly expedited by the use of a heavy roller. The roller should be a hollow cylinder of cast iron of four-and-a-half or five feet in diameter, be divided into three equal parts of its length, each of which should revolve independently of the others. In a future paragraph the reader will find a description of the method of road making in which the *steam roller* is used.

Mixtures of Materials not to be used in the Macadam System of Road Making.

A matter of much importance in road making is, that hard and soft materials should never be used in mixture, but should be used in separate strata, or in different parts of the road. For the harder crushes the softer when used together, and causes the road to be more speedily worn than when it is made entirely of soft material. It is best, when circumstances compel the use of a portion of soft material, or of materials of different degrees of hardness, in the construction of a public road, to spread the softest in the lowest stratum, and the hardest at the surface, using that of intermediate quality between.

Finishing of Macadam Road Surface with Soft Material a Great Error in Practice.

The only matter in the construction of roads wholly with broken stone yet remaining to be noticed, is a practice in road making which, although very common, is now mentioned only to be condemned as most pernicious. The practice referred to is covering the surface of a newly made or repaired road with soft material, capable of absorbing water, with the notion or under the pretence of binding the broken stone of which the covering of the road is composed. The absurdity of the practice referred to will at once be apparent when the object and effect of having the stones for the covering of roads broken into angular fragments, instead of being nodules of gravel, is for a moment considered. The object and effect of breaking the original blocks of stone for road covering into angular fragments called the "road metal" are, that the faces of the fractures may come into contact with each other to the greatest extent. Contact in rounded nodules can only take place at *points*, and therefore no contact except a few points at their surfaces can take place in the covering of roads by unbroken gravel, and such cannot be formed into a solid mass. On the other hand, in the covering of a road with broken stone, there are many *faces* of the fragments in contact, and the smaller the fragments, the greater will be the number of surfaces in contact. The action of the traffic on broken stones newly spread will be to produce, as it were, a self-arrangement of surfaces in contact, until the fragments become locked or fixed to each other by their surfaces and solid angles. This taking place in several strata in the depth of the covering, in which the joints in each stratum are continually breaking with those below and above; and, by the motion of the fragments amongst themselves for a time, the very air is displaced, and the faces and angles of the fragments of stone gradually come into almost perfect contact, by which cohesion of the fragments with each other takes place. And thus, at last, the covering becomes a solid mass with a smooth surface impervious to water.

To interpose, then, any soft or slightly cohering matter between the surfaces of the fragments is to prevent their cohesion in the manner described. If such matter be of a loamy nature, it will absorb water into the mass of the covering, which, being expanded by the frost in winter, will thereby have a tendency to break up and separate the fragments from each other, and destroy any cohesion of the covering. If the interposed matter be sand, by the motion of the fragments, and water also entering amongst the broken stones before they become fixed in their position by the action of the traffic, they speedily become rounded, and thereby incapable of cohesion; and are the source of mud, which forms on the surface of the road from the *débris* of the stone worn down by the combined action of sand and water. The circumstance last spoken of will be further referred to in a subsequent paragraph, when the effect of mud upon roads comes under discussion.

From the foregoing remarks it will be seen that, by the practice of covering a newly made or repaired road with any other matter than clean broken stone, the very object of breaking the stone into angular fragments becomes frustrated, and an expensive operation in road making rendered of no avail.

It will be seen by reference to a preceding paragraph that the force of traction required to produce and maintain motion in a wheel-carriage weighing one ton, on a level road made of broken stone, when in good condition, is 65 lb., and that the angle of friction is equal to a gradient of 1 in 35; therefore, in laying out roads on the construction treated of, steeper gradients in the ascents and descents in their line of direction should as much as possible be avoided.

The Construction of Roads with a Rough Pavement beneath the Covering.—The Telford System of Road Making.

It has been already stated that "in some cases it may be necessary to underlay the surface covering with a rough pavement." This necessity may exist when greater than ordinary strength of a road may be required; when it may be desirable to have a road requiring a less than usual force of traction in working the traffic; and in cases where the most thorough drainage in clay soils—particularly in the blue drift clays—cannot be accomplished. The mode of road making now about to be treated of originated with the late eminent engineer Telford, under whose direction the grand highway from London to Holyhead, for the transmission of the mail between London and Dublin, was constructed, and which will ever remain a monument of the ability of that great master of engineering in carrying out the most useful and gigantic of the public works of this country in the past age, and which has only been surpassed by the railway system of the present. The bed or form of a road on the construction now being treated of should have a convexity from the sides to the crown of 1 in 60. Upon this form should be laid a rough pavement of flat stones on edge, the stones carefully set by hand, and close packed or wedged. The stones of this pavement should not be more than five inches, nor less than four inches broad at the top. The thickness of this pavement should be seven inches in the middle, five inches at nine feet, four inches at twelve feet, and three inches at fifteen feet from the middle at each side; beyond which breadth the pitching or pavement need not be continued. On the pavement being laid, its surface should be brought to its exact form by breaking off the tops of any of the stones that may be above the height just prescribed.

Instead of the pitching recommended above for the foundation of a road, a concrete composed of six parts by measure of gravel to one of freshly burnt but thoroughly slaked lime, or of Portland cement, may be laid on the form of the road to a thickness of six inches or more to great advantage, where draining in a blue clay soil cannot be accomplished.

The Surface Covering on the Telford System of Road Making.

The surface covering of roads on Telford's system of construction may be spread to the same depth, brought to the same form at the surface, and every condition be fulfilled as to the preparation and application of the materials, as already recommended when treating of McAdam's system of road making.

The force of traction required to produce and maintain motion on a level road on Telford's construction, in a wheel-carriage weighing 1 ton, is 46 lb., against 65 lb. on that of McAdam; and the angle of friction is equal to a gradient of 1 in 50, whilst that on a road on McAdam's principle is equal to a gradient of 1 in 35. The advantage, then, as regards force of traction, is upwards of 41 per cent. in favour of Telford's system; while as to the angle of friction, the advantage is upwards of 43 per cent. compared with that of McAdam.

THE ALKALI MAKER AND HIS TECHNICAL WORK.

INDUSTRIAL IMPORTANCE OF HIS PRODUCTS—THE MAKING OF SULPHURIC ACID, SODA ASH, CAUSTIC SODA, SODA CRYSTALS, USED IN A WIDE VARIETY OF PROCESSES.

CHAPTER III.

Manufacture of Black Ash (*continued*).

OF late years revolving furnaces have been successfully introduced for making black ash, with the objects of economising labour, insuring the complete mixing of the charge, and operating on larger quantities of material. The mode of working will be easily understood by referring to fig. 10. *a* is the fireplace, from which the flames pass through the cylinder *b*, kept revolving by machinery, and which contains the charge of salt cake, limestone and coal. The finished black ash is removed by the door *c*, which opens just above the barrow *d*, placed to receive the charge. The waste heat, as in the older furnace, serves to evaporate liquor in the pan *e*.

Composition of Black Ash.

The composition of black ash is by no means uniform, but the average proportion of its chief constituents may be taken to be about the following :—

Sodium carbonate . . .	23 to 45	parts per hundred.
Sodium hydrate . . .	11 to 25	" "
Calcium sulphide . . .	28 to 34	" "
Calcium carbonate . . .	3 to 12	" "
Sodium chloride . . .	1 to 2½	" "
Coal	1½ to 8	" "

Lixiviation of the Black Ash.

The lixiviation of the black ash balls is accomplished in a series of iron tanks placed side by side, and furnished with false bottoms, perforated with small holes, on which the black ash rests. The tank is nearly filled with the broken balls, and warm water is then run in up to the top; after the lapse of some hours the solution thus obtained is drawn off by a tap at the bottom of the vessel, and fresh water poured on the residue. By repeating this operation two or three times the soluble matter is nearly extracted, and the weak liquors at last obtained are allowed to flow into tanks containing fresh black ash. The residue in the tanks still contains from 2 to 3 per cent. of soda, but its chief constituent is sulphide of lime—known as vat waste—which in some works is treated for the recovery of the sulphur it contains (about 20 per cent.), in others it is simply piled up near the works, and by giving off sulphuretted hydrogen for many months constitutes a great nuisance to the neighbourhood.

Evaporation of Black Ash Liquor.

The liquor obtained by the lixiviation of the black ash balls is allowed to settle for some time in tanks, and the clear liquid is then drawn off and evaporated in furnaces closely resembling the black ash ones, but provided on the bed with an iron pan to contain the liquor. The flames bending down on the surface of the liquor soon cause it to boil, and the process is carried on until nearly all the water has been expelled. The residue is raked back and forward, and ultimately withdrawn, and placed in a second similar furnace (but without an iron pan), on the bed of which it is thoroughly dried, and then forms the "soda ash" of commerce. As already noted, the waste heat of the black ash furnaces is often employed for evaporating the black ash liquors; in such cases the residue is transferred to a finishing furnace exactly similar to the one just described.

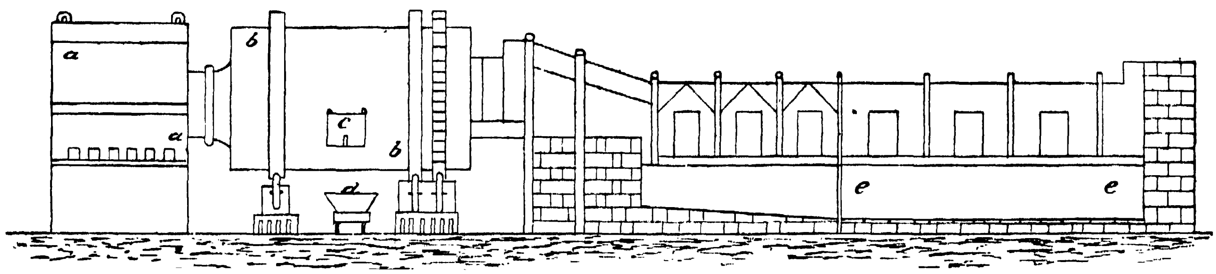


Fig. 10.

Soda ash consists essentially of hydrate and carbonate of soda in very varying proportions; the chief impurities are sulphate and sulphite of soda and common salt.

Analyses of Different Samples showing the Different Compositions of Soda Ash.

The following analyses show the great differences in different samples of soda ash :—

	(1)	(2)	(3)	(4)	
Carbonate of soda	71·25	67·89	73·62	68·90	
Hydrate of soda	24·50	14·25	13·60	14·43	
Sulphate of soda	—	4·58	6·12	7·01	
Sulphate of soda	0·12	—		2·23	
Aluminate of soda	—	1·21		1·01	
Chloride of sodium	1·85	6·06	4·43	3·97	
Other impurities	2·28	6·01	2·23	2·45	
	100·00	100·00	100·00	100·00	100·00

Soda Crystals (Carbonate of Soda, or Washing Soda).

When it is desired to obtain soda crystals, the soda ash is dissolved in hot water contained in large tanks, and the solution is allowed to settle. It is then heated in open boilers until it reaches a density of about 1·3, when it is replaced in a settling pan, and some bleaching powder thrown in to oxidise the impurities. As soon as the temperature falls to 92° F. the liquid is run into large hemispherical crystallising pans made of iron; pieces of wood are placed on the surface, and afford starting points for the crystals, which form in a few days, and sometimes assume extremely beautiful forms. The crystals form both on the sides of the pan, and grow down from the wood supports; the latter are the best, and are technically known as "points," from their peculiar shape. After being allowed to drain, the crystals are broken up and are then packed for sale.

Commercial soda crystals generally contain as impurities nearly 1 per cent. of sulphate of soda, and about ½ per cent. of common salt. The salt crystallises with ten molecules of water, and therefore contains the large amount of 62·5 per cent. of water—a fact which ought not to be overlooked by the purchaser of this useful compound.

Caustic Soda.

In order to convert carbonate into caustic soda, a very simple reaction is required; it is only necessary to treat the dissolved carbonate with lime, which by combining with the carbonic acid, leaves the soda in the caustic form. This will be understood by a glance at the following equation:—

Sodium carbonate (Na_2CO_3) + Water (H_2O) + Lime (CaO) = Caustic soda ($2NaHO$) + Carbonate of lime ($CaCO_3$).

Now, as the black ash liquors consist of a mixture of hydrate and carbonate, it is evidently only necessary to add sufficient lime to decompose the latter, in order to render the whole liquor caustic. The more caustic the liquor the less lime is required, and consequently such liquors are preferred for the manufacture of caustic soda. The process is managed in the following way: the black ash liquor (or sometimes a solution of soda ash) is placed in an ordinary iron boiler cut lengthways in two, and provided with an agitator worked by machinery. To this is added the proper quantity of milk of lime, which effects the decomposition in about half an hour. The turbid liquid is transferred to a settling pan, where the carbonate of lime deposits, and the clear liquor is then concentrated by evaporation, some nitrate of soda being added to decompose the impurities. During the evaporation certain salts separate out (chiefly carbonate and sulphate of soda), and are fished out with a ladle, and the liquor after settling is finally boiled down in an iron pot about five feet deep and five feet in diameter. The fused mass is allowed to cool, and is then run into iron casks, where it solidifies.

In some cases where very caustic liquor is obtained the use of lime can be altogether avoided by carefully removing the salts from time to time deposited, and finally evaporating the caustic liquor as in the other process.

Commercial caustic soda contains from 60 to 75 per cent. of soda, and is invariably sold according to the amount of alkali present as ascertained by analysis.

Bicarbonate of Soda (Baking Soda).

When crystallised carbonate of soda is exposed to carbonic acid gas, water is expelled and bicarbonate of soda formed;—

Sodium carbonate (Na_2CO_3) + Water ($10H_2O$) + Carbon dioxide (CO_2) = Sodium bicarbonate ($2HNaCO_3$) + Water ($9H_2O$).

Advantage is taken of this reaction for the preparation of bicarbonate on the large scale. Soda crystals are placed in a large chamber into which carbon dioxide (generated by the action of hydrochloric acid on chalk) is led. Great heat is developed, and after the lapse of some days the mass is entirely converted into bicarbonate. The water which separates damps the product, which requires therefore to be dried, and this operation is accomplished by placing the salt on shelves in a chamber to which hot air is admitted. The dried powder is then ground in a mill, and forms the baking soda of commerce.

By-products of the Alkali Manufacture.—Hydrochloric Acid.

Occurrence. Hydrochloric acid exists in nature only in small quantities and under exceptional circumstances. It is one of the gases evolved from active volcanoes such as Vesuvius, and is also present in the fumaroles of Hecla. Occasionally it is found in solution in rivers in volcanic districts, especially in South America.

History. Basil Valentine in the fifteenth century first describes this acid and the method for its preparation, but the pure acid was not obtained till 1772, when Priestley fully described it under the name of "marine acid air." Subsequently it was known as muriatic acid, or spirit of salt, and is still called in alkali works "spirits." On the introduction of the Le Blanc process, hydrochloric acid was looked upon simply as a waste product, and enormous quantities of it were conveyed from the alkali works to the nearest river, where owing to its ready solubility it was rapidly absorbed by the water. But the conversion of the river water into a dilute acid—for such was the result—could not take place without injurious consequences, and complaints became frequent that the iron work of boats and ships, which formerly lasted for years, was now rapidly corroded. The cause of this was soon traced to its true source, the hydrochloric acid sent to the river by the alkali maker; and as the nuisance had become intolerable, the legislature interfered and passed a bill known as the Alkali Act (1864), which compelled manufacturers to condense the hydrochloric acid evolved in the Le Blanc process by a method easily carried out, and which has proved highly remunerative to the manufacturer.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER X.

In preceding chapter we drew attention to the important influence heat has on the molecular disposition of bodies, and to the fact that though heat cannot be indicated sensibly, it is still present. We have seen, indeed, that the molecular or even the atomic condition is supposed to be entirely dependent upon the action of heat, so far as the spaces or voids between the molecules are concerned, the holding together of the molecules—so to express it—being, on the contrary, due to the operation of the law of attraction, and to which the property of a body known as its cohesion is due. And as the accession of heat to a body causes the spaces between the molecules to be increased, and the molecules thus to be further separated, we have the condition or property of a body known as dilatation or expansion, by which the bulk is increased, as we see in the work of the smith. This repulsion caused by heat is that which overcomes the cohesive force, or that of attraction, and when carried far enough will melt the metal and cause its molecules to flow freely amongst each other. This flowing property, as we have before named it, is seen in the heated bar of iron upon which the smith is working. But the reader may be surprised to learn that the wide variety of mechanical operations dependent upon the property which we call "ductility" (see a future paragraph), such as drawing out of metals in plates, rods, rails, and in smaller sections as wire; the coating or covering of one metal with another, and the numerous methods of stamping out and pressing of materials to make them assume new forms and take up new positions, is due to this flowing property. In future paragraphs we shall have illustrations of the phenomena of molecular influence drawn from practical work in the mechanical and industrial arts; as this present paragraph is designed to concern itself with mere general explanations, necessary to the due understanding of certain subjects, and as introductory to the special paragraphs devoted to other laws of nature upon which all mechanical work is based. Meanwhile, for the purposes of the present paragraph, we have to refer to another condition in which molecules are present, constituting a peculiar feature in some bodies, from which certain mechanical results of an important character flow out.

Further Considerations connected with the Molecular Disposition of Bodies.—Crystallisation.

We have seen that in our consideration of the physical condition of matter we have advanced from its minutest or primary or ultimate form, known as atoms—if indeed, as the reader may be thinking, the term physical can be applied to those, which can neither be seen nor handled, to a condition known as molecules, which are larger than atoms—if largeness is a term at all applicable to those, although its use is inevitable.

We now come to a condition which in some instances the molecules of bodies assume, and take what may be called a larger form; this form has the name of a crystal given to it. We have hitherto conceived of molecules of matter being congregated together, so to say, in their normal or ordinary condition, taking up no definite position, but changing or liable to be changed in a way thoroughly irregular, according to the action of the laws of repulsion and attraction. We say the normal or ordinary condition, although in reality it is difficult to say what is the normal condition, that condition depending, as we see, upon a variety of circumstances themselves continually changing. But in taking up the new form, we see that in certain bodies or substances the molecules appear in the form of crystals. And we find that the uncertainty of position above noticed disappears, and we have the phenomenon called crystallisation, coming under the operation of a law which gives to each material or substance its own peculiar form or configuration of "crystals," seen only in it and in no other. This crystalline condition of bodies is taken advantage of in many mechanical and industrial operations, and made useful in giving certain forms to mechanical parts. The opposite condition to "crystalline" is that known as "fibrous," and the distinction between cast iron and wrought iron, considered from a purely mechanical or physical point of view, is that the cast iron is crystalline, the wrought iron fibrous in its nature. We have other molecular conditions, as cellular and tubular, and these conditions enable us to carry out, in certain materials, certain industrial operations of great value. To some of these, as to those dependent upon the other forms of molecules and their properties, we shall directly allude in future paragraphs.

The Condition of Bodies known as "Mass."

From what has been said in the preceding paragraphs the reader has now a fair comprehension of what a "body" is, scientifically or theoretically considered. And although he may not be able to give an exact definition of what a body is, viewed in this aspect, assuredly he will in practical everyday life have no difficulty whatever in knowing and in satisfying himself as to what a body actually is. What is called in popular language a piece or lump of stone or wood, coal, or tin, or in fact anything which can be seen, felt, measured, or weighed, is a "body." But pieces or lumps or bodies of the same matter vary in size—that is, some have a greater number of atoms and particles aggregated than others; those aggregations have sometimes the term "mass" applied to them. In one sense the terms "bodies" and "mass" are synonymous; thus an aggregation of "atoms" forms the mass called a "particle," and an aggregation or a mass of particles is called, as we have seen, a "body." And this view is supported by the derivation of the word "mass," which comes from the Latin *massa*, the German *Masse*, and this from *massein*, to knead. The idea here conveyed may be illustrated by supposing us to take a quantity of fine flour, each atom of which is quite invisible, and knead it or press it together; we form then a "mass of flour." If we use water in the kneading process we then form what is called a mass of dough. A mass has been defined, therefore, as a great quantity or amount of matter collected together, and comes closely to the popular idea of the term, with which great quantity of materials are always associated—the ideas of "bulk," "size," or "magnitude." This general or popular idea of the term is illustrated in a heap of "breeze," which every one knows is a product of brickmaking. If from this heap an individual piece be taken, consisting of a hard, burnt, or calcined particle of clay, no one would under ordinary circumstances speak of it as a mass—he would call it a body, possibly a lump or piece—but in speaking of the heap generally, which might be made up of but two or three barrowfuls or of several cartloads, he would without hesitation define it to be a "mass." We may thus define this popular or general conception of the term "mass" to be that which possesses greater bulk, size, or magnitude than a less quantity or aggregation of the same matter which is known as a body, and is spoken of in common language as a "piece" or "lump."

The Condition of Bodies known as Volume.—Bulk—Size—Magnitude.

The term "volume" is one which the reader will frequently meet with in mechanical disquisitions. While "mass" is always applied to designate a certain attribute of solid bodies, "volume" is usually applied to gaseous bodies, and frequently to liquids—although the word "mass" is often used with reference to those latter, as "a mass of water." The term "volume," with which the popular mind invariably associates the idea of a book or mass of printed leaves or sheets, in its derivation justifies its application to scientific subjects; for as a book is made up of a series of leaves one added to the other, so a volume of gas or of water is strictly made up of a series of small or comparatively small bodies, or masses of bodies, added together. The term "bulk" is often applied to liquids, as in the case of bodies, of which one may be said to contain a greater bulk of water than another. It is derived from an Icelandic word *bulka*, to swell, which conveys the idea of increase of size very fairly. The word "size," which is used so frequently in making comparative observations as to the mass of bodies, has a very curious derivation. It is a diminutive of the legal term "assize"—which is derived from the Latin *ad*, to, and *sedere*, to sit—and as assizes were in former days frequently held to decide matters relating to weights and measures, the abbreviated term became applied in connection with the measurement or the "size" of bodies. The term "magnitude," applied generally in a comparative sense, as "one body was of greater magnitude than another," is derived directly from the Latin *magnitudo*, and the root of this is *magnus*, great. It is generally, and, as will be seen from this derivation, correctly applied to bodies comparatively of great mass; the term size generally being used in relation to bodies of comparatively small mass.

Weight, Gravity, or Gravitation.

But with increase of bulk, size, magnitude, or mass, the mind as an almost invariable rule associates another attribute or quality—a something to which the name of "weight," or, as in another word, "heaviness," or in that of "ponderosity," is given. It is impossible to conceive of a body of matter without this attribute of weight; this is purely relative, and we speak therefore of bodies as light or heavy. We do not mean that the term "light" conveys the idea that it has no weight, but simply that the light body has less weight than what we call the heavy body. Another—and it is the accurate or scientific term—is "gravity." This is derived from the Latin word *gravitas*, the root of which is *gravis*, signifying weight. Gravity in its special sense may be defined as the force which attracts bodies or masses of matter towards, that are placed at distances from, each other. Hence it is called the "attraction of gravitation," to distinguish it from other "attractions" so called which form part of the science of physics or "natural philosophy," and of some of which, so far as they concern the special work of the machinist, we shall hereafter take note. The characteristics of the attraction of gravitation are perhaps most strikingly displayed in the way in which bodies "fall" towards the surface of the earth when left free to do so, and this simply from the enormously greater mass of the earth as compared with any body which man can deal with in lifting it up above the earth's surface. But this attraction of gravity exists in the case of all bodies, however minute; it affects the atom as well as the particle, the particle as well as the body (see in preceding paragraphs "body," "bodies"): the quality, so to express it, of the attraction of gravitation, or the force with which a body is thus drawn to the earth, is the "weight" of that body.

Popular Misconception as to the Action of Gravity, as in the Phenomenon of Bodies falling or dropped from a Height.

In connection with this "falling" or dropping of bodies to the surface of the earth, which are suspended—or, say, held in the hands, for example—a very generally held view must be noticed here, and this is that the rate of descent, or the velocity with which the body will fall to the surface of the earth when let go by the hands, is dependent upon the weight. Philosophers, who know that this is not so, express surprise that this erroneous opinion should be so general that it may be said to be the universally *popular* one. But a little common-sense consideration would show how it is really very natural. Before one can take up so as to suspend bodies in the air, or, as the saying is, "keep them up above the ground," it is obvious that they must be lifted from the earth or from some other place to the point or height at which they are held in the hands, or suspended, to use the ordinary expression. Now, as every one knows, and but too painfully, that it is not so easy to lift a "hundredweight" as it is to lift a "quarter" or a "56," and that the *time* taken is just so much the longer as the weight is heavier, the natural deduction is that as bodies do fall when let go, the heavier body will reach the ground sooner than the lighter one. We might say that, as a rule, most people if asked would admit that they intuitively felt that this must be so, and this simply from the general experience of what weight is; or, as they might put it, the heavier a body is, the readier it is to fall. We do not at present enter into any full illustration of this point, but we content ourselves with the simple repetition of our previous assertion that this popular belief is erroneous, and that the contrary or converse is the truth—namely, that all bodies, irrespective of weight, fall with the same velocity to the surface of the earth—a mass of a hundred pounds in weight equally with one of but a pound. Galileo's experiment, again and again repeated, of dropping from a high tower two balls, one twice the weight of the other, proved this. It is therefore quite true what the well-known "guess" or "riddle" involves, that a pound of lead would fall to the ground in the same time as a pound of feathers, if both were allowed to drop from a height above it at the same instant of time. It would not be so under ordinary circumstances, from the fact that the feathers, offering so much surface to the air, are mechanically, so to say, kept up by it and prevented from falling freely. But when the experiment is made in a vacuum, thus getting rid of the action here named, the truth of the above statement is made evident. What may be called the mechanical condition of bodies has therefore in this connection always to be considered. A sheet of paper may in point of fact be positively prevented from falling, if left free in the air, suspended or kept up by the air acting on its large surface. If while thus suspended we could conceive of some agency instantaneously doubling and crumbling up the sheet, so as to form it into a compact ball, we should see it no longer kept up or buoyed up by the air as before. Each approach to a compact condition, however slight in itself, would overcome the action of the air in keeping it floating, and, in proportion, enable the attraction of gravitation to act. This looking at all the circumstances of the condition of bodies should be part of the mental training of every machinist; this habit and all such habits of thinking are valuable to him. The following will still further tend to make clear the above point, which has been, and is, a puzzle to many in connection with the falling of heavy and light bodies freely dropped in air. When the velocities of two falling bodies—such as a feather, and a ball or mass of lead—are seen to be so different in amount, we know from what we have stated that it is owing not to the difference of actual weight, but of mechanical condition between the two, offering different degrees of resistance to the air; and that in a vacuum both would reach the bottom of their drop or fall precisely at the same instant of time. But let it be remembered that gravity draws or pulls—we have no other term to indicate the effect—equally at each atom, and must overcome its natural inertia equally whether it is alone or in conjunction with other atoms. And in the case of two heavy bodies, the inertia of the heavier body takes longer time to overcome than that of the lighter body, so that its velocity of descent being proportional to this, is just the same as the lighter body; or proportionately greater force is required to set, so to say, the heavier body in motion than the light. In Galileo's celebrated experiment one ball was just twice the weight of the other, and according to the schoolmen of the time it ought to have fallen, and they persisted in asserting that it would fall, twice as fast, and would therefore reach the ground at the base of the tower from the top of which the experiment was made in just one-half of the time in which the lighter ball—of half the weight—fell. Galileo knew that his reasoning was correct, and did not fear to put it to the test—a test which surprised the schoolmen. This celebrated experiment is worthy of note, if for no other reason than that its era indicates a point of departure in the physical sciences which was of the highest possible importance. The schoolmen, brought up on the Aristotelian system, indulged in the most decided of assertions and conjectures, assuming them to be truths and facts which no one had the right to dispute. To put any of these to the test of experiment and trial was never dreamed of by them. The new school of thought, of which Galileo may be here taken as the founder or first expositor, made experiment of essential importance: nothing was taken for granted; everything had to be subjected to tests and trials. The young reader should take note of the point here named, as it involves considerations of the highest importance.

Action of Gravitation on Ascending Bodies, or Bodies projected Vertically into the Air.

With the idea of the action of attraction of gravitation, or the weight of a body, is always or generally in the popular mind associated the act of falling or descending. But the attraction of gravitation acts also in the case of the opposite—namely, in the rising or ascent of bodies. As the velocity of a body falling *increases* in the ratio of the time, as we shall presently see more fully, so that of a body thrown or shot upwards vertically gradually decreases as it goes upward, till it reaches a point at which motion ceases, and it then begins to descend. Now, the time taken to reach this so-called stationary point in it upward flight, is the same as the body will take to fall from this point to the surface of the earth from which the body was shot up or projected. Strictly speaking, and again in consequence of what we may once more call the mechanical influence of the air, this is not absolutely true,—the resistance offered by the air retarding the ascent and descent,—but in the case of heavy bodies shot up to comparatively small heights, the difference caused by the resistance of the air is practically nothing.

The "Law of Attraction of Gravitation."

From this law certain points of great importance to the machinist are deduced. It may be stated thus: that the force by which one body is attracted by another is in an inverse ratio to the squares of the distances between the centres of their masses. In other words, the nearer the bodies are, the greater the attraction, and this decreases as the square of the distance by which they are separated. Thus, at a distance of one foot the attraction being 1, at two feet it is not doubled, or acts directly on the distance, but as we have said inversely, so that the attraction is only one-fourth as strong; at three feet, one-ninth as strong; at four feet, one-sixteenth. Conversely, at half the distance the attraction is four times as strong, and so on. A graphic illustration of this law, which is that regulating all the phenomena of known forces proceeding from a given centre, is given in fig. 1, which represents how the intensity of a light *a b* decreases as the square of the distance which any surface lighted by it increases. Taking the decrease of the intensity to be represented by the surfaces on which it casts a shadow, we see in the figure at a distance of one foot from source of light, as at *c d*, the intensity of the light is *unity*, or 1; at *e f*, when the distance is two feet, the shadow is increased, or intensity of light decreased, so that it covers four squares equal to, or four times the surface; at the point *h j*, distance three feet, the intensity is decreased as represented by the increased surface of shadow, now nine squares; at another foot distance the shadow is increased to sixteen squares, so that the intensity of light at this point is only one-sixteenth of that at point *d e*. Conversely, the light is four times as strong if the distance between *d e* and this last-named point be halved, as at the point *e f*.

The Law regulating "Velocity" of Descending Bodies.

This velocity increases simply as the time. That the velocity of a falling body does keep on increasing

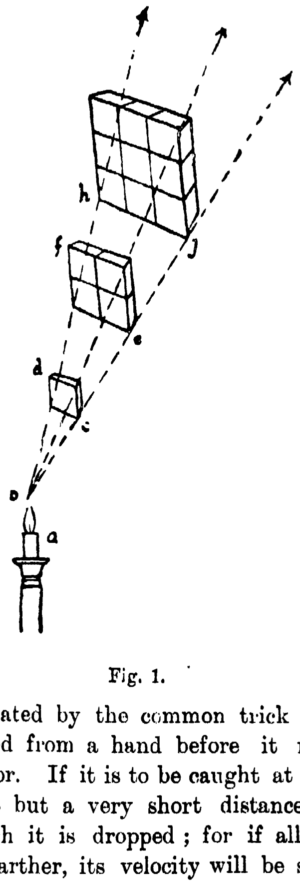


Fig. 1.

is duly illustrated by the common trick of catching a ball dropped from a hand before it reaches the ground or floor. If it is to be caught at all, it must be at a point but a very short distance from the point at which it is dropped; for if allowed to go but a little farther, its velocity will be so increased that the hand will not be able to descend quickly enough to reach and catch it. This increase in velocity as time is thus stated: the speed in falling is twice as great in two seconds as that in one second; three times as great in three seconds as in one, and so on. The velocity acquired by a body by the force of gravitation is such, that the body in falling from a height is carried through a space equal to sixteen feet, discarding fractions (the actual height being 16·11), in the first second of time.

THE BOAT AND SHIP BUILDER.

OUTLINES OF THE PRINCIPLES AND PRACTICE OF HIS ART.

CHAPTER VII.

How so small an object as a "helm" exerts such an influence in controlling so large an object as a ship, we shall presently see; but it will be necessary first to consider some points in the action of oblique forces which play so important a part in the sailing of ships and in the guiding of their movements by the helm.

Oblique Action of Force or Forces in Bodies.

In the case of the force of any moving body, such as that of air or water, striking against, or exercised upon, another body, the direction of the force and that of the plane or surface of the body being oblique to each other, while the force, represented by the arrows *a, a, a,* always acts on the surface of the body *b c d e* (fig. 17) in a direction as *a, a, a,* perpendicular to a vertical line *f g,* passing through the axis of the body,—the power or pressure exerted by the force, acting as at *a,* is less than if it acted upon the body the whole surface of which was at right angles to the face, as *i h* to force *j.* That is, the force or

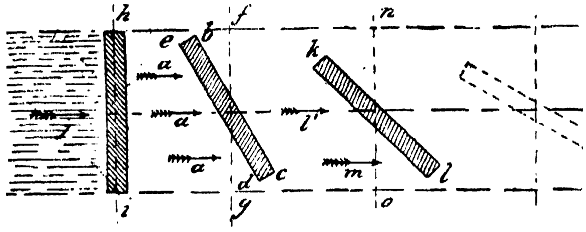


Fig. 17.

pressure a moving power exerted by a given force, as *j,* is less when acting upon the body placed obliquely to it, as *b c d e,* than that when applied to *h i,* and still less when the body, as *k l,* is still more oblique to the force or forces *l, m,* acting at right angles to the line *n o.* This may be proved graphically as follows:—Let *a c* or *b d* (fig. 18) represent the full width of a running stream of water passing through say a trough *a b c d,* having a certain velocity; the power exerted by this is obviously given out fully to a body, as *e f g h,* placed at right angles to the line of flow represented by the dotted line *i j,* passing through the centre *f′g′*—corresponding to *e f g h*—in the sections at foot of diagram, parts as *k l, m n, o p* representing top and bottom of trough *a b c d.* If we carry out the full width *d b* of force, and place, at *g r, s t,* the same width of body, as *e f g h,* but obliquely to the force, and at different degrees or angles of obliquity, we have graphic illustrations of the loss of pressure, the result of the plane or surface of the body being placed obliquely to the moving force. For in place of the full width a force or pressure of the moving body of water, as *f′ g′,* acting as it does on the full extent of body to be moved, as *e f g h* or *f′ g′,* by placing it at that angle *q r* or *q′ r′,* we have the force *a b c d* minus, or less by, as much of the water which passes by the body *q′ r′* without touching it, as is represented by the vacant spaces not lined at either end, the water pressing on the body *q′ r′* being only that depth lined as in the diagram. The body or bulk of water passing freely past the body is obviously increased when the body is made to assume the oblique position *s t,* or *s′ t′,* this increase being represented by the still greater free space which represents by consequence the proportionate lessening of pressure of the water *a b c d* on *s t* or *s′ t′.* In like manner the loss of pressure is greater the more the body is placed obliquely. The minimum of pressure or force of *a b c d* is exercised on it when this is placed in the horizontal position as at *u v* or *u′ v′*; for the only part of this which is acted upon by the water is the end surface represented by the thickness and the

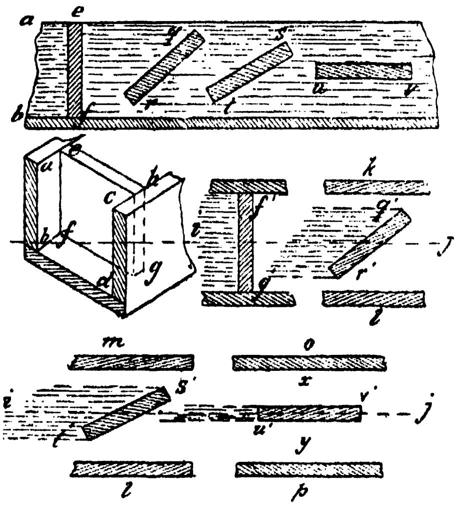


Fig. 18.

breadth, the great bulk of water passing by in the streams occupying spaces *x* and *y* without exerting any pressure on the flat surface as on *e f g h.* If this body is supposed to be hung on a central axis, the reader will recognise in the different positions it assumes in the diagram the position and uses of the throttle valve of a steam engine, or *e f g h* thus swivelled at its centres may be looked upon as a sluice valve regulating the flow of water through a channel *a b c d.* This principle of lessened pressures in proportion to obliquity of surfaces on which the force acts, is exemplified in a wide range of mechanical subjects both in bodies in motion and at rest.

Oblique Action of Forces Exemplified in the Sailing of Ships.

The whole of the movements of sailing vessels depend upon the way in which this principle of oblique forces is availed of, by adjusting the sails so that the pressure or force of the vessel in one direction may be made to produce a pressure or force in another direction, and thus enable the navigator to sail in directions different from those due to the actual direction in which the wind may be blowing. As we have seen from last paragraph, and as graphically illustrated in fig. 18, the greatest force due to a given velocity, such as that of a body or volume of wind, is obtained when it acts upon the whole surface of a body presented to it, as the force of the body of water *a b c d* acting on the board *e f g h* or *f g'* in fig. 18. At first sight, therefore, it might be supposed that the most favourable wind for driving a ship through the water would be one directly "aft," that is, blowing in the direction of the stern of the ship, as might be represented in fig. 18, in which *a b c d* may be taken as the line of wind, and *e f g h* one of the sails—that nearest the stern. But as is known, the sails of ships are often hung from more than one mast placed in line along the length of the vessel. By this disposition it is evident that the sail, as *e f g h*, catching the wind prevents it from passing into the sail next in advance, which may be supposed to be at

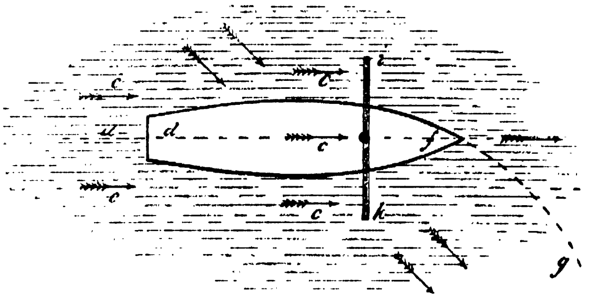


Fig. 19.

the point *q' r*, but of course parallel to the sail represented by *e f g h*, or at right angles to the line of wind *a b c d*. In practice, therefore, a wind blowing directly astern, that is, in a line coincident with the course which the vessel has to take, is not the best wind for a quick advance, but better effects are obtainable when the wind blows from the side oblique to the line or "course" of the vessel, as in this case the sails hung from the different masts receive the action of this side wind.

Oblique Action (*continued*)—**The Sails of Ships.**

And although the wind blowing in the direction say of the two upper oblique arrows in fig. 19 has a tendency to shove the vessel laterally towards *g*, that is, out of the correct or due course, *d e*, the length of the ship, as *d f*, is so much greater than its breadth, that the ease with which the vessel passes in the direction from *d* to *e* is greatly in excess of that with which it passes in the direction of the line *i* to *h*, the whole side of the ship having then to be forced through the water. It is this which makes a canal boat, although pulled actually sideways by the horse on the bank, in the direction of the line *f g*, advance straight on, as the distance which the vessel moves towards the bank is but infinitesimal as compared with that due to the length of the boat through the water in the direction of the length of the canal. In ships under sail, just as in the case of the canal boat now alluded to, there is always of necessity a deviation, however slight, sideways, towards *g*, fig. 19, from the true line, whenever the wind acts on the sails obliquely, as in direction of upper oblique arrows; and this represents a loss in sailing or propelling power. Our young readers have no doubt heard the expression "working up lee way," which obviously involves the idea of a loss; and it is the deviation from the true line of a ship's course, caused as above stated, which, as a loss, is, in the technical language of seamanship, called the "lee way." This loss by deviation so called may be constructed graphically, as well as the effective pressure exercised upon a sail of a ship under the influence of a side wind, and also the loss of pressure,

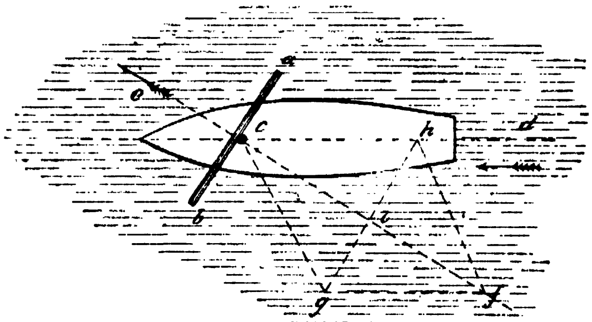


Fig. 20.

due to the obliquity, as follows: let *a b*, fig. 20, represent a sail placed obliquely to the direction of the line of blowing wind *d c*; and *e f* a line at right angles to the line *a b*, passing through the centre of the mast *c*, In virtue of the law or principle which regulates the reflection of bodies in which the angles of incidence and reflexion are always identical or equal (see remarks on "action and reaction equal," in the paper entitled "The Technical Student's Introduction to the Principles of Mechanics"), the angle *d c g*, fig. 20, at which the wind blowing from *d* to *c* deflects or bends away from the oblique surface as *a b*, is equal to the angle *d c f*. Or, to put the point inversely, the line, as *c g*, in which any wind blowing as from *d* is deflected from an inclined surface, *a b*, is found by drawing from the point of contact, *c*, a line, as *c f*, at right angles to *a b*, and then making the angle *f c g* equal to *f c d*. Having thus those lines *d c*, *c g*, we assume the distance, *h c*, to represent the force or pressure exerted by the wind blowing in direction *d c* on the oblique sail *a b*.

THE FARMER AS A TECHNICAL WORKMAN.

His Tools, Implements, Machines and Materials. —The Principles of his Work in its Various Departments.

CHAPTER IV.

At the end of last chapter we noticed the difficulties attending the endeavour to ascertain with definite precision the results of farming work, and in illustration of those we referred to certain questions which it will be well for the reader at this point again to glance over. Till we can answer these questions it is in vain to say that we know what all the points of farming are. But if knowledge in its fullest development be as yet hidden from us, conjecture has been and is open to us, and it is really marvellous to think how much this has done and is daily doing for us. But conjecture is but a failing friend at times to the best of us; and it is only a certain class of minds which can avail themselves of its powers, and work them out to practical results. Hence it is perfectly and practically true—what to many appears an absurdity—that the scientific man is an imaginative man. He is so. Imagination or conjecture—for they are here identical—is what the man of science gives at first; no less does the idle man dream over a thing, with this mighty difference between the two, that the scientific man tries to realise his dream, and thus has ever something practical before him as its result. In more senses than one the scientific man is a poet.

Some of the Causes which give rise to Discrepancies between the Indications of Science and the Actual Results in the Practice of Farming.—Rotation of Crops.

Nor, in naming the causes we have done which give rise to such discrepancies in the practical results of farming—discrepancies which are often as startling and unexpected as they are productive of something more serious than mere "surprises"—do we by any means exhaust the list. Take, for example, the subjects of rotation of crops, and the feeding values of crops from the same fields in different seasons; and in connection with those alone there comes up a wide variety of facts and circumstances in every way calculated to make the thinking farmer pause before finally deciding upon any one point presented to his notice.

Take rotation of crops first. On the introduction of the drill husbandry system—which may be said to have completely revolutionised the practice of field work—by Jethro Tull—of whom it may be said that up to the present time farmers have not estimated his work at anything like its value—he had a theory that the plants derived their nourishment from the soil in what might be called a mechanical fashion, taking the soil particles up by means of their pores, so to say; and therefore the finer the soil the better able were these nourishing soil particles to pass into the plants by their pores. Hence the very essence of his system was to pulverise the soil. His theory was wrong, as one accounting for the way in which plants derived their nourishment from it—or rather, to put it more correctly, how the soil by means of rotation is placed in the best condition to enable plants to take advantage of what nourishment or fertilising properties it either contains or has presented to it. Still there can be no doubt whatever of this: that Tull was essentially right in his system of pulverising it, the beneficial effects of which were exceedingly valuable, and of which we shall have hereafter to take special note. Although Tull's theory could scarcely lay claim to be considered one of rotation, it drew attention, or is supposed to have drawn attention to the system; for the effects of continuing to draw the same crops from the same soil had been known from ancient times, and to overcome it the system of fallowing had been introduced. Brugmans, so early as the end of the eighteenth century, had started the theory—which was afterwards taken up and so elaborated by De Candolle, that to him alone is attributed such merit as is due in connection with the theory—that each plant excreted or threw out into the soil a certain substance or certain substances which, while they were inimical to itself, were on the contrary valuable to other plants; so that if these were grown in the same soil they took up these substances, which thus added to their growth. This "excretory" theory of rotation, as it has been called, has, however, been nearly altogether supplanted by the much more scientific one of Liebig, which proceeds upon the assumption that each plant draws from the soil certain constituents only, leaving others untouched; those in turn being useful to another and a different set of plants. By alternating the plants, therefore, on any space of ground, the constituents left by one set will be used by another, so that all may ultimately be used. As a practical offshoot from this comes the theory of manuring of the same eminent chemist, and to which we have already alluded. But, beautiful as the theory of rotation propounded by Liebig is, it is found in practice that there are not a few points which turn up to throw around it many elements of uncertainty. Some, indeed, go the length of altogether discarding the theory of Liebig, maintaining that it cannot have such a very decided influence as that celebrated *savant* claimed for it, seeing that the analyses of our farm crops show a very slight difference indeed in their ash, inorganic, incombustible, or mineral constituents (for all these terms mean the same thing, and the opposite of the organic constituents). So slight, indeed, is the difference, and so minute the quantity—in some cases almost inappreciable by weight—that the inorganic constituents in the soil may be deemed inexhaustible; and that therefore what is necessary in a rotation is to furnish the organic constituents only through continuous supplying of manure. Some maintain that these are to be given in farmyard or artificial manures, while others go to a still more simple style of treatment, and maintain that the air alone is the grand source of manurial agencies so far as the organic constituents are concerned, the inorganic present in the soil being, as we have said, by such held to be inexhaustible. In this simple style of treatment the air is allowed to play its complete part by having access to the soil, by working this in the most complete manner attainable by suitable implements, having it thoroughly pulverised and deeply stirred, thus allowing the plants to penetrate deeply into the soil to take up and assimilate the fertilising constituents present in it, while by drainage the air acts also on the soil, being carried down by the rain, etc., raising its temperature (see the chapters entitled "The Land Drainer") and generally ameliorating it. We shall see hereafter how the main feature of this simple style of treatment of the soil forms in fact the basis of the most advanced system of scientific farming. On these two methods of treatment what is called the "perpetual system of cropping" is based, which dispenses altogether with a rotation, or with the necessity indeed of having one. What lessons are to be derived from these systems we shall in due course see. We shall see also how they affect not only the implements by which the soil is worked, upon whatever system adopted, but the whole range of farming practice.

But departing from these what some call purely speculative theories as to rotations, and returning to what, on the other hand, they term the "commonsense theory of Liebig," and which, in ways more or less modified, is that which is carried out almost universally in the kingdom, and glancing at the plan proposed to do away with this system of rotation by simply supplying the soil with a manure which would contain all the elements of fertility—such as farmyard manure or dung—one is, however, compelled to come back to the one grand feature of Liebig's theory, as thus: As each plant withdraws from the soil its own peculiar constituent—as wheat, for example, withdraws more of silica than it does of potash—it is obvious that by supplying the soil with a manure containing all the elements of fertility, and growing on it a succession only of one kind of crop, as, say wheat, while this would draw from the soil what *it* required, there would be left in the soil the constituents which it did *not* require, and which it would therefore not assimilate. These, therefore, would be in process of time a bank, so to say, upon which no draughts were being made. Hence, then, a rotation within a rotation, if the phrase be allowable, is necessitated in practice, by which a succession of plants is taken from the land, so that one plant shall take up the fertilising constituents which another plant had left in the soil derived from the manures applied to it. We thus have in practice the two great divisions of crops: first, white, grain or cereal; and second, the green and forage crops. But even with these the principle of an involved rotation named above is still more completely extended, and we "alternate" the narrow-leaved crops, such as the wheat, the oats, the barley, and the rye, with the broad-leaved turnips, mangold-wurtzels, and the cabbages. But whatever be the theory of rotation adopted of those which have been promulgated, or however varied may be the methods of working them out in practice, or however diverse may be the opinions held as to the action of manures or the modes of applying them, no matter of what kind, to the crops,—in all, working or tillage of the soil comes to the front as the important work of the farm. And it is in connection with this tillage, working, pulverising, comminuting or breaking up of the naturally more or less crude and close-set soils into the finely pulverised condition known to farmers as "tilth," and more popularly as "garden soil," which is the best adapted for crop culture, that we find the wide extension of mechanical appliances which is one of the most marked features of modern farming, and of the boldest and most successful attempts of our practical farmers.

This rapid review of the leading features of farming might be here extended to embrace a glance at the general details of its practice. But this is not necessitated in the present sketch, inasmuch as we proceed forthwith to take them up in regular sequence. Enough has been given for the purpose we had in view in opening up the subject, in showing—what some readers may only have had the crudest conception of—that the technical work of the farmer is, on the one hand, based upon essentially scientific principles; some knowledge of which will at least be required before an approach to the highest success in practice can be obtained. At the same time, much of what we have already given will tend to make the fact clear, on the other hand, that farming depends greatly for success on the habit of observation, a capacity to adapt its indications readily to practice, and of a technical, or, as some may call it, a manipulative, skill in carrying out its various requirements.

From all this it will be seen that farming, if carried out in a way to secure success, is not the easy, "happy-go-lucky" business so many seem to think, and which not a few have not hesitated to say. In point of fact, it is difficult to point to many professions or callings which demand such a wide range of knowledge, to say nothing of the business habits and skill which are necessary to its successful prosecution.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER VIII.

WE concluded last chapter by giving an illustration of the "polled Angus" breed; the following are remarks by a well-known authority on the polled breeds, having reference largely to the polled Angus.

"One of the principal is in the formation of the head. In the pure-bred polled there is generally, almost invariably, a prominent knob on the top of the head, although it has been observed in those animals having a strain of the blood of any horned breed. The frontal bone is also narrower. The cheek-bone of the pure polled is usually cleaner than that of the cross-bred animal. The ears of the pure polled —Angus, Aberdeen, and Moray—are rounder at the tips, and the animal appears to have greater facilities in moving them. The formation of the head, the prominence of the eyes, the form and quick movements of the ears, give a peculiar character to the expression of the polled Angus—a full grown and well fattened ox of the breed recalling the expression of the hippopotamus. With a strain of the shorthorn the hooks get very wide apart, and at the sides of the tail they get patchy; there is also a prominence of the hooks and at the sides of the setting-on of the tail, which indicate affinity to the shorthorn. The prominence of patchy lumps on the thighs and other parts of the body indicate affinity to the shorthorn."

Having thus given our notes on the varieties of breeds of cattle, we proceed to the important subject of breeding.

Practical Points connected with the Breeding of Cattle.—Breeding "In and In."

Viewed from one point, the art of breeding would appear to be one of comparatively easy attainment, and this from the simplicity of its general or leading principles as stated. But in practice it is an art by no means devoid of difficulties. In examining what has been given in connection with it by various authorities, it might rather, indeed, be said to be one so surrounded with difficulties that, amidst the abundance of opinions which these give rise to, on the part of writers who have discussed it, it is not an easy matter at times to say what is the right conclusion to arrive at. It is not necessary here to give even a brief *résumé* of what those difficult points are; but we may say that they chiefly are connected with two points—first, the influence of the parents on the progeny, or rather which of the parents influence or principally influence the progeny, the male or the female; and second, which is the better principle upon which to breed, the "in-and-in" or the "crossing" system. It is essential here briefly to describe what is meant by the terms "in-and-in" and "crossing." If the animals selected to breed from are taken from the same breed, possessing more or less the same characteristics, and dating their origin from the same one or two animals which began the breed or race, the breeding is called "in-and-in." "In-and-in" bred animals are all, therefore, related to one another more or less remotely, consanguineous, or of the same blood. The object of "in-and-in" breeding is, having by selection or otherwise obtained animals possessing what are esteemed to be good "points" or characteristics of excellence, to perpetuate or send down these good points in a series or succession of generations, this perpetuation being founded upon the principle that "like begets like." The opponents of "in-and-in" breeding, pointing to the well-known and evil results of consanguineous connexions in the human race, say that the like evil results must arise in the case of stock—that is, a weakened, enfeebled, and diseased progeny. But, as a writer remarks, "because this is the law of man's nature, it by no means follows that it is a law of animal life, as some have rashly concluded. With regard to most animals we find no *instinct* forbidding the intercourse of near relations, and to a considerable extent it seems a matter of chance. In the case of many insects, breeding in-and-in is the law of their existence. The female honey bee has no connection with the males of strange swarms, but her intercourse is with the males of her own hive. Many insects fertilise themselves.

"Some experienced breeders of cattle and horses think that by breeding 'in' and then 'out' is meant breeding an animal into the same family from which it sprang, and then into a family of the same breed several degrees of relationship removed from it. The English racehorse you may breed to pure blood, and yet the two animals may be only very distant relations. But if one is very desirous of establishing a new breed or variety, one must to some extent breed 'in and in,' in order to perpetuate the qualities prized in the original, and to give the stock bred that fixedness of type and uniformity which is of great importance. But this alone is not sufficient. Care must be taken to select animals that bear the closest resemblance to the original, including form, size, colour, movement, expression of countenance, and temper."

Practical Points connected with Breeding—"Cross" Breeding.

"Cross" breeding, or "crossing," is the very opposite of "in and in"; and is the selecting of animals of different breeds, with the object of getting the good points of one to make up the deficiencies of the other. The union of a male and female of different qualities will sometimes produce a happy combination of the qualities of the two, and considerable uniformity in the produce. We cannot further enter into the subject, as our limited space prevents us from doing so, however interesting further inquiry might be. We content ourselves by giving our opinion, by way of suggestive conclusion, that perhaps the safest and the most practical course is, to adopt the system of breeding which avails itself of the principles of both the "in-and-in" and "cross breeding" systems; or rather, that which rejects the idea that either the one or the other is of itself the only true one to follow. If a pure-blooded or pure-bred animal be met with, however well attested its pedigree, if it is deficient in any of the characteristics which a good animal should possess, it should at once be rejected. No animals should be selected, for breeding with or from, which have faults. These faults *are* faults—a truism too often forgotten—however pure the breed or the blood may be. "Pedigree" is not everything; or rather, it does not bring with it everything that is good—a fact which we see exemplified in every agricultural showyard.

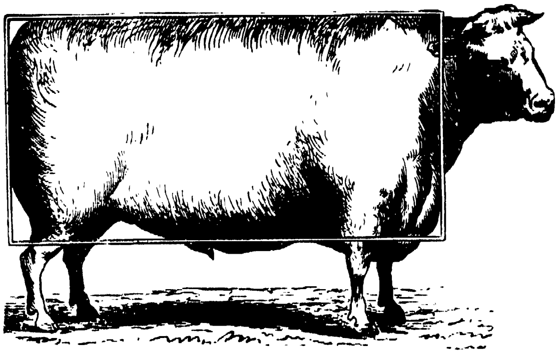


Fig. 11.

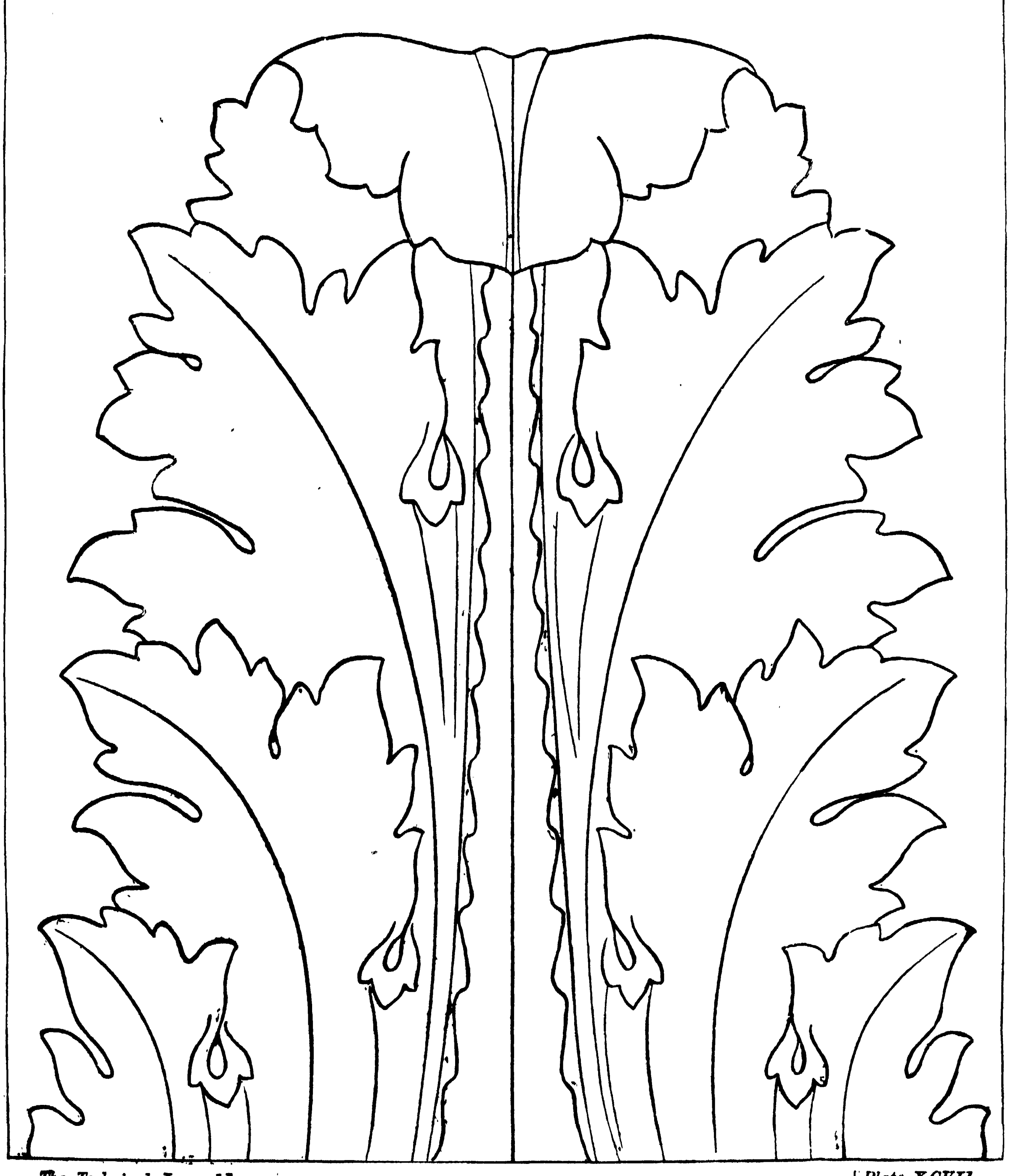
The "Points" which Constitute Good Fattening Cattle.

We now come to the brief consideration of the "points" which constitute good fattening cattle. One of these is a straight or horizontal line of spine or back, with level or flat upper surface. Another point is the depth of the body. Those points give to the outline of the animal as looked at from the side a rectangular shape. This is illustrated in fig. 11. When viewed from the front this right-lined outline should also be observable. But not only is symmetry of form a requisite in a good animal, but size, bulk or weight also. (See fig. 11.) This will be easily understood, when it is considered that the paying qualities of the animal depend upon the weight of the flesh which it yields—this meaning the edible parts, not the offal, which has the least value, although even this is not, as some might suppose, altogether valueless. The "case" must not only be well filled up, as in fig. 11, but it must have breadth as well. This assumes the possession on the part of the animal of broad rumps, which yield the finest and most highly esteemed parts of meat; and it also assumes a fine broad capacious chest, in which all the higher functions of the animal can go favourably on, and thus produce the maximum of meat and fat with the minimum consumption of food. The following, from the pen of an able authority, will be of service to the reader, in giving him a good idea of what the "points" of a good animal are.

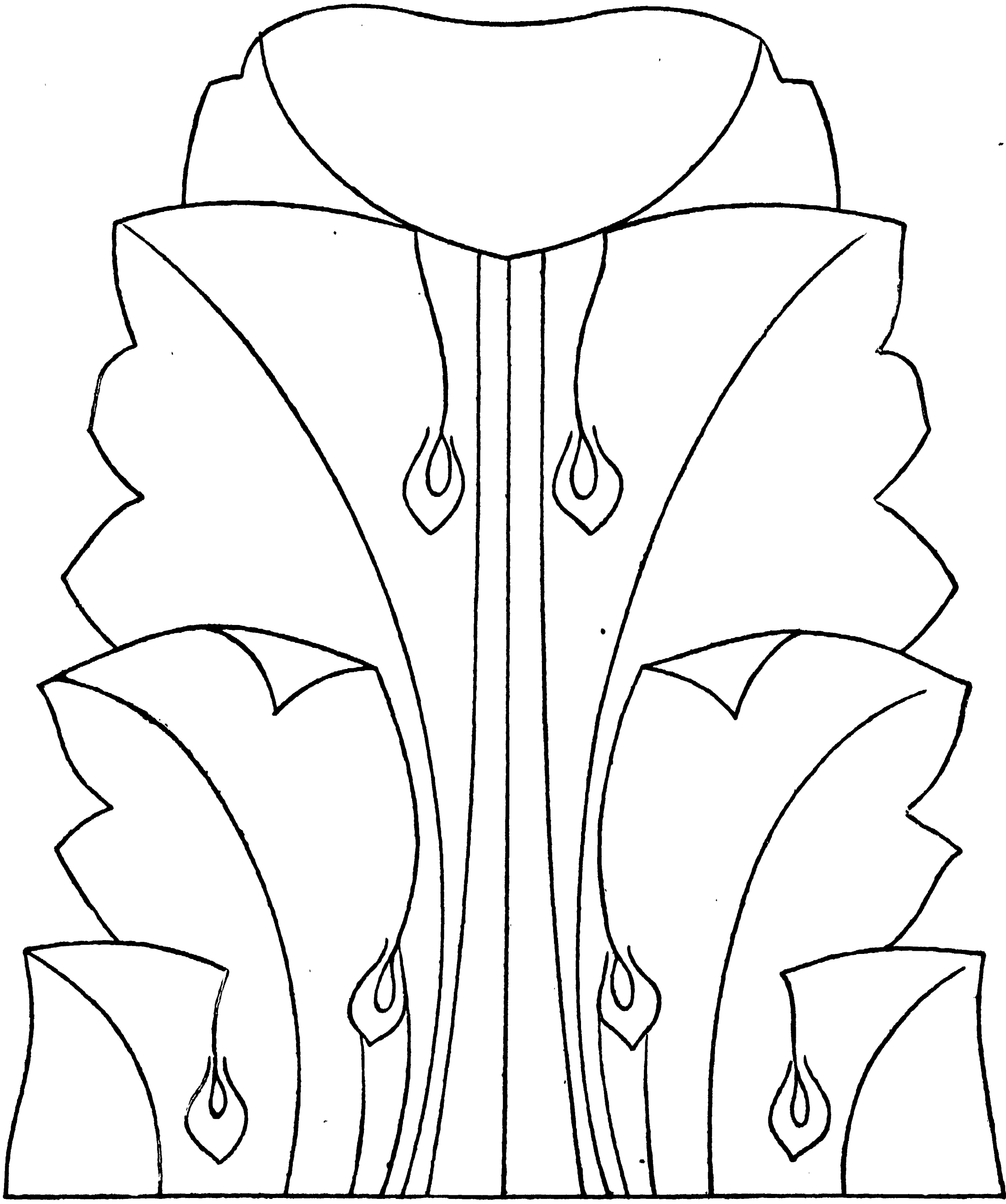
As regards the form of the head, "I attach," says this writer, "great importance to a large wide forehead, and a somewhat short face, in all cattle intended for grazing purposes. There was a very fine specimen of a head in the yearling bull Bushire 2nd, bred by Mr. Leck, and sold for forty guineas at Mr. Cat's sale. The head of that young animal was a model, and I was going to add, alone worth the sum for which the fine fellow was sold. Animals with the forehead wide between the eyes, and expanding well out also in the upper portion of the skull, are more intelligent, and therefore more manageable, than animals having narrow or convex heads, which is the index to coarseness everywhere, and often the index, too, of a bad constitution—what we should term rickety or scrofulous in the human subject. Size and strength are not identical in living tissues and structures: the small bones of the gazelle and the chamois, supporting them in dashing leaps from crag to crag, are natural illustrations of how strength may be condensed in the small bone. The large bones are full of cells—are porous, so to speak—and bear about the same relation to small bones as the branch of the pithy alder tree does to the dense and compact stem of the oak. It is pleasant to find very strong testimony on this point by one of the most successful graziers and cattle feeders that England has ever known. Mr. Colley, who realised a very large fortune by the purchase and sale of feeding stock, writes thus: 'For I aver that no large boned animal will feed so quickly, or cover so readily and thickly with fat flesh, as one with a small bone, if well formed. This is the criterion, this is the main principle, that we found our judgment upon, respecting all animals which are to be fatted for the support of mankind, and we can justly say that this judgment is confirmed by nearly forty years' experience.'

"Well, having for the most part dealt thus far with minor points, what may be considered good ones? In the bull, the head should be well set upon a broad, deep, muscular neck, the horns short, and not too bright; the ears long, and situated near to the head, the inside skin having an orange tint. The forehead should be broad at this point, with a somewhat concave appearance between the eyes—the eyes themselves large, mild, lustrous and prominent. The butcher knows if he finds the eye of the calf protuberant, and by elevating the eyelids sees fat underneath, that the protuberance is caused by fat in the socket; and if it be found in quantity here, it is a fair criterion that it is well diffused in more important parts."

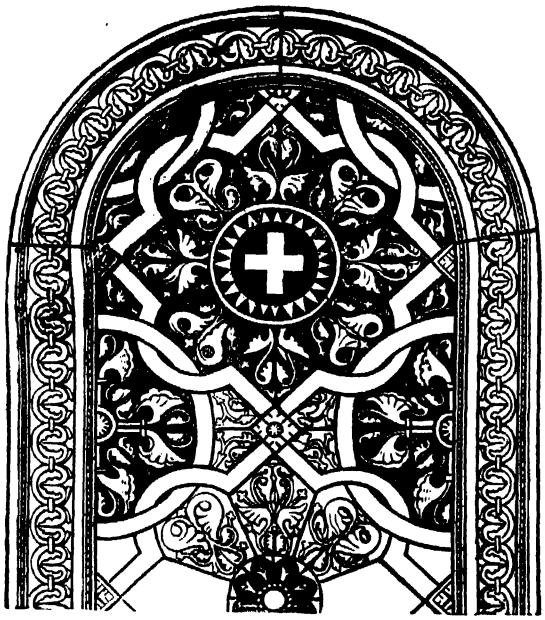
THE ACANTHUS LEAF.



BLOCK OF SUBJECT IN PLATE XCVII.



FORM AND COLOUR IN INDUSTRIAL DECORATION (see Text).



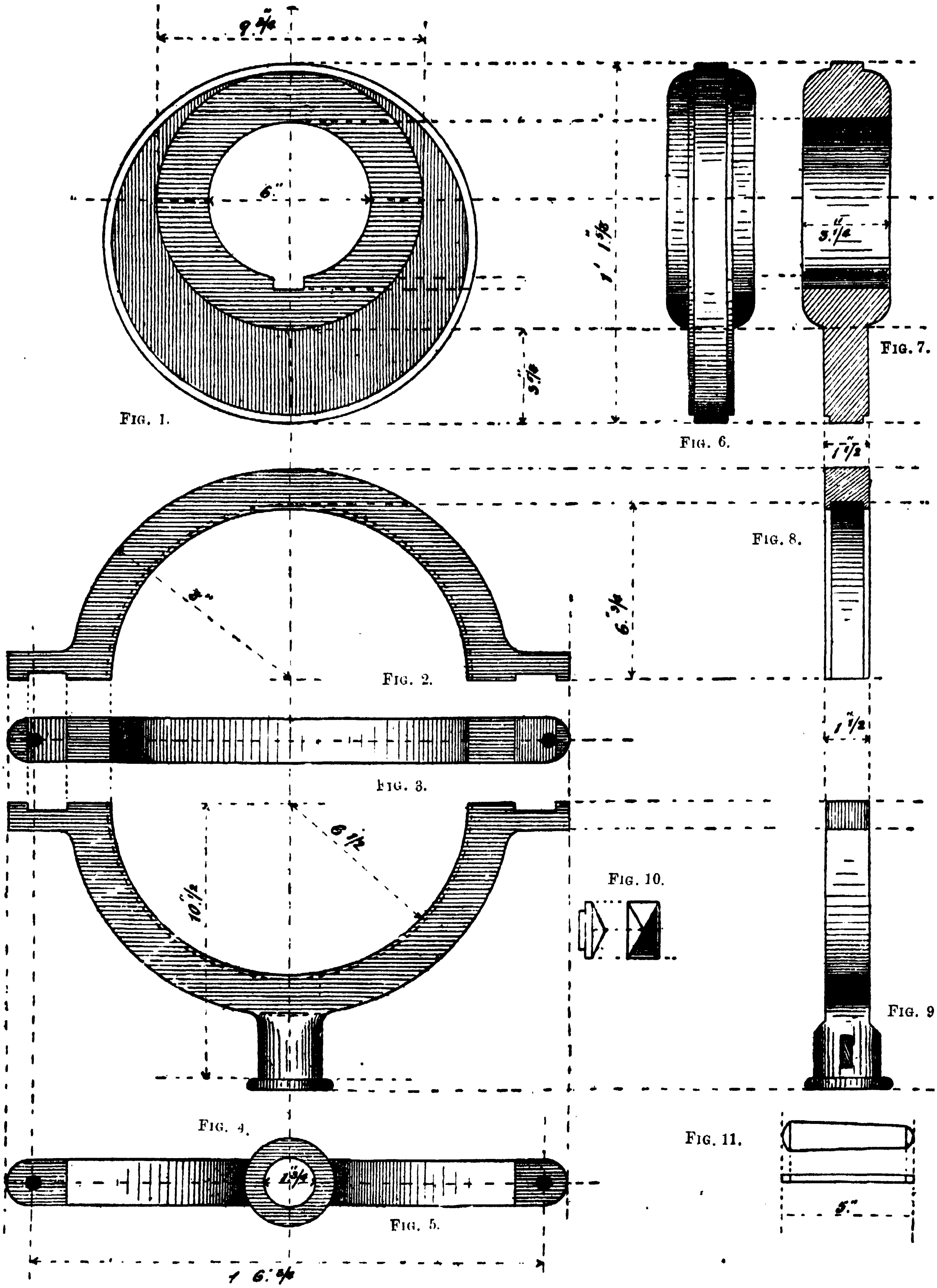


FIG. 1. ELEVATION OF ECCENTRIC.—FIG. 2. ELEVATION OF RIGHT-HAND STRAP OF ECCENTRIC.—FIG. 3. INSIDE PLAN OF STRAP. FIG. 4. ELEVATION OF LEFT-HAND ECCENTRIC STRAP.—FIG. 5. PLAN LOOKING UP OF STRAP.—FIG. 6. END OR EDGE VIEW OF ECCENTRIC.—FIG. 7. SECTION OF ECCENTRIC.—FIG. 8. EDGE VIEW OF RIGHT-HAND STRAP.—FIG. 9. EDGE VIEW OF LEFT-HAND STRAP.—FIG. 10. OIL CAP.—FIG. 11. KEY OR COTTAR.

Mitre Wheel (Bevel) Toothed Gearing.

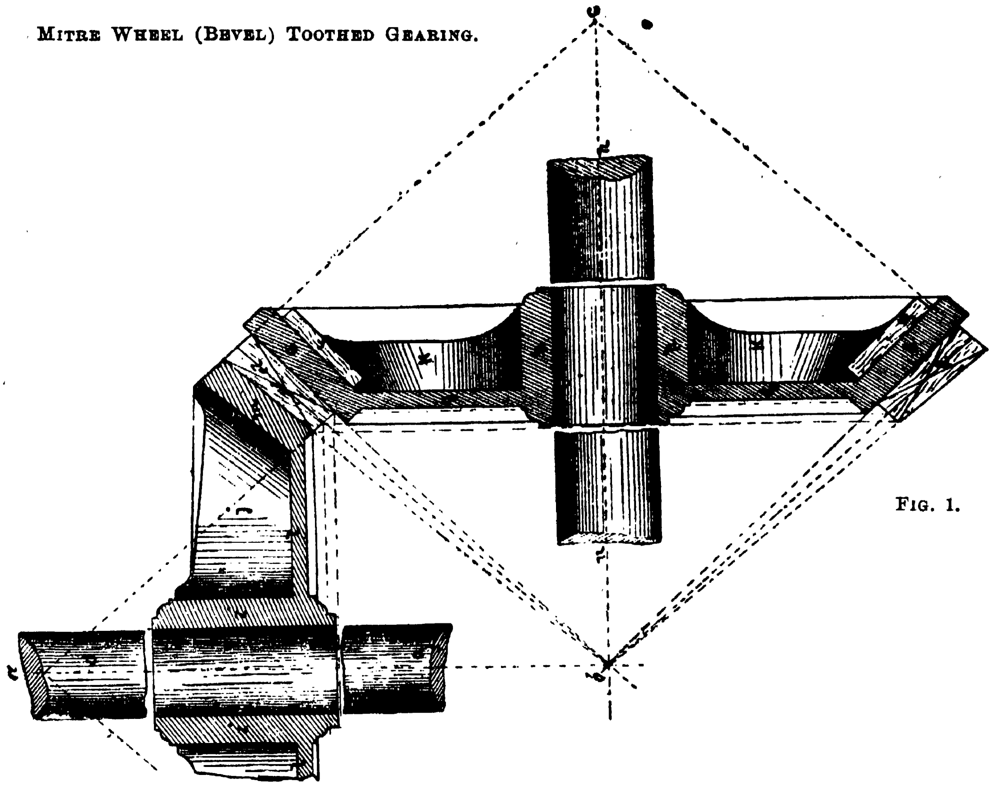


Fig. 1.

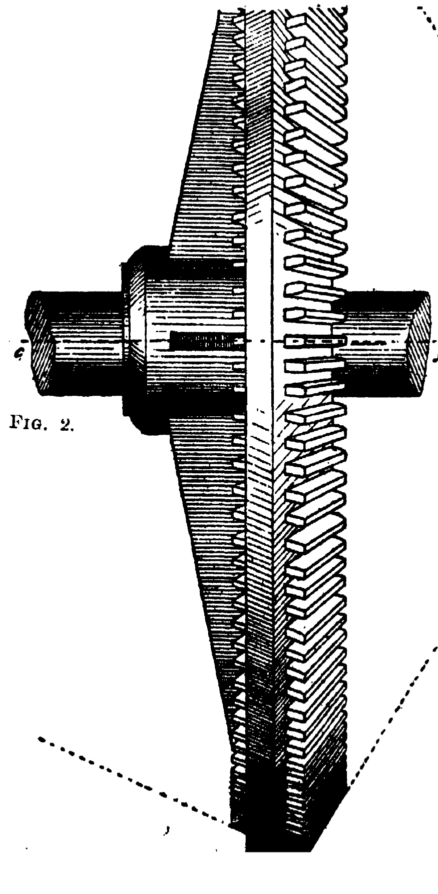


Fig. 2.

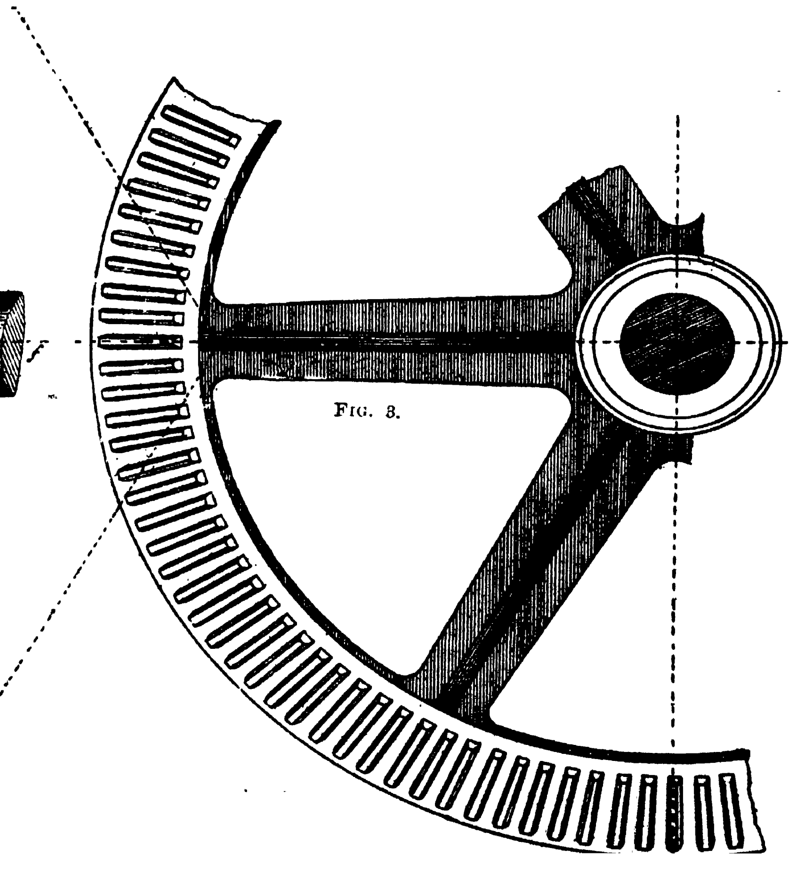
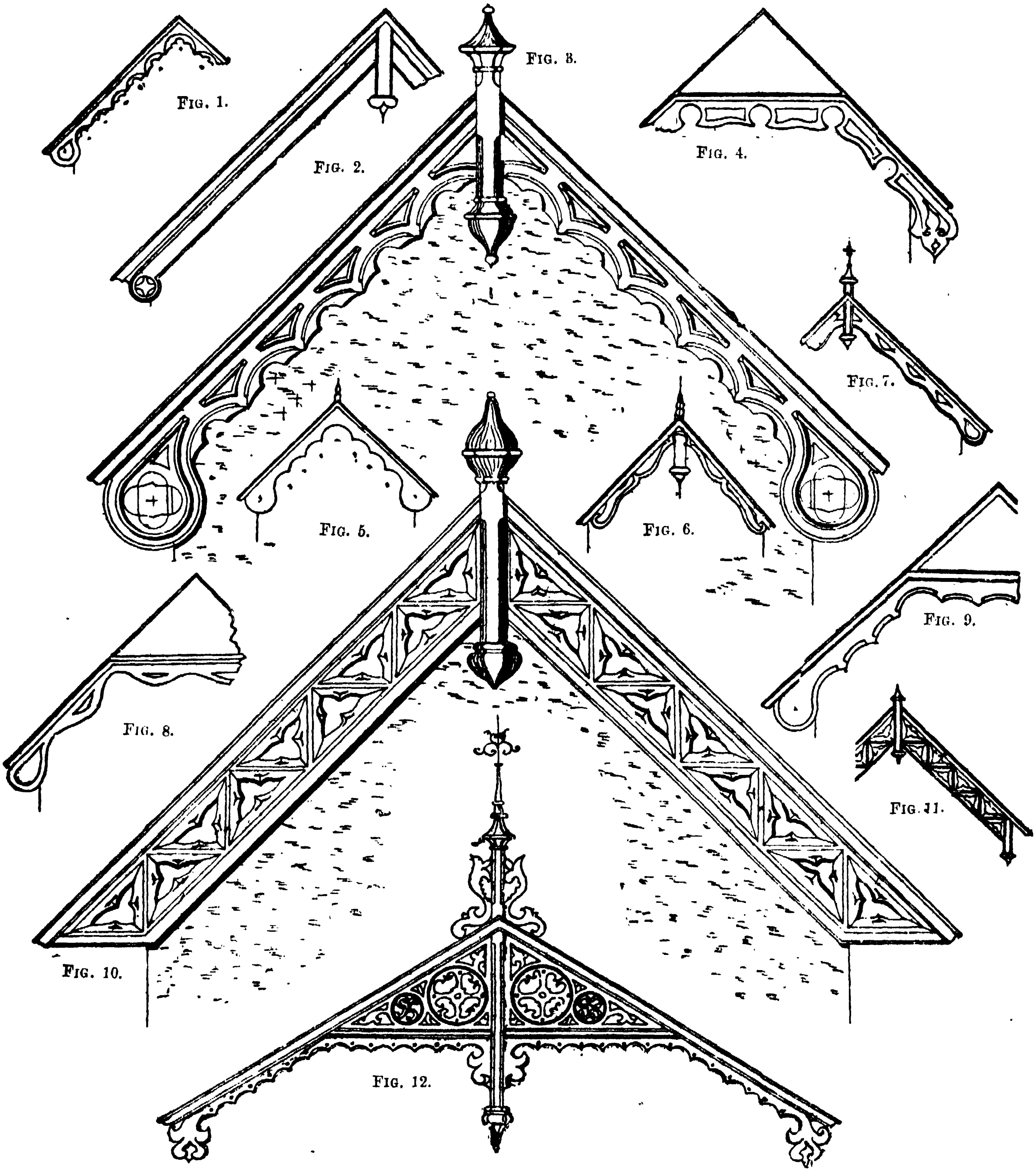


Fig. 3.

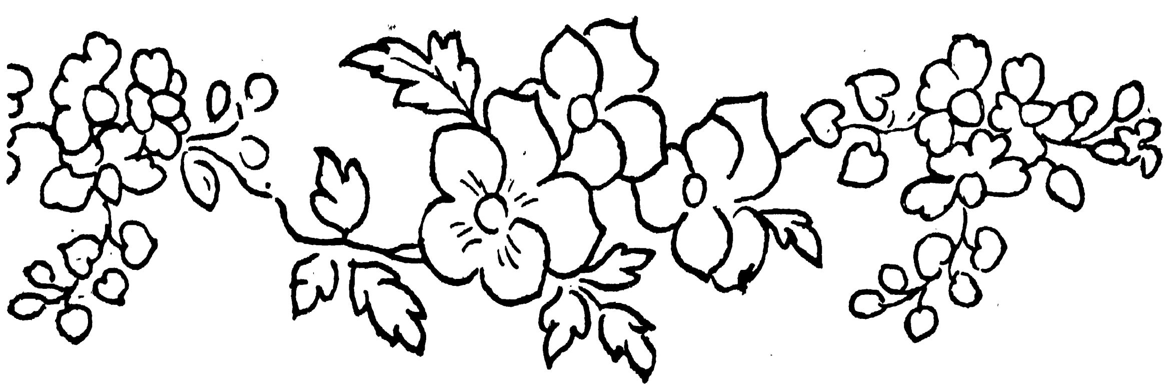
THE JOINER" AND "THE CARPENTER" (see Text).

SUGGESTIONS FOR BARGE BOARDS—DOMESTIC ARCHITECTURE.



FORM AND COLOUR IN INDUSTRIAL DECORATION (*see Text*).

CONVENTIONALISED FOLIAGE AND FLOWERS FOR TEXTILE DECORATION.



"THE JOINER" AND "THE CABINET MAKER" (*see Text*).

INTERIOR DECORATION FOR DOMESTIC ARCHITECTURE—STYLE, ITALIAN.

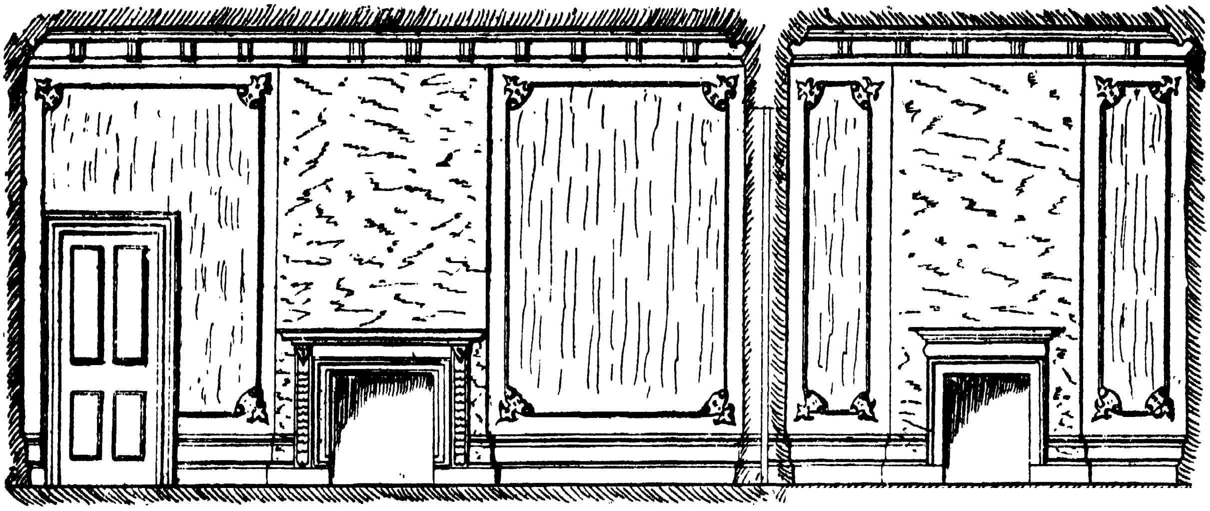


FIG. 1.

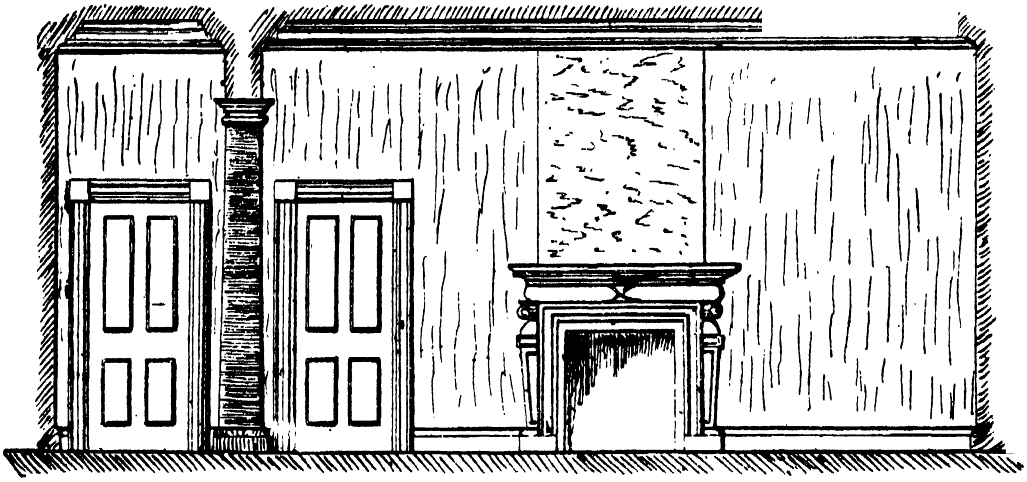


FIG. 2.

FIG 3.

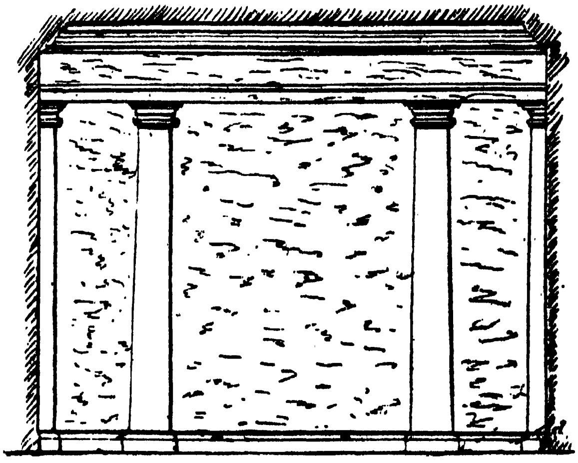


FIG. 4.

THE STEAM ENGINE USER.

The Different Classes of Engines used chiefly for Manufacturing and Agricultural Purposes.—The Leading Details of Steam Engines—Constructive and Operative.—Their Practical Working and Economical Management.

CHAPTER VII.

At the end of preceding chapter, in making some remarks on the "oil" used for lubricating machinery, we said that the competition in the trade caused all kinds of admixtures to be used for this purpose. This competition makes the article passable to the eye, and also, to all appearance, a good lubricant. Thus the purchaser is led to accept the character given of the oil, and so gives an order for a trial cask. It is no uncommon occurrence for those who are using it at once to give it praise, before any real test has been made of its qualities.

The next step to take is to apply to those who attend to getting up the steam in the boiler—of course after about three or four weeks' using it in all the machinery: 'Can you tell us how many tons of coal you consume per week?' The answer often turns out to be an indirect one—merely saying, 'I use very much more than I used to do. The engines require more steam.' This often leads to a safe conclusion—*i.e.*, if the same coal is being used. If a lower quality of coal is now used, or a different kind of coal, say from another colliery, such a course could not then be relied upon. We here refer to the consumption as another proof of the different quality of oil being the cause of the extra power being required. It is, to those unacquainted with the difference there is in the friction of oils, strange that in such a change from one kind or quality of oil to another there should be any appreciable difference in friction. Experience has decided that all who have had the opportunity to test it by the indicator are quite satisfied. This fact alone adds very considerably to the value of the indicator. In short, too high a value cannot be attached to it by those who are steam-power producers and users. (See the forthcoming notes on the Friction of Shaft Bearings, under the department of "Technical Facts and Figures," for information on this important subject of machine lubrication.)

Illustration and Description of Richards' Indicator.

We have in fig. 1 given a popular and a general description of the indicator in what may be called its ordinary form; we now take up other forms, as it seems desirable that sketches should be given of them and an explanation of their separate working parts, in order that those who are not in any degree conversant with the apparatus in its different shapes and with their mechanism may more readily grasp their working,—and this even in the case of those totally unacquainted with it, if of a mechanical turn of mind, in which case we hope they may gain knowledge of its working and also of the value of its use to employers of steam power.

In fig. 3 we give an illustration sufficiently detailed to give a good idea of the arrangement and construction of Richards' indicator. *a* is the part to be screwed into the steam top of the cylinder cover of the steam engine to be indicated, giving access to *b*, the stopcock of the indicator, opened and closed by the

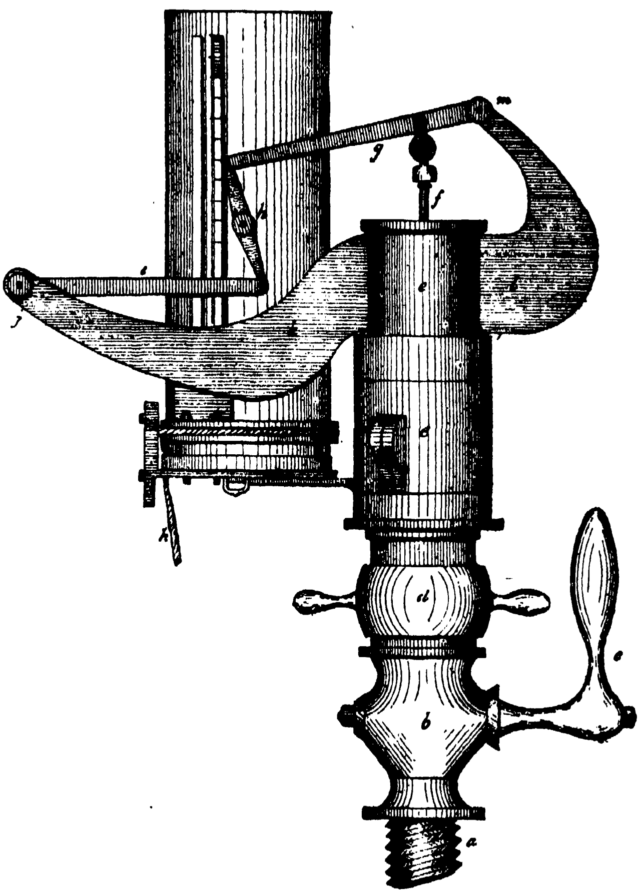


Fig. 3.

handle *c*, and which lets out the steam from the cylinder of the engine to the indicator, or *vice versâ*. It also allows the vacuum to act on it as the cylinder piston returns. The vacuum is always acting in conjunction with the steam upon the piston; *i.e.*, the steam presses on one side of the piston, and on the other side of it the vacuum is drawing—one pressing and the other pulling, both acting upon the piston for the same purpose. This is continually taking place. At every reversion of the piston the change is made—*i.e.*, the steam is on the opposite side of the piston to that of the vacuum. In this way the paper which is on the drum indicates the changes which are continually going on. We have referred to the movement of the pencil, which makes traces upon the paper which is on the drum *h*, fig. 3. The pencil, it must be remembered, is attached to the piston in the indicator, and therefore when the piston is in any way affected by pressure, from whatever source, the lines on the paper will be truly represented. *e*, fig. 3, is the tube or cylinder in which the piston works; *h'* the card passing round the bottom wharve or pulley of the drum *h*; when the card is relaxed by the change in the motion of the engine, a spring within the drum takes up and causes the drum to go back. The reversing of the motion of the engine then draws the drum back again. The lever *h*, connected with the lever *i j k l*, carries a pencil which traces the diagram upon the paper as the steam and vacuum operate upon the piston. Fig. 4 is a section of the coupling marked *d* in fig. 3, which is used to couple the indicator to the tap on the cover of engine cylinder.

Having briefly described Richards' indicator, and

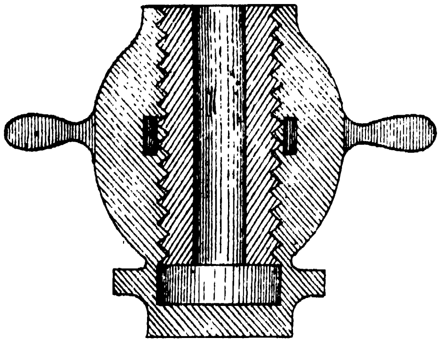


Fig. 4.

given a sketch of it, it may be desirable to compare it with a sketch of an indicator which has been in most common use. It is a very simple one compared with the form in fig. 3 or in fig. 5. The only difference of moment is in the elaborate arrangement of the pencil motion of Richards, which claims the power to produce a more accurate diagram. Under some circumstances its claim can be substantiated, but not in all. Where the steam comes on the piston early, it does what it professes to do. (See fig. 1, with its general description, *ante.*)

Description and Illustration of Kenyon's Pistonless Indicator.

It is pleasing to the man of inquiring mind to be able to say that he is not indifferent or strange to the various arrangements of indicators. Every different construction of a machine widens the path, and thus the mind becomes more ready to grasp changes; and in addition the same individual can not only take in the developments of other men's ingenuity more quickly, but he often becomes an original inventor himself in devising some new machine, or an improver of some form or forms now in existence. The more conversant we are with machinery, the more readily do we comprehend the value, or otherwise, of supposed improvements or real improvements. It is within the reach of man to make alterations in the arrangement or in the form of a machine, but changes of that kind are not often improvements. Such changes in form often mislead men—those especially who are but little acquainted with the practical part of the machine; and hence the importance of sketches of those which are in daily use, or any that may have just been produced likely to be really serviceable.

Kenyon's pistonless indicator, shown in fig. 5, was only intended at first for the use of high-pressure

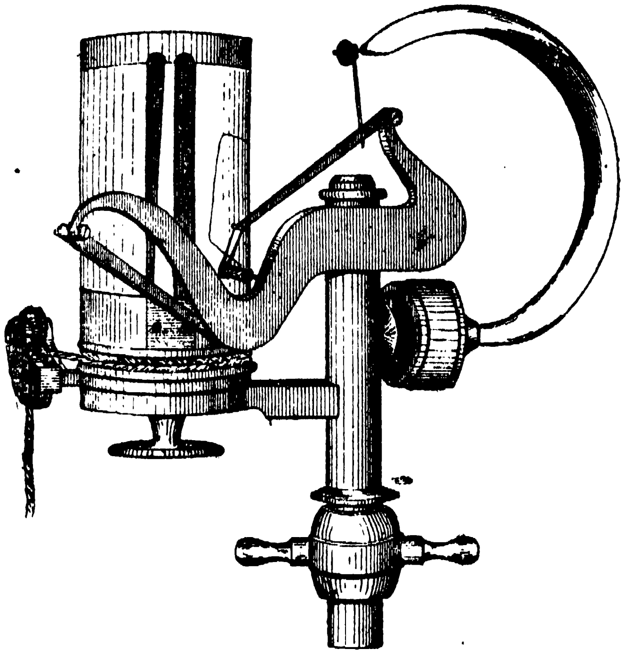


Fig. 5.

steam engines, and is well calculated for short-stroked engines and those running at very high speeds. This will no doubt be readily understood. Undoubtedly this arrangement has its sphere of usefulness. Thus it may have been the inventor's aim to arrange an indicator to meet a want which we have often found to exist. Richards' indicator has in a measure met that want. Kenyon's is expected to have a little preference: in that particular part of the diagram where the flirting or jerking of the spring in the former indicator was incomplete, this arrangement of letting the steam into the tube more gently is designed to overcome it entirely. We have said that Kenyon's "pistonless" indicator is best adapted to high-pressure steam engines, and no doubt but such is the case.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER VIII.

At the end of last chapter we stated that the term "mechanical drawing" was used to distinguish the specific drawings known generally as constructive from those as freehand or artistic. This specific difference may be described here, and very generally, in a few sentences, although the minute and in all cases many shades of distinction between them will be elucidated specifically and in due sequence in future paragraphs. Architectural and engineering drawings, which are to be used by the workmen in carrying out construction of whatever class, or prepared to explain for any special purpose a building, a machine, or an engineering structure, are prepared by the draughtsman by the aid of mechanical appliances and instruments more or less numerous and complicated, according to certain methods or constructions, or—to call them by a mathematical name which to a very large extent is directly applicable to them—"problems." Every operation done by the "mechanical" draughtsman (using here the generic term we have said is very frequently employed to designate architectural and engineering drawing work), every line in that operation, whether curved or straight, is done with absolute precision and accuracy by the aid of the mechanical appliances and instruments we have referred to, and some of which we have already described in preceding paragraphs, and others remaining yet to be noticed will be presently given. The draughtsman who has a straight line or a curved one to draw on his paper must not draw it "in any fashion" so that it may look "like the thing." It must be drawn with such absolute precision as to be "the thing" required and no other. Nothing is to be left either to the manipulative dexterity of the hand in drawing the lines required, or to the education of the eye in estimating form and distances or measurements. The draughtsman has certain rules to guide, certain appliances and instruments to aid him. Those he must follow, those he must use. Hence, as all his work has to be done with precision and extreme accuracy, and by aid of certain fixed conveniences, the comparative accuracy of the generic term we have alluded to, which classes all architectural and engineering drawings under the class "mechanical." The work is, in truth, very nearly wholly mechanical—that is, using the term in its popular and generally received sense, distinguishing as it does work done with precision and accuracy; although, as we shall see as we proceed, there is ample scope for the exercise of the mind, and that in our highest walks of geometry or practical mathematics.

General Conditions of Free Hand, otherwise called Drawing.

In the work of the "artistic," or, as he is frequently termed, the "freehand" draughtsman, we meet with totally different conditions. What the details of his work are will be found fully described and illustrated, to an extent of completeness rarely, we believe, secured, although it has, no doubt, been not unfrequently attempted, in the series of papers entitled "The Ornamental Draughtsman," yet to be completed. Suffice it here to say that all the work of the freehand draughtsman, whether it be in straight lines or in curved, or as in general practice in a combination of both, depends wholly upon, first, the manual dexterity in transferring to or rather in putting down on his drawing surface, paper or canvas the lines and curves of the objects he is looking at in order to delineate or draw; and, second, upon the accuracy of his eye in estimating not only the forms, but their distances, lengths, or extent, in such a way that, whatever be the scale or size of his drawing in proportion to the object he is attempting to delineate or draw, they will all be in relative and accurate proportion and position in the drawing he makes. We have used the word "attempting" here with a fixed purpose in view, and that is, in order to make clear the essentially different nature or character of the work of the artistic or freehand draughtsman from that of the architectural or engineering or mechanical draughtsman. In the work of mechanical drawing, a line, or a distance which is to be shown by a line, can be, must be, measured with definite precision; and the accuracy of the distance, or say the length of the line, can be tested either by the draughtsman or by any one supervising his work. There is a standard to which both and all can appeal. But in the work of the freehand draughtsman there is no standard beyond which there is no appeal. There is, in truth, a standard; for there is the object to be delineated, made up of certain lines and curves the existence of which no one can or does dispute. But in almost every case it will be, and is in practice, found that the difficulty is to decide who has followed the standard. Two artists drawing the same object from the same point of view—in short, under precisely the same circumstances—produce drawings which to a spectator, a third person, appear to be at first sight an accurate resemblance—or copy, to use the technical phrase—of the object which both draughtsmen have been delineating. But a closer inspection of the drawings reveals the fact that in several points the two drawings differ materially. The spectator or examiner may or does not pretend to decide which of the two drawings is the correct one: he sees only that they are not precisely the same; a certain curve in the one not being the same as the "fellow" of that curve in the other, a certain line being longer in the one than the other, and both not taking exactly the same position or following the same direction. The spectator or examiner may, indeed, in his own mind decide, if he do not name it to the two artists, that neither has succeeded in delineating the object accurately—at least, as *he* sees it, from the same point of view as the draughtsmen have seen it or looked at it. Both the drawings look like the object, but the examiner can truly say, as far as he is concerned, that neither the one drawing nor the other *is* precisely the object, or rather the resemblance or copy of the object. Yet both draughtsmen can truly and honestly say that they have faithfully copied what they saw, or to put it in the most strictly accurate terms, what they thought or conceived that they saw. They can both appeal to the same standard; for notwithstanding what has been said, there is a standard, and it is there before them in the object which both have been delineating. But as to which is the attempt only, and which is the success, there is apparently no "standard" to appeal to, for half a dozen spectators or examiners of the work will give each a separate judgment—each antagonistic to the other. How this arises requires greater space to explain fully than can be afforded here, nor does the scope of the present paper demand it; suffice it to say that it arises from a circumstance which every artist understands, although he may not be able to explain it explicitly in set terms. But it may be sufficient for our purposes here to be made clear to our readers if we state that, however it arises, whether from a physical or physiological peculiarity or defect, or whether from careless teaching or equally careless learning, the fact remains: one draughtsman is dominated, so to say, by this cause—that he cannot see the object properly which he purposes to copy. He looks at it: that he cannot help doing—must do if he designs to do any work at all. But how great is the distinction between looking and seeing, all who have investigated the subject know very well. Goethe and Ruskin, as leaders eminent in their respective lines of thought and study, have alike pointed out the difference; and the latter has, with all the perspicuity and brilliancy of language of which he is pre-eminently a master, enforced upon the artist pupil the necessity of studying to see. A young freehand draughtsman "puts in" (to use the technical term for drawing sometimes used) a line representing the curve which is given in a drawing or object he is expected to copy. He gives it as he says he "sees it," and in using this expression he is thoroughly honest. And yet even a tyro, with a moderately well trained eye—in other words, who sees a thing accurately enough—can tell at once that the curve is not accurate. It looks, no doubt, like the true curve, or that given in the drawing or object; but it is notwithstanding not the curve which that presents in reality. The draughtsman may have this again and again pointed out to him, and again and again he may fail, and in such cases generally does fail, to give the true curve. He is so dominated by the cause—whatever it be—that he cannot do otherwise than he does. And yet he may and can honestly say that he draws the curve as he sees it, or to use the words he very probably employs, as he "looks at it." One who cannot advance beyond this stage and master the dominating cause has no chance of ever becoming a good freehand draughtsman. We can appeal to teachers who have had some fair amount of experience if they have not had pupils under their charge to whom it was a matter of the greatest difficulty to impart a knowledge of what accurately "seeing" the object was—if not some so obtuse in this respect as to make it an altogether hopeless thing to expect that they ever could learn this. We do not here ignore or in any way lessen the value of mere manipulative dexterity. This is essential in its way to all true success in freehand drawing; but we maintain—what few who know what art is will dispute—that the difference between the true artist and the pseudo is caused almost wholly by the fact that one sees accurately, the other does not—or sees wholly in a wrong way. Where so much apparently, as things go, must be left to individual judgment, or rather estimation, the necessary result must be that general work must be characterised by much that is varying and unequal. There is a proverb well known to all, "many men, many minds," which, being paraphrased thus, "many eyes, many kinds of drawings" of the same object, explains this statement.

Freehand Drawing in the Special Class known as Ornamental Drawing as Essential to the Building or Architectural Draughtsman as a Knowledge of Mechanical Drawing or Plane Projection, in the Preparation of what is called Working Drawings.

We have thus dwelt upon the point of difference between architectural and engineering or mechanical drawing and that known as freehand or artistic, not merely because some of the points involved have a closely practical bearing upon the subject of our paper, but because what we have said may have something practically suggestive to the mechanical draughtsman whose speciality is architecture; for in one department of his practice he has to execute drawings, as the details of architectural ornament, in which a knowledge of freehand or ornamental drawing is absolutely necessary. To those of our readers so situated the paper under the head of "The Ornamental Draughtsman," as well as those which concern themselves with the subjects of design specially, as that entitled "The Ornamental Designer in Wood, Stone, and Metal," prove themselves to be of great practical value.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER VIII.

3. Fast Steam Colours.

THIS division comprises vast number of colours, chiefly the anilines, and most of the vegetable colours in use. In most cases the solution of the dye is mixed with the thickening and mordant, and printed on, and the goods are steamed, and either soaped or passed through tartar emetic, bichromate of potash, or other solutions necessary to complete the formation or the fixing of the colour. They are then washed in water and dried, and are ready for finishing, etc. The colours thus produced are more or less fast, and comprise the larger number of colours in general use.

The steam style may conveniently be divided into five classes:—(1) Aniline and allied colours; (2) aniline black; (3) Prussian steam blue; (4) logwood and other vegetable colours; (5) catechu.

ANILINE REDS.

The chief aniline reds in use are (1) aniline scarlet, which cannot be fixed upon cotton, and has already been referred to in the loose steam colours; (2) magenta, which is an exceedingly pretty crimson; (3) saffranine, or safranine, a beautiful rose or pink; (4) eocine; (5) cotton "fast" scarlet.

Magenta.

A moderately deep and very bright shade of magenta may be obtained on cotton according to the following recipe:—

Magenta crystals . . . . 7½ oz.
Acetic acid at 4° T. . . . . ½ gall.
Warm till dissolved, pass through fine calico, and mix into starch paste . . . . 2 galls.
Alumina paste . . . . 2½ galls.
Mix well, strain in the usual way, print, and steam.

Saffranine.

The following gives an exceedingly brilliant but fugitive pink:—

Saffranine, *pure* . . . . 8 oz.
Acetic acid, 8° T. . . . . 1 quart
Warm till dissolved, filter, and add to
Starch paste . . . . 8¾ galls.
Alumina paste . . . . 1 „
Mix well, strain, print and steam.

Eocine.

This interesting compound is seldom or never applied to cotton except in the discharge bronze style, under which heading we will treat of it.

Cotton Fast Scarle

Scarlet powder . . . . 3¼ lb.
Acetic acid, 8° T. . . . . 1 gall.
Dissolve, filter, cool, and add to
Tannic acid paste (1 lb. gall.) . . . . . 4 galls.
Mix, strain, etc., print, steam, pass through tartar emetic and soap for five minutes at 120° F.

ANILINE AND OTHER STEAM BLUES.

The most important blues in use are—(1) Methylene blue, a comparatively modern dye; (2) Ceruleine blue; (3) Alkaline aniline blue; (4) Alizarine blue; (5) Dark blues (mixtures).

A large variety of other kinds of blue colouring-matters are in use, but the above are sufficient for nearly every purpose, and are (except the last) inexpensive. Alizarine blue has been, to a great extent, superseded by printed indigo. Indophenol blue is not, as far as the author is aware, now employed; at least not generally in the trade.

Methylene Blue.

A dark shade of methylene blue is obtained in the following manner:—

Methylene blue, powder (patented) . . 1 lb. 9 oz.
Acetic acid at 8° T. . . . . ½ gall.
Warm till dissolved, filter, cool, and mix into
Tannic paste . . . . 4¼ galls.
Dissolve
Citric acid . . . . 10 oz.
Water . . . . 1 quart.
Add the solution of citric acid to the above paste, mix well, strain in the usual way, print, steam, pass through tartar emetic, at ¾ oz. per gallon, soap in neutral soap solution at 130° F., wash, and finish as required.

A *pale* shade of methylene blue of an exceedingly pretty greenish shade may be obtained by reducing the above colour, say 16 times (that is, equal to ¼ oz. of methylene per gallon) with a paste composed of

Wheaten starch . . . . 5 lb.
Water . . . . 4½ galls.
Acetic acid, at 8° T. . . . . ½ gall.
Pure tannic acid, in crystals. . . . 15 oz.
The tannic acid is mixed with the acetic acid, and the solution, together with the water and wheaten starch, are boiled, strained, and used cold.

Methylene blue is one of the fast aniline dyes, and is in extensive and increasing use in the calico printing trade.

Ceruleine Blue.

A medium shade of a bright sky-blue is obtained as follows:—

Ceruleine blue paste, 20% . . . . . 1½ pints
Acetic acid, at 8° T. . . . . 2 „
These must be mixed into a smooth paste, and the mixture added gradually and with stirring to
Alumina paste . . . . 4 galls.
Starch paste . . . . ¾ „
Mix well, strain twice through fine calico, print, steam, and soap in neutral soap solution at 120°F. for 3 minutes. Wash, dry, and finish.

To obtain a pale shade, beautiful pure sky-blue, reduce the above colour—say 20 times—with a paste consisting of

Alumina paste . . . . 1 gall.
Starch paste (1 lb. per gallon) . . . 8¾ galls.
Acetic acid . . . . 1 quart

Aniline Alkali Blue.

This dye is fixed in exactly the same manner as ceruleine blue. which it closely resembles in shade and in properties. It is sold as a powder. A moderately deep and bright shade may be obtained by dissolving 12 ounces in ½-gallon acetic acid and otherwise mixing exactly like the deep shade of ceruleine blue given above. A good pale shade is obtained by reducing 25 times with the same reducing paste as mentioned above in connection with ceruleine blue. A shade of alkali aniline blue so pale as this must not be soaped except very lightly.

Steam Prussian Blue.

The following is a recipe which has been for many years largely followed for the production of a dark steam Prussian blue:—

Yellow prussiate of potash	2⅝ lb.
Red do. do.	¼ lb.
Tartaric acid crystals	1 lb. 9 oz.
Persulphate potash	15 oz.
Oxalic acid	3½ oz.
Sal ammoniac	15½ oz.
Water	1½ galls.
Prussiate tin pulp	9½ oz.
Starch (wheat)	2½ lb.

The first five ingredients of this rather complicated mixture are mixed with the water and starch, and boiled up, cooled, and the sal ammoniac and the pulp are then added. The mixture is then well strained. After printing, the cloth is steamed, passed through bichromate of potash and alum, and washed.

The tin pulp is made as follows:—1 lb. of yellow prussiate is dissolved in 1 gallon of boiling water, and 1 lb. of tin crystals dissolved in another gallon. These solutions are then mixed cold, when a copious precipitate of prussiate of tin forms, which is filtered on flannel or fine calico, and the pulp used as in the above recipe.

The above Prussian blue was largely employed before the introduction of aniline blues, and is yet used on a less extensive scale.

4. Alizarine Extract Style.

Alizarine colours are produced in two ways: namely, by printing on both alizarine extract and mordant, and by printing on the mordant alone and afterwards dyeing up in alizarine. We take the former first.

RED OR SCARLET.

Of all the colours that demand the colourist's close attention this requires the greatest care and cleanliness in mixing, as the slightest dirt may turn the shade produced from intended scarlet to a dirty chocolate. Such care is now taken in its working that even nickel-plated doctors and rollers are being introduced in place of steel and copper, to decrease the contamination of the colour in the colour-box with foreign matter, as the metal nickel is less acted upon by the acid, etc., used in mixing alizarine colours, than either copper or steel.

The mordant for scarlet is acetate or sulphocyanide of alumina, which is mixed cold with the alizarine paste, and printed on oil-prepared cloth, steamed, and soaped. (For explanation of the *Prepared Cloth* see p. 53.) The following are the proportions for *Extract Alizarine Red*:—

Alizarine paste 10 %	8 lb.
Thickening (extract paste)	2 galls.
Acetate of alumina 20° T.	3 gills
Acetate of lime 20° T.	2 gills

Mix cold, print on cloth which has been prepared in oil-emulsion, steam 2½ hours, soap 20 minutes, from 130° to 140° F. at about ½ oz. of soap per gallon of water.

A much superior scarlet is obtained, but at greater cost, by substituting sulphocyanide of alumina at 15° T. for the acetate at 20° T., and the former compound is that in general use. This produces a magnificent brilliant fast scarlet.

PINK.

This is simply a reduction from the red given above; a medium pink consisting of the above colour, reduced two or three times with thickening (extract paste). It is, of course, treated in a similar manner; being printed, steamed, and soaped like reds.

Utilisation of Old Alizarine Red Colour from the Colour-box.—In printing it is, of course, impossible to use all the alizarine red colour in the colour-box of the printing machine; and as it becomes unfit for the production of a good red after exposure to the air for a short time, a quantity of it is always left over. This may be conveniently used up in making browns, maroons, and chocolates. In the case of brown, about one ounce of red prussiate of potash per quart of old red colour is added; in the cases of chocolates and maroons a little logwood black colour is added. For a moderate shade of chocolate about 1 part black to 8 old colour may be taken. Instead of the logwood black colour the requisite quantity of iron liquor may be used.

Chocolates and Maroons are generally made in the manner above described—namely, by addition of logwood black colour to old alizarine red. However, if made from good alizarine paste, the following recipe may be used for chocolate:—

Water	8 pints
Alizarine paste 10 %	6 „
Acetic acid at 8° T.	2 „
Chlorate of potash	2 oz.
Best wheaten starch	1 lb.
Boil, cool, and add	
Acetate of chrome at 24° T.	2 pints

Alizarine Purple or Lilac—

Thickening (extract paste)	5 pints
Alizarine 10 %	5 gills
Acetate of lime 20° T.	5 oz.
Acetate of iron 20° T.	1 gill

Mix well in the cold, strain, and it is ready for printing.

THE ORNAMENTAL DRAUGHTSMAN.

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER XI.

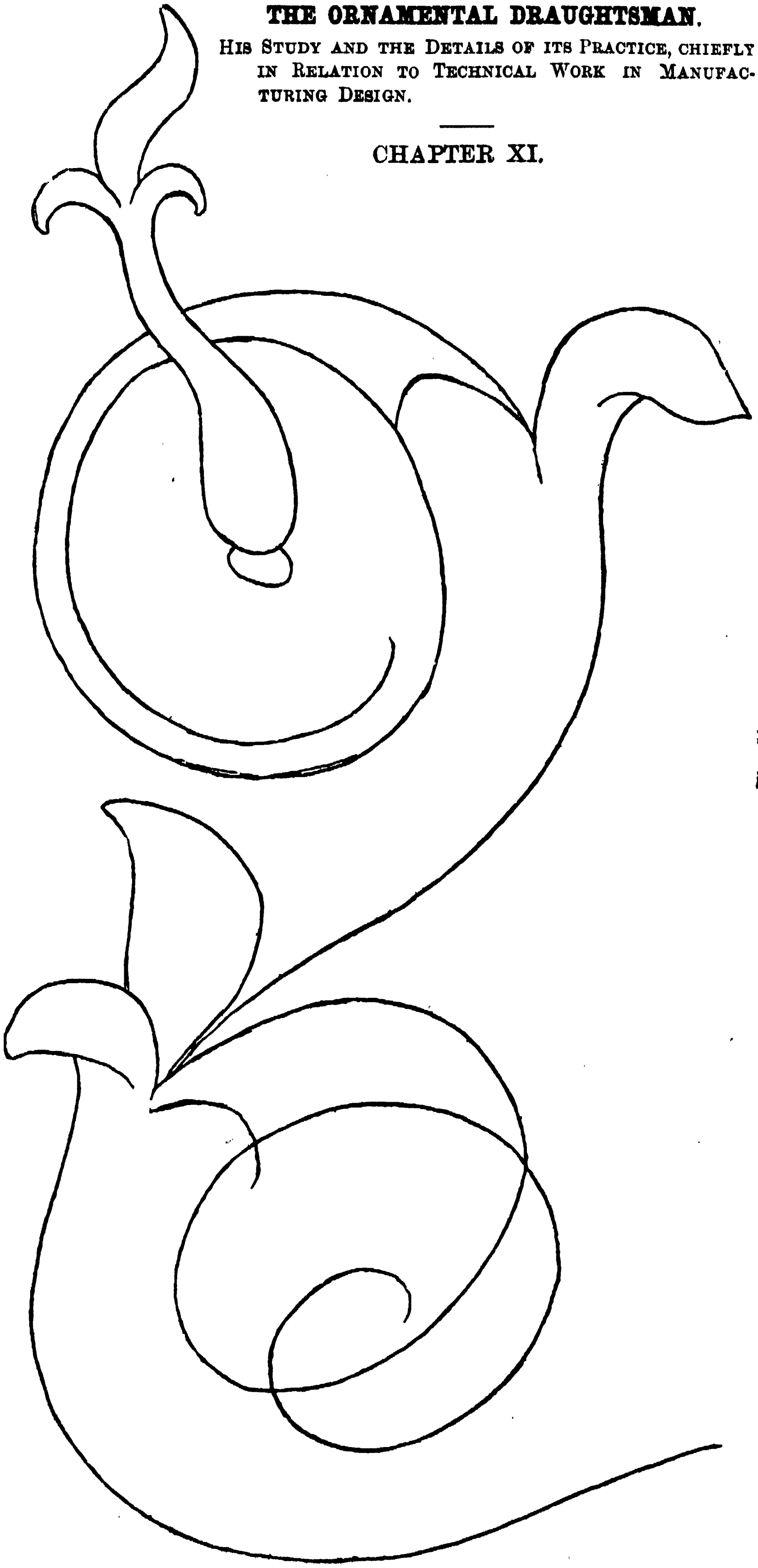


Fig. 51.

IN fig. 45 (p. 18) we gave the blocking in," and in known technically as the "honeysuckle," the form being

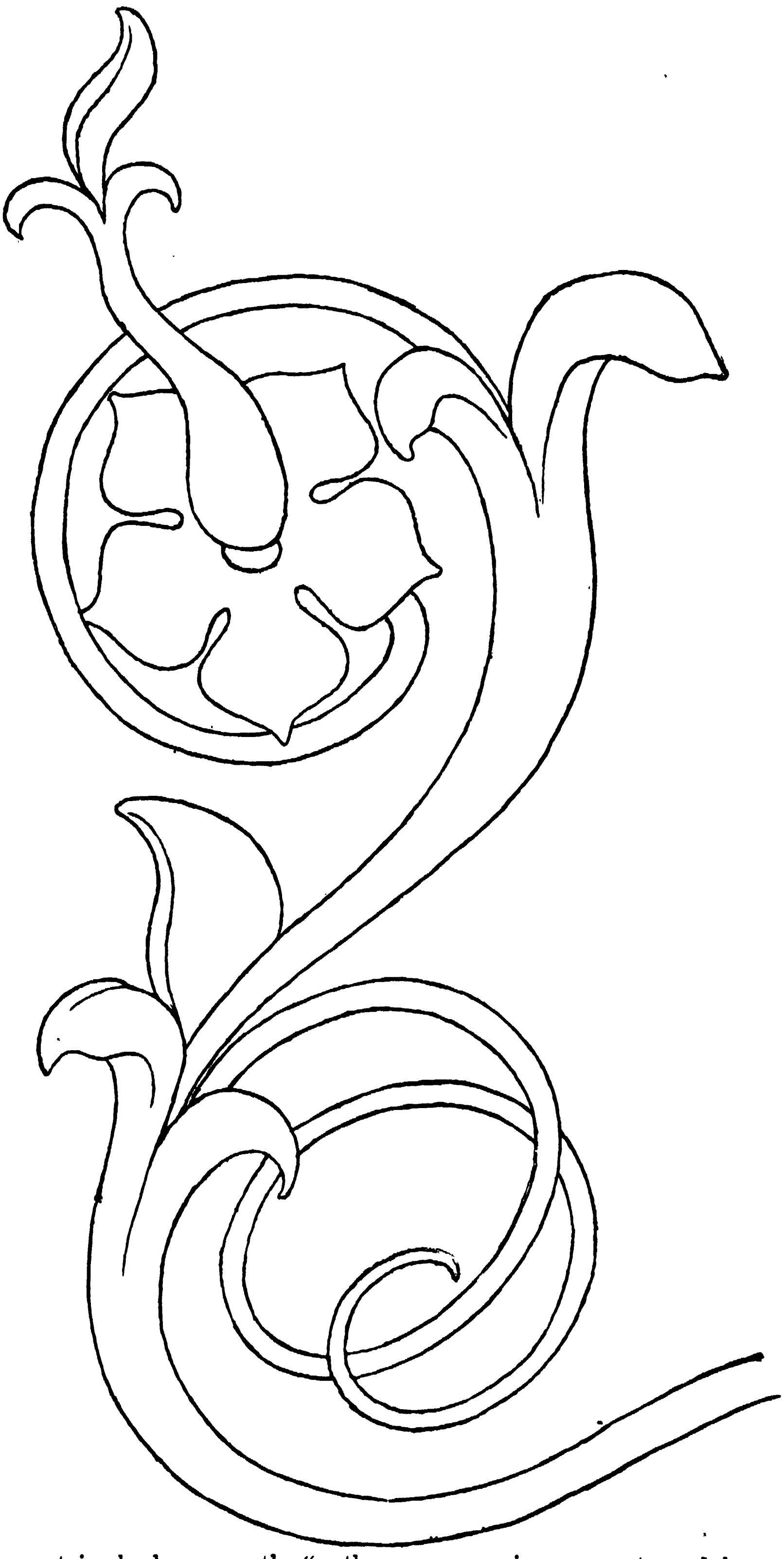


Fig 52.

flower. The ornament is also known as the "anthemion," and the student will find this form quite common in ornament, used in various ways and in great variety.

THE CARPENTER AND HIS TECHNICAL WORK.

ITS ORIGIN AND EARLY WORK—THE PRINCIPLES AND DETAILS OF ITS PRACTICE.

CHAPTER VI.

Analysis of the Foregoing Joint.

To gain the full efficiency of the simple joint at *c*, fig. 1, it is obvious that the "seat" must be such that the whole of the meeting surfaces shall be perfectly straight and flat, or even, in other words, be free from all protuberances, which, existing on any surface, cause of necessity corresponding hollows or depressed parts. Hence a requirement in all carpentry work where junctions are to be formed between its members—a test of the carpenter's ability as a handicraftsman—is that he makes his joints perfect in surface. When so treated, they are in technical language said to be "well and truly wrought" or worked, although in specifications of work to be done the word wrought is generally employed. But on the supposition that the "seat" *c* of the simple joint now under consideration is correct, or that the two "butting" or meeting surfaces are "well and truly wrought" by the handicraft carpenter, their junction would only be maintained if the pressure on *b* was vertical. Any pressure exerted upon the "foot" of the piece *b* near the seat *c* in the direction indicated by the arrows *d*, *e*, or in an opposite direction, would clearly tend to push the foot of *b* away from the seat, causing it to slide along the surface of *a a*, either to the right from pressure in direction of arrow *d*, or to the left if much pressed in the opposite direction.

The young reader must not suppose that we are needlessly extending or elaborating our description of this illustration in fig. 1. We are on purpose going fully into it, and before we can finish with it we trust that the pupil will be able to gather from it certain principles of or points in construction which will be of practical utility to him in his more advanced study of the art and science of carpentry, and those being understood by him at this the earliest stage of it, will not have to be repeated by us in illustrating and explaining the various forms of "joints" in use, as these principles affect all combinations. Indeed, it is only by comprehending them thoroughly that the pupil can see the object which a particular joint has in view—its *raison d'être*, as the French phrase has it—which, truly translated, means its very right to exist or to be.

Still keeping under consideration the simple "butting" joint of the pieces *a a* and *b*, fig. 1, *ante*, p. 11, we can conceive that the piece *b* might be subjected to pressure in directions other than those indicated by the arrows *d*, *e*. In *a a* the piece is supposed to be lying on the flat, so that we can only see, when looking at it directly and on the same level, the side or edge of it. This, as in *a a*, is called a "side elevation" in the language of what we may call technical drawing as different from that known as pictorial representation. (See the paper under the head of "The Building and Machine Draughtsman.") Let us suppose that we are now looking vertically down upon the piece *a a* from a point above the upper termination of the piece *b*, and in a direction coincident with its axis or central line. If we put on paper a technical view of what we see in thus looking, we have what in architectural and engineering drawing is called a plan of the pieces *a a* and *b*; and this is shown in fig. 1 at *f f*, which is the plan of the piece *a a*, *g* being the end of the piece *b*. To make the distinction between the two pieces more obvious, we have lined or "hatched" the plan of *b*, which gives it in what is called a "section" or "sectional plan" (see "The Building and Machine Draughtsman"). The pupil will from this sketch see how pressure may be exerted

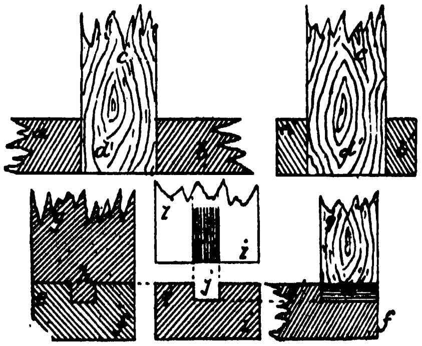


Fig. 26.

upon the foot of *b* in directions other than those indicated by arrows at *d*, *e*, as in that of the arrow *h*.

The next form of joint which we may conceive the early workers to have made is illustrated in fig. 26, it being very likely suggested by their previously well-known experience in fastening vertical posts by simply pressing them into the soft, or digging a hole in hard, soil, inserting in this, and then securing it by means of softer soil rammed round it, or by putting in stones to act as wedges. In process of time it would be required in some work that a piece lying horizontally (*a b*, fig. 26) should support a vertical piece (*e d*). A hole, either rectangular or square, as at *o o* in the piece in fig. 1, p. 11, vol. i., would be cut in the piece *a b*, and the end of *e d*, fig. 26, simply passed into it, as shown in the section to the right at top of figure. It might have been desirable to have the piece *g* penetrating as little as possible into the piece *e f*, or to have avoided cutting too much out of *e f*, as shown at *a b*, and thus weakening it; this would be done by cutting the end of piece *g* so as to leave a projecting part, as at *h*, right across the breadth of the piece. By cutting a groove near the end of the piece *e f*, as shown in the plan at *j* in *i i*, and in the lower diagram in section, the piece *g* could be slipped with its projection *h* into the groove, as shown in longitudinal section to the right of the lower part of diagram at *g′ h′ f*.

Simplest Form of the Mortise and Tenon Joint.

This would be the origin of the "mortise and tenon joint," of which we give an illustration in front and side elevation in fig. 27, and in details in fig. 28. In

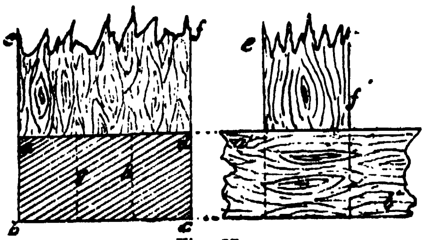


Fig. 27.

fig. 27 *a b c d* shows the lower or horizontal piece in section or end view, with the upper or vertical piece *e f* joined to it by the projecting piece at the end of the piece *e f* going into a slot or hole cut in the piece *a b c d*—*g h* giving the thickness of the piece, and the breadth being equal to the breadth of the piece so shown in side elevation at *e′ f′*, *a′ b′* being side view of piece *a b c d*. The part *g h*, cut at the end of the piece *e f*, is called the "tenon"; the aperture made in the piece *a b c d* is called the "mortise" or "mortice." The depth of the "tenon," as *l j*, fig. 28, is generally

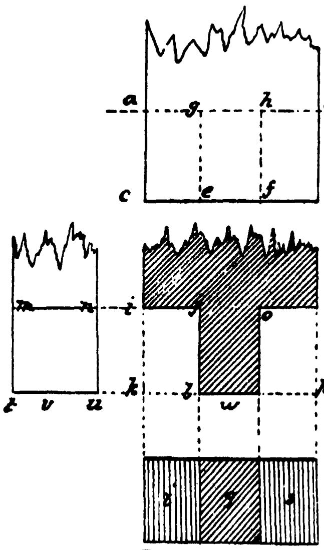


Fig. 28.

equal to the depth of the piece, as *a b c d*, to which it is joined, and the thickness or width of the "tenon," as *j o*, is, when well proportioned, about one-third of the width of the piece. *j l w o* shows a side view of the piece of which *m n u t* is the edge view, *i q s* being the plan of the end of "tenon" as it is looked vertically down upon.

Practical Points connected with the "Mortise and Tenon" Joint.

The mortise aperture, or hole cut in the lower piece or member, should be of the shape and of the dimensions of the tenon formed at the end of the upper piece, which is to fill it without leaving any space round it. The thickness of the tenon should be equal, as we have said, to the third of that of the piece of wood into which it is put, in order that it may have sufficient strength, and that the piece out of which is hollowed the mortise into which the tenon must enter may not be too much weakened by any considerable loss of wood. The depth of the mortise, which should be equal to the length of the tenon, is generally two-thirds of the thickness of the piece out of which it must be cut; in any case, it should not exceed three-quarters of this thickness, above all when the piece which bears the tenon is to be placed upright. The illustration fig. 28 shows a frequent exception to this, as the mortise goes right through the thickness of the piece. The object of leaving a part of the piece uncut in the lower member *a b c d*, fig. 27, is to give a good butting sound joint to the end, as *w*, of the tenon. The parts *i j* and *o*, which are on each side of a mortise, fig. 28, and which should have, like the mortise, the third of the thickness of the piece of wood, are called the "shoulders" of the tenon. When the tenon is sunk or driven into the mortise, the shoulders (as *i j*, fig. 28) of the tenon should touch the face or cheeks of the mortise; the pieces are then fastened by one or two wooden or iron pins—generally wooden. These bolts should be placed so as to penetrate the cheeks and the tenon, passing through the middle of the length of the latter. If one does not wish to put in two pins or trenails, we divide the width of the tenon into three equal parts, to retain sufficient space of solid wood round the pinholes, and so secure for the tenon the greatest amount of strength.

This joint has all the necessary solidity only when the tenon is driven forcibly into the mortise. When the tenon works loose in the mortise the joint is very soon destroyed by the strain to which it is of necessity subjected. It is obvious that the pins which help to keep together a joint add nothing to its solidity. To make this joint, we commence by drawing carefully on the two pieces which are to be joined lines which shall determine the shape of the tenon and the mortise, so that we may take away only the useless wood, and succeed in easily making the tenon and the mortise of equal sizes, and perfectly true to one another—the latter in the form of a hollow or part cut out, the former (the tenon) as a projection. We shall now point out the way in which this outline is to be made, commencing with the tenon:—Let *a b c d*, etc., fig. 28, be the piece which is to have the tenon cut on it: draw, at a distance from the end of piece equal to the length of the tenon, a line *a b* parallel to *c d* : divide *a b* or *c d* into three equal parts in points *g h*, taken on the width of the piece (that in the middle, as *g h*, *e f* being reserved for the tenon) with a saw, and following the line *a b*, cut the wood to *g*. Do the same on the surface *b h*, cutting to *h* ; cut away the pieces *a g e c* and *f h b d* by sawing on the lines *e g f h*, and we thus form the tenon.

Cutting out of Double Tenon—Cutting out of Mortise.

To form a double tenon, divide the width *b c* (fig. 2, *ante*, p. 11, chap. I., vol. i.) of the piece of wood into five equal parts—*c g h i j f*—instead of three, as in fig. 28, and give one of these five parts to each of the tenons, as *g h i j*, taking or sawing away the two outside parts, as *c b f c*, similar to those of the simple tenons. Next cutting out the central part *h i*, we form two projecting parts, each of which is a tenon on the end of the piece *a e f d*, as shown in cross section at *v w*. The plan or upper face of the lower piece, in which the mortises are cut, is at *m n* ; the lines giving the breadth, as *s r n p*, of this being taken down from the side elevation, as shown by dotted lines from points, as *k l*. The length of the mortise, as *o n* or *p q*, is, of course, equal to the thickness of the piece, as *g*, bearing the tenons, as at *t u*, which is a side view of tenon; *x x* being part longitudinal section though tenon and mortise.

The cutting out of a central part, as *h i*, fig. 2 (*ante*), to form the void space, as between the two tenons *v* and *w*, cannot be done wholly with the tenon saw, as at the line *h i*. The lines, as *i k*, are first sawn down to the points *h* and *i*, and then holes are bored with the "brace and bit," as at *r*, *s*, fig. 29. These holes go through the whole piece, so that by striking the piece with the hammer or the mallet it can be easily detached, as there is but very little solid wood between the holes *r*, *s*, fig. 30. There then remains nothing but to square or face up the sawn or rough surfaces of the two tenons, as *v* and *w*, fig. 2 (p. 11, vol. i., *ante*).

In making a mortise when the tenon is already made, we commence by making fast the piece of wood in which we wish to cut out the mortise, and if the tenon, should be in the middle of the piece—*i.e.*, a single tenon, as at *w*, fig. 28—we trace a line, *b m*, fig. 29, at equal distance from the two arrises or edges, *h* and *i* ; we take then the half of the thickness of the tenon, which we set off on each side of the centre line *h g i* to points *l* and *m*, and we draw parallel to *b m* two lines, as at *h* and *i*. We then take the width of the tenon, and set it off from central point *g* to *h* and *i*, carry it between these two lines, and thus have exactly the size of mortise hole. If, instead of being in the middle of the piece of wood, the mortise hole should be carried more to one side than another, we must commence by drawing a line which shall fix the position of the tenon, taking its thickness and drawing it at the side of this line—for, in carrying this width between these two lines, we shall get the exact place for the tenon.

The position and size of the mortise being outlined as above, to form the hollow or cut out part, next pierce holes at each of the corners, as *n*, *o*, *p*, *q*, fig. 29, and then connect these by a row of holes as at *r s*, or at *t u*, and the small widths of solid stuff between the holes can be cut through with the chisel, or divided by using the narrow, thin-bladed saw, used for cutting out keyholes, called the "fret saw." This may also be used to cut out the solid part in the centre of the mortise, as the part *n o p q*, fig. 29, connecting the holes at the four corners made by the brace and bit.

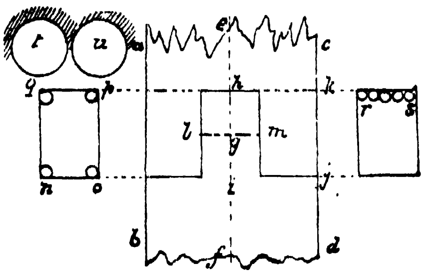


Fig. 29.

If the tenon were double we should require to draw also two mortises near each other bearing exactly the breadth and the thickness of each tenon. These two mortises would be made separately and in the same way as ordinary mortises. This joint has everywhere the same thickness, but the pieces which bear the tenons are not always placed vertically or perpendicularly ; often, as in floors, they must be placed horizontally. In this position, the tenons being placed on the flat side only, all strain is supported by their thickness ; then, to give to the tenon greater solidity, it is strengthened by a small canting or sloping shoulder which joins the piece to the tenon.

Mortise and Tenon Joints—Forms other than those already Illustrated.

In fig. 3, p. 12, vol. i. (*ante*), we give a drawing illustrative of a mortise and tenon joint at which one piece, *b b*, receives at its end another piece *a e b*, as shown in section at *h*. The tenon in this case is not square or rectangular, as in the other and preceding examples given, but is of the form known as the "dovetail," as at *e* ; this is cut at the end *e* of the piece *a a*, which corresponds to *h* in form and size.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL APPLIED OR MANUFAC-TURING CHEMISTRY — INDUSTRIAL DECORATION— SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

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106. The New Standard, the Ordinary or Trade, the "Birmingham," and "Lancashire" Wire Gauges.—Technical Points connected with the Subject.

IN pages 84 and 184, vol. i., under this title, we gave a statement showing the probable origin of the Birmingham Wire Gauge ("B. W. G."), the first of all the gauges established; and drew attention to a technical point connected with it—this being the relation between the resistance to drawing and the cohesive strength of the metal to be drawn into wire. This relation opens up many considerations of a wider value than that connected with this special subject only—of some of which we have space merely for a brief *résumé*. And here we may remark—as affording something for the thinking of the young reader—that there is nothing more calculated to surprise him when he takes up any special subject in practical mechanism than the fact that it seems to cluster round it such a great number of theoretical and practical points, that to master it alone would seem to be the work of a lifetime. And when he begins to extend the range of his practical studies, and finds that each subject has its own series of clustering facts and theories, he is apt to suppose that there lies before him a field so wide that he cannot hope to be able to cultivate it to any purpose of practical utility. But this feeling will get modified as he gains experience; and the difficulty, such as it is, is much lessened in the practical life of mechanics, by the fact, which is every day becoming more and more exemplified, that the work of mechanical engineering is divided into branches or specialities. Not so very long ago, so limited was the range of work of the engineer and machinist, that in practice one man or one firm undertook to do all classes of work, however diversified in character. Then the demand for the new things was exceedingly limited, and in point of fact many branches of engineering now giving employment to thousands of machinists did not exist. Take, for example, the department of railway locomotives, which now gives employment to so many thousands of workmen, and has created establishments—such, for example, as the locomotive works of the London and North-Western Railway Company, at Crewe, in Cheshire (and each great railway company repeats the example)—which, for the high class of work done, and for the in many respects wonderful machines and appliances employed in the doing of it, are in every way entitled to the praise of thorough efficiency in design, arrangement, and administration.

learn that the railway system was inaugurated as a practically working one barely more than half a century—fifty years—ago, and that the modern system, as we now see it, with all its marvellous developments of rapid travelling, has been in reality the work of the last generation only. At first the locomotive engines were made by the ordinary firms and establishments of the country; and although some—as, for example, Sharp, Stewart and Co., and Hawthorn, of Newcastle—to a large extent made this work a special department, still it was long before the gigantic works, such as those at Crewe, above noticed, were established as a feature of the great railway companies' systems. Hence it came about that some of our ablest machinists became specialists, and devoted their eminent abilities to the work and the perfecting of the locomotive only. We see the same narrowing-in of the work of machinists in other departments, as for example in that of hydraulic mechanism. Some generation ago, or but little over, the work done in this might be said to be limited to the making of hydraulic presses and water-wheels, and to by no means large exemplifications of pumping machinery. But when the celebrated William (now Sir William) Armstrong showed what could be done with water in the working of a wide variety of mechanism, such as hydraulic cranes, the working of the heavy gates of docks, etc., quite a new department of mechanical work has been introduced as a specialty, and we have now mechanical specialists who devote themselves to this department only, and who have large works in which scores of men are employed. And the naming of the above now celebrated mechanism reminds us of another department of mechanical work which has also become a specialty—namely, that which we may call the "mechanics of warfare." This affords indeed the most striking development of this specialising of mechanical work which we are now considering; and although it be perhaps no great matter to boast of in these "piping days of peace" talking, or by no means matter of congratulation in relation to the progress of true civilisation, it is the fact nevertheless that the implements and appliances designed to kill and maim mankind have called forth during the last generation only—for the period is but so limited—possibly the widest, certainly the most remarkable development of mechanical ability to design and of skill to construct, that modern times can offer for our consideration. We could go on to great length in the illustration of that peculiar feature of modern mechanical work, and detail facts which would be more than merely interesting to the youthful machinist connected with the establishment of various special branches of work which have been the outcome of that truly marvellous development of inventive ability which forms not the least interesting feature of the times we live in. But for the present at least we have given enough in proof of our position, and enough to give food for thought to many of the rising generation of machinists. The subject is indeed so fascinating, and carries with it so much that is really of practical interest, that we may possibly return to it, and give it that special treatment which a mere sketch precludes. Returning now to the special points of our "Note," we remind the reader of what was stated in a former note in our first volume, in regard to the origin of the modern wire gauge, and which has been the one principally used, known as the Birmingham Wire Gauge. This point naturally brought up the points connected with what Mr. Latimer Clark—the authority on this important subject we are at present following—calls the "drawability" of metals used in the making of wire. In investigating the details of the Birmingham Wire Gauge, it is presumable that there will be found some "constant" relation between the breaking weight—*i.e.* the strength—of each wire of the gauge, and the resistance which is opposed to the "draw plate" in the work of drawing down the wire to its "standard" size in the gauge from the larger wire passed through the process. This "constant" relation Mr. Clark shows exists. The results of his investigations and calculations will hereafter in another note engage our attention. Meanwhile, as giving some interesting information on this "constant" relation between the coefficients of resistance to the drawing of the wire through the draw plate, and the absolute strength or resistance to a tensile breaking strain—information which will be useful to the young machinist in other directions,—the following table gives the relative "drawability" of various metals, based on the experiments of a German scientist—M. H. Karmarsch. Mr. Clark has in this table converted Karmarsch's relative values into English pound equivalents, by assigning to iron the value usually given it in mechanical tables of strength, comparing it with the common coefficient of absolute strength as follows. We should note that the various metals here named are compared to a standard provided by hand-drawn steel wire, the value of which is put at 100.

TABLE A.

(1) Kind of Metal.	(2) Relative Dra[w]ability as giv[en] by Ka[rmarsch]	(3) [...]ving [...] inch	[...]engt[h] [...] inch	(5)
Hard-drawn Steel	100	285,000	125,000	0·430
" Iron .	88	250,000	115,000	0·460
" Brass	77	220,000	84,000	0·382
Annealed Steel .	65	185,000	75,000	0·405
Hard-drawn Copper	58	165,000	60,000	0·363
Annealed Brass	46	130,000	57,000	0·438
" Iron .	42	120,000	56,000	0·466
" Platinum	30	108,000	49,000	0·453
" Copper	38	108,000	49,000	0·453
Silver . . .	34	97,000	45,000	0·464
Gold . . .	27	77,000	33,000	0·428

The fifth-column figures will be explained in a succeeding note, when we take up the subject of calculations, meanwhile noting that in the expression $\frac{s}{r}$ "s" denotes the coefficient or constant of (cohesive) strength of the wire, *r* that of resistance to the drawing.

107. The Metrical or Continental System of Weights and Measures—Their Relation to our System.

In Note No. 75, p. 388, vol. i., we gave a brief description of the general features of the French or Metric system of weights and measures: we now propose, in this and succeeding notes, to place before the reader the different classes, contrasting them for the most part with those of our own corresponding to them.

(1) *Linear Measurements, or those of Lengths and Distances.*

The unit of the French system of this measurement of length is the *Metre.* The length of the metre in English measurement is 1·0936 yards, 3·281 feet, or 39·3710 inches. The multiples of the metre are 10, 100, 1000 and 10,000, which are named by prefixes derived from the Greek—viz., the multiple of 10 by the prefix of "*Deca,*" of 100 by "*Hecto,*" of 1000 by "*Kilo,*" and of 10,000 by "*Myria.*" The divisors are obtained by dividing the metre by 10, 100 and 1000, and named by prefixes from the Latin, as—10 "*Deci,*" 100 "*Centi,*" and 1000 "*Milli.*" The unit, or metre, being = 39·3708 inches, then we have the following:—

					Inches.		*Frlngs.*	*Yds.*	*Ft.*	*In.*
		1 Millimetre	=		0·03937					
10 Millimetres	=	1 Centimetre	=		0·39371					
10 Centimetres	=	1 Decimetre	=		3·9371					
10 Decimetres	=	1 METRE	=		39·37079	=		1	0	3·371
10 Metres	=	1 Decametre	=		393·71	=		10	2	9·708
10 Decametres	=	1 Hectometre	=		3937·079	=		109	1	1·079
10 Hectometres	=	1 Kilometre	=		39371·79	=	4	213	1	10·79
10 Kilometres	=	1 Myriametre	=		393710	=	49	156	0	11·9

The English Inch is equal to 2·54 Centimetres, or 0·0254 metres.
" Foot " 3·048 Decimetres, or 0·348 metres.
" Yard " 0·9144 Metres.
" Chain " 20·116 Metres.
" Mile "

An extent, length or distance expressed in the metric system, in metres and its subdivisions, as decametres, etc., in several terms, is as easily calculated and expressed as a simple term: thus—2 metres 9 decimetres 5 centimetres 7 millimetres is 2957 millimetres, or 295 centimetres 7 millimetres, or 29 decimetres 5 centimetres.

The following are the decimal values of millimetres, centimetres, decimetres, and metres :—

Millimetres.			*Decimetres.*			
10	thus	0·010	10	thus	1·000	Metre.
9	,,	0·009	9	,,	0·900	
8	,,	0·008	8	,,	0·800	
7	,,	0·007	7	,,	0·700	
6	,,	0·006	6	,,	0·600	
5	,,	0·005	5		0·500	
4	,,	0·004	4	,,	0·400	
3	,,	0·003	3	,,	0 300	
2	,,	0·002	2	,,	0·200	
		0·001	1	,,	0·100	

Centimetres.				*Metres.*		
10	thus	0·100	Met	10	thus	10·000
9	,,	0·090		9	,,	9·000
8	,,	0·080		8	,,	8·000
7	,,	0·070		7	,,	7·000
6	,,	0·060		6		
5	,,	0·050		5		
4	,,	0·040				4·000
3	,,	0·030		3	,,	3·000
2	,,	0·020		2	,,	2·000
1	,,	0·010				1·000

The following gives the lineal measures in our own system :—

		Yards.	*Feet.*	*Inches.*
6 Points	= 1 line			
12 Lines	= 1 inch			1
3 Inches	= 1 palm			
4 Inches	= 1 hand			
	= 1 link			7·92
9 Inches	= 1 span			
12 Inches	= 1 foot	$\frac{1}{3}$	1	12
$1\frac{1}{2}$ Feet	= 1 cubit	$\frac{1}{2}$	$1\frac{1}{2}$	18
3 Feet	= 1 yard	1	3	36
5 Feet	= 1 pace	$1\frac{2}{3}$	5	60
6 Feet	= 1 fathom	2	6	72
$5\frac{1}{2}$ Yards	= 1 rod, perch, or pole	$5\frac{1}{2}$	$16\frac{1}{2}$	198
22 Yards or 4 Poles, or 100 Links	= 1 chain	22	66	792
40 Poles, or 10 Chains	= 1 furlong	220	660	7920
8 Furlongs	= 1 mile	1760	5280	63360
3 Miles	= 1 league.			

Lengths in land measurements or surveying are measured by the imperial chain and link. In geographical calculations, 1 geographical mile, or *minute*, is equal to $2038\frac{2}{3}$ yards, and 1 degree is equal to 60 minutes or $69\frac{1}{2}$ English statute miles. The fathom is used for measuring depth, as in the sounding of the sea. In measuring horses and other domestic animals, 4 inches = 1 hand. Formerly the "hand" of 4 inches and the "span" of 9 inches were in common use. In mechanics the following are used. 1 foot = 12 inches (in.); 1 inch = 12 seconds ("); 1 second = 12 thirds ('''); 1 third = 12 fourths ('''').

(2) *Square, Surface, Superficial or Land Measure.*

The unit of the French land measure, which is called an *Are*, is equal to 10 square metres or 1 square decametre. This in our measurement (see below) is equal to 119·60 square yards. The multiples are 10, 100, 1000, and 10,000, denoted by the prefixes "Dec," "Hect," "Kil," and "Myria." The divisors are 10 and 100, and the prefixes are "Deci" and "Centi."

A Centiare is $\frac{1}{100}$th part of an Are.
A Deciare ,, $\frac{1}{10}$th ,, ,, ,,
A Decare ,, 10 Ares.
A Hectare ,, 100 Ares, or 10,000 metres square.
A Kilare ,, 1000 Ares.
A Myriare ,, 10,000 Ares.

1 Milliare	= ·1196 sq. yds.	= 1·07 sq. ft.	= 155 square inches.
Centiare	= 1·196 ,,	= 10·764 sq. ft.	
1 Deciare			
1 ARE	= 119·60 yds.		
1 Decare	= 1196·0 sq. yds.		
1 Hectare	= 11960·3 sq. yds.	= 2·4736 acres.	
1 Myriare	= 119603 ,,	= 24·736 ,,	
1 Square inch	= 6·45137 sq. centimetres.		
1 ,, foot	= 9·28997 ,, decimetres.		
1 ,, yard	= ·8361 ,, metres.		
1 ,, pole	= ·2529 Are.		
1 Rood	= 10·11678 Ares.		
1 Acre	= 40·4671		

		Sq. Feet.	*Yards.*	*Acres.*
1 Centiare, or 1 square metre		= 10·7643	= 1·196	
10 Centiares	= 1 Deciare	= 107·6429	= 11·9603	
10 Deciares	= 1 Are, or 100 sq. metres	= 1076·4298	= 119·6033	
10 Ares	= 1 Decare	= 10764·2980	= 1196·033	
10 Decares	= 1 Hectare	= 107642·980	= 11960·33	= 2·471
10 Hectares	= 1 Kilare		119603·3	= 24·71
10 Kilares	= 1 Myriare		1196033·0	= 247·1

(3) *Square, Surface, Superficial or Land Measure on the English System.*

144 sq. in.	= 1 sq. foot.
9 sq. ft. or 1296 ,,	= 1 sq. yard.
$30\frac{1}{4}$ sq. yds. or $272\frac{1}{4}$ sq. ft.	= 1 ,, rod, pole or perch.
40 perches or 1210 sq. yds	= 1 rood.
4 roods or 160 perches or 4840 sq. yds. or 43560 sq. ft.	= 1 acre.
10 sq. chains	= 1 acre.
640 acres	= 1 sq. mile.

30 acres = 1 "yard," and 100 acres = 1 "hide" of land.

Acre.	*Roods.*	*Perches.*	*Sq. yds.*	*Sq. ft.*	*Sq. in.*
1	= 4	= 160	= 4840	= 43560	= 6272640
	1	= 40	= 1210	= 10890	= 1568160
		1	= $30\frac{1}{4}$	= $272\frac{1}{4}$	= 39204
			1	= 9	= 1296
				1	= 144

or, as otherwise expressed :—

			Yards.	*Feet.*
144 Square inches	= 1 square foot	=	$\frac{1}{9}$	= 1
9 ,, feet	= 1 ,, yard	=	1	= 9
100 ,, ,,	= 1 yard of flooring	=	$11\frac{1}{9}$	= 100
$272\frac{1}{4}$,, ,,	= 1 rod of brickwork	=	$30\frac{1}{4}$	= $272\frac{1}{4}$
$30\frac{1}{4}$,, yards	= 1 pole, perch or rod	=	$30\frac{1}{4}$	= $272\frac{1}{4}$
16 ,, poles	= 1 square chain	=	484	= 4356
40 ,, poles	= 1 rood	=	1210	= 10890
4 Roods or 10 chains or 160 poles	= 1 acre	=	4840	= 43560
640 Acres	= 1 square mile	= 3,097600		

By this measure (3) anything that has length and breadth is calculated, such as ground, flooring, painting, woodwork, etc. The Scotch chain of 74 feet long is sometimes used yet: 4 Scotch acres are equal to 5 imperial acres 4 poles $16\frac{7}{9}$ yards.

The surface of a square is obtained by *squaring* the length of one side, or, which is the same thing, by multiplying the length of side by itself. Care must be taken, therefore, to distinguish between "inches or feet square," and "square inches or feet." Thus "2 feet square" means a square having a side of 2 feet, which gives a surface of (2 × 2) 4 square feet, which is very different from "2 square feet," which means = 288 square inches.

108. Ventilation of Dwelling-Houses.

Note 93, p. 104, was concluded by drawing attention to the point of fresh air admission, and the great objection made to ventilating systems in ordinary living-rooms, from the draughts which this admission created, or rather which it was supposed to create. But the question may be asked, Why not warm the air?—one more easily asked than answered, at least so far as how to do it is concerned. We may yet see, as no doubt with advancing experience we shall see, plans introduced by which our rooms can be supplied with abundance of fresh pure air, warmed to any degree of healthy temperature. But judging from the present state of matters we should say that it will be some time yet before this improvement in house comfort is secured. There are many difficulties in the way, not the least being, not so much the expense of erecting and maintaining in work the necessary apparatus, but the getting of the domestics or servants of the house to look after it. Meanwhile, in the absence of any better plan, we should strongly recommend the interior lobby of the house to be supplied with a stove. The air will then be warmed as it enters the house, and ascending the open staircase, will enter the rooms at a much more comfortable temperature than is universally the case now in cold weather. If a coal-heated stove be objected to on any ground—and one will be that just noticed, the difficulty of getting it attended to—then, if the house be supplied with gas, this may be used to heat the stove; or some one of the petroleum stoves now before the public may be used. These stoves have this great advantage: that once lighted (and that is the work of a second) they require no further attention, at least till the petroleum requires to be supplied, which is only at long intervals. We incline to believe this plan about the best which can be adopted, under present circumstances; and the interior passages being thus supplied with warm air, it may be admitted to the rooms in various ways, some of which, as apertures over the doorways, will suggest themselves to the reader, but which the architect or builder will at once design.

The withdrawal of the used or foul air from the interior of a room is the second essential in ventilation. The carrying out of this is a more easy matter than the supplying of fresh air, with all its "draught difficulties," and a variety of modes are at the choice of the owner or occupier. Where the room is lighted with gas, and by a central gasalier, then the most effective method can be adopted—a pipe leading off the products of gas combustion, as well as the used air of the room, to the chimney flue. This itself can be made available by simple arrangements for carrying off the used air. Or where there is an outside wall, the cornice can be made to conceal apertures through which it can be passed at once to the external atmosphere. We have thus briefly explained the two leading principles of ventilation—admission of fresh air, withdrawal of foul, which are essential; and also hinted at the direction in which those can be carried into practice with some degree of efficiency. Thorough efficiency can only be attained when we make the ventilating arrangements an essential integral part of the whole structure, designing their details from the beginning, and with as much care and attention as are given to those of other parts. It is not an easy matter to adapt plans for ventilating to existing domestic buildings, the whole structural arrangements of which are almost directly antagonistic to the system. Still much can be done, and that by comparatively simple means, to make our dwelling-houses, which are now bad, much better as regards their supply of fresh air; and when a new house is about to be erected, the owner should at least ask his architect or builder to consider the subject, and possibly something practical may come of it. If owners or occupiers would only determine that their houses must be ventilated, more would be done to advance the progress of the art than will be done by a century of talk or of volumes or papers on the subject.

At the same time, it may be asked Why do architects require to be urged to introduce into the houses they design such structural details as will aid if they do not fully realise all the requirements of a good system of ventilation? The answer to this is easy; and we have indeed at an early part of these remarks already partly at least answered the question. It is not that architects are either indifferent or incapable, but that clients will not pay for what could be done.

Take, for example, the universal method adopted for forming the ceilings of our rooms. A flat space horizontally above, meeting and supported by flat spaces vertically at the sides, has been for generations, and is the conventional mode of treatment still likely to be carried out for generations more. Now, it is impossible to design a room which is better adapted to its *non*-ventilation than this, to say nothing as to the canons of taste in design which it violates in the most forcible way. Yet architects could, and the majority of them would, most willingly design ceilings which, while they would be the best adapted to aid ventilation, would also at the same time be most pleasing to the eye. But we venture to maintain that if such ceilings were introduced, the owners of the property would be the first to call out against them, not solely on account of the slight extra expense which their erection would involve, but as being by far too bold an inroad upon their tastes and prejudices. A ceiling could be designed with curved lines so as to present a charming effect, and the ventilating parts of which would add rather than detract from this; but the architect would be met with "Whoever saw or heard of a ceiling to a room like that! why, ceilings for ages have been flat: why not make them flat still? And not a few, moreover, would have, if they did not give expression to it, a vague kind of feeling that such a startling innovation could not be altogether safe to sit under. We argue the matter in a circle, for we return to the same point: that with the owner chiefly rests the future of ventilation as an art applied to all domestic buildings. And there apparently it must be left.

Closely connected with the subject of ventilation is that of *artificial lighting* of rooms, inasmuch as the methods by which this is carried out could be made subservient to the plans for withdrawing of the used air from them. We have in this department of domestic house arrangement and construction got also into a conventional groove, out of which it seems exceedingly difficult to find a way.

This seems to render it impossible to light—we refer to gas at present—a room excepting in one way: the universal gaselier or lustre hung from and at the centre of the ceiling; the only departure from this being the fitting up of a few branch lights at the chimney- or mantel-piece, or at a few points in the walls. It would be an easy matter comparatively to arrange the lights in a room in such a way that while they would give a more diffused light, and one pleasant to the eye, they would aid greatly in the removal not only of their own products of combustion, but of the used air of the room, arising from the people who are in it. We have seen some very effective designs in this way, which kept a crowded room with an atmosphere as pure and pleasant as the open air.

But here, again, in carrying out some of the designs the architect would be met with objections from his clients of very much the same character as those we have but just now named in connection with improved ceilings—expense, and startling innovation. Not that those whose profession is to design and to see designs faithfully carried out are altogether blameless in the matter. For it may be said to have been, and indeed to be still, a rule with us to relegate this department to other hands, as if it were a mere tradesman's work to look after its details and to carry them out. At one time the "lights" of churches and other public buildings were thus left; but were at last taken up by the architect as belonging to his department, and designs for them in accordance with the style of the building which they lighted were brought out, to the manifest æsthetical improvement of the interior. Let us hope that the same result will soon be seen in the case of domestic structures of the better classes. We should not, however, insist so much upon the design of the lighting details as their arrangement with a view not only to yield pleasing effects to the eye, but perhaps chiefly to aid the ventilation. We see at present not a few signs around us of a time coming when gas will be used in a variety of ways, and for a number of useful purposes in houses, of which as yet we have but few conceptions.

109. Ensilage—Crops Suitable for the Process.

In the last note, No. 94, p. 105, we gave some details as to the grasses or clovers which might be called the typical crops of the system, and, as we have already stated, were at first the only green-cut produce for which the system was proposed, and for which, as was then supposed, and is still by some believed, it is only suitable. Experience has, however, shown that a much wider variety of crops is suitable for ensilage. Of those, the first we take up come under the class of farm crops generally known as forage crops. Of these the first we name is Lucerne, *Medicago sativa*. This is a valuable forage crop, for which we are indebted to the Continent. It is particularly well suited for light, dry, or chalky soils, but which are deep; and with a singular power of penetrating deeply with its roots into the soil, it is calculated to stand even the severest season of drought without much injury. Once rooted in the soil, it may be looked upon as a certain crop in all weathers. It is best sown in drills; and thus cultivated, it may occupy the ground for a long series of years. It comes to its best as a forage at the end of the third year, and it will give three or four, or even (with the best of cultivation) five cuttings a year, for a further period of eight or ten years. If sown broadcast it does not keep the ground so long, and the soil should be turned at the end of the fourth or fifth year. The reason of the difference between the two systems is that in the drill the plants can be kept free from weeds by hoeing—an essential when the best results are desired. The plants grow to the height of a foot-and-a-half to three feet. When cut from two to three inches of stalk should be left.

Sainfoin or Saintfoin, *Onobrychis sativa*, is another esteemed forage crop, for which also we are indebted to the Continent. As the Lucerne, so the Sainfoin is perennial, occupying the ground for about a like period, coming to perfection, like the Lucerne, about the third year, and affording a succession of cuttings for years if grown on the drill system. The soil best suited for it is a light calcareous one; it may be grown, and with profit, in poor, chalky soils which would yield little under any other crop, and is the best crop for bringing such poor soils into cultivation.

Another forage crop well adapted for the ensilage system is the Vetch, commonly known as the Tare, and the botanical name of which is the *Vicia sativa.* The vetch does best in a loamy, this suiting it better than a light or sandy soil. There are two varieties grown—the "winter" and "spring." It is one of the most valuable of the forage or green-cut crops, and is relished by all classes of live stock. The winter variety, sown in October and November, will give a good cutting of green food early in spring. The spring variety, to give a succession of cuttings in summer and autumn, should be sown from March up to the end of May. The vetch as a forage crop is very usually sown down along with rye, (for which see a note in a succeeding paragraph,) the rye when cut green being also a good foragé crop, affording with its stems good supports for the vetch, which is a clinging and a climbing plant like the pea.

Another crop suitable for the soiling or house-feeding system, or for ensilage, is the Rape, *Brassica napus.* It is one of our best forage or green-cut crops. The "Colza," another oil plant, is grown so largely on the Continent as a forage crop—as well as for seed for oil-making purposes—as to make at certain periods of the year the yellow patches in almost every farm one of the striking features of rural districts. We incline to believe that rape will be one of the crops hereafter most largely cultivated in this country as an ensilage crop. Cattle are particularly fond of it, and it is beyond all doubt specially good as a food for milch cows. It largely increases the flow of milk, and adds to its richness; while it imparts no bad taste to the butter made from it, such as that but too well known as a consequence of feeding the cows on turnips. Rape may be grown in spring, as well as in winter; but for a winter-grown crop it is well adapted, as being hardy it stands frost well. Colza, *Brassica campestris,* being more succulent than rape, *Brassica napus,* will perhaps take precedence as an ensilage crop; it may be grown on heavier soils than the rape. Both crops give the best results when sown in drills fifteen to eighteen inches apart. The method of sowing in seed-beds and *transplanting* the plants to the drills is largely practised on the Continent, and with, it is said, a better yield than the ordinary drill sowing. Good crops of both plants may be grown on the widest possible range of varieties of soil.

We now come to the corn or grain crops which, when cut green, form excellent produce for ensilage preserving. Of these, by far the most valuable is the "oat." It is long since that green-cut oats were recognised by some practical men as affording most valuable forage for live stock. But the investigations made by the late Dr. Anderson, chemist to the Highland and Agricultural Society of Scotland, and by Dr. Voelcker, the late and lamented able consulting chemist to the Royal Agricultural Society of England, drew pointed attention to this value. Care should be taken to cut the grain when thoroughly succulent. Rye is another crop which has long been used as a green-cut forage food, and its cultivation will no doubt be largely increased with the increase in use of the ensilage system.

We now come to notice some crops which may be looked upon as forming *new produce* for the ensilage system, some of which have been used experimentally, or to a small extent, others have only been suggested as likely to form good ensilage crops. Of those latter we have first Buckwheat, *Polygonum fagopyrum.* This may be said to be practically unknown to our farmers, largely as it is grown on the Continent, where the seed or grain is not only much used for domestic purposes—a kind of thick porridge or pottage, lentil fashion, being a great favourite with many—but for the feeding of fowls and pigs, the latter having what may be called a craze for it, so fond are they of it. The crop may be grown most easily, and upon almost any soil, however poor it may be; and it can stand also almost any degree of drought. When in flower it is, like the flax, a very pretty plant; and it is worthy of note here—as affording the small or amateur farmer who may go in for bee-keeping a useful hint or suggestion—that bees are particularly fond of the blossoms. When a field of buckwheat comes into flower, the fact soon becomes known to the bees at a distance, for although only seen in comparatively small flocks before, they will appear in what seem to be perfect droves. We remember once, in one of our many rambles abroad, coming on a large field of buckwheat in flower on the shores of the famous roadstead or harbour of Kiel, which seemed to be literally alive with bees, whose humming noise was audible for a considerable distance. One great advantage possessed by the buckwheat crop as an ensilage one, in addition to that above named (its capability of growing well in the poorest of soils) is that, cut green, it forms a food of which cattle are extremely fond—this being true especially of milch cows. And when given to the latter, the increase in the flow or yield, and in the butyraceous richness of the milk, is a very marked feature.

The next crop proposed to be cultivated as an ensilage forage crop is Maize, or better and more widely known in this country as Indian Corn, and throughout the whole of North America simply as "corn." This term, or name when read by our farmers in American publications, puzzles them sorely —as corn with us means something very different; being pretty universally applied to wheat only, although in the north and elsewhere it is employed to designate oats when used in connection with the feeding of horses. Maize or Indian corn seems to be a crop particularly well adapted for ensilage; it may be said to be the ensilage crop *par excellence* of the United States and the Canadian farmers. This may be said to arise from the fact that the crop is grown to a very large extent in North America; but as they have other crops suitable for ensilage, it may be assumed that they find maize to be the best, hence its extensive use for preserving in silos. Doubt has been expressed by many as to its suitability for this climate; but this doubt may take its rise from an altogether mistaken conception of what the true question is *from an ensilage point of view*. It is not that maize or Indian corn cannot be grown in this country as it is grown in warmer climates—that is, in the ordinary or farming sense, as a grain-producing crop. If this were the question it might be practically answered with little hesitation in the negative, as it appears pretty well established that it would not as a rule ripen so as to produce the commercial grain or product which we know as Indian corn. But the real question at issue is this: Can maize be grown in this climate to reach that stage at which when cut green it is in its succulent condition best fitted for the ensilage system, precisely as it is used for that system with such striking success in the United States and Canada? To this question only one answer can be given, and it is wholly in the affirmative. Let us keep out of sight the fact, established beyond a doubt, that in the south of England at least, maize has been grown and ripened for the grain (witness what the celebrated William Cobbett did many years ago, and coming down to our times Mr. Hope on his sewage farm near Romford, in Essex), and *per contra* look only to the growing of the plant for green-cut or forage food: we say unhesitatingly that there is nothing whatever in our climate, any more than there is anything in our soils—which at all events the most doubting does not say there is—that prevents the maize from being grown anywhere as a green-cut forage plant. We have grown it in a northern county in England with perfect success up to the flowering period of its growth, beyond which—and indeed below which is safer—no ensilage producer needs to or should grow it. As comparatively few of our farmers—certainly, as a rule, none of the class of small farmers—have seen maize growing, we would recommend such to grow a few plants in their garden or some spare corner of a field. If they do, we feel assured that they will see in the vegetable richness of the splendid-looking plant—for it is in appearance such—evidence enough that its choice by the North American farmers as the principal ensilage crop is a wise one. We shall never forget our feelings of delighted surprise when we first came in view of a large field of Indian corn in its flowered stage of growth on a farm in the State of New York, United States of America.

Like the oat, the rye, and our other cereal plants, maize belongs to the family of grasses; there is but one species, although its cultivation in such a wide variety of climates and localities has formed two great varieties: first, that known as the American maize, *Zea altissima s. hirsuta*, and which grows to a height of from twelve to fifteen feet; and second, that known as the European maize, *Zea Mais et præcox* of Linnæus, which is of less height, growing from four to eight feet high. A rich loamy or lightish soil suits the maize better than a heavy soil. It is best sown in drills, and each plant is hoed up into the form of what is technically called a hill. The first hoeing or "hilling" is done when the plant is from nine to twelve inches high, the second when it is about two feet. The second hilling is absolutely essential, and must be done with the greatest care; for the root sends outwards and upwards small roots, which if carefully covered with soil go largely to increase the bulk of the plant. If ensilage becomes, as there is at present every presumption that it will become, an established part of English farming, we shall be much surprised if the cultivation of maize be not taken up as a regular crop for the process. And it is just one of the striking characteristics of the ensilage system that it lends itself to, or rather we should say is the promoting cause of, the introduction of new crops, creating a variety of feeding produce infinitely wider than that hitherto characterising the food resources of English farmers. To some of those we have alluded; we shall in next note draw attention to other crops which are proposed in this direction.

110. To find the Weight of a Round or Circular Bar or Body of Cast Iron, the Diameter and Length being given.

Square the diameter and multiply it by ·7854, which gives the area of the end. Multiply this product by the length of the rod in inches, and divide the product by 3·84: the quotient is the weight required.

111. When the Breadth, Weight, and Length of Flat Wrought Iron Plates are given, to find the Thickness. (*See* Note 100, vol. ii., p. 110.)

Take the length in inches and multiply it by the breadth, then take this as a divisor, dividing by it the product of the weight multiplied by 3·6; the quotient is the thickness required.

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY.

(43) In Note No. 36 we gave some remarks as to the mechanical work obtained by the combustion of coal. We now glance at some of the leading points connected with the process of combustion of a fuel. And at this point let the young home student distinctly bear in mind that the substances known as "fuel"—such as coal, coke, turf or peat, charcoal, wood, and for kindling purposes wood-shavings and paper—are no more combustibles (that is, things which can be burned and consumed wholly away, leaving behind nothing but what is called ash) than lumps of stone or sheets of tin-plate or iron—that is, are not combustibles in the ordinary sense of the term any more than a brick or a stone, *unless* they are placed in certain conditions in relation to agencies other than themselves. This fact is one which when lost sight of or overlooked, as too many overlook it, gives rise to many grave errors in practice. In view of it, we have men who, claiming to be practical, will insist that if they have a certain weight of coal, they ought to and do get a certain amount of heating work out of it; for being, as they say, a combustible, it must burn away and be consumed, and must therefore give out so much heat. But they wholly overlook the influence which the *conditions* of the fuel and the furnace exercise. Combustion accurately defined is a process of combination with other agents, one being a gas (and that gas oxygen), the other heat. Oxygen is the great supporter of combustion, without the presence of which combustion cannot possibly go on or take place. It is also the great supporter of animal life, the processes of which are, in fact, processes of combustion, the fuel being the food, which produces the heat which supports the body. As the constituents of coal—the general fuel used—are solid, and the great supporters of combustion are gaseous, there must be a definite way in which the necessary combination between the two is effected; and there must be a source from which the oxygen is obtained. That source is the atmosphere, the ordinary air, surrounding us everywhere, of which oxygen, the supporter of combustion, forms but a small proportion or constituent, compared with nitrogen, which is not a supporter of but antagonistic to combustion, as it is also to animal life. When heat, the second essential agent in combustion, is applied to coal—the fuel almost universally used for steam-raising in this country—it softens, disintegrates, and breaks it up into fragments; and as the heat continues and increases in intensity—that is, as the temperature rises—certain gases are formed, and pass out and away from it; and being lighter than common air, rise in an upward direction, being visible in the form of a vapour known as smoke, of which watery vapour or steam forms a certain proportion, and unconsumed portions of the carbonaceous constituents of the coal another proportion. At another and advanced stage of the application of heat and of atmospheric air, the fuel or the gases evolved from it, mixing with the ordinary air, which must be allowed free access to the burning fuel, and which also becomes itself heated or raised in temperature, flashes into flame. After a further lapse of time, the red-hot incandescent stage of the burning fuel is reached, this portion being coke or cinder, or that portion of the fuel from which the bituminous constituents—the hydro-carbons, forming illuminant gas—have been expelled by the heat. But if combustion, considering the term in its true meaning, were properly carried out, there would be no smoke; for the unconsumed matters of the fuel, which give the dark sooty hue to smoke, would be consumed within the furnace, and we should then know that economical combustion of the fuel had been secured,—just as, in the case of an oil lamp, which, badly adjusted, passes off smoke to the room in which the lamp is placed, we know that combustion is imperfect, that the oil is not being wholly consumed. The gaseous products, which pass off from coal in the earlier stages of the application of heat—which is practically a species of distillation similar to that which is carried on within a closed retort—arise from the product of the bituminous constituents of the coal, and which gases are technically termed the hydrocarbons. These of themselves, in the form of gas, would give out or afford no heat unless mixed with a certain proportion of atmospheric air; and it is only when so mixed that they flash at once into flame, and thus in that condition form active sources of heat as steam-raisers or water-heaters. The other portions of the fuel remain solid, and these are the carbonaceous constituents, or what in ordinary phraseology are called by the name of carbon of the coal. And it is only in the solid form that this carbonaceous part or carbon of the fuel is useful as a combustible—that is, as a source of active heat, raising the temperature of, and evaporating the water in, the boiler. Before the two classes of coal constituents—the bituminous, yielding the hydrocarbon vapours or gas, and the solid carbonaceous parts—can be used or made available as

heat-producing media or agents, they must be separated and dealt with independently, as individual substances—that is, the volatile portions of the bituminous class of constituents must be driven off by the action of heat from the solid carbonaceous part of the coal. And this is the office which heat has to perform when it is applied to coal in "setting fire to it," or in "kindling it," to employ the popular phrases. And the young home student will be perhaps surprised to learn that the primary volatilisation of the bituminous portions of the coal is actually a cause of cold, or rather of the lowering of the temperature of the burning coal present in the furnace. This the student will see when he considers that this change of the bituminous parts of the coal into the vapour or gaseous form requires heat. This necessary heat must come from somewhere, and the only source of it is, of necessity, the already burning coal in the furnace: just as we shall see further on that one of the gaseous products of the carbonaceous parts of coal—namely, carbonic oxide gas—produced under certain conditions, although itself a combustible gas, is nevertheless a producer of cold, that is, brings about a lowering of the temperature of the highly ignited fuel in the furnace. Under the action of heat, air being supplied to the fuel in the furnace, the hydrogen, which we have seen in a former paragraph to be one of the constituents of coal, takes up, so to say, with the oxygen present in the atmospheric air supplied to the furnace, in the proportion of one atom of the hydrogen to one atom of the oxygen, the product of the combination being water, which takes the form under the action of heat of aqueous vapour or steam. The hydrogen is twice the bulk of the oxygen, and the bulk of the two atoms when combined is two-thirds of the bulk of the two taken together. The relative weights of the two volumes are one of the hydrogen to eight of the oxygen. It is this disproportion between the relative volumes of the atoms which make up certain gases, and the respective weights, which tends to puzzle the student when considering the gases produced by the combustion of fuel. Thus, as stated above, while an atom of hydrogen is twice the bulk of an atom of oxygen, yet the oxygen is actually eight times heavier than the hydrogen. In like manner the carbon of the coal unites with the oxygen of the air, forming carbonic acid gas, in the proportion of one atom of carbon to two atoms of oxygen. Here, again, we see the disproportion between bulk or volume and weight of the two gases: oxygen is twice the bulk of the carbon—the relative weight of the carbon being six, that of the oxygen sixteen. The air being the source of the oxygen required to carry on the combustion of the coal, it is necessary to know the amount of air required in order to yield the oxygen required by the volume of the two gaseous constituents produced by the coal under the action of heat. We have seen what is the amount of oxygen required in the combustion of the two constituents of coal gas; and as oxygen in the air constitutes but one-fifth of the bulk of the air, five volumes of it will be required to produce each volume of oxygen required. And as two volumes of oxygen are required for each volume of the gas, ten volumes of air will be required for the one volume of the coal gas. The carbonic acid gas, produced as above described, is a non-combustible gas, and is inimical to combustion and to animal life. But there is another gaseous product of carbon present in furnaces which is a combustible gas: this is carbonic oxid gas. That is, like coal, it is only combustible when placed under certain conditions, or in relation to the air, which is the source of the oxygen necessary to support combustion. When the carbonic oxide is therefore brought into combination with ordinary atmospheric air it flashes into flame, and becomes an active source of heat. Carbonic oxide gas is composed of one atom or volume of carbon and one atom of oxygen. We have seen that carbonic acid gas is formed by the union or combination of one atom or volume of carbon with two atoms or volumes of oxygen; but carbonic oxide gas, although containing only half the amount of oxygen, is yet equal in bulk to the carbonic acid gas volume. Carbonic acid gas being composed of two atoms of oxygen to one of carbon, and carbonic oxide of equal proportions of oxygen and carbon—one atom or volume of each—it follows that if to any given atom or volume of carbonic acid gas another atom of carbon is added, we shall then have the proportion of carbon and oxygen due to the formation of carbonic oxide gas—that is, in which the oxygen and the carbon are in equal volumes. And we thus, by the above, change one volume of carbonic acid gas into two volumes of carbonic oxide gas. This change is that which takes place in furnaces, on the bars of which a large and often a very deep or thick layer of red-hot or incandescent coal or coke is burning. Two atoms or volumes of oxygen of the air, entering from below, and between the fire bars, combine with one atom or volume of the carbon vapour of the red-hot fuel, and form carbonic acid gas, which is productive of a large number of increments of heat. The carbonic acid gas, at a high heat, passes upwards by virtue of the action of the draught of the furnace with its chimney flue, through the upper layers of red-hot fuel, and in doing so takes up a second or another atom or volume of carbon; and thus, as the oxygen and the carbon are now in equal volumes, carbonic oxide gas is formed, of which the bulk is doubled, one volume of the acid gas giving two volumes of the oxide.

THE STONE MASON AS A TECHNICAL WORKER.

The Principles and Practice of, and the Materials he employs in, his Work.

CHAPTER VII.

Interlocking or Binding of Stones in Arches and in Stairs.

The principle of interlocking blocks with each other is further illustrated in fig. 46, which shows the

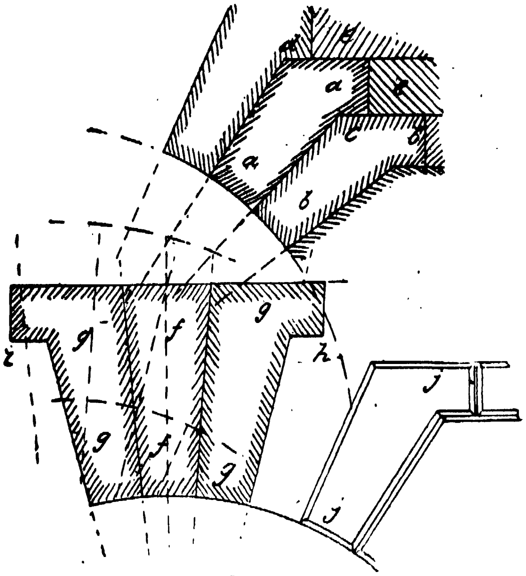


Fig. 46.

forms given to the blocks forming an arch, as in a bridge. The blocks *a a*, *b b*, are part of the series of arch blocks near the piers, and are so cut that, while their lines converge to the centre of the arch, shoulders are made at *c* and *d*, into which the horizontal stones forming the courses of the wall or faces of the bridge between the arches lie or butt, as shown. In the lower part of the diagram, *f f* is the "key stone" of the arch, *g*, *g*, side stones, with shoulders *h*, *i*. The sketch *j j* shows how the joints, in place of being plain, are formed as in figs. 17 and 25. The diagram

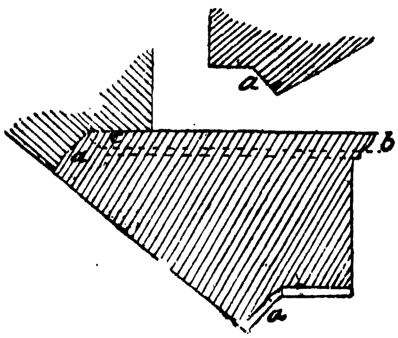


Fig. 47.

in fig. 47 shows how the steps of a stone staircase are cut in cross section, to afford a bearing or interlocking surface, as at *a*. The dotted lines at *b c* show the "return" of the moulding *b*, at the end elevation —for the sketch is in section—of the step. The moulding at *b* runs along the whole length of front of steps; the point *b* is called a "nosing."

"Joggling" or Joining of Stones Vertically.

We now take up the methods of joining blocks placed at right angles to each other, or vertical pieces resting upon one another. Figs. 48 and 49 show

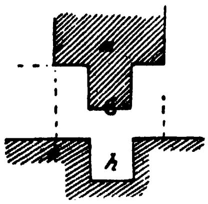


Fig. 48.

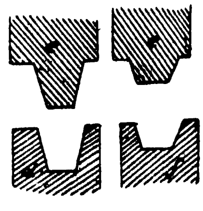


Fig. 49.

two methods—the projecting part *g*, fig. 48, on block *a* passing into the hollow *h* in the lower block *b*. In fig. 49, the parts, as *e e*, are tapering at different angles, corresponding hollows being made in the under blocks *d f*. Fig. 50 represents how part of a cylin-

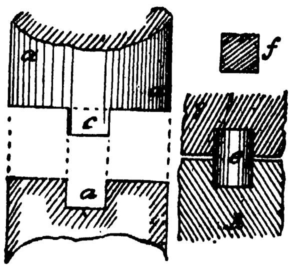


Fig. 50.

drical stone column *a a* may be secured to the lower part *b b*, by a joggle *c* passing into it. Or a hole may be made in each part, and a circular or square block of hard stone or of iron inserted, as at *e*; or this may be made square, as at *f*. Fig. 51 shows how a c—

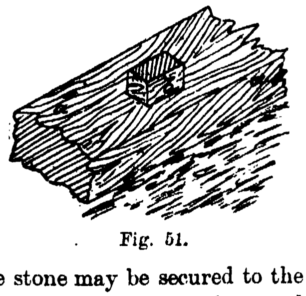


Fig. 51.

block or cope stone may be secured to the sloping surface of a pediment or gable of a house, shown in part *a a*, by leaving a projecting part on its surface, as at *b*; this, of course, going into a corresponding hole cut in the lower bed of the cornice block or coping stone. In a course of "cope" stones forming the last or upper course of a gable, the connection may be made, as at *e* in fig. 50, by a square or round pin of hard stone.

Joining of Blocks of Stone by "Dowels."

These last methods are, indeed, illustrations of the methods of effecting supplementary or additional bond, to which the name of "dowelling" is given. The parts corresponding to *e* and *f* in fig. 50, or *b* in fig. 51, of a pin are known as "dowels," and may be made either of stone or iron. "Dowels," if of stone, are small blocks of greater or less length, square in section or rectangular, which are let into holes or apertures cut in the edges of the two stones to be secured together. The size of the aperture or "slot" is a little larger than the size of "dowel" or small "key" or block, so that it can slip easily in when the stones are put in place, or "*in situ.*" The length or depth of each slot cut into the stone is half the length of the "dowel." In fig. 52 the two stones *b*, *c*, bedded

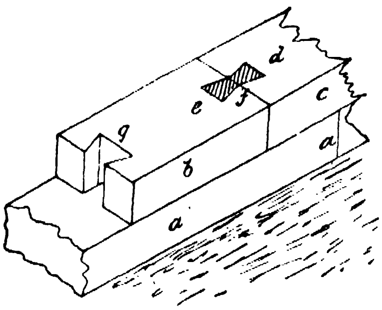


Fig. 52.

on the course *a a*, are shown secured together by the "dowel" let into the hole formed by the junction of the two stones, half of the length of which is cut on each stone, as the part *g*, which corresponds to the hole into which the end *d* of the "dowel" *d e* slips. If the stone is very broad, two "dowels" may be put in at the joint, spaces being laid out equally across the face. The form of "dowel" shown at *a* in fig. 53,

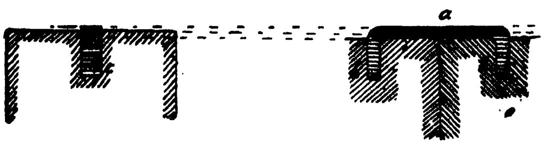


Fig. 53.

or at *b* in fig. 54, joining the two stones *d* and *e* is sometimes used; but it is obvious that this section, or the square "dowel" *c* in fig. 54, does not take so firm a grip of both stones as the dovetailed shape at *a* in this figure, or at *d e* in fig. 52.

"Dowels" of Iron as well as of Stone—Best Sections of, or Forms for, Dowels to resist Great Pressures, to which Masonry is so Frequently Subjected.

The "dowels" may be made of iron—but this, rusting rapidly, is not so durable as a dowel of hard stone. The rusting also tends to discolour the stone. They may, whether of hard stone, as granite or trap, or of iron, be of various shapes, or rather sectional forms; but it is clear that, as the object is to keep the stones in contact, to prevent them under pressure slipping away from each other, there are certain sections better calculated to secure this end than others. And all pressures should be provided for, however unlikely it may be that some of them may ever have an existence in practice. A section of dowel, then, which can meet a strain or pressure coming on it in any direction should, if possible, be obtained, for it is exceedingly difficult to predicate that that strain will never exist. In marine work, for example, one has to deal with a power, or rather with powers—that of the wind and

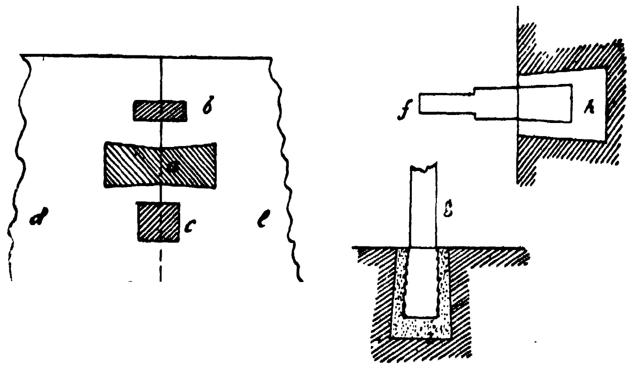


Fig. 54.

that of the waves—not only of enormous force, but which are exerted in the most uncertain, or, if the expression be preferred, in the most capricious of ways. Of the mere force exerted both by wind and wave, the majority of people have literally not even the faintest of conceptions. It requires one to have opportunities, and those often repeated—and to be possessed of powers of observation and reflection, without which all opportunities, however striking, will be useless—to give one an idea of what gigantic power winds and waves possess, and of the strange work of destruction they can with such apparent ease perform. We could cite cases, many of them derived from personally obtained experience—not always by any means safely gained—of such work, to which the popular mind would give so little credence that it would almost without hesitation set our statements down as the mere hallucination of an excited and all-too-credulous mind. Yet the actual facts exceed even what those best acquainted with the effects of winds and waves would expect from the mighty power they exercise.

THE LAND DRAINER.

Drainage of Lands or Soils suitable for the Crops and Live Stock of the Farmer.—Its History, Principles, and Practice.

CHAPTER IV.

At the conclusion of preceding chapter we pointed out that though many think out or reason carefully about a subject in which they are interested, as the work they are daily engaged in, still many do not. But stolid as farmers are said still to be, which it is said they have always been (whether there be good grounds for this opinion, but too widely held by us as a people, the reader may perhaps be able to decide from what is stated by the author of the paper on "The Farmer as a Technical Tradesman"), it would not be long, even in the stolid and steady days of old, when surface drainage was the method and only method in use where drainage of any kind was considered necessary,

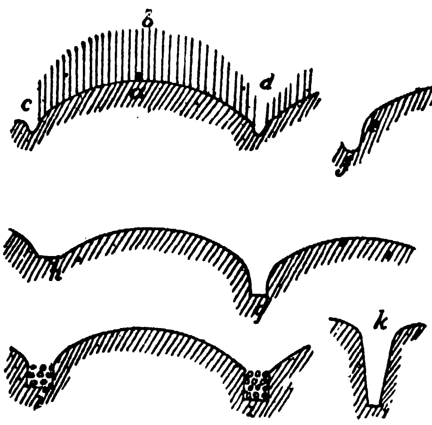


Fig. 2.

before some farmer, wiser and more far-seeing, because more thoughtful than his neighbour, would see this: namely, that his crop—as for example wheat—would be various in point of goodness according to its position on the ridge or stetch. He would probably see, year after year, that the tallest straw, with its finest ear of grain, would be always at the top or higher part of the ridge, as at *a b*, fig. 2, and that from this point downwards towards the water furrows at *c d*, the straw gradually decreased in height, and in its prolific or grain-bearing capabilities. As a rule, or at least very often, he would find that the produce at the extreme edges of the ridge, as at *c* or *d*, was so poor that it would not be "worth his while" to reap it, save but for straw, and that would be of the poorest. In thinking over the matter he would be compelled, as it were, to admit that the reason why the high part of the ridge, as at *a b*, fig. 2, bore the finest grain, was that it was highest out of the water, stagnating more or less at the furrows, at *c* or *d*, or farthest from the wet puddle of mud left there when the water had either passed away, if on the incline, or been partly dried up. To get as good crops on the outer edges, as *c d*, he would perceive he must do something with them in like fashion as he had done with the crown of his ridge, at *a*. With his wretched implements he could not do this easily, if at all, so as to make the edges of the ridge or stetch as at *e*; thus raising it high above the water furrow *f*.

Further Steps in the Discovery of the Value of Under Drainage of the Soil.

But if he could not raise *e* with the means at his command, those means would enable him to do the exact converse: he could still in effect raise *e* by lowering *f*. He would thus dig out or deepen the furrow, as at *g*, first widening it probably, as at *h*. The next step would follow, but as progress in the arts was at first very slow, it might follow very long after. The mere open trench would be possessed of many practical inconveniences: it would be liable to cause accidents to the ploughing animals, or oxen—for oxen were used almost universally in early days, and are in some places used still. The animals would also force in the sides of the trench, and cause increased labour in again opening it up. But by filling in the trench with

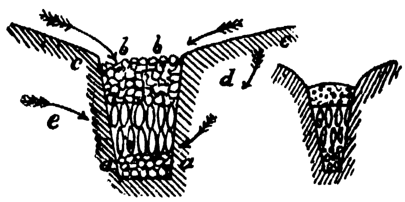


Fig. 3.

stones, as at *i*, fig. 2, those two difficulties would be met in great measure, whilst also the openness of the channel would be preserved to a large extent, through the interstices or hollow spaces left or formed by the irregular shape of the stones, as at *a a* in fig. 3. But while drains of this kind would be wonderfully efficient as compared with the open shallow space, as at *h* in fig. 2, and even much more so than in the deeper form, as at *g* in the same figure, they would possess another advantage in this respect over the shallower trenches here referred to; and it would be this,—that these deep trenches would not act merely as conduits or channels for carrying away the water which would be shed over the sides from the surfaces of the ridges *c c*, fig. 3, in the direction of the arrows; but there would be a percolation, so to say, or gradual passage of the water contained in the soil near the sides *a a*, and from the soil above the range of mean level of the drain, as at the higher part of the ridges *c c*. The course of the particles of water, or small streamlets, may be supposed to be in the direction of the arrows *d, e, a*. Fig. 4 further illustrates what may be taken as the action of open stone-filled trenches or drains, as at *a a*, *b b*, fig. 3, the water from the ridges *a*, *b*, shedding right and left, as shown by the arrows *c, d, e, f,* to the side, or rather the midway deep furrows or channels *g, h, i.* This action of the deeper watercourses thus introduced would soon be noticed by observant men; and it obviously introduces a new feature in drainage, and that feature may be said to have opened up the way for the great principle which distinguishes modern drainage—namely, the getting rid of the superfluous water contained in or held by the great body of the soil lying underneath the cultivable or cultivated surface soil.

Practical Peculiarities of the System of Surface Drainage.—Still practised on Arable Lands.—That pursued generally in Hill Pastures.

For obviously the old system of surface drainage dealt, and proposed to do no more than deal, with the water which was shed on the upper surface, and which without the open drains or furrows would have remained stagnant on the upper soil. And this surface retention would as obviously be more decided in heavy, close, retentive clays, which would present greater difficulties to the passage of the water through the pores—so to use this expression here—of the surface, than would soils of a freer or looser texture,

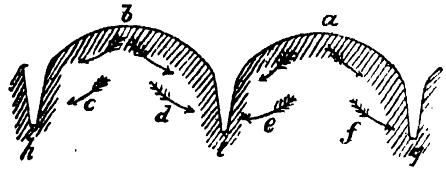


Fig. 4.

such as certain classes of loams and light sandy soils. Hence the reason why the surface drainage was so applicable to and yielded its best results in close clayey soils. And hence also why, even after the modern system of deep drainage had long been adopted, it was for such soils long used. It is indeed used in many districts still. But where used it is more efficiently carried out than in the olden times, with which at present we are more especially concerned. The watercourses or furrows are left quite open, but carefully kept open by means of the horse-dragged plough and the hand-worked spade or trenching tool. This work of keeping open the furrows or water channels between the ridges constitutes, in the heavy clay soil, or corn-growing districts, in cases where it is yet practised, a large portion of the labours of the ploughman in the winter and early spring months, special attention being paid to this work after heavy rainfalls, it being almost wholly executed at such times by the spade. The spade is also freely used to form what may be called minor furrows or smaller water channels, to run transversely or diagonally across the furrows, opening up channels by which the water in hollow places, etc., can be led as directly as possible to the midway furrows, which finally are led across the lowest part of the field leading to the outer or main ditch, which acts as the "outfall" of the whole system of furrows. The general appearance of a surface-drained field may be illustrated in fig. 5, in which *a, a, a,* are the open furrows lying between the ridges *b, b,* the land supposed to be sloping in a direction from the to top the foot of the page, as shown by the arrows *e, e, e*; *c, c* are the minor furrows or catch-water channels dug transversely across the ridges *b, b,* either at right angles or directly across, as at *c, c,* or obliquely, as at *d, d,* according to the "lye" or "lay" of the surface and the position of the hollow parts. All the furrows, *a, a,* cross the lower part, *f f,* of the field, which, known by the name of "head-ridge," popularly called "head-rigg" in Scotland, "head-land" in England, (a curious perversion of this word is met with in some districts of the north of England in the word "nettlin," or as we have heard it sometimes as "yettlin," the syllable

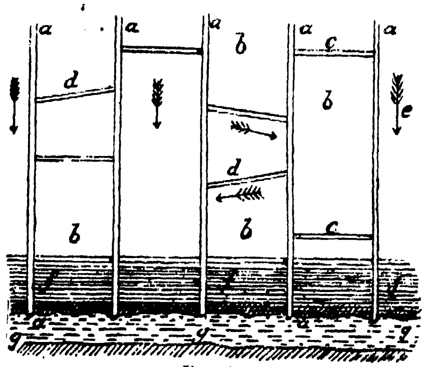


Fig. 5.

"yett" being sounded somewhat like the word "head" is pronounced—namely, "hyead" or "yhidd,") is a few yards in breadth, and which is ploughed in a direction at right angles to the general ridges *b, b,* so as to deliver the water to the ditch which carries it off right or left, either to another and larger ditch or watercourse, receiving the water of several minor ditches, as *g, g,* or leading it at once to a stream as the final outfall or place of delivery. Surface drainage is also carried out on hill-side pastures, but the furrows seldom run parallel to one another — generally following the direction of the slopes and inequalities of the ground. Many are led directly to the foot of the hill, where the general outfall naturally lies, or lead first into larger furrows, the course of which is directly to the outfall. But even in arable land in lowland or flat districts it does not follow that the furrow drains are parallel to one another. Their direction, as we shall see, ought to be attended to in modern deep drainage systems—should, in fact, be dictated and guided by the general contour of the land.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL.—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER VI.

IN preceding chapter we concluded last paragraph by stating that the beater of the scutcher makes no fewer than eleven to twelve hundred revolutions per minute. Thirty-three hundred blows are therefore given to the cotton in one minute; most part of it being beaten with numberless blows while in the jaws of the fluted rollers. The reader will at once see how hardly the cotton is treated in this machine: soft and tender articles should not be so roughly treated, as the staple is liable to be damaged (broken), and thus the finished goods cannot be so perfect; besides which, the broken fibres are mostly lost in the different operations; being short, they do not hold on till the other processes are reached, and hence the loss which must arise from broken fibres.

The beater, as a matter of course, must form a circle, and in that circle an arrangement is made whereby the dirt which is beaten out of the cotton by the blows from the beater can escape. This is effected by a series of ribs forming a regular grid; these grids are so closely fixed that little more than sand can pass through them. It will naturally be asked, But what becomes of the cotton? Any material running at so high a speed must to a certainty create a draught, and then follows where it can escape. Immediately behind the beater there is a wire cage, of course of a fine mesh, so as to prevent anything passing through it except that which is considered useless,—sand and dust. In connection with this cage a fan is attached running at a high speed, thus drawing through the wire cage all particles of dust, etc., and this passes away through a tunnel under the floor where the machine stands into an open chamber, called the dust chamber. The dust chamber has an outlet by which the air produced by the fan and the light dust can be liberated. This arrangement draws the cotton from the beater to the cage, and the cotton comes in flakes against the cage. The cage runs at a very slow pace. Beneath it there is a creeper or apron, both the cage and the creeper going in the same direction. The cage is about 24 inches in diameter.

The Scutcher or Beater, the Principle and Details of its Operation.—The Finishing or "Lap" Mechanism and Management.

The "creeper" carries forward the cotton to another pair of feed-rollers, which also run very slowly—*i.e.*, about the same speed as those before named; after which it goes through a process as above described, so far as the beating, cage, and fan are concerned. Instead of undergoing any further beating or harsh treatment after this second beating or scutching, the cotton is carried forward to plain rollers, which are intended to solidify the loose cotton; and thus is passed to the part of the machine at which the lap is formed. It is called the lap end or finishing end of

The cotton, as it leaves the calender rollers which are close to the cage, is put round a wooden roller and then pressed between two large fluted rollers of iron, and thus the lap is finished. This machine may be called a double-lap machine, having two beaters and two cages. Another machine, called a single-beater machine, follows this, where three or four laps are put upon a creeper or apron. This is often called a finishing lap machine; and its special object is to double three or four laps, so as to make the lap at this machine more even. We should much favour a plan which is adopted in many mills, of having two single-beater machines in place of the double-beater machine we have just described. As we have said, and though the same principle is adopted in all spinning concerns, every opportunity which offers itself to make the cotton fibres more regular should be at once accepted.

The Single (Beater) Lap Machine or Scutcher and the Double Lap Machine—Comparison between them as effecting Economy in Working.

Now let us glance briefly at the advantage of two single-beater lap machines over the one double-lap machine, not so much in respect to its cleaning as to its value in equalising powers. Suppose two single-beater machines were used in the place of one double, the advantage to be gained would be, feeding the single-lap machine precisely as the double-beater machine. The cotton would only receive half of the beating, and it might be said half the cleaning only; but this is the point gained,—a lap would be made on this machine as on the double machine. Now, the laps made on the single-beater machine would be put on the second single-beater machine—*i.e.*, three or four laps would then run through the second single-lap machine, and would thus, in the end, have received the same amount of beating or cleaning with the two single-beater machines as with the double-beater machine. It will be seen that beside having all the advantage of the double-beater machine, it has a benefit in its favour which is by no means to be lost sight of, and that is of equalising to a greater extent: *i.e.*, four laps could be put up at the latter machine. The second single-beater would be acting the part of the finishing lap in the first part—*i.e.*, the one following the double-beater scutcher. This would in most instances do away with the single-lap machine; or instead of having a double-beater lap machine and a single-beater lap machine to follow it, it would be better to have two single-lap machines, and the same point of doubling is attained which has been in some instances carried out with entire satisfaction.

Our own experience has satisfied us that this plan would be very good if carried out as we have described. We have reason to say that the cotton would be cleaner as it left the second machine than when it left the double-beater machine. Very short and very dirty cotton might not suffer so much by excessive beating, but if cotton which is longer in staple than Surat be used, it is always in danger of being impaired in quality. We speak on this subject after some experience in using the double-beater and then the single-beater, in comparison to using a single-beater only after opening, and that has made a difference in the spinning of one-tenth gain in the "counts." The longer and woollier the staple, greater and greater would be the mischief done.

Importance of attending to the Weighing and Spreading of the Cotton supplied, and Thoroughly Cleaning the Parts of the Scutcher or Lap Machines, to secure Economy in and Efficiency of working in this part of the Blowing Room Work or "Preparation."

A careful weigher, with a careful spreader, are valuable hands in the scutching room; for irregularity—that is, heavy or light in turns—is the cause of much trouble, and inferior yarn. Testing the regularity of the feeding and weighing at the machine is done by taking off a few laps, about two yards each, from each lap, and weighing them separately; this is a check upon those entrusted to do the work, and it is very generally adopted in mills.

The next consideration is of importance in obtaining good work, and also for the benefit of the machines in the working of which there is great quantity of dust and objects hurtful to the machine. Hence it is of consequence that frequent cleaning should not be neglected. The first point to be attended to is that of oiling. Be careful not to put too much oil on, and cause it to run outside of the bearings. It is not only useless and wasteful, but it is actually objectionable in this way: wherever an excess of oil is used, it runs on the frame, and thus collects every kind of refuse which comes near it. Attention to cleaning and oiling will tend much to prevent that amount of wearing which all machines are subject to wherever high speeds are attained. It will also be found to the advantage of the owner to keep it in good repair; for if any one thing gets much worn, something in connection with that part must suffer as much as the part so worn.

Remarks on the Class of Work done in the "Blowing," "Scutching," or "Machine" Room of a Cotton Mill.

There is one other thing which we might dwell upon for a moment or two—namely, the class of work which has to be performed in what is known by the name of the blowing room or scutching room. The room where the cotton is first operated upon by any machine after it arrives at the mill is denominated in one spinning district by the name of "blowing room"; in another district, probably the next town, it might be designated "scutching room"; and we have been in districts where it is known as the "machine room." It might be of advantage to those readers who are not much acquainted with terms used in the cotton mills if we thus explain those used which are known in one circuit by one name and in another circuit by another name. This may not be the most pleasing form to those who are fully posted up in the various customs of denominating machinery or naming other modes of working in cotton mills; nevertheless, we must accommodate ourselves largely to those who are the least learned in the working of machinery.

Some Hints as to Workpeople, or "Hands," employed in the Blowing or Scutching Room, in relation to its Work—Passing Cotton Twice through the Scutching Machine.

We conclude our remarks on machinery of the blowing, or, as above, scutching room, by saying a few words on the class of men or women who are engaged in that department as the workers of the machines. It is well known by all who are connected with cotton working that those, be they men or women, are, for the most part, the unfortunate of society,—very often as the result of their own misconduct. So, then, they obtain employment at such machinery as the more thoughtful, or may we be allowed to say the more refined? would feel themselves out of place in attending or working. The most unlearned man or woman in the work of a cotton mill will ask for work in the blowing room, showing that for almost any individual, however little he or she may be acquainted with machinery, there is a chance of employment if a hand is required.

The machinery in a blowing room, nevertheless, requires judgment in its working. Such attention, then, as is required for such important machinery cannot be had from those who are ignorant of its necessary requirements; and hence the need of some more competent mind having a general supervision. This want is, to some extent, furnished by a competent man, termed the "carder," the overlooker of the preparing room, that room which takes the cotton direct from the blowing room. His time is largely taken up in the card room (preparing room), and therefore but little of it can be bestowed to the superintendence of so important a department as that of blowing or scutching. We have often said that in small mills, where a foreman over such a room cannot be afforded, there should be a superior mind engaged; and one, also, of experience in the working of openers and blowing machines, to be entrusted with the working of the cotton in that room.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER IV.

IN view of the large quantities or weight of metal required to meet the demand for weapons of warfare in the early times, when fighting constituted a large portion of the work of man, we have said in preceding chapter that iron merely in its malleable form would not have answered to the conditions demanded of weapons calculated to cut as well to thrust. That even the malleable iron must have been of a superior kind, we shall see pretty well substantiated when we come to consider the materials which, as we have said, the early iron workers were from their circumstances compelled to use.

The very vastness of the weight of the metals which we thus see must have been in existence even in the early stages of man's civilisation, who from the very earliest period we know to have been a "fighting animal," must of necessity have engaged the attention and demanded the hand labour of a host of iron makers. And it is scarcely possible to conceive that, as the result of experience extending over a long period of patient labour, some if not many makers had discovered the art of making steel or fine malleable iron at will. And if to this conjecture be brought the statement to controvert it, that no record has been handed down to us of the method or methods so discovered and used, there may be brought this, which we know to be a fact—that, without exception, every art in the later stages of civilisation was a "secret one," that is to say, that if man discovered a new metal or an improved method of making it, or any method of doing work in a way superior to his fellows, he did his best to keep it secret. We have abundant evidence to prove how this was the rule in all trades, and with what jealous care such secrets as were discovered were guarded. Secrets were handed down as valuable properties from father to son; and some ceased from one cause or another to be so dealt with, and were lost—some for a time, again to be discovered or to be rediscovered, while others were wholly lost and have never yet been rediscovered, to the great loss of more than one trade of the present day. This careful guarding of trade secrets gave rise, indeed, to those "close corporations" of the middle ages known as "guilds," and these in turn gave rise to the system of "apprenticeship," the very essence of the existence of which is, that the youths have the secrets of the "craft" to learn.

Practical Lessons to be derived from a Glance at the Early History of the Art of Steel Making.

Much of the lack of precise thought on this far from unimportant phase in the history of steel making arises from the confusion of ideas prevalent with so many, originating, as this does, in the many forms in which iron now exists amongst us—in those of cast or pig iron, malleable or wrought iron, and of steel —and this has become all the more decided in its influence in the way we have noted from the fact that of modern steels there are so many varieties. One has to go back to the earliest periods in the history of man, and to take note of the circumstances in which he did his work of iron making (using this general term to include steel as well), in order to see how the special trade of steel making arose. And in doing this we shall obtain further information on and the direct introduction to the modern art of making this metal.

First Work in the Early Art of Steel-making.

That iron ore was early discovered we know to be the case, and its presence could scarcely be overlooked when we consider what in the chapter entitled "The Iron Worker" we have stated—namely, that in many districts it crops up to, and is often lying upon the surface, or so near to it that one or other of the many ways in which men for various purposes—of food-producing, shelter or defence—dug and excavated the soil, would lay bare supplies of greater or less amount. They would soon find out that this ore was capable of being changed in appearance and character by the action of heat. And further, the early workers would find that the iron ores did not possess the same characteristics: that some would be more easily acted upon by heat; others would be less so, or more refractory; while the quality of the "yield," or make, that is, the result of the "smelting" or "reducing" process, would in like manner vary.

The melting, or as it is called in the technical language of the trade, "smelting," and sometimes, indeed more frequently, "reducing," would be effected in the earliest times by the simplest of methods and in the simplest of furnaces (see the series of chapters under the title of "The Furnace Builder). We have some information, more or less detailed, but still sufficiently clear and distinct to enable us to judge pretty accurately of what the earliest methods of steel making were. We know that one of the characteristics of Eastern peoples is that they are so conservative of their habits and customs that these are handed down from generation to generation, unchanged through a long course of centuries. We can thus safely predicate that the things we see that those peoples do to-day have been done in the days of their forefathers centuries ago. The same is true of the processes connected with the few and generally simple industrial arts they practised. The method, then, of making steel, which we know to be practised even now in some districts of India—giving the widest acceptation to this local term—and which we have authentic documentary and other evidence to prove was the method universally practised by the natives not so many years ago, we may with all safety infer was the method practised in the very earliest times.

In these early methods it would, as we have said, be only the richest iron ores which would be dealt with, for the reason that the simple apparatus at their command would in effect be capable of melting or reducing only the ores most easily acted upon by heat. And in those early times the fuel used—indeed, the only one practically at command—would be wood. This at first would be used in its natural, but in a dried condition. The very process of so burning it would soon lead to the discovery of the art of making charcoal; and the value of this in the reduction or smelting of the iron ores would also be early known.

The steps of the process which would lead up to the discovery of the value of a closed furnace as compared with an open fire in giving intense combustion, will be found explained in the series of chapters under the title of "The Furnace Builder." And so also it is not difficult to trace the process of thought and observation which would lead to the value of artificial supplies, currents, or blasts of air to the interior of a closed furnace, as increasing to a still greater intensity the heat due to the combustion of the fuel in the furnace in its normal or ordinary condition.

The Three Elements in the Art of Steel Making possessed by the Early Workers.

Here, then, we have the three elements of the primitive method of making steel: first an iron ore rich in metallic iron, easily smelted or reduced, and yielding instantly the most valuable product; second, fuel in the form of charcoal; and third, a closed furnace, supplied with a blast or current of cool air, produced by the simplest form of bellows (see "The Furnace Builder"). The charcoal would be supplied to the furnace, lighted in the first instance in all probability by wood in a dried state; and when brought to a condition of active combustion, and forming a somewhat dense mass of hot burning fuel, the iron ore would be added—this probably being broken up in small pieces if the nodules in which it was dug up or mined were large. The bellows would then be set to work to make the combustion still more active and the heat more intense than before, till the ore would become partially melted, and would fall to the lower part of the furnace in a semi-fluid or what is technically called a "pasty" condition. It would soon be discovered that this pasty mass, if taken out at a high heat, could be hammered and compressed so as to form a mass more or less uniform or homogeneous in character. This, when allowed to grow cold and again heated, would be found to possess the same malleable properties, and could therefore be hammered or forged or drawn into its various forms.

This method was, in fact, the one by which what we call "iron" was originally produced; the metal possessing the properties of malleability—that is, of being hammered and drawn out or rolled, and of being welded together when two pieces were brought to a white heat, laid upon each other and subjected to hammering or compression. But the iron thus produced by the simple process just described might or might not be the metal we call "steel," or that which possesses the property of being hardened and tempered, so that it can be brought to an edge capable, according as it is treated, of cutting ordinary iron, or of dividing the finest filaments. We say that the product of the primitive method of reducing or smelting of iron ores *might or might not* be steel. At a future stage of our inquiry we shall see that steel and iron are products of the original ore which vary simply from the proportion of carbon which they contain. Now, in the primitive method of smelting we have described, the ores only of the richest being used, the iron produced would possess just sufficient to form a quality which would come very near the modern metals produced by the Bessemer and Siemens processes which are known as "mild steels" or "ingot steels." And as in the primitive method, now under notice, all the processes of working would be practically done on chance, or in a haphazard style, and as the ores would vary in quality, and the actual process of smelting would also, and naturally, vary—such as in the time of smelting, or blowing the heat of the furnace, and the manipulation of the pasty mass—the final product would vary very much at times in real quality. We thus see how the primitive iron workers would, as it were, stumble upon, and in a certain sense foreshadow, what are now considered to be the discoveries of modern times, and produce steel capable of being hardened and tempered after being hammered and wrought into form, such as that of a rude knife or sword, so that they would have sharp cutting edges. But this stage of uncertainty as to the real quality of the product of the primitive method of smelting or reducing iron ore must at a very early period have given place to a more trustworthy and definite one, by which a determinate quality of produce could be calculated upon. This discovery must have been early made, as the records of history are abundant enough to show that in very remote times implements of all kinds capable of cutting were used in large numbers, requiring of necessity a large supply of good steel. How steel was then made we now proceed to describe.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER VI.

"Rose" Pigments (*continued*).

At the conclusion of preceding chapter we stated that these "rose" pigments were not real or true ones. They are, as a rule, simply some base coloured with brazil-wood or aniline scarlet, and it need scarcely be added, they lack stability, and are suitable only for special purposes: thus, in giving a pink in paper-hanging printing they "come in" very useful, and are sufficiently permanent for the purpose. Magenta may be employed, but is objectionable owing to its exceeding delicacy to the action of light; but some of the aniline scarlets which are now manufactured in England give a product of a brilliant red or pink, and of tolerable stability. In our next paper we propose to treat briefly of some bright scarlet and red pigments which have been prepared for use in painting, but which have never found application, owing to their instability, their cost, or other objection, and which therefore possess more a chemical than a practical interest.

Red Pigments never, or rarely, used in the Arts.

Many red compounds are known to the chemist which would prove most valuable pigments if they could be obtained cheaply, or if they were of more stable natures. Chief amongst these may be noted—(1) the scarlet iodide of mercury; (2) cobalt red; (3) terchromate of thallium; (4) chromate of silver; (5) perchloride of chromium; (6) ferrate of barium; (7) persulpho-molybdate of lime and baryta. These, although now never, or but rarely, employed in the arts, are yet interesting and worthy of brief notice in this paper.

Scarlet Iodide of Mercury.

Mercuric iodide, HgI, is a brilliant scarlet pigment soluble in traces in water, alcohol and ether, readily soluble in iodide of potassium, from which solution it crystallises in beautiful red quadratic octahedrons. It may be obtained by the gradual addition, by portions of 10 grammes at a time, of 124 grammes of solid iodine to a jar containing 100 grammes of mercury and 1 kilogramme of alcohol. After each successive addition of iodine the mixture is stirred until the metal has abstracted all the iodine from the alcohol, which acts simply as a carrier of the iodine to the metal. The whole of the mercury is converted into the scarlet iodide, the product is washed with alcohol several times, and after drying is ready for use. We have found this process to be much inferior to the iodine method of producing HgI. This mode of preparation, which is preferable to the above, consists in gradually mixing eight parts of mercuric chloride and ten parts of potassic iodide, when the iodide of mercury is precipitated; it is washed, dried, and is ready for use. This beautiful compound of mercury is readily acted on by sunlight and prolonged exposure to the air, and is attacked and its colour destroyed by sulphur fumes. It is still used by artists to some extent. It ought always to be used in a medium which on drying forms a varnish which protects the colour as much as possible from the air.

Cobalt Red.

Red cobalt ochre or erythrine is a hydrated arsenate of cobalt, represented by the formula $Co_3AsO_4.4H_2O$, which varies greatly in shade, from a deep rust-red to different shades of grey-violet. It is found in the earth in Schneeberg in Saxony, Saalfeld in Thuringia, in Riechelsdorf in Hessia, in Baden, and also in Norway, and in Cornwall and Cumberland. It was formerly extensively used by the artist, but is now superseded by madder and alizarine lakes.

Thallium Red.

Thallium bears in many points a close resemblance to lead; in both cases treatment of the dichromate with nitre yields a red compound. Trichromate of thallium, $Ti_2O.(Cr_2O_3)_3$ is a cinnabar-coloured salt, only slightly soluble in water, but which is unsuitable as a pigment.

Silver Red.

On adding chromate of potash to a soluble salt of silver a bright-red-coloured precipitate of chromate of silver ($AgCrO_4$) is formed, which is of course inapplicable, owing to its expense, as a pigment.

Chromium Red.

A compound of a beautiful peach-blossom colour which has been proposed as an artist's pigment; is obtained by igniting anhydrous sesquioxide of chromium with lampblack in chlorine gas, washing and drying. The formula is Cr_2Cl_6.

Iron-barium Red.

Ferrate of barium, $Ba_2O.F_2O_3$, is a rose-red precipitate obtained by decomposing ferrate of potassium with chloride of barium—the former salt obtained by gently heating oxide of iron and caustic potash.

Molybdenum-lime Red.

Tersulphomolybdate of calcium, like most salts of the same acid, especially baryta, is cinnamon-red, and but slightly soluble in water. It is highly costly, and is not now used in the arts.

Yellow Pigments.

Under this heading we will include, in addition to yellow pigments, orange and orange-reds, buff and brown, as these are often simply modifications of the yellow products. We divide this branch of our subject into the following convenient classes: (1) Iron ochres, or buffs, browns, and dark maroon-reds, obtained from compounds of iron, mostly the oxides; (2) Chromates of lead, yellow and orange; (3) Other chromates, as zinc, baryta and lime; (4) Sulphides, as of cadmium, arsenic, and antimony; (5) Cobalt and other minor mineral yellows; (6) Yellow lakes, as berry-carmine. It may be remarked here that, as in flowers, yellows, and colours containing yellow, are by far the most abundant of all shades; in the mineral kingdom impure yellows, as buffs, are also the most frequent. It will be observed, too, that in human coloured ornamentation, yellows and compound colours containing them probably occur more frequently than any other shades.

Iron Ochres.

The iron ochres, yellows, and browns and dark maroon-red pigments derived from iron, are obtained both naturally and artificially. For the purposes of the artist and the calico printer—both of whom, but especially the latter, require their pigments to be in the finest possible state of division—the latter way has sometimes to be resorted to get pigments fine enough and pure enough in shades. In most cases the natural product, after thorough washing, is ground in a mill, and is then fit for use by both these users. Iron ochres are natural clays which derive their buff or red colour from the iron they contain. There are, of course, an infinity of shades of iron ochres, owing to the amount of iron and the other constituents of the clay. We have found a large number of the "buff pigments" of the market to consist of silica and alumina and hydrate and carbonate of iron and water. These pigment clays vary greatly in shade, some being quite red, others pale buff, and others drab, "slate" or brown. They are prepared for use from the natural clay by repeated washing by decantation with water, filtering, and if required, grinding and drying. Thus prepared they are excellent pigments, being quite unaffected by the air, sunlight, and alkali; and they work well with any other pigment.

The manufacture of iron buffs and browns, though simple in theory, is somewhat difficult in practice. So many varying shades may be obtained by a variation of the materials, and heat employed, that to obtain uniformity of results is not always an easy matter. It will be useful to survey briefly the chemical facts connected with the oxides and hydrates of iron, the "colouring principle," as it were, of clays and iron ochres.

The Chemistry of Oxides and Hydrates of Iron.

There are at least three oxides of iron: viz., the protoxide or ferrous oxide, FeO, contained in ordinary sulphate of iron or green vitriol; sesquioxide or ferric oxide, Fe_2O_3, contained in common chloride of iron, and magnetic oxide, Fe_3O_4. Ferrous oxide, FeO, is never found native in the free state, owing to its affinity for oxygen, by which it is connected in the higher oxides. It exists in combination with carbonic acid, CO_2, as spathic iron ore, and with sulphuric acid in green vitriol. The *hydrated ferrous oxide* or *ferrous hydrate* $Fe(OH)_2$ is formed when a solution of the last-named salt is precipitated with ammonia, and is of white colour, but it rapidly oxidises in the air to the higher hydroxide.

Ferric oxide, Fe_2O_3, occurs in nature very abundantly, as in red hæmatite. It is formed by igniting green vitriol with salt, and the product, after washing, is the "Indian red" described hereafter. It is a brown-red substance, or, if prepared under certain conditions, nearly black. *Hydrated ferric oxide*, or *ferric hydrate*, $Fe_2(OH)_6$, occurs very abundantly in brown hæmatite and in clays. It is obtained by adding an excess of ammonia to ferric chloride, when it is obtained as a rust-red flocculent precipitate. It is in this form chiefly that the iron in clay exists, and gives the colour to natural iron ochres. To produce ferric hydrate for use as a pigment the ferric nitrate—obtained by dissolving wrought iron in nitric acid—is precipitated by ammonia or caustic soda in excess, and after thorough washing is put in the filter press and brought to a thick pulp, and, if necessary, dried and ground. It is thus a deep red-brown extremely fine pigment, admirably suited for use either by the artist, the calico printer, paper maker, or house painter.

Indian Red.

This pigment consists simply of a mixture of the red oxide of iron, Fe_2O_3, with a basic sulphate of iron. It is prepared by heating ferrous sulphate, $Fe_2SO_4.7H_2O$, until the water of crystallisation is expelled, and then calcining at a red heat in a furnace until acid fumes cease to come off, when the product is cooled, washed and dried. The addition of common salt is sometimes made in calcining, and has the effect of hastening the calcining process. Indian red is largely used as an artist's colour, and as a common 'dark-red" paint. It need hardly be said that it is perfectly fast to the prolonged action of the air and moisture, etc. A great variety of paints of brown and buff colour appear in the market under fancy or arbitrary names, which are nothing else than hydrates or oxides of iron, alone or mixed with sulphate of lime and other pigments. Thus "Mars brown" and Mars yellow and red are pigments of the former description, and form excellent paints.

Testing Iron Ochres.

The presence of iron in any pigment may be readily detected by dissolving in warm concentrated hydrochloric acid, when a yellow solution of the iron is obtained, which gives with solution of ferrocyanide of potash a *copious* deep blue precipitate.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XI.

AT the conclusion of last chapter we partly explained the law regulating the velocity of falling bodies. We now proceed with our remarks. The accelerating influence of gravitation is shown in the increase of velocity in the division of the first second: thus the first foot of the sixteen feet passed through in this second takes the fourth of that second, but the second fourth gives a velocity equal to carrying the body not through one, but through three feet; the third fourth carries it through five feet; and the last fourth through seven feet. Adding those together, we have $1 + 3 + 5 + 7 = 16$. Taking the times in units, the spaces through which a body falls in a number of seconds is as the numbers 3, 5, 7, 9, 11, etc. Thus the space fallen through by a body at unity, or the first second, being, as we have seen, sixteen feet, the space fallen through in the second second is forty-eight féet, $16 \times 3 = 48$; the space in the third second is eighty feet, $16 \times 5 = 80$; in the fourth second the space passed through is a hundred and twelve, $16 \times 7 = 112$; in the fifth second a hundred and forty-four, $16 \times 9 = 144$; and in the sixth second the space fallen through in the descent of the body is a hundred and seventy-six, $16 \times 11 = 176$. This being, as we have seen, in the increasing ratio of 1, 3, 5, etc., simply for each unit—*i.e.* each second—of increase of time, the multiplier the space passed through, the other factor (16) is constant. Taking the whole distance dropped, bodies fall through a height of 16 feet in one second. Accurately the distance is 16·11 or 16 feet and an inch; 64 (16×4) feet in the two seconds; 144 feet (9×16) in three seconds, and so on, the whole drop being as the square of the time.

Phenomena connected with Falling Bodies—Their Velocity.

But "velocity" in a falling body must not be confounded with the spaces or distances passed through in certain numbers of seconds, as now stated. The space passed through, as we have just seen, is sixteen feet in the first second; but the velocity due to or acquired by a body during one second, if from the attraction of the earth at its surface—attraction of gravitation—is such that the velocity maintained at a uniform rate would carry it over, or cause it to traverse through a space, *without any further force of gravity*, equal to thirty-two feet in the **next second** of time. But while this is the velocity due to a second of time, it is likely to puzzle the young mechanical student, when compared with the statement that the space passed through in the first second is only sixteen feet; this point, with some of the facts which flow from it, will be made clearer when we have discussed the subject of a succeeding paragraph, that of *Inertia*, but the apparent contradiction just named will be understood by these general statements. In virtue of this principle of inertia, yet to be fully described, a body at first starting into motion, caused by any external force—in the present instance the force of gravitation—has but a slow motion; but inertia being overcome, the body being as it were left free to receive the action of the force, produces a quicker and still a quicker motion as the time increases during which the force acts. For if we conceive of a certain amount of motion being received during the first second of time, it does not lose this motion, but retains it, so that the motion due to the action of the force in the second, or succeeding "second of time," has this first motion added to it, and as much more is added to that due to the third second, the fourth second receiving a still larger amount. So that we see how a falling body is receiving each successive increment of time, fresh supplies, so to say, of velocity. As velocity is thus therefore gradually acquired or obtained through the acting force continuing, it so results that during the first second of a falling body's descent, the body has only half of the velocity due to a second, which full amount is, as we have seen, thirty-two feet per second. And it is obvious that before it reaches the point of its descent corresponding to half the second, it will have had less than half, just as after it passes the point of half-second and goes a little farther on, it will have more—the result of the two being that it falls through a space of not thirty-two feet, but only half of this, or sixteen, and this although the velocity due to the one second is thirty-two feet. But in the second or next "second" of time, it falls through the whole thirty-two feet, as the velocity of sixteen feet is doubled—the velocity, as we have seen, of a falling body being simply as the time, but with the addition of sixteen feet, or the renewed or continued action of gravitation; this, it will be perceived, is equal in all to forty-eight feet, or a distance "three" times as great as in the first second ($16 \times 3 = 48$); so that at the end of the second "second" of time it has fallen a distance four times as great (the square of two, $2 \times 2 = 4$), as in the first second: namely, the first "second" sixteen feet, the second "second" thirty-two feet, with the new action of gravitation sixteen feet, or $16 + 32 + 16 = 64$. Tracing further the course of the falling body, we have at the beginning of the third **second a** doubled velocity, that is of sixty-four feet, to begin with, which, as we have seen, was the velocity attained at the end of the second "second" of time; to this is added sixteen feet, as the new or continued action of gravitation due to the third second, simply considered as such or by itself alone: those two added together give us eighty feet fallen through by the end of the third second, or five times as far as the first "second" of time; and to this is added the sixty-four feet due to its doubled velocity, so that in $64 + 16 + 64 = 144$ we have the distance fallen through at the end of the third second, or nine times as far as the body fell through in the first second, or the square of three. At the end of the third second we have a tripled velocity, or ninety-six feet: the fourth second, beginning with this, has added to it the sixteen feet due to gravitation, which gives a hundred and twelve feet, or seven times as great a distance for the body to fall through as in the first second ($16 \times 7 = 112$); and at the end of the fourth second, with a graduated velocity, it has fallen through a distance sixteen times as great (or the square of four) as the first second, or two hundred and fifty-six feet. In the numbers placed within inverted commas, as "three" and "five," we have the ratios of time to space elsewhere noted.

discarding or keeping out of view external, or as we have called them mechanical or physical circumstances, such as the effect of air and the bulk or surface of the body. The same law regulates the velocities and the times of bodies projected horizontally: thus, if we suppose a ball to be shot from a cannon placed at the top of a tall or high tower, as *a* in fig. 2, it will reach the ground at the same time as another ball simply dropped or allowed to fall vertically from the top, as from *a* to *b*. Some youthful readers may have a difficulty to conceive how this should be so, as they are apt to associate with the fact of a long passage through the air, the direction of which is chiefly horizontal, a length of time greater than that they associate with the shorter height of the tower, this being small as compared with the length to which the ball is thrown in front of it. But a little consideration will show that the vertical fall, its height, and the velocity of the body due to it, must be that which decides the time taken by the body, the projecting force acting on which is in a horizontal direction or

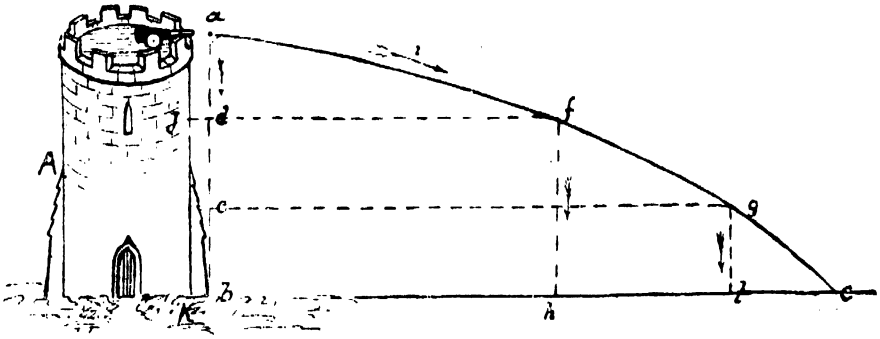


Fig. 2.

Accelerated and Retarded Motions.—Action of Gravitation on Bodies projected Horizontally.

In a preceding paragraph we have pointed out that the attraction of gravitation, generally associated with that of the descent or falling of a body vertically from a height, which is a "motion of acceleration," acts also in the converse direction, which is a "motion of retardation"; both of those motions coming under the class of "variable" motions, the velocities, as we have just seen, increasing as the time. To reach a certain altitude on being shot up or propelled vertically into the air, a body must have precisely the same amount of velocity given to it which would be due to the same body if it were allowed to fall from the same altitude or height. Thus, if a body in reaching the ground had a velocity of a hundred and twelve feet, this body would have to be projected or shot upwards with a precisely similar velocity to reach this height. Hence, as we have seen, the time taken for bodies to ascend and descend, to rise or be propelled, and to fall or drop, are equal—that is,

parallel to the ground. But this horizontal direction is not maintained by the body and its forward motion, otherwise it would go on for ever keeping parallel to the ground, or after reaching a certain point in this parallel course it would at that particular point drop suddenly to the ground. Neither of those two courses, which are of course absurd in their conception, takes place. For the student puzzled with the statement of fact that the times for the two balls to reach the ground are the same has but to recollect that the attraction of gravitation at every point on the path of the body shot or projected horizontally is acting just as forcibly as it is in the case of the body falling vertically. The result is a compromise, to use a familiar expression, between the force of gravitation pulling as it were the body downwards, as in the direction *a b*, fig. 2, and the projecting force tending to send the ball in the horizontal direction, as *b c*; and this gives a curved line, as *a f g c*. Let the young reader who has been puzzled at the statement referred to above conceive the point *sd* and *e* to represent the seconds in falling from *a* to *b*, the point *a* representing 1 or "unity." If lines be drawn from these at right angles to *a b*, they will give points in the curve, as *f* and *g*, which represent the same times. And if we suppose the projecting force sending forward the cannon ball *a* to be suddenly stopped at the point *g*, gravitation would then act at that point precisely as at point *e*, and the body at *g* would reach the ground as if dropped from *e*, with the velocity due to it from the height. The same holds true at the points *d* and *f*: *b* and *c*, representing the termination of the path of the two balls, are dropped from the point *a* to *b*, the other shot forward from *a* to *c*. The line or path of a body projected horizontally must therefore, as a resultant of, or to use the popular phrase, a compromise between the force of propulsion in direction *a c*, fig. 2, and that of gravitation, be a curve, and this curve, as *a i f g c*, is that known as the "parabola" (see "The Geometrical Draughtsman" in this work). But this curve is modified considerably under certain circumstances; as in the flow of water issuing in a horizontal direction, we may suppose at the line *d f*, from an aperture in the vertical side of a tall vessel or reservoir, which we may suppose to be represented by the tower *a* in fig. 2. This is the consequence of the resistance of the air to the body or volume of the projected water; and it may here be stated, although the practical points involved may be detailed in the paper "The General Machinist," that the theoretical calculations of the effect of gravity in proportion to "head" or "pressure," this being in proportion to depth of water as from *j* to *k*, above point *k*, are very much modified by circumstances, such as the shape and position of the orifice through which the water is forced; thus the conditions of flow are very different in the two positions, one of which is a simple orifice cut in the side of the vessel, the other a curved pipe opening outwards like a trumpet mouth. The flow of water under pressure from orifices or pipes of different form or section is one of the most interesting points connected with hydraulics, and may be noticed in another paper in this work.

Accelerated Motion due to Gravity—Facts connected with it Interesting to the Mechanic.

The accelerated motion due to gravity, or in other words, and those which are generally used, the velocity which it acquires, receives some curious and suggestive illustrations in a number of physical facts interesting to the machinist, who has so much to do with motion. The one perhaps the most familiar is displayed in the rolling of a heavy stone down an incline or the foot of a hill. At first the speed is very slow, but as the time increases the speed increases, till—if the length of its course be great—at last it may sweep past one near it so quickly that its form is totally indiscernible. A falling body has been likened by a well-known writer to a reservoir which receives every succeeding second or instant of time a fresh accession of speed or velocity; and this which it receives it retains, and it is this which gives the continually increasing velocity. For the speed which it receives the first second, say, of its course being retained, is added to that it receives in the second unit of time, and those two accessions of velocity being retained are added to the speed received in the third, and so on, the principle of which has been already fully explained. This acceleration of velocity or speed in falling or descending bodies is curiously illustrated in the case of liquids. Thus when a liquid falls from a vessel through any aperture giving out a certain section of flowing stream, this section is not retained throughout the whole extent of "drop" of the liquid—that is, till it reaches the place where it is deposited; but the section or bulk of the descending stream gradually diminishes, the velocity at the same time gradually increasing, so that, while it may be said that as the diminishing of the section is in proportion to the increase of velocity, so the increase of velocity is due to the diminishing of the section, the former of those two statements is the correct one. This is illustrated by supposing that a vessel containing liquid, with an aperture in the bottom giving a certain section to the affluent liquid, is placed on the top of a tower. The section or bulk of the liquid at the place where it issues from the vessel is not continued throughout the drop, but gradually diminishes as the liquid recedes from the opening, till at last, if the height be great, the liquid may reach its final place of deposit in the form of a mere thread. If a thickish syrup be used, and it be poured from the vessel which contains it, the effects of accelerated speed will be easily traced even with small heights. Some excellent lessons may be learned by the youthful reader in this subject by so simple a method as this of experimenting. And it at first might puzzle youth, that the thin thread, so to call it, of treacle nearest the dish, delivers it so quickly that it is capable of taking up and disposing, so to say, of the thicker stream where it passes from vessel above. This, however, will be explained by a close examination of the process. This diminution of the section of the stream of a falling liquid in proportion as its velocity increases is observable in the escape of effluent water from a vessel, as through a hole near the bottom, at side, of a tub or deep barrel; the full "bore" or section being at the side of the barrel, the section of stream gradually diminishing towards the place of final deposit, as the ground, in front of it. The same principle is also illustrated in water flowing over the top of a weir, or the edge of the embankment of a reservoir: the water being shed over this is at its greatest depth just as it flows over, and has its velocity slowest—so slow that a cork may float quietly to the very edge,—increasing comparatively at a slow rate; but at a distance but an inch or two from the edge is carried away with such velocity that it might have been shot out of a gun. At a point farther from the edge and lower down the velocity is still greater; and greatest of all near the surface of the water below, where the section or thickness of the water shot over the weir-edge may be so reduced that it is a mere knife-edge in thickness. The principle of "retarded motion" we have already named is illustrated conversely to the above in the case of water projected by pressure, or by a pump, upwards from a tube as in a fountain, or from the jet of a hose. Here the section of the water increases as it goes from the point of exit, till at last it may be said to be without section, taking the form of mere spray as it reaches the limit of its ascent. Where, therefore, a solid body of water possessing a somewhat considerable force is required at the point of delivery, when projected from a pipe, allowance must be made for the extending bulk of the stream as the velocity diminishes.

Some Practical Points connected with Falling Bodies.

In connection with the subject of bodies falling freely in space—that is, when for example, a body, as a ball, is dropped from a high to a low level, the following rules will be useful. This action comes under the head of an unbalanced "effort," and is to be considered as the result or effect of a uniform accelerating force, the unbalanced effort being represented by and considered only as the body's own weight or density or heaviness. For explanation of the terms "effort," "unbalanced," "density" or "weight," see paragraphs in other parts of this paper. (1) In the case of a body, as a ball, supposed as above to be dropped from a height, if we know or take the "time" in seconds during which it falls or drops—that is, from the time it leaves its position of rest, as the hand, at the height, to the time when it reaches the ground or surface on which it falls and comes to rest, we can find the velocity in feet per second which the body possesses at the end of its journey—that is, at the instant it strikes the ground —by "multiplying the time taken in the drop or fall by 32·2." (2) The converse of this—that is, to ascertain the extent of the drop or the vertical height or distance through which the body falls—we must know one of two factors or elements: either, first, the "velocity in feet per second" which the body has acquired at the moment it ceases to drop, or reaches the ground or surface; or, second, the "time in seconds" taken for the completion of the drop. If we have the latter factor, which is most generally that obtainable, we find the depth of the drop or the height of the fall "in feet" by multiplying the square of the "time in seconds" by 16·1—half of 32·1 in (1). If we are told the "velocity in feet per second" acquired by the body at the time its drop or fall is completed, we can tell the distance of the drop in feet or height of the fall by "multiplying the time in seconds by half the velocity in feet per second." (3) If we have the height in feet of a given fall or the depth of the drop, we can ascertain the time in seconds which will be taken to complete the drop from a state of rest till it reaches the ground or surface, by "dividing the depth of drop or height of fall in feet by 16·1, and taking the square root of the quotient." (4) If we have the height of the fall, or the depth of the drop in feet, we can find the velocity in feet per second which the body falling or dropped acquires at the time it reaches the ground or the surface by "multiplying the height of the fall or the depth of the drop in feet by 64·4 and taking the square root of the quotient," or we can "multiply the square root of the height of fall or depth of drop in feet by 8·025." (5) If we wish to know what is the height of fall a body should have, or the depth through which it should drop, in order to have a certain velocity in feet per second at the completion of its fall or drop—or if we desire that a body should have a certain velocity at the time it reaches the ground or surface, we can find the height of fall or depth of drop which will give it that velocity by "dividing the square of the velocity in feet per second by 64·4." In all those cases the velocity acquired by a body dropping a certain number of feet is said technically to be the "velocity due to the given height," just as the depth through which a body must drop, or the height from which it should fall to give it a definite or required velocity, is said to be "the height due to the given velocity."

The Pendulum affording in its Working Examples of Accelerated and Retarded Motions.—Its History.

In referring to certain mechanical applications in which the pendulum and its movements, and that of another variety of motion known as centrifugal force —which will be explained in a future paragraph— are concerned, it will be necessary to employ certain terms or phrases the meaning of which in a mechanical sense we have not as yet explained, nor the principles they involve as yet discussed. These will engage our attention chiefly in the next few paragraphs; but meanwhile they may be employed, and so that they can be understood in the special reference about to be made to them. To the celebrated Galileo the world is indebted for the discovery and the enunciation of the principles of this most valuable apparatus. And this, as illustrating the value to the machinist of the habit of close and thoughtful observation, as well as that other of not despising common or little things, is of such value that we, in the paper on "The Technical Workman as a Student," go somewhat fully in the points those habits involve.

THE IRON MAKER:

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS

CHAPTER IV.

At the end of the preceding chapter we stated that the first recorded trial of coal as a smelting fuel for pig or cast iron, was that made in 1612. This was made by one Simon Sturtevant, evidently a foreigner, or of foreign extraction. It is, in fact, a Low Country name, so that Sturtevant might have had some practical connection with Continental iron making in which coal was the fuel used. A patent was granted to him for thirty-one years, which appears to be the extent of monopoly then granted; and by its terms he was bound to publish an account of his invention. This he did in a work entitled "Metallica,"—but, somewhat after the fashion of the time, when those who knew the "arts" made of them a "mystery," this gave no practical information bearing on the subject. The patent of Sturtevant was rendered void, as he seemed really to have had no more practical knowledge of the subject than his book had information respecting it. His patent was followed by a pretty long list of other patents, which, all practically failing, are considered by many writers as being possessed of no value. It is exceedingly difficult to believe that this was so in all the cases; so difficult that the writer of these lines, assuming that some other and more credible cause existed for the unvarying failure which met patent after patent, and turning to the recorded facts of history, arrived at the conclusion that the true cause of the failure of all the plans produced from time to time, through a long course of years, lay as much in the direction of the inveterate prejudice which the iron workers of our country had to any scheme by which coal was to be used, as in that of the inability of the patentees to carry their particular scheme into practical effect. That this view is upheld by what we know were the circumstances of the time, and by the still more striking, and, as the reader will presently say we have good reason to call startling, evidence afforded by the career of the next patentee who took the improvement up, and beyond all doubt succeeded in making it a practically paying success. Notwithstanding the evidence they now had of the silliness of their opposition—at least, of the belief which led up to it and maintained it—such was the inveterate prejudice above alluded to which they entertained to the new system that they and their successors actually succeeded, as we have already said, in keeping the new process as much out of use as if it had never been introduced, for a long course of years: some readers will be surprised to learn, for a period of considerably over a hundred years.

The Method of Making Iron with Coal as a Fuel the Turning-point in the History of the Trade—Dud Dudley's Great Invention.—Important Lessons to be Derived from History of his

This brings us to the period when the inventor or introducer of the new system appeared upon the scene and gave his name to it,—a name which occupies the same brilliant position in connection with the
of the iron trade as that of Watt occupies in story of the steam engine, Smeaton in that of civil engineering, Arkwright and Crompton in that of the cotton trade, of Stephenson in the history of railways, and of Wheatstone, Siemens, Swan and Edison in the story of electrical engineering, — Dud Dudley (a name at once the honour and the disgrace of the iron trade), in or about the year 1619, was granted a patent for thirty-one years for the use of coal as a fuel for reducing iron ores and running them off as cast or pig iron. This was the year, however, in which Dudley left Oxford, where, at the age of twenty, he was then studying to take charge of, or at least to assist in the management of his father's iron works, situated at a place called Ponsuet, in Worcestershire. It was here that Dudley conceived the idea of making pit coal useful for iron reducing purposes; and his attempts to utilise it succeeded beyond his best hopes. In the early days of the iron trade wood was not used in its crude or natural state as fuel, but was first converted into charcoal, and thereafter in that form introduced into the furnace. Whether this change was what suggested the previous treatment of coal, or whether the first trials were made with raw or crude coal, indeed, in failures which thus led up to the idea, certain it is that from almost the very first coal was used in the iron furnace in the form of coke, in which form, as shall afterwards see, it is now, we may say universally, used in the blast furnaces throughout England. The exceptions to this we shall hereafter notice.

Circumstances which retarded the General Introduction of Dud Dudley's System of Iron Making with Coal as a Fuel.

Successful beyond a doubt in his system of reducing iron by means of coal, Dudley had to contend with a power with which even he, with all his known skill, his equally well known courage and perseverance, could not cope, and which converted at last his success into a miserable loss, and caused him to end his days a ruined and broken-hearted man. It is alike pitiable and pitiful to read the record of Dudley's life. We know nothing, indeed, so touching as the story of it, as given in a memorial he drew up on the subject and presented to Charles II. Pitiful we call this record so far as regards poor Dudley—rich now in a rare memory; pitiable as regards his enemies—for such they were, as they did what keen prejudice, business rivalry, and bitter personal dislike could do to hasten on his ruin, and such satisfaction as this miserable ending could give them they certainly secured. None other did they receive, for some idea of the loss which they themselves sustained by preventing the general acceptance of a thoroughly economical system of working may be gathered from the enormous loss which their conduct, and that of their successors, caused to the nation. In thinking calmly over this strange and humiliating episode in the history of the iron trade, and trying to deduce from it the valuable business lesson which it is assuredly well calculated to afford, it is difficult, we confess, for any one giving due heed to the matter to understand now this fatal blindness to the true causes of their individual prosperity as iron workers, keeping out of view those which operated so painfully upon the national well-being. Still more difficult to comprehend how it could have been self-created. There is such a thing as national suicide, just as disgraceful as personal self-murder in its unmanly motive, just as ruinous in its pitiful, and in not a few of its aspects its contemptible, results. We do not need statistics, although they are ready enough to our hands, to tell how painfully ruinous to the vital interests of the people were the results of this pitifully contemptible national suicide. We have but to look around us for evidence—and everywhere and always is it so abundant and striking that a child may comprehend its meaning—of what the results of this suicide were, and how it must have told adversely in a thousand-and-one ways upon national comfort, necessities, and prosperity. As to what iron can do, and does daily, and what it has done in promoting the material well-being, and in its higher and brighter workings the intellectual prosperity of man, it around and amongst us records its own brilliant successes. And if we thus see what command of it in rare abundance has done for *us*, the most thoughtless may form some conception of what its absence must have deprived so many of the generations which preceded us.

And yet the deprivation was, as we have seen, self inflicted. It is easy for us now to deplore the loss and to denounce the gross stupidity—the moralist is right when he bans it as wickedness—the barbarity of opposition which wilfully threw this loss upon our people.

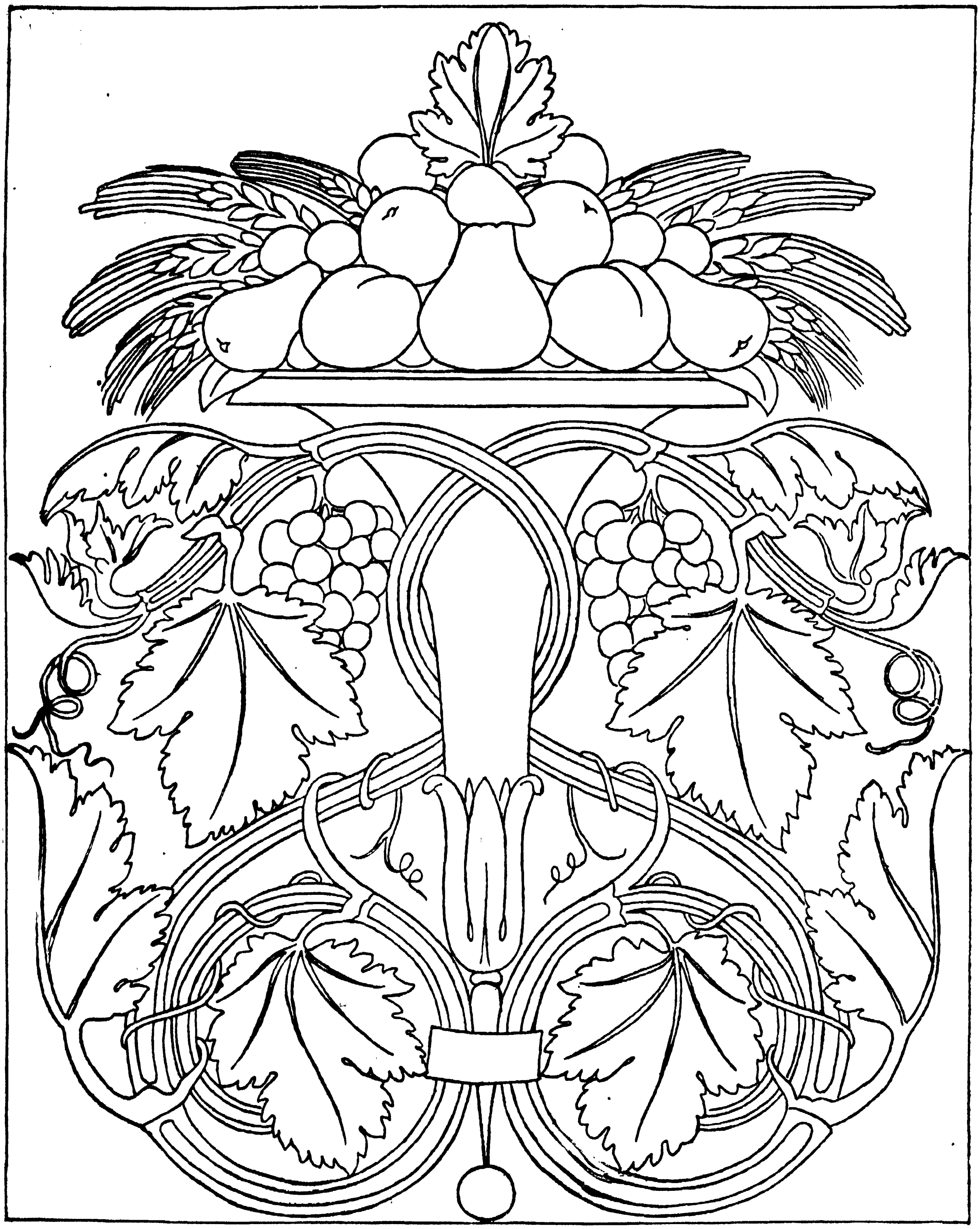
Effect on the British Iron Trade of the Opposition made to, and the Long Neglect of, Dudley's Successful System of making Iron with Coal as a Fuel.

Such had been the malign—those are not far wrong, if indeed they be not wholly right, who call it the malicious—influence of the manufacturers who "combined" to stop by all means, fair and foul—more foul by far than fair, and such are not quite unknown to us now—the progress of the truly beneficent invention of Dud Dudley, and to "lock him out" from the benefits of the trade which he had established, and which at last broke his heart, as it did his fortunes, that nearly one hundred and fifty years ago (date 1740) the total produce of iron in the kingdom reached only the truly miserable amount of 17,350 tons. Such was the result of the hundred and twenty-four years during which Dudley's invention passed out of practical existence, and also actually out of the minds of the people, by the mad combination of the masters, so thoroughly had the evil work been done. The process was at last introduced in times not quite so evil—at a time, indeed, which proved providentially ordered, for it enabled us to meet the hard fortunes of the period when we had literally to struggle as a nation for a nation's existence. The beneficent influence of the free unfettered working of the process was not long in being felt. In a little under half a century—but as a day in the history of a great nation such as we have the privilege to belong to—the make of iron had risen to four times nearly, or to 61,300 tons, which was the produce in 1788. The process by this time began to exercise its full power, for at the end of the next eighteen years the make for the year 1806 was no fewer than 250,000 tons. In 1827 it had got over the half-million — 654,000; in 1845 more than the million—1,250,000; and now this may be safely set down as being multiplied six times. Such was the influence of the new process. Take the contrast presented by the two modes of dealing with it,—the "combination" or "lock out" of the masters, operating with its malign influence for a century and a quarter, caused the iron trade of this great country—a material and a manufacture which has been second to none in making that greatness—*to decline to three-fourths*; during the like period of a century and a quarter it has *increased* nearly *five hundred times*. This increase—and what a mighty power for national good the figures represent!—"was directly and mainly due to Dudley's invention." He who runs may read the lesson these facts teach.

Practical Effect of the New System of making Iron with Coal in changing the Localities of the British Iron Manufacture.—Brief Glance at the Iron Districts.

In the first chapter of the present series of papers we gave a description of the peculiar and characteristic features of the districts in which the iron trade is carried on. It is worthy of note that those districts are situated in parts of the kingdom wholly different from the early seats of the trade. As that trade depended upon charcoal for its fuel, that, again, could only be supplied where forests or woods abounded. Hence it was that the more densely timbered or most freely wooded localities were naturally chosen as the seats of the iron making furnaces.

THE ORNAMENTAL DRAUGHTSMAN (see Text).



,,THE JOINER," "THE CABINET MAKER," AND "THE STONE MASON" (see Text).

BASE AND CAP MOULDINGS.

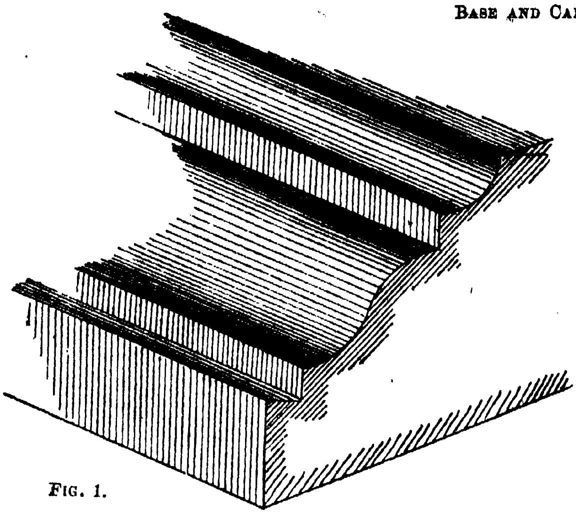


FIG. 1.

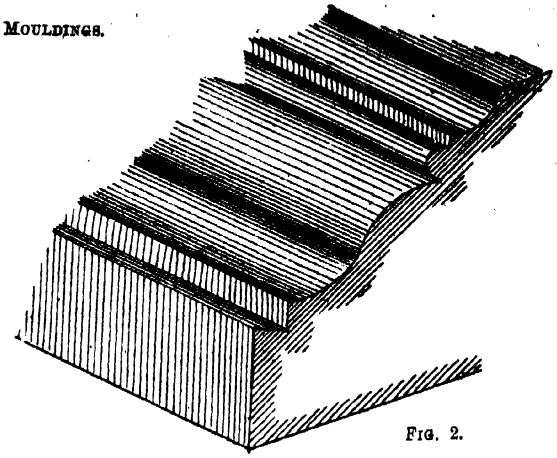


FIG. 2.

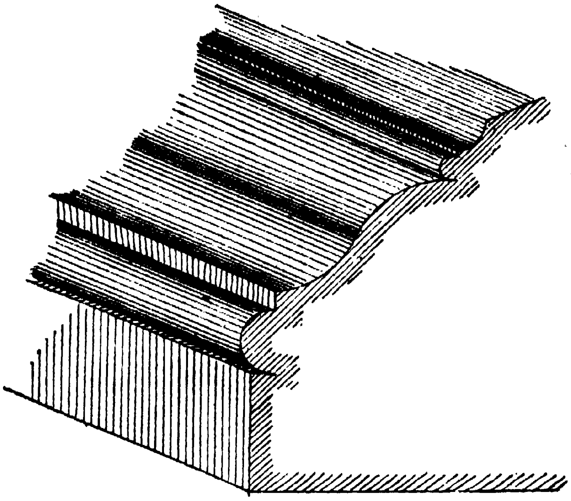


FIG. 3.

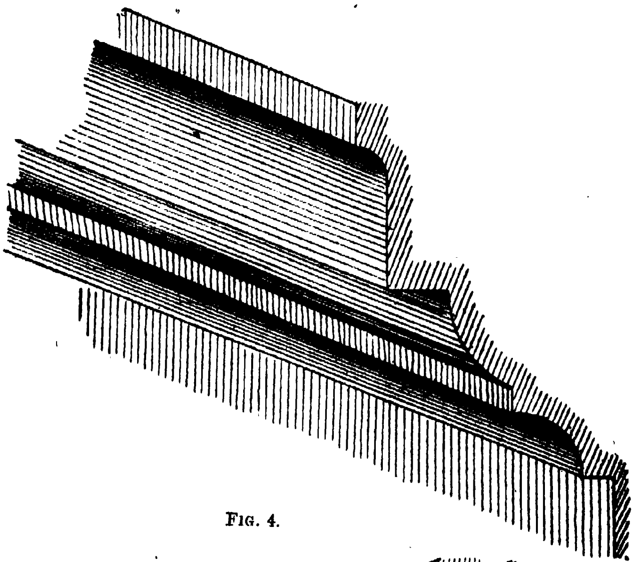


FIG. 4.

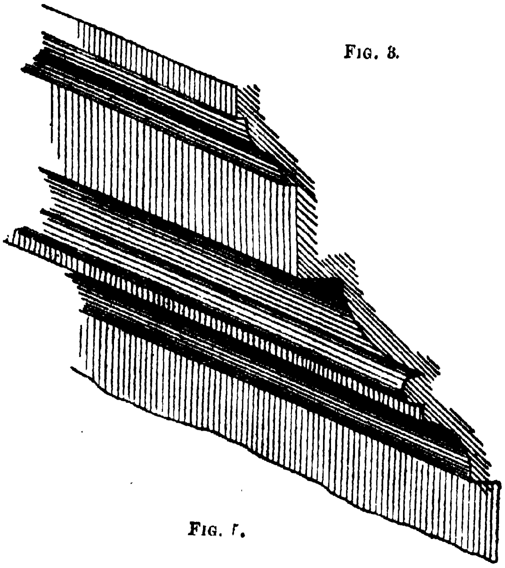


FIG. 5.

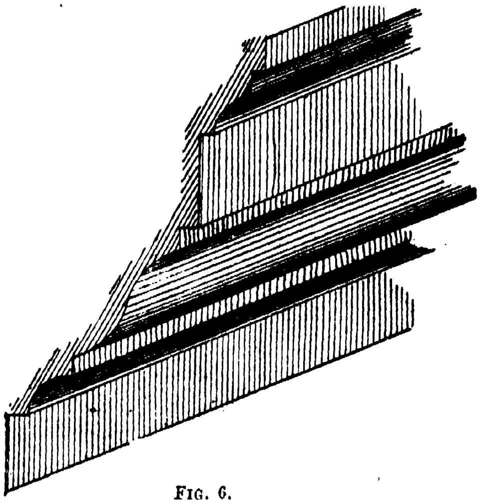
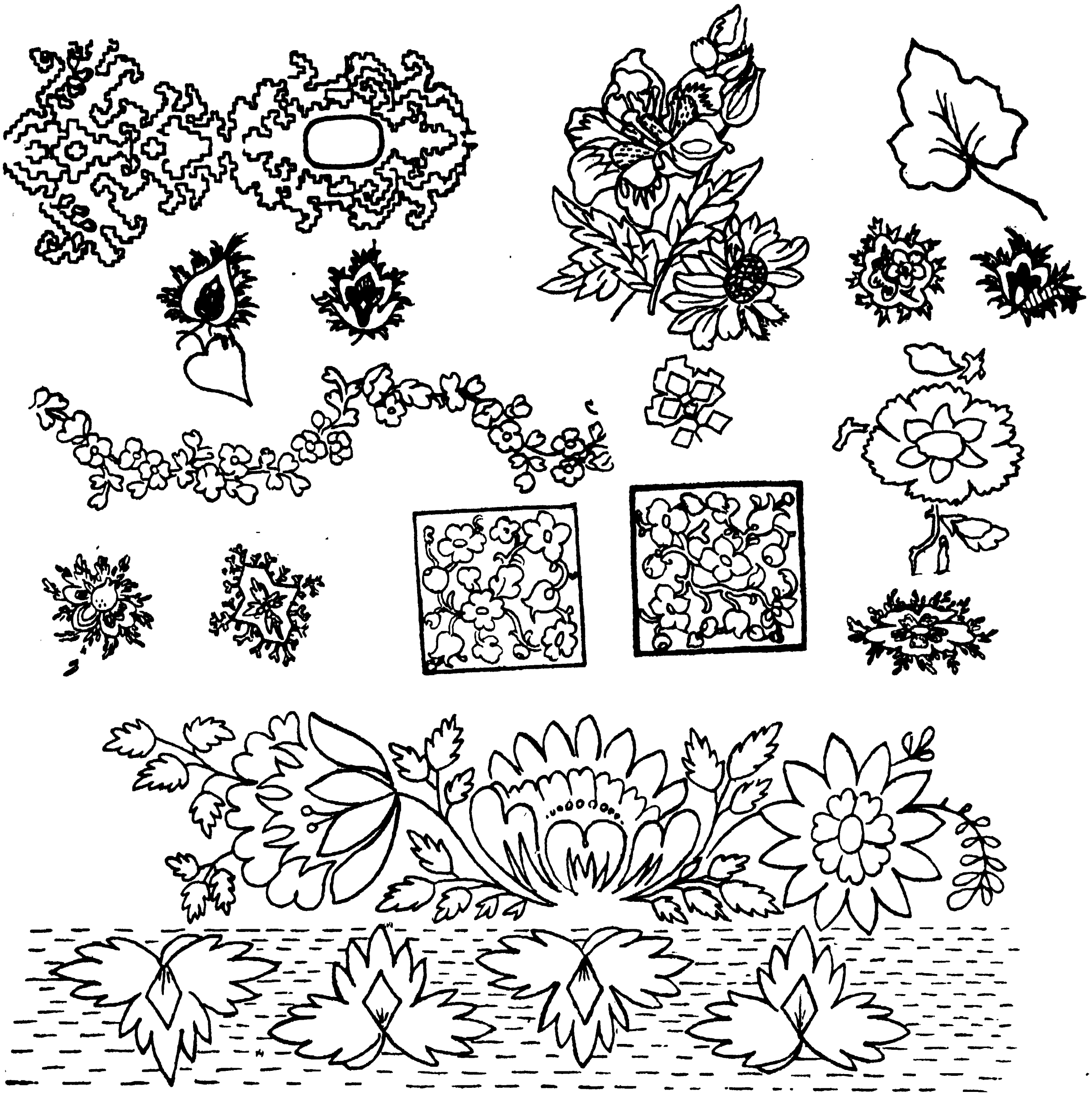
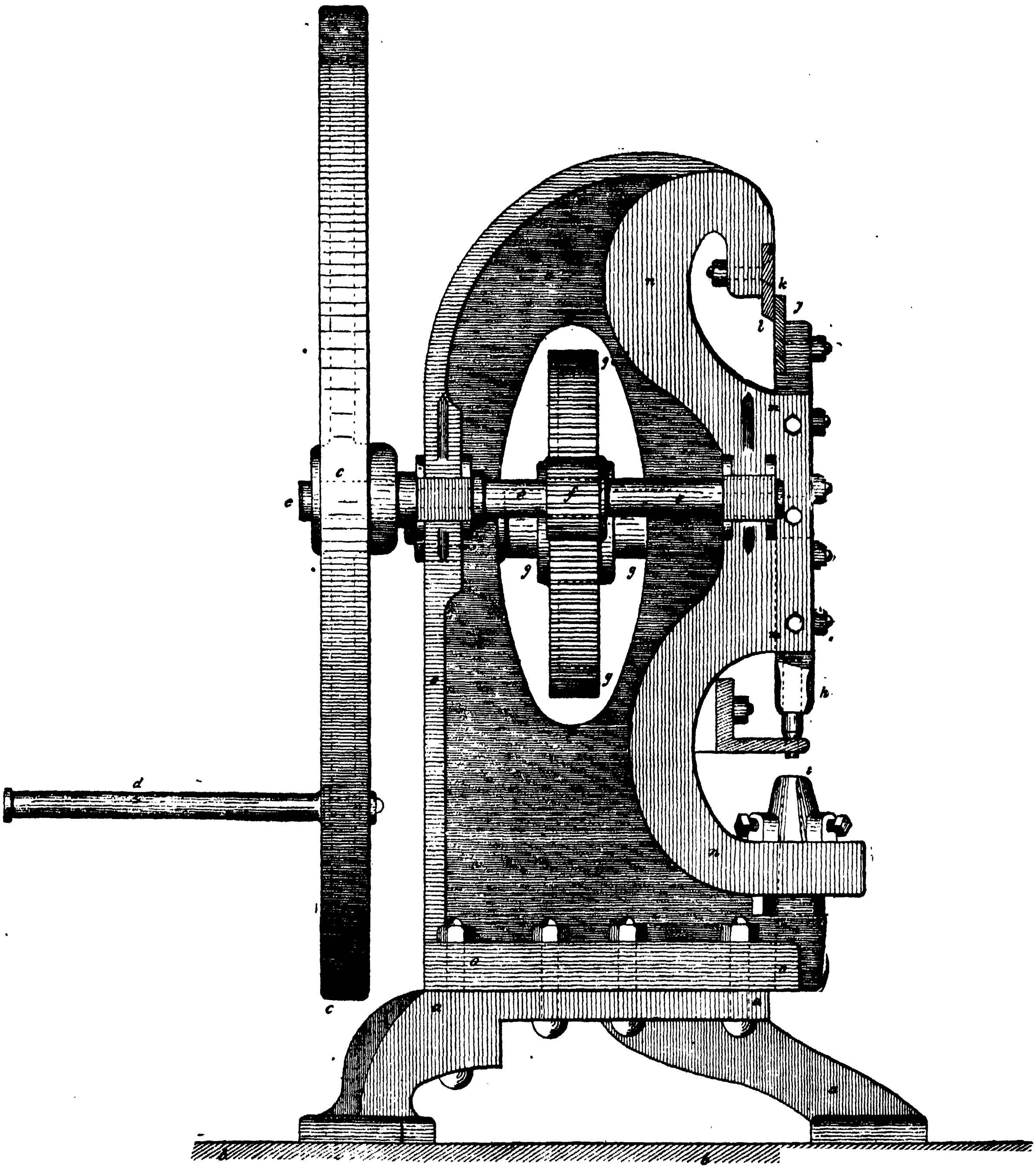


FIG. 6.

Conventionalised Foliage and Flowers.



TYPICAL OR REPRESENTATIVE MACHINE TOOLS.



COMBINED PUNCHING AND SHEARING MACHINE.

ORNAMENTAL BRICKWORK.

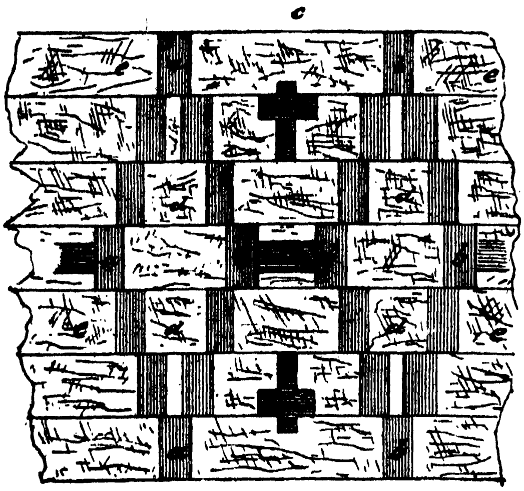


FIG. 1.

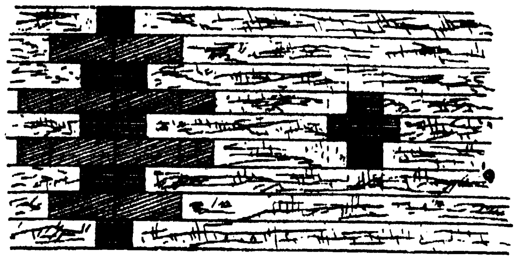


FIG. 2.

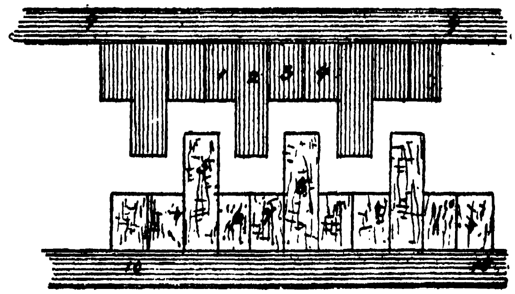


FIG. 3.

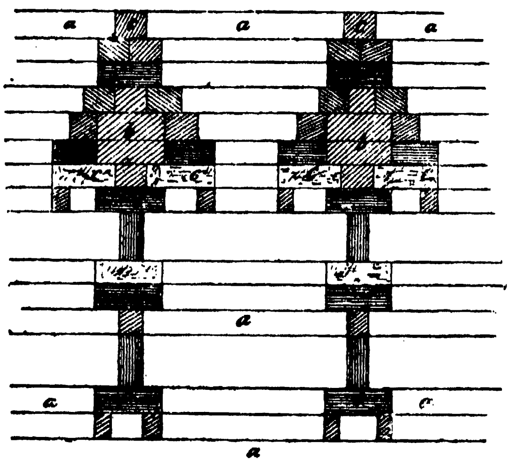


FIG. 4.

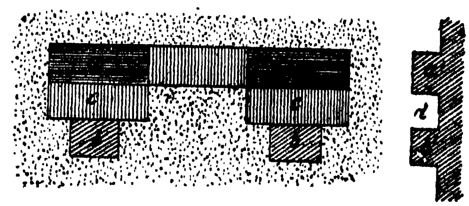


FIG. 5.

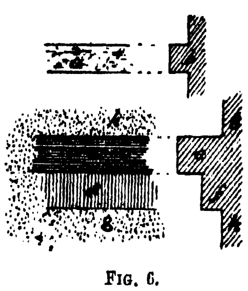


FIG. 6.

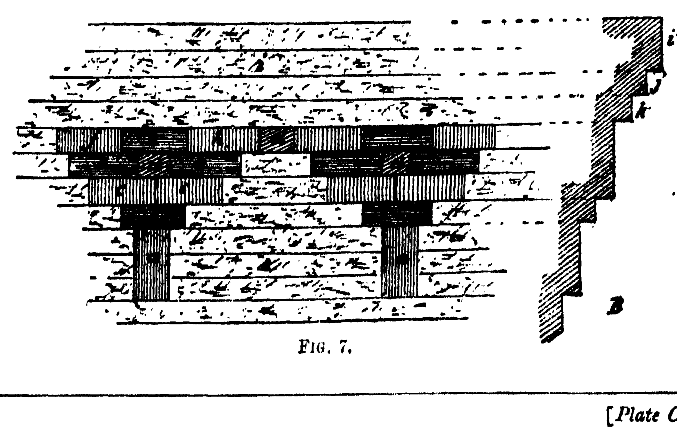
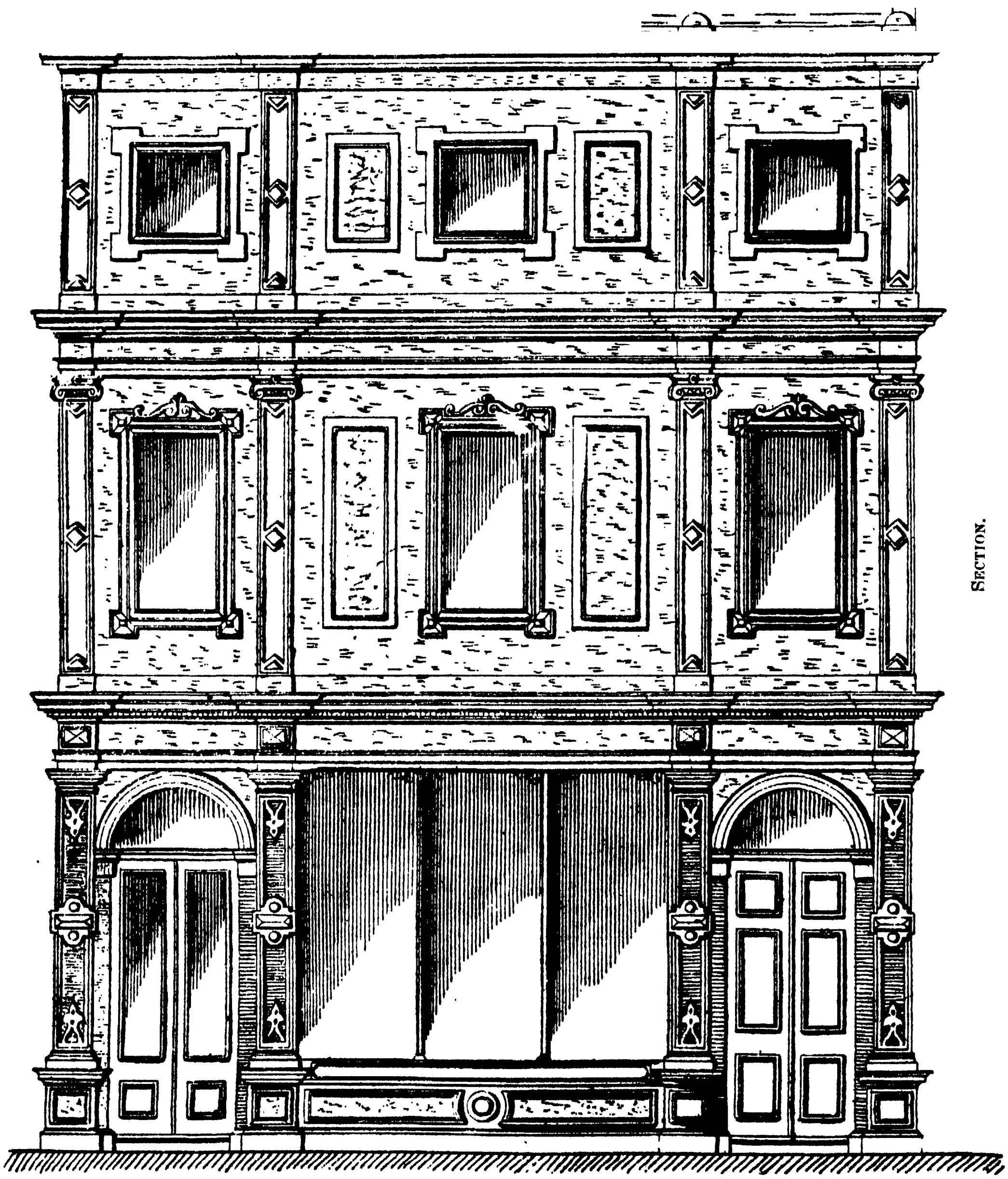


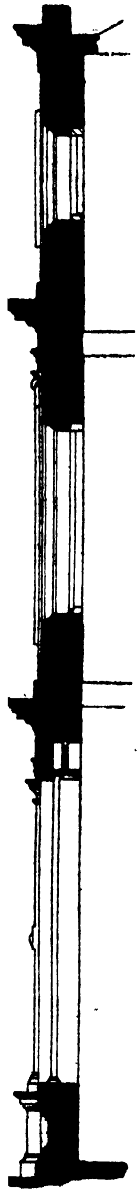
FIG. 7.

SHOP FRONT WITH DWELLING-HOUSE OVER. STYLE—ELIZABETHAN.

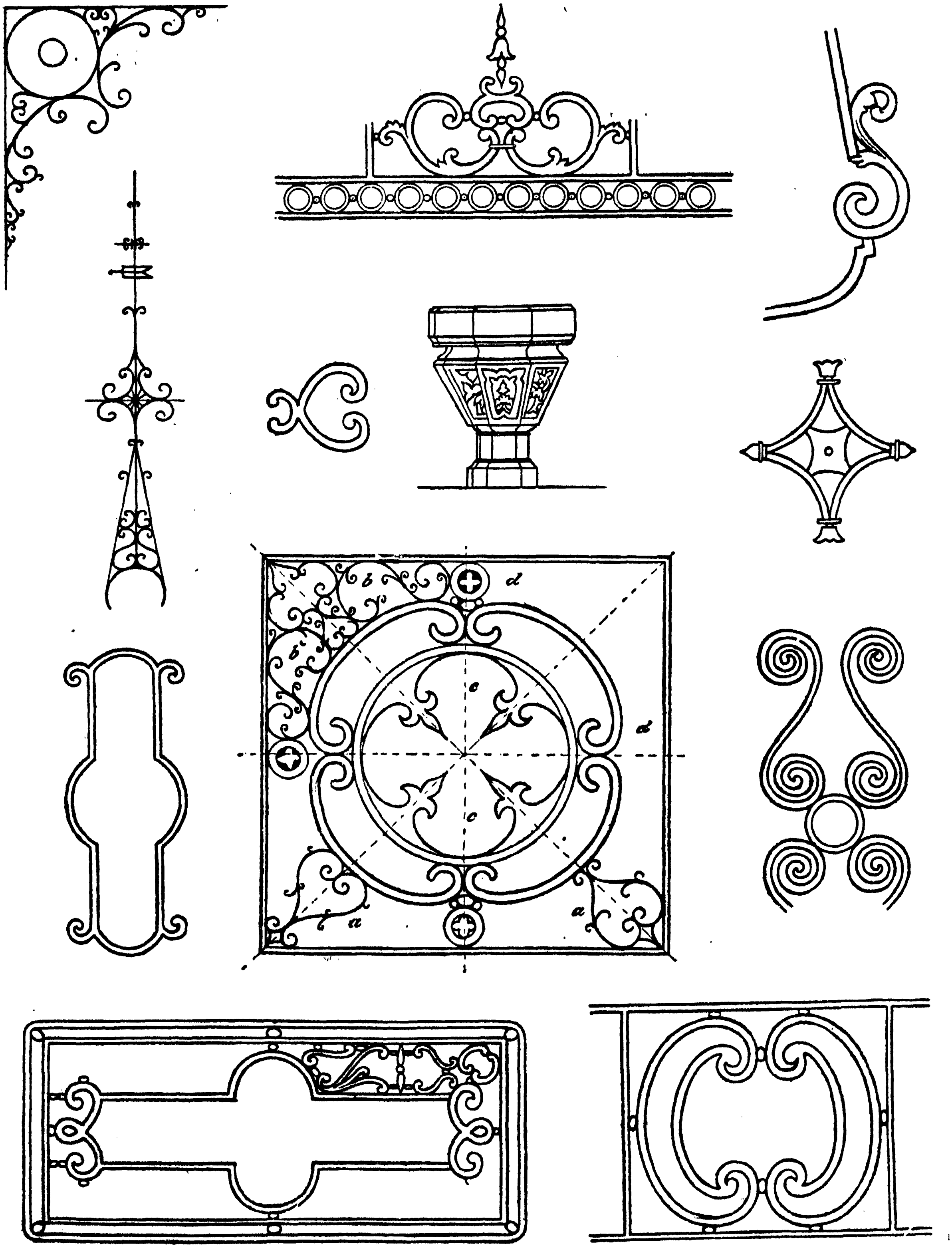
ELEVATION.



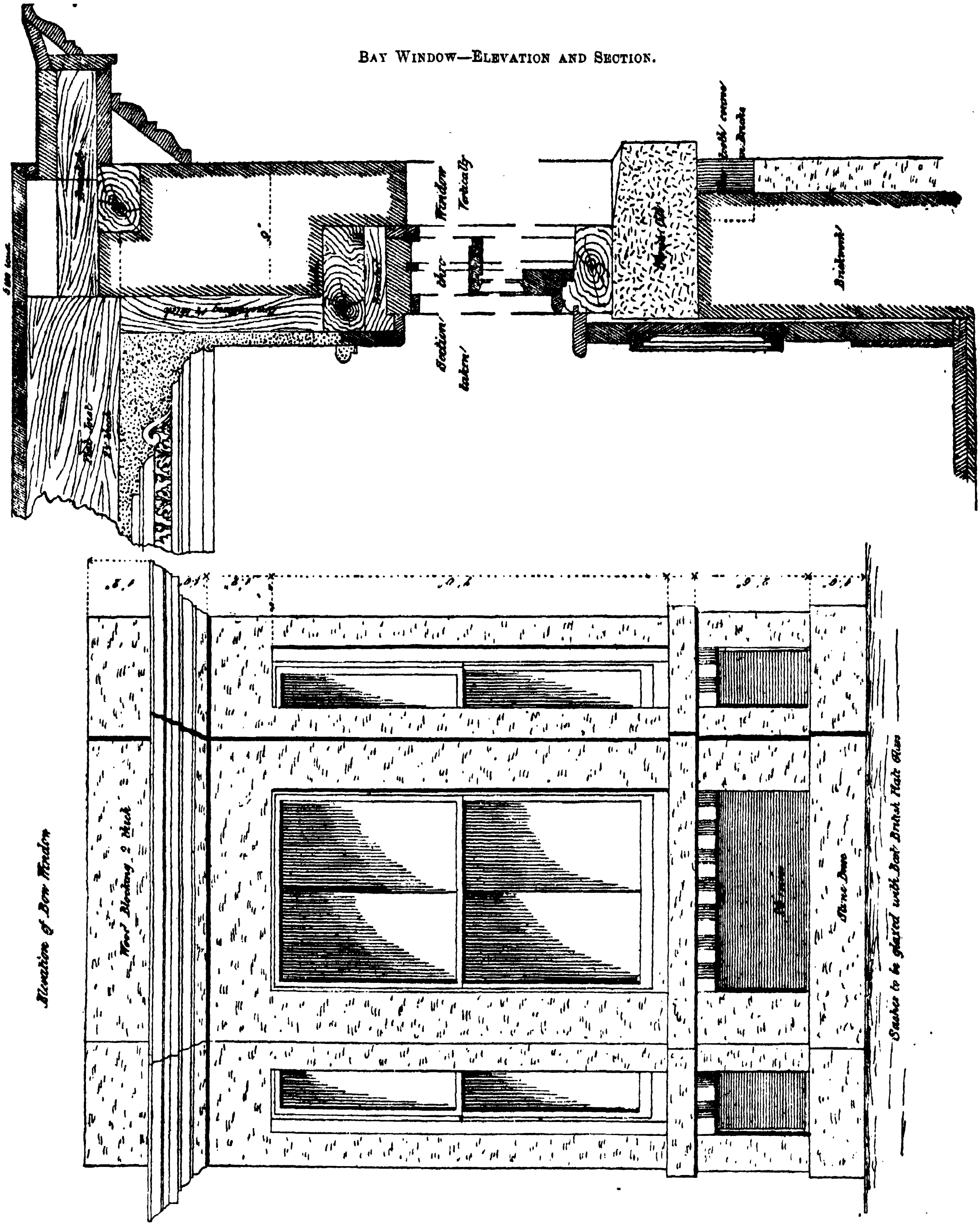
SECTION.



ELEMENTARY FORMS.



BAY WINDOW—ELEVATION AND SECTION.



THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER VI.

Method of using the Protractor in setting out Angles.

How to use the protractor thus constructed in fig. 20, we now proceed to show; premising first, that the diagram in the figure is cut carefully out by passing a knife all round the line *a b* and the semicircle *b d a*, and pasting it evenly on a piece of thick cardboard or thin wood, and thereafter cutting the edges perfectly square, according to the outline of the diagram. (Protractors are sold made either in wood, such as pear-tree wood, plane-tree, or, more usually, in metal; not solid throughout, but having a central space, as *d*, fig. 21, cut out.) Let *a b*, fig. 21, be the line to which another is to be drawn at a certain angle, and let *c* be the point through which the angular line passes, or at which it terminates. Place the protractor (fig. 20) on the line *a b* (fig. 21) so that it coincides exactly with or lies upon the line, and so that the centre, *c*, of fig. 20 coincides with or cuts the point *c* on line *a b*, fig. 21. Suppose now that the angular line is to form an angle of 30° with the line *a b*. When the protractor is placed as above directed, the position of the radial line passing through the part marked 30 is pricked off with the sharp point of the compass leg, or, better, with the fine point of a pencil. This position is at *e* in fig. 21, and when the protractor is removed from the line *a b*, if a line be drawn from the point *c* cutting or passing through the point *e*, the line will be at the angle required, as at *b f g* in the lower diagram. This is an "acute angle," as in *f g*, which, as we have already stated, is less than 90°. The line *f i* shows an obtuse angle, as *h f i*—an obtuse angle being greater than 90° and less than 180°.

The Use of the Protractor in finding the Extent or Number of Degrees of any given Angle.

The converse of the operation above described—namely, an angular line being given, to find what that angle is by means of the protractor—will be obvious on a little consideration of what we have said above, and of the illustration in fig. 21. A word of explanation will, however, suffice to make the use of the protractor in such cases easily understood. Suppose the lines *h, f, g* to be given (fig. 21). Place the base (*a b*, fig. 20) of the protractor on the line *f h* (fig. 21), so as to coincide with it, the centre, *c* (fig. 20), coinciding also with the point *f* (fig. 21). The line *f g* will cut, or pass through, the outer circle at a certain point, as at *g*, and the angle can then be "read off"—to use the technical term—on the circular scale. Should the line *f g* be too short to reach the outside circle of the protractor, as *b d a* (fig. 20), it may be "produced" or extended, as shown by the dotted line *c e* (fig. 21), so as to be long enough to cut the graduated circle of the protractor. Flat protracting scales, and rectangular in form, are usually provided in what are called "sets," "cases" or "boxes" of "mathematical instruments";

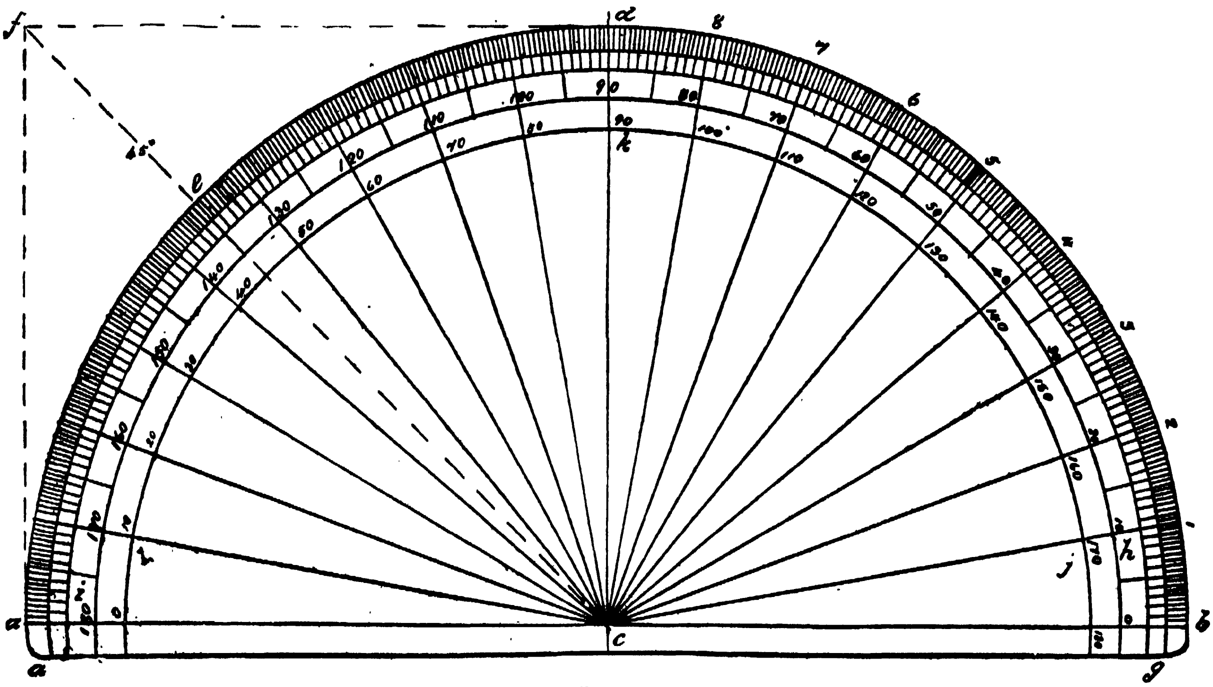


Fig. 20.

they are very convenient in marking or "plotting off" angles. They are usually provided, also, with what is called a "scale of chords," very useful either in "laying down" angles or in measuring angles which are already drawn. These two appliances will be

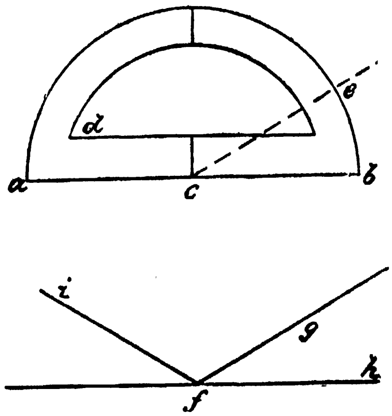


Fig. 21.

described further on, when we come to give various constructions connected with angles.

Various Points connected with Angles.

From the preceding remarks we see that an angle, as *a b c*, fig. 22, the apex, *a*, of which is in the centre, *a*, of a circle, measures the number of degrees comprised between its sides, as *d e*. We have said that

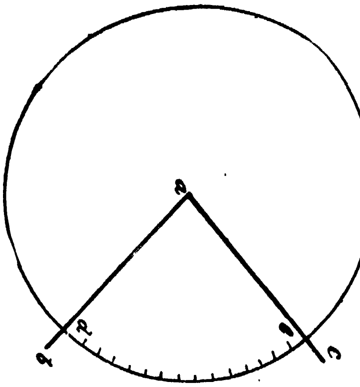


Fig. 22.

the "complement" of an angle is the number of degrees wanting to be equal to a right angle or one of 90°, and the "supplement" of an angle is the number of degrees which must be added to this angle to be equal to two right angles, or 180°. An angle is said to be "inscribed" when its apex, as *a*, fig. 23, is on the circumference of the circle, as *a b c d e*, and measures the half of the arc *b e c*, comprised between its sides, *a b*, *a c*. Consequently all angles inscribed in the same arc, that is to say, the sides of which border upon the extremities of the arc, and the apex to it matters not what points of the circumference are equal, for they all have the same measurement, that is to say, the half of the arc, as *b e c*, comprised between the sides *a b*, *a c*.

Various Problems connected with Lines.—Parallel Lines.

Having in the preceding chapters given a variety of *definitions* connected with geometry, we now proceed

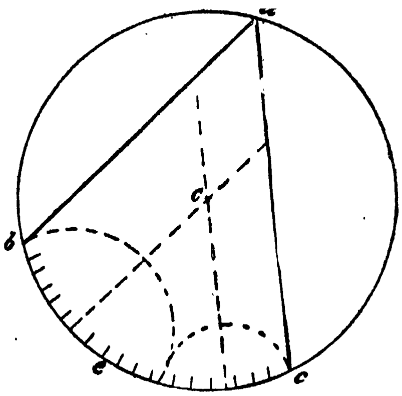


Fig. 23.

to place before the young geometrical draughtsman the various *problems and constructions* which constitute his practice, and which are used in a wide, variety of industrial operations. The first of those problems and constructions will be connected with lines. Through a given point *a*, fig. 24, to draw a line

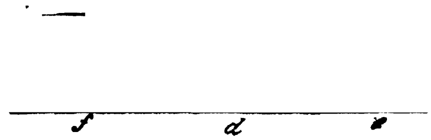


Fig. 24.

parallel to the line *b c j*. From any point *d* taken on the given line *b c*, describe a semicircle cutting this line *b c* in two points *e* and *f*. Take the distance *f a* in the compasses, and set it off from point *e* to *g*; draw the straight line joining the points *a* and *g*, which is parallel to *a b c*. Through a given point *c*, fig. 25, to

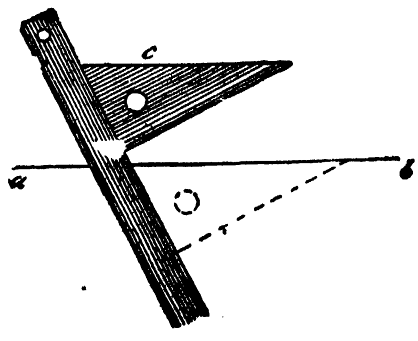


Fig. 25.

draw any number of lines parallel to a given straight line *a b*, by means of the "set-square" and straight-edge, or flat ruler.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER IX.

From what has been said as to the chief characteristics of architectural and engineering drawing—namely, precision and accuracy—the reader will perceive the necessity there is that his mechanical appliances and his instruments must be both accurately made and accurately maintained, that is, kept in good working order.

Detailed Description of the Instruments and Appliances required by the Building and Machine Draughtsman in the Preparation of Working Drawings or Objects delineated on the Principles of Plane Projection.—Varieties of Compasses.

We have in a preceding chapter described the appliances, under which term we comprise the drawing board, the "T-square," "set-squares," and pencils; we now proceed to offer a few remarks on the important subject of "instruments" proper. The two classes of appliances and instruments are generally included in one class and designated "drawing materials," often by some "drawing gear" or "drawing plant."

The drawing instruments at first purchased by the young draughtsman need not be numerous, although they should be the best of their kind or class; that, however, need not be the "first," in which silver or expensive material is used for the mounting, and on which a large amount of "finish" has been expended, which, however far it goes to please the eye, does not add to the practical value or working efficacy of the instruments. When the apprentice or articled pupil (see the paper "The Technical Student as an Articled Architect" and "The General Machinist") reaches the position of foreman, or clerk to the works, or becomes an architect or builder or engineer or machinist on his own account, he may then "launch out" and buy himself not only a "complete set," but all the pieces of which are finished and fitted in the highest style of constructive excellence. We say all this, for not seldom does it happen that the beginner throws away much money in the purchase of what he does not require, and of instruments which are not fitted for the rough-and-ready treatment they often obtain at his hands and those of his fellow-students. Moreover, some run away with the idea that good work cannot be done with a few instruments of very humble finish. All that is required is that they be accurately made. For a pretty long period of his early practice the following instruments will suffice for the young draughtsman: (1) a pair of large compasses with one of the legs movable, or rather capable of being taken out and its place supplied either with the "pencil leg," required for describing large circles or arcs of circles, or the "pen leg," as described. (2) Compasses of a size smaller than No. 1, but having both legs not removable. One leg, however, is provided with a "spring," which, being adjusted by a small thumb-screw, the nicest alteration in the position of the leg, and of course in the measurement taken by the compasses for being "laid down" on the drawing paper, can be secured. By turning the screw, one leg is made to advance to or recede from the other leg in proportion. Thus, suppose the point of one leg were fixed in a certain point of the drawing, or say for example a division on a "scale," and the other leg were extended to take in the measurement required, but that it were found to be short of the point, or in advance of it as the case might be,—without removing the point of the other leg the distance of the other could be adjusted by means of the screw. (3) Where a number of small or comparatively short distances are to be measured off repeatedly on a given line or lines, the large compasses (1) or the spring dividers (2) above described are not so useful, as they are liable to be shifted by being moved from place to place, or handled so that the measurement taken or drawn will be altered. To avoid this awkward misfortune, as it involves loss of time to the draughtsman, and which may happen to him without his knowledge (although, as will be noticed hereafter, he should now and then test his measurements), the instruments known as the "spring dividers" are extremely useful. These are formed wholly of steel, with the exception of the upper part, or part by which they are handled, which may be of plain brass or of electroplated white metal; the legs are formed with a strong spring at the point of junction, and the adjustment or distance from one another is secured by a screw and small nut; this screw is joined to one leg by a pin, which allows of the movement of the screw, as the angle of the legs extends by their opening widely. (4) For drawing in small circles in pencil the small or "spring pencil bow compasses" are used; these being made on much the same principle as the "spring dividers" (2), the legs being united at the top so as to form a spring controlled by a screw. (5) As the range of this instrument is limited, for larger circles and work the small pair of "bow pencil or pencil bow compasses" are used; the legs of this are jointed at the upper part, like those of the ordinary or large compasses (1); the pencil passes through a split holder and is secured by a small screw. The points of the compass legs, as in (1) and (2), become in course of time very blunt, and require to be sharpened or re-pointed. This blunting shortens the legs and thickens the points, as the width increases upwards, and tends to disturb their right adjustment. To obviate these inconveniences, what are called "needle points" have been for a long time introduced, although they were unknown to the general draughtsmen of a generation or so ago. The lower parts of the legs are made tubular and hollow throughout their length; this admits of a needle being inserted and kept adjusted at any point desired by a screw. As the point becomes blunt, the needle is taken out, its points sharpened, and then is once more inserted in the tube and secured by the screw. "Needle points" are now given to "hair divider compasses" (2), and also to other forms of compasses, to the great advantage of the draughtsman. They add slightly to the cost of the instrument, but are well worth the additional sum. (6) The "spring pen bow compasses" is a companion instrument to the spring pencil bow compasses" described in (4). To these a "needle point" is given to one leg. For larger circles and work, a pair of "pen bow compasses" are used, jointed at the upper part, the pencil leg having its place taken by a pen leg.

For reducing and enlarging drawings the instruments known as "proportional compasses" are often used. The simplest form of this instrument is, however, known by the name of "wholes and halves," being formed of two legs jointed at a point in their length so that the one set of legs is just twice the length of the other. The result is that when the compasses are opened the distance taken with the long legs is just twice as great as the distance given by the short ones. In the "proportional compasses" proper, these legs are of precisely the same length and form, each being formed with a central opening, "slot" or "groove," in which a small bar slides up and down—this bar being secured at any desired point in the "slot," to which the instrument is adjusted by a round-headed screw. When the instrument is closed the two legs or pieces so exactly coincide in every way that the points of each pair of legs are exactly the same length. The slider with its adjusting screw has across the face of it a single gauge line engraved or cut on the surface. This line can be made to coincide with any one of a number of lines marked on the solid side of one of the legs on the right hand of the groove, and termed the "scale of lines." Those lines are the marks or indices of certain "proportions" which can be made between the length of the short legs and that of the long ones. Thus, by moving the slider till the line on *its* face coincides with the line on the solid part marked with the figure "2," and then, on screwing down the screw of the slider till it is tight in the slot or groove of the two legs, if the points of the upper or shorter part be extended by opening the compass, they will give half the distance between the points of the lower or longer legs. If the mark in the slider coincides with the line "3" on the solid part of the leg, the distance between the upper points will be one-third of that between the lower. The point "4" on the solid part will give measurements at the upper points one-fourth of those at the lower, the point "5" one-fifth, and so on.

The instrument obviously, therefore, gives the means of either reducing or enlarging drawings. For reducing a drawing, the measurements are taken from the drawing by the upper points of the short legs, and according to the adjustment of the mark in the slider with the lines on the solid part of the leg will be the extent of the reduction at the lower points. For enlarging, by measuring the distances of the drawings with the short legs, the enlarged or extended measure will be between the points of the longer part of the legs. Some "proportional compasses," in addition to the lines or mark of the lines on the solid part, as above named, have on the opposite part or the left-hand side of the groove divisions between the points marked 1 and 20 into certain parts beginning with 1 and ending with 20. This is termed the "scale of circles," and is useful for finding the length of the side of any polygon up to one of twenty sides. The slider can be set so that the line across it will coincide with any line denoting the polygon and its sides. Thus, if set to the line 10, the distance between the upper points of the short legs will be equal to the length of the side of a decagon or ten-sided polygon, inscribed in a circle the radius of which is equal to the distance between the points of the long legs. These two scales are the most used by draughtsmen. Better forms of proportional compasses have additional scales, such as the "scale of planes," which gives the proportions between certain areas or surfaces. A "scale of solids" gives the proportion between cubes and spheres. It is scarcely necessary to add that the "setting" of the instrument can only be done when it is closed; the slider would not indeed slide if the legs were in any degree opened forming an angle,—it can only slide when the two grooves in the legs are perfectly coincident. When the slider is adjusted to any required line, the screw is to be tightened, and then the legs may be separated in order to take measurements, the legs working on the stud of the "set-screw" of the slide as a centre. When the distances obtained are to be used or set off frequently, they should be transferred to paper and taken up by the "spring dividers," to avoid wearing down the points of the proportional compasses. For it is obvious—and the importance of this point we draw special attention to—that on the maintenance of the relative lengths of the legs will the accuracy of the instrument depend. Hence, the division or index lines on the sides of the legs will, in course of time, be only approximatively correct. Absolute correctness depends upon this circumstance,—that the original and actual length of each of the legs, that is from point to point, be always maintained. To illustrate the point we may put it arithmetically. Supposing the length of each leg, that is from point to point, to be precisely eight inches, so long as each leg remains of this length, when the slider is adjusted to any one index line the proportion between the lengths of the short legs and the lengths of the long legs close to that index line will be maintained. But suppose that the points of the legs have been worn down to the extent of one-tenth of their original length, while the points of the long legs have, from one circumstance or another—superior metal or better usage, for example —not been worn down at all. If on this supposition the slider be set at the index line due to the proportion previously tried, the proportion between any distance given of the points of one set of legs and that of the other set, no longer exists accurately. The index line is invariable; but the other condition, which should also be invariable—namely, the original length of the legs—is not so now, inasmuch as one-tenth of their original length has been taken away. Theoretically, or strictly speaking, the exact proportion due to any index line is only maintained for an exceedingly short space of time; for any use of the instrument results in a wearing down of the points. This may be of almost infinitesimal proportion, even after some considerable period of working. But if it exists at all—and in practice it does actually exist—in proportion as it does so, so in proportion is the absolute accuracy of the adjustment per index line engraved on the compasses themselves. And it takes no very long period of use of the proportional compasses to throw those index lines out of all true position, so that they are practically useless. Hence it is that to make sure of the accurate adjustment of the instrument, it is necessary to adjust them by means altogether independent of the index marks engraved on them.

This adjustment is effected by using a very accurately divided scale of equal parts. Thus, suppose a drawing is to be reduced to one-half its original dimensions: after having closed the instrument in order that the set-screw can be screwed up so as to fix the slide at a point which the draughtsman may guess to be pretty near the part which will give the proportion desired,—after some experience he will be able to guess pretty accurately, so that there will be comparatively little work of readjusting to be done,—setting the slide very slightly, by giving the set-screw a turn or two, sufficient only to prevent the movement of or sliding upon one another of the two legs, the draughtsman will then open the longer legs of the compass till he takes in from the scale of equal parts an accurate given length, say two inches. He will then reverse the instrument, and applying the extended points of the shorter legs to the same scale, if they take in between or cut precisely the length of one inch, the compasses are obviously adjusted properly; and if the screw be now firmly fixed at the point at which it was conjecturally or by guess placed, then all measurements taken by the long legs will be halved by the short legs—that is, the distances given between the points of the short legs will be precisely one-half the distances taken between the points of the long legs.

But this accurate adjustment of the proportional compasses, while it may be obtained at first essay or trial, is much more likely—at least, in the case of beginners or those possessed of no great range of experience—to be arrived at only after repeated trials and readjustments. Thus, if the exact proportion between the points of the two ends or legs of the proportional compasses be not got at the first trial, the set-screw must be loosened to admit of the slide being pushed along either to one end or the other as required, till a point be reached at which another guess will be made, which may be the precise one desired. If it be not, the scale is then used to test the distances between the points of the two ends or legs of the instrument, and this must be repeated till the accurate adjustment be obtained, when the set-screw is firmly screwed up, so that no shifting of the two legs will be admitted. *One caution in the use of proportional compasses must here be given to the inexperienced draughtsman.* Unlike all the other forms of compasses or dividing or measuring instruments used, by the architectural or engineering draughtsman, the proportional compasses are possessed of sharp points at both ends; and as they are of considerably greater length as a whole than any other compasses used, unless the draughtsman be careful he may in suddenly reversing the instrument cause the points of the legs or ends being reversed to come in contact with some part of his face, or—what is worse, and what indeed has happened before now—to pierce more or less deeply or scarify the eyes. Some draughtsmen, not always on account of shortsightedness, but rather from an awkward habit, are accustomed to pore so closely into the drawing that the head is brought into such proximity to the surface that it may be dangerous when the proportional compasses are being used. And if for the moment they intuitively raise the head so as to be clear of the upper points of the proportional, they may as intuitively lower it quickly, and forgetful of those same upper points, may get, as not a few have got in such practice, a pretty sharp prick on some part of the face. In such a case the easy and elegant, not the "poring" posture, will be the safest.

The engraved and figured lines of the proportional compasses give only accurate adjustments for a time—determined by the length of time during which the compass legs maintain their original and accurate adjustment of length.

THE MARKET GARDENER.

His Work in Producing in Bulk, Vegetables, Fruit, and Flowers.

CHAPTER III.

At the conclusion of the last chapter we stated that much of the neglect of the poorer classes in the use of vegetables as part of their daily food arises from prejudice. But this is being rapidly overcome; and just as we find that vegetables and herbs are beginning to take a place on the tables of the well-to-do classes in Scotland, which were never, as a rule, seen even so lately as thirty or forty years ago, and if seen, were partaken of chiefly by southern visitors, so do we find that vegetables long known, largely used, and greatly valued on the Continent, are now used, and becoming more and more used, at the tables of English houses. A wider knowledge of the health-promoting value of vegetables is also becoming a feature of our national life; so that, altogether, there is the prospect of market gardening being still more and more widely extended, and of its embracing within the range of its work a much wider variety of vegetables than it now does.

General Features of Market Gardening as an Art.

Market gardening, as a rule, is carried out on what is called the "spade husbandry" system, the extent of land being small comparatively—from two to five, say up from ten to fifteen acres, which may be taken as an average maximum. Where what may be called vegetable farming is carried out, the acreage is much larger —up to fifty and even more acres; and in such cases not only the implements and appliances used, but the methods of culture adopted, are much more in accordance with the usual procedure of ordinary or general farming than with those of gardening. Such vegetable farms are not, however, numerous, and as they are chiefly confined to certain zones not greatly distant in mileage from the Metropolis, they may be looked upon as the exception to the rule generally observed in what is called the art of market gardening.

As there is a difference between the styles of working in these two methods—the spade-husbandry and the farming market gardens—so there is a no less marked difference between the style of cropping, or rather the crops produced. What may be called the rarer and finer products of the market garden, such as asparagus, sea-kale, broccoli, celery, and what are known as salad vegetables, are cultivated only in the smaller or spade-husbandry market gardens; while on the larger and farm-style-cultivated gardens a much narrower circle of plants is grown, and those chiefly of the cheaper and less rare kinds, which are required in vastly huger bulks than the rarer products of the smaller gardens. Of this lesser circle of plants grown in the larger or vegetable farms, the cabbage and the turnip may b just as asparagus and French or kidney beans may be taken as the types of the spade-husbandry market gardens.

Special Districts for Special Crops another Feature of Market Gardening.

But there is another peculiarity of the market garden system of Great Britain—certainly of the southern part of the kingdom, which falls to be noticed now. And this, that while there is the distinction in the system considered generally of small and spade- and large and farm-cultivated market gardening just noticed, there are some districts and localities which are noted for their cultivation of special crops only, and no other. Thus in Cornwall, notably, if not wholly in the immediate neighbourhood of Penzance, near the Land's End, potatoes are the staple crop, and of those only the early varieties. Those, from the nature of the soil, as well as from the sheltered position of the fields chiefly or largely bordering the beautiful bay of Penzance, in which St. Michael's Mount is the grand and romantic natural feature, are produced at a very early period of the year. To get the *first* crop of potatoes into the London market the greatest exertions are made by the cultivators or gardeners; and most exciting stories are still told of the "races" run by the fast sailing boats which were employed to take the earliest crops to the Thames, before the introduction of the railway. And just as we find the bay of Penzance famous for its one market-garden crop of early potatoes, so do we find other districts famed, more or less, for their special crops. Of these we may name—Leicestershire for its cauliflowers, Bedfordshire for its onions, Surrey and Wilts for their carrots; while we find Cornwall again famed for another crop—broccoli—and it again has its competitors for early potatoes in certain parts of Lancashire, Cheshire, and Yorkshire. Still further it is to be noted as a feature of British, certainly of English market gardening—that whilst certain methods of cropping are adopted and carried out as a rule in market gardens, those methods are frequently modified, and often indeed wholly set aside, in order to take what may be called catch or occasional crops, for which there may at one time or another, and in certain districts and localities, be a special demand, or what may be called a fashion; while there are many more, especially in the smaller holdings, who go in for occasional crops of some special vegetable, as early potatoes and peas, carrots, onions, or the like, according to the probable or possible demand.

Special Features of Fruit and Flower Cultivation as a Branch of Market Gardening.

Many of the features here named are found to belong to fruit culture, although there is of necessity, seeing trees of slower or quicker growth are here concerned, the feature of permanence observable. Fruit culture for the general market is thus more of a speciality, and its practice is dictated and controlled by a much more fixed and permanent characteristic than vegetable culture—inasmuch as locality, and especially climate, have largely and closely to be considered. Fruit culture is often, however, considered as merely a department of market or vegetable gardening—the two often being carried on by the same individual—although as a rule the only fruit strictly so called with which market gardeners concern themselves is "strawberries," to which some add "tomatoes"—if these be a fruit, which some deny, and not as they say purely a vegetable (see the paragraph on the culture of this delicious production of nature). For the purposes of this paper, then, we shall consider fruit culture as a department of the general subject of market gardening—an arrangement in favour of which must be said this, at all events: that as in ordinary gardening fruit is embraced and considered quite as legitimate a part as flowers, so in gardening as carried on in the "market" style fitted to produce largely to meet great demands, fruit culture may be considered as a legitimate part of its system. For the same reason flowers can scarcely well be excluded from our papers. And here again we find that in practice the market style—or production in bulk, as it may be called—is adapted to flower culture. And this not merely to satisfy the large and growing demand for potted flower plants, and for "cut flowers" for personal and household decoration, but also for the production or manufacturing of scents, perfumes, and pomades. So that, as thus outlined, our readers will perceive not only how wide and practical in its technical aspects, but how interesting, is the subject the several departments of which lie before us.

Selection of the Land or Site for the Market Garden.

In taking up the consideration of the various departments of our interesting and practically useful subject, as above outlined, in such order as the natural sequence of the subjects dictates, it is to be noted that on several of the points details have been pretty fully given in the series of papers entitled "The Cottage and Villa Gardener." These details are chiefly connected with the subject of soils, and of their preparation for the work of cultivation, such as locality, site, laying out and drainage of the land. The preparation of the soil, as in trenching, digging, planting and after-care of the growing crops, is also there pretty fully explained. Much, therefore, of the preliminary matter connected with the special subject of the present series of papers thus receiving special treatment, will demand here only a general glance, thus giving more space to take up the special points of market gardening.

The first point on which a few general remarks are to be offered is the selection of the ground for the market garden. The district and the special locality of that district will obviously be decided by circumstances, such as nearness to a good market, which will be largely independent of those connected purely with the practical work of gardening. The district and locality being decided upon, the market gardener on the look-out for a plot of land will therefore give his attention to the finding out of some point at which the best quality of the soil suitable for his purposes will be met with. His task will of course be reduced to the minimum of difficulty in cases where ground which has already been under cultivation is offered to him. Closer attention and a higher degree of knowledge will of course be demanded of him in a locality in which the land has not been used for market gardening. His difficulties will be lessened if the land has been under arable or general farm crop culture; but even then he will require to look closely into all the peculiarities of the soil, and not only of this, but of points connected with the locality and actual site or position of the land he proposes to take. For obvious reasons we consider the subject as taken up from the first or initial step—that is, the formation of a market garden; not merely the management or the improvement of one which has been already formed and cultivated, maybe with skill, mayhap the reverse. But as the greater includes the less, all points connected with the latter will be included in those connected with the former position. We presume, therefore, that the market gardener begins with the formation of his garden, including in this his choice of its site and locality.

Points to be attended to in connection with the Soil.

In looking out for a plot of land sufficient in extent for his projected operations, the market gardener should bear in mind that the depth of the vegetable producing soil is of greater importance than the quality of the soil at the surface. Ground is extremely well adapted to market gardening if it has a bed of free working loam two to three feet deep or so, and if at the same time this bed rests on an under-soil of sand or gravel. Such ground, when well cultivated, yields very fine produce. Comparatively poor crops are to be expected from a bed which is sandy and of a considerable depth, and which rests upon a clayey under-soil. Indeed, in this case, should the garden lie low and the water consequently be slow in running away by the drains, early-spring crops of vegetables will be impracticable. Upon the clayey under-soil water will remain stagnant, the beds will be completely saturated both in winter and spring, and whatever grows there will be backward and slow in growth.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER XII.

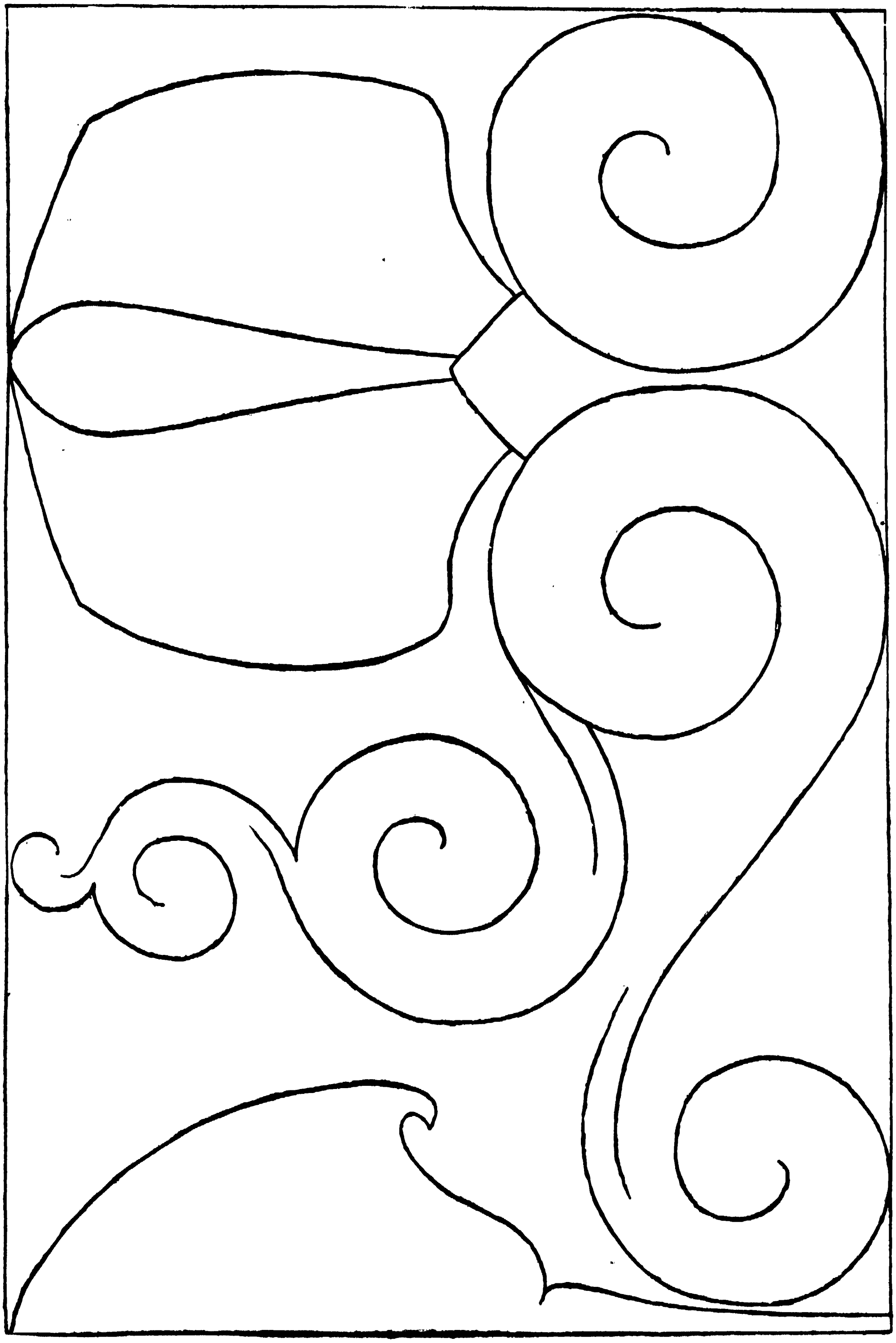


Fig. 53.

The ornament known as the honeysuckle, technically the "anthemion," referred to in the concluding sentence of last chapter, is very much used by the Greeks in all their decoration, in their architecture and on their pottery. We give two or three illustrations of it, for the purpose of directing the student's attention to it, and we hope he will study it very carefully. We also give an illustration of the Assyrian honeysuckle, to show the difference of treatment.

In the example placed before the student in figs. 47 and 48, he will see the manner in which the Greeks used the honeysuckle and tulip form, and how beautifully the lines harmonise and run into each other without any break (see fig. 4, p. 230 *ante*).

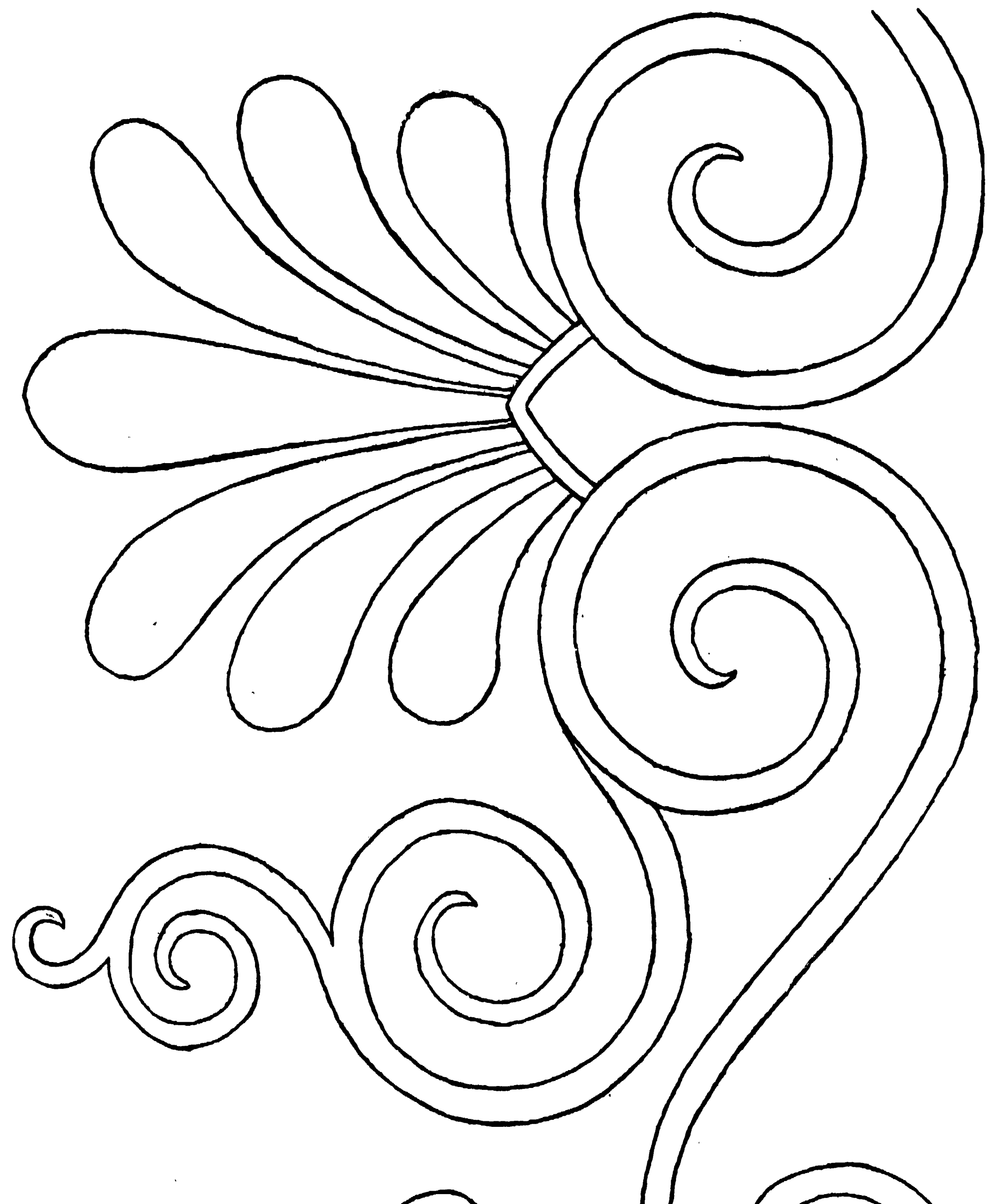


Fig. 54.

THE JOINER.

The General Principles and the Details of his Work.

CHAPTER VII.

Joints for Pieces Circular or Round in Section (*continued*).

In preceding chapter we gave in fig. 52, p. 91, one method of joining two round or cylindrical pieces. In fig. 53 a more secure method of making this joint is illustrated. In this the angular part *a b c* —side view—is not cut out right across the piece, but only to a certain depth on each side, leaving a central diaphragm, tenon, or tongue *d* in the centre of the angular cut. The end of the other piece, *l*, is cut to the same angle as *a b*, *b c*, at *i j*, *i k*, but is provided with a groove or open mortise, *i*, into which passes the tongue or tenon *d*. The central

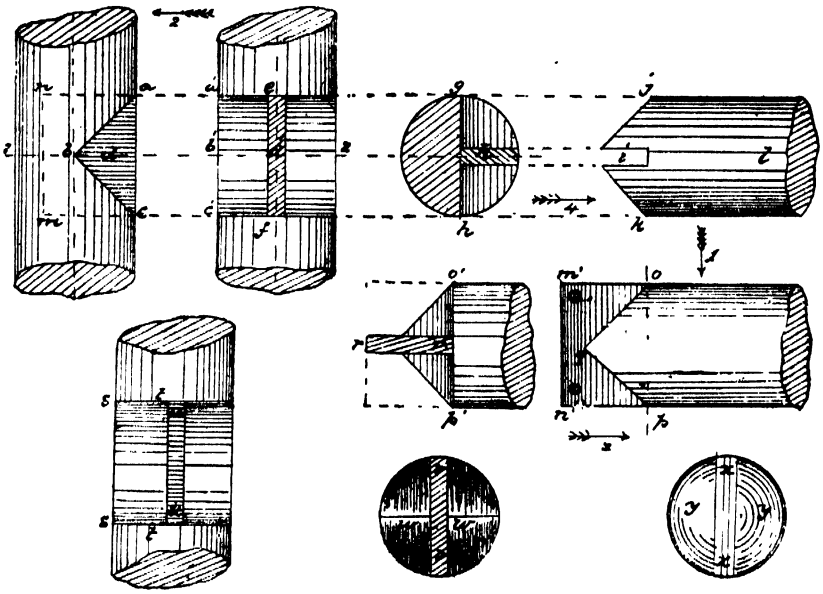


Fig. 58.

diagram at top, *h g*, is a cross section of piece to the left on the line 1 2 ; the lower diagram to left shows a front elevation or side of piece *a b c d* when looked at in the direction of the arrow 2 ; *d'* being tenon or tongue *d*, the line *b* 2 being that in which the two sides *a b*, *b c* meet at point *b*. In another modification of this joint, the angular piece is cut out as before, as at *a b*, *b c*, upper diagram to the left, but a square mortise is cut out at the back to the depth and position shown at dotted lines *a n*, *c m*. This mortise is shown at *u u* in the lower diagram to the left, and as seen when looked at in the direction of arrow 2. In this case the end of the other piece is cut off at each side to the same angle, as shown at *o q*, *q p*, but a tenon or tongue is left in the centre of which the outer edge is at *m' n'*, *m' n'* being equal to the diameter of the rounded piece. This tenon or tongue is shown in plan as seen when looking down upon side *o m'* in the direction of the arrow 1 at the diagram to the left at *r*, *o'* and *p'* being the sloping sides of angular shoulder or butting faces. The end views of those two last described diagrams, as seen when looking in the direction of the arrow 2, are at *v v* and at *y y*, *x x*.

General Work of the Joiner—Panel Work.

Before proceeding to that important part of the work of the joiner—the framing of doors and windows —we shall take up and illustrate various forms of joints and of framing work which have a more or less direct connection with those essential parts of the fittings of a house. These preliminary illustrations cannot always or easily be grouped under distinct divisions; still a general classification, useful for most purposes of reference, may be attempted. The first we shall take up will embrace general panel work.

"Panels" may be defined as parts marked off by some peculiarity of position and formation, as distinct from the general body of a framing, or framework, or a boarded surface. Usually the "panel" is placed in relation to the general surface of the framing by which it is surrounded, so that its surface is sunk, so to say, below the surface of the frame ; in some cases, as we shall see, the panel is raised above the surface of the surrounding framework. When there are several panels in a piece of work, as in a door, they are usually placed symmetrically in relation to the framing, generally in pairs alongside of each other, and there may be two or three sets of those pairs in the framing. In other work they may be ranged in line at the same height, and at certain distances from each other. Panels are used in a wide variety of work, such as in doors, window shutters, staircases, and in the decoration of walls or parts of walls. (Illustrations of panel work under those heads hereafter.) This panel work will be found illustrated in figures 1 to 7, Plate XI., and in Plates XVII. and XXV., Joinery.

Square Panel.

In fig. 2, Plate XI., Joinery, we illustrate a "square" panel—to $\frac{3}{4}''=1$ ft. scale—in cross section at top on the line 1 2 in the elevation below. In this *a, a*, are the "styles" or side bars of the framing which are shown in elevation at *c c*, with cross-bar called a "rail," *d d*—in lower diagram elevation—the framing enclosing the panel *b b*, which is let into the styles *a a* in the centre of their thickness; thus leaving square recessed parts in each side: hence the name "square panel." The diagram to the left of lower drawing is a vertical section on line 3 4 showing the cross-bar *d'*, corresponding to *d d*, *c' c'* style, *e' e'* panel.

A Flush Panel.

In fig. 1, Plate XI., we illustrate a "flush panel"—so called because *one* surface or side of the panel *c c*, in cross section at top on line 1 2, in drawing at bottom, (scale same as fig. 2, Plate XI.), is flush with the surfaces of the styles *a, b*. In the front elevation, *d d, e e*, "styles," *g g* "top rail," is the framing enclosing the "panel" *f f*. The diagram to the left is a vertical section on line 3 4, showing panel *h h*, style *i i*, "top rail" *g'g*.

Raised and Moulded Panel.

Panels of the ordinary kind or cheap class are perfectly flat in surface, as at *b b* in fig. 2, or *c c*, fig. 1, Plate XI. But in the better class of work the panelled surfaces are ornamented by raised parts and by mouldings. In fig. 2, Plate XI., we illustrate in the upper drawing a cross section of a "raised and moulded" panel, the raised part being from *b b* to point 4 in centre, in larger scale at *g h*; the flat part, as at *f* or *c c*, is called the "margin," and it is separated from the "raised" part of the panel by a "moulding" at *e*. The panel is let into the styles *d, d*. The second diagram represents another form of "raised" panel, with "margin" but no moulding. In this the part *a b* is raised above the "margin" *c c*, as shown at *j*, *i* being the margin and body of panel. The lower diagram below to the left is elevation of the moulded and raised panel *f e h g*, in section above, and *i' i' j' j'* elevation of *i j*.

Moulded Styles enclosing Panels—Bead Flush.

The styles are sometimes ornamented with a "moulding" worked on the side or edge nearest to and extending in length from top to bottom of the panel. This is shown in fig. 4, Plate XI., in which *a a* is a square panel let at *b* into the style *c*, the edge of which is shown moulded as in front elevation at *d*. This is more completely shown in fig. 5, Plate XI., in which the upper drawing is a cross section of style *b b* and panel *c c*, *a a* showing the "moulding" worked on the inner edge, *a a*, of style. The part elevation is shown in lower diagram, *d d* being the style moulded in margin, *e e* the "flush" panel. This arrangement is technically termed a "bead flush" panel.

Bead Butt Panel.

In the arrangement called "bead butt" the moulding is worked upon the "panel," not upon the "style" as in fig. 5, Plate XI. This is illustrated in fig. 7, Plate XI., in which *a a* shows the "style" with groove *b*, into which part of the "margin" of the panel (see fig. 3, Plate XI., at *f f*) which forms the tongue is inserted; *e e* shows the moulding worked upon the panel *d*. The lower drawing in fig. 7 gives elevation, showing the mouldings of cross section marked 1, 2, 3, etc., in front elevation. In this *f f* is the cross-bar or "rail," *g g* part of the "style" of framing which encloses the panel. In the arrangements illustrated in figs. 5 and 7, Plate XI., "bead flush" and "bead butt," it will be seen that in the finished work the panel shows as ornamented or "margined" with the moulding at the side only. In the "bead butt" arrangement, in fig. 7, Plate XI., while the moulding can be worked along the length, or in the direction of the grain of the wood of the panel, it could not be worked across the breadth or against the grain (see "Grain" in "The Cyclopædic Dictionary of Technical and Trade Terms") of the wood. The moulding at the two sides of the panel —one of which only is shown in lower diagram in fig. 7, Plate XI.—stops short therefore at the point where the panel joins the cross-bar or rail *f f*. Again, the same peculiarity is shown in the panel work known as "bead flush," illustrated in fig. 5, Plate XI., in which the moulding, as *a a*, is worked on the margin of the "style" *b b*. For although the moulding might be worked on the lower edge of the rail, as *f f* in fig. 7, Plate XI., the grain of the wood running rightly in the direction of the length of rail, the young joiner will perceive that the moulding on the inner margin of the "style," and that on the lower margin of the "rail," would not meet properly—that is, could not be made to "mitre," so that there would be a break at the corner where the vertical moulding or margin of style and horizontal moulding or margin of rail approached each other.

"Stuck-on" Mouldings in Panel Work.

Where, therefore, a panel is to be surrounded on all sides with mouldings, at top and bottom as well as at both sides, the arrangement known as "stuck-on mouldings" with "square flush panel" is adopted.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

Embracing the Various Departments of Technical and Industrial Work, such as Mechanics and Machine Design and Construction — Building Design and Construction—General Manufactures, as Textile and Metal—Applied or Manufacturing Chemistry — Industrial Decoration — Sanitary Engineering—Gardening and Rural Matters—Miscellaneous.

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112. Bessemer Steel Castings.

In our last note under this heading we promised to glance at the different views which have been expressed as to the best method of securing that homogeneity or equality of constitution in Bessemer steel ingots so essential to sound construction, and at the various points, all more or less valuable in connection with the metal, which those methods open up for consideration. That promise we now proceed to redeem. Although the present note concerns itself with Bessemer steel as used in *castings*, still, as closely bearing upon the point of homogeneity in the metal of the ingot, and on the views held as to its formation when cooled, it will be useful to glance at what Mr. Allen says in reference to the value of a well-stirred ingot when that is to be used for plate-making purposes, as for the plates of boilers and ship-building plates. Considering the importance of those two classes of work, and the lives and property dependent upon them, the perfect homogeneity in the steel of which they are made is of the greatest consequence; in no class of work can this be of higher value, in none can its absence be so destructive. We can suppose an ingot to be used in the plate *rolling*, the metal composing which was imperfectly mixed, not being stirred or agitated as by Mr. Allen's method we have described. In consequence of this, incomplete admixture in the ingot metal, when rolled, gives to the plate some veins more or less parallel to each other, and which veins or fibres, so to call them, consist of those parts of the metal which partake to some extent of the soft and weak quality which it possesses when it has not received its due amount of spiegeleisen, and this from improper admixture of the contents of the ingot. Next to those soft veins would be others which, in consequence of their having more than their share of the spiegeleisen, would be unduly hard, being too highly carbonised. If a plate so constituted were rolled from the ingot in such a way that the veins ran parallel to the surface of the plate, any weakening or deteriorating effect would be so minute as not to be worth noticing. But if the plate were rolled with the veins at right angles to its surface, the consequence would be that they would be found in the finished plate in the condition of bands separated some inches apart. And as the strength of a plate—as of a machine—is determined by its weakest part, the strength of the plate so rolled with widely separated bands of soft and weak metal would be regulated solely by the strength of those weak bands to resist tensile strain, or upon their cohesive strength. The young reader is requested to take special note of the point here stated, as it conveys to him a lesson of the highest technical importance—namely, that the value of mechanical work depends upon the conditions under which it is done, as well as on the way in which those conditions may be fulfilled or availed of. No doubt this is true also of all work, still it is directly and specially true of mechanical work; and great as its value is, it, we regret to say, is too frequently neglected, or what is worse, ignored, or considered to be a matter of no moment. And the young mechanic should remember in this connection that neglect of a valuable principle is not so bad as denying or ignoring its value: there is hope that one who neglects a duty at one time may not neglect it at another time; there is no hope of him who denies that it is a duty at all. As we have said, this point of condition under which mechanical work is done opens up a question of the highest importance in the technical education of the young and inexperienced. It would appear to be but a matter of indifference in which way a plate was rolled composed of steel of the unequal quality referred to; and yet we see what the good result of rolling it one way would be, the bad of rolling it in another way. If the young mechanic will but practise careful, thoughtful observation, he will come across not a few examples of the principle we have pointed out. That for steel plates—and we need scarcely say, for all castings as well—"the most perfect homogeneity and the most thorough admixture" of the widely different materials or constituents present in a steel ingot is essential, is a point no one will dispute, however much one may cavil at the way in which the admixture is performed. Without it it is impossible to develop in the metal the "full ductility and cohesive strength of the plate" made of it, or of the casting obtained from it. How the elements or constituents of the steel are distributed within the ingots made under the ordinary conditions of the manufacture—that is, apart from any special treatment of the metal, such as by Mr. Allen's mixing or agitating method—is a question upon which the most diverse views are held, and on some of the points of which it may, perhaps, with perfect truth, be said that we have yet everything to learn. That practical men are, however, approaching each other in the views they hold, is clear enough from what has taken place lately; and the investigations being made into the question, and the close and careful experiments, lead us to entertain the hope that before long we shall have a theory of the distribution of the elements of steel ingots in which most will coincide, and which, if not perfectly meeting all the points, will for practical purposes be a good working theory. That we shall ever come to a full knowledge of all the points of this important question in metallurgy, there is grave reason to doubt. It is not given to man to wrest from nature all her secrets; it is well for him that he is permitted to be able by patient and long-continued investigation to wrest so much as he generally does, and which is sufficient for the doing of his work, marvellous as much of that work is, alike in its development and the beneficial influence it has had upon our national prosperity. One would at first sight conclude that when a metal was poured into the ingot or mould in which it was designed to cool and solidify, it would so solidify as to present when taken out all the features of a mass of uniform character. But here again the young reader will have another exemplification of the importance of attending to the conditions under which the solidifying ingot or casting is placed. Even in cases where the metal is homogeneous, as we may suppose it to be, and it often practically is in the case of cast iron of various qualities, as No. 1, No. 2, etc. (see "The Iron Maker"), all the constituents being thoroughly mixed, the effect of the mere cooling of the casting—nay, more, of the condition and character of the mould, and the way in which the object is cast—may, and in practice does, bring about a condition of the ultimate casting differing—and in many cases this to a very large extent—from the condition which might have been expected and hoped for. Every iron founder who makes castings in ordinary cast iron, and every mechanic who uses them in his constructions, is well aware of this, and in many cases to his cost but too painfully aware. The reader of this Journal will find in the series of papers entitled "The Iron Maker," in the section treating of chilled castings, several details bearing upon the important point above alluded to. But leaving the consideration of homogeneous metals, if we come to the casting of a Bessemer steel ingot, we have a different order of circumstances. Here we have a metal in which more than one constituent is present; and homogeneity of the mass depends upon the "behaviour" of the different constituents in the ingot; and presuming them to have been well mixed or intermingled in what we may call their proper condition or relation to each other, it is upon the way in which they *maintain* this normal relation one to another that the ultimate homogeneity of the solid and cooled ingot depends. Now, if in cooling and solidifying, the constituents from one cause or another, or from several causes, change their relation to one another—or if one part of the mass draws, so to say, more of the constituents to it than another part—it is obvious that homogeneity of the resulting solid metal or ingot will not be secured. The question for the consideration of the young reader now is, Do changes of this kind go on in the ingot mould in the course of its solidifying and cooling? He will find it is the reply to this question which carries with it so many important issues to the engineer who uses steel in one or other of its various applications. Some four years ago Mr. Stubbs, at a meeting of the Iron and Steel Institute, announced the "fact"—or what from his experiments he felt himself justified in assuming was such—that cast steel ingots could not be homogeneous in the character of the cooled and solidified metal, inasmuch as a redistribution of the elements or constituents of the metal took place during, and in consequence of, the solidification through cooling. This redistribution was such that the carbon, sulphur and phosphorus went—or, as would be popularly described, were drawn—to the centre of the ingot, or that which remained fluid the longest; and thus the centre of the ingot was composed of metal the weakest and least valuable, and this because the impurities became concentrated there: just as if the mere act of cooling caused the metal to eject or cast out its impurities, and as the outer parts of the mass nearest the ingot mould sides naturally cooled first, the ejected constituents, so to call them, as naturally went or flowed towards the central part. An illustration of this curious process may be had in the solidification or forming into ice of water containing solid impurities: as is known to every schoolboy, the resulting ice is quite pure and clean, the mere crystallisation or freezing in effect acting as a power for casting out or ejecting of the solid impurities. It would at first sight be considered by the young reader a right conclusion to come to, that if this redistribution of the constituents of steel takes place which the investigations of Mr. Stubbs showed did take place, this redistribution would be met with in very small as in very large ingots. Here, again, the question of condition comes up, for it appears from other investigations made into the point, that the element of mass or bulk of the ingot has a decided influence on the redistribution of the elements or constituents in the way we have named above. For Mr. Snelus, another well-known authority on practical metallurgy, having had suggested to him by Dr. Percy, the eminent scientist, now President of the Iron and Steel Institute, the desirability of knowing whether spiegeleisen was thoroughly diffused throughout the mass of a Bessemer steel ingot, made a series of experiments in connection with this inquiry. Mr. Snelus analysed the first and the last ingot from one charge or blow of the Bessemer converter, and also the top and bottom part of an ingot. The conclusion come to as the result of those analyses was, that there was "no practical difference in the composition of the steel at any point." Mr. Snelus from this came to express a doubt as to the accuracy of Mr. Stubbs' view as to the redistribution of the elements in the way we have above stated. But it will be observed that the crucial point in the experiments of Mr. Stubbs—namely, the concentration of the debasing or weakening elements in the centre of the ingot—was overlooked, or had no place in the experiments of Mr. Snelus, who analysed the top and bottom only of the ingot, not touching its centre. Further, Mr. Lowthian (now Sir Lowthian) Bell pointed out to Mr. Snelus that Mr. Stubbs had expressly stated that analysis of the top and bottom of the ingot gave the same results, thus agreeing with the deductions of Mr. Snelus—which they were very likely to do, seeing that the course of the redistribution of the elements, as maintained by Mr. Stubbs, was in the direction *from* the ends *to* the centre—and that as both ends were equally distant from this centre, the redistributing process would thus act equally on both top and bottom, which would thus of necessity, as it were, show in analysis the same constitution or value. But Sir Lowthian Bell went further, and reminded Mr. Snelus that Mr. Stubbs had experimented on very large ingots. Here we meet again with the question of condition, for this would show that the process of redistribution would take place, if not more effectually, yet more certainly, in a large mass than in a small one of metal. Mr. Snelus therefore took the investigation up again, experimenting on large ingots 7 feet long and 19 inches in the square section, and borings were taken from the centre as well as from points from this to the corner of the ingot; and slices or cuttings one from the top part, 21 inches from the top, and one 4 inches from the bottom. While the slice taken from the bottom showed a section in which the metal was perfectly sound, the slice taken at a depth of 21 inches from the top displayed a section of unsound metal, "a spongy mass full of cavities, some of them being gas cavities, but many of them doubtless due to contraction." Borings from each slice were then analysed, and the results very clearly corroborated the investigations made by Mr. Stubbs. To make sure, second sets of borings were then analysed, still showing a remarkable similarity to those made by Mr. Stubbs. "These analyses show," says Mr. Snelus, "clearly that when the chemist's work is properly performed great reliance can be placed upon the actual results." This opinion of so high an authority as Mr. Snelus is worthy of being recorded, as many practically engaged in steel making make somewhat light of the help which is offered them by the chemist in their labours. We have not space to give the details of the analyses: suffice it to say that they confirmed "the molecular interchange discovered by Mr. Stubbs in large ingots, showing in the redistribution that carbon, sulphur, and silicon become concentrated in those portions of the ingot which remain fluid the longest, leaving iron and manganese in excess in the portion from which they have liquefied." There being thus far no doubt as to the redistribution of the constituents of the steel in large ingots, it became a matter of importance to see how this affected plate and rail ingots of the ordinary dimensions.

Mr. Snelus therefore took an ordinary Bessemer steel ingot, 4 feet long, with $11\frac{1}{2}$ inches square section at top, and 12 inches at bottom, and cut slices—one from the top 12 inches thick, and one from the bottom 3 inches thick. Another ingot made, however, by the Siemens open-hearth process (see "The Steel Maker" in the text), length 3 feet 6 inches, 21×17 inches at top, and $21\frac{3}{4} \times 17\frac{1}{2}$ at bottom, was then sliced 10 inches thick from the bottom, and 4 inches thick from the top. The analyses of these several and corresponding slices from the two ingots—the first the large, and the second the small—were so nearly alike that few chemists would have positively asserted that there was any real practical difference between the steel of the slices at top, and those at bottom. "And yet," remarks Mr. Snelus, "it is remarkable that, looking at the results as a whole, the probability of redistribution having taken place to a remarkably small extent is possible." Altogether, however, while fairly assuming that ordinary steel ingots are not seriously affected by this redistribution or interchange of elements or constituents, Mr. Snelus says that the action cannot be neglected in making large castings and forgings; as in his opinion it accounts in "all probability for the mysterious fractures which have occurred to many such articles." Finally, he took the central part of the largest-sized ingot, and cut a slice from the bottom part of it 5 inches thick, and one from the top part 22 inches thick. The difference between the mechanical condition of the two was most marked: the top slice, near the centre, was most difficult to cut, while that near the bottom cut quite easily. Mr. Snelus himself enters into no speculation on this important question of ultimate condition of ingots after solidifying and cooling; he merely gives the results of his investigations, with the practical counsel he deduces from these. What others think of the matter we shall see in our next note.

French and English Measures and Weights.

Measures of Capacity—Solid or Cubic Measure.

(For Measures of Length, see note No. 107, p. 141.)

113. English Cubic or Solid Measure.

1728 cubic inches = 1 cubic or solid foot
27 cubic feet, or 46,656 „ „ = 1 „ yard.

Cubic yard.		Cubic feet.		Cubic inches.
1	=	27	=	46,656
		1	=	1728

40 cubic feet of rough timber = 1 load; 50 cubic feet of hewn timber = 1 load; 42 cubic feet = 1 ton of shipping; 1 cubic yard of soil or earth = 1 load; a load of soil before being dug out averages 16½ bushels (see "Measures of Capacity" in a future note), and 22 bushels after being dug out; 17 cubic feet of clay (average) = 1 ton; 24 cubic feet of sand = 1 ton; 18 cubic feet of soil or earth = 1 ton.

Note.—A cubic foot, containing 1728 cubic inches, is equal to or contains 2200 cylindrical inches, 3300 spherical or globular inches, or 6600 conical inches.

Cubic or solid measure is obtained by cubing the linear measurements of a body—that is, by multiplying the linear measures or "dimensions" into themselves twice: thus, 12 (inches) × 12 × 12 = 1728 cubic inches; 12 inches is 1 linear foot, therefore the cube of 12 (1728) is a cubic foot; also 3 linear feet = 1 linear yard; cube of 3 = (3 × 3 × 3) 27; therefore 27 cubic feet = 1 cubic yard. Cubic or solid measure always involves three dimensions—length, breadth, and thickness.

French Cubic or Solid Measure.

The unit of this measure is the "Stere," which is 1 cubic metre. The stere in English equivalent = 35·317 cubic feet or 1·3079 cubic yard.

1 Millistere	=	61·028	cubic inches.
1 Centistere	=	610·28	„ „
1 Decistere	=	3·5317	„ feet.
1 Stere	=	35·317	„ „
1 Decastere	=	13·08	„ yards.
1 Hectostere	=	130·8	„ „
1 Kilostere	=	1308·0	„ „

A cubic yard English = 0·7645 cubic metre French; 1 cubic metre = 1·3079 cubic yard, or 35·317 cubic feet; a cubic foot = 0·0283 cubic metre; a cubic inch = 16·387 cubic centimetres. The multiples of the French measure unit, or stere, are 10, 100, and 1000, and are denoted or indicated by the prefixes "Deca" (10), "Hecto" (100), and "Kilo" (1000). The divisors are 10, 100, and 1000, and are indicated by the prefixes "Deci" (10), "Centi" (100), and "Milli" (1000).

114. English Measures of Capacity.

Liquid Measures.

(Used either for Liquids or Solids.)

4 gills = 1 pint, containing 34⅗ cubic inches.
2 pts. or 8 „ = 1 quart „ 69·318 „ „
4 qts. or 8 pts. or 32 „ = 1 gallon „ 277·27 „ „

(Used only for Dry Goods.)

2 gallons or 16 pints = 1 peck = 544⅘ cubic inches.
4 pecks or 8 galls. = 1 bushel = 2218⅕ „ „
8 bushels or 64 „ = 1 quarter = 7745 „ „
5 quarters or 40 bus. = 1 load.

load		grs.		bus.		pks.		gals.		qts.		pints		gills
1	=	5	=	40	=	160	=	320	=	1280	=	2560	=	10240
		1	=	8	=	32	=	64	=	256	=	512	=	2048
				1	=	4	=	8	=	32	=	64	=	256
						1	=	2	=	8	=	16	=	64
								1	=	4	=	8	=	32
										1	=	2	=	8
												1	=	4

34·659 cubic inches of distilled water at the temperature of 62° is equal in weight to 1·25 lb., or 1 Pint; 69·318 cubic inches of distilled water = 2·5 lb. of water, or 1 Quart; 277·274 cubic inches of water = 10 lb. in weight, or 1 Gallon; 554·548 cubic inches of water = 20 lb. in weight, or 1 Peck; 2218·92 cubic inches of water = 80 lb. in weight, or 1 Bushel; 17745·526 cubic inches of water = 640 lb. in weight, or 1 Quarter.

Measure of Capacity—French.

The "Litre" is the unit of this measure, and is equal to 1 cubic decimetre. The multipliers are as in the other tables—10, 100, and 1000, and are indicated by the prefixes, as before—"Deca," "Hecto," and "Kilo." The divisors also 10, 100, 1000; prefixes "Deci," "Centi," and "Milli."

Millilitre	=	·06102 cubic inches.	
Centilitre	=	·07043 gills, or	0·6103 cubic inches.
Decilitre	=	·17607 pints, or	6·1028 „ „
Litre	=	1·7607 „ or	61·028 „ „
Decalitre	=	2·20096 galls., or	610·28 „ „
Hectolitre	=	22·0096 „ or	2·75 bushls. or 3·530 c. ft.
Kilolitre	=	27·51208 bus., or	35·317 cubic feet.
Myrialitre	=	353·17 cubic feet.	
1 Pint	=	·5679 litres.	
1 Quart	=	1·1359 „	
1 Gallon	=	4·54041 „	
1 Bushel	=	3·63233 decalitres, or	36·347 litres.
1 Quarter	=	29·0586 „ or	2·907 hectolitres.

A Litre = 1 pint 26·36 cubic inches liquid measure; a Decalitre = 2 gallons or 1 peck 1 pint 26·77 cubic inches; a Hectolitre = 2 bushels 3 pecks 2·816 cubic inches; a Kilolitre = 3 quarters 3 bushels 2 pecks 28·16 cubic inches; a Myrialitre = 34 quarters 3 bushels 1 gallon 4·328 cubic inches.

115. English Measures of Weight.

1. *Avoirdupois Weight.*

			lb.		c		
16 Drachms	= 1 ounce (oz.)	=	1/16				
16 Ounces	= 1 pound (lb.)	=	1	=	16	=	256
14 Pounds	= 1 stone (st.)	=	14	=	224	=	3584
28 Pounds	= 1 quarter (qr.)	=	28	=	448	=	7168
4 Quarters	= 1 hundred (cwt.)	=	112	=	1792	=	28762
30 Cwt. or 80 qrs.	= 1 ton	=	2240	=	35840	=	57344

This table is used for weighing all articles sold by weight, with the exception of those sold by troy.

2. *Apothecaries' Weight.*

		℈	grs., apoth. or troy.
20 Grains (gr.)	= 1 scruple (℈)	= 1 =	20
3 Scruples	= 1 drachm (ʒ)	= 3 =	60
8 Drachms	= 1 ounce (℥)	= 24 =	480
12 Ounces or 963	= 1 pound (lb.)	= 288 =	5760

Although apothecaries compound their medicines by this weight, they buy and sell them by avoirdupois weight. The pound, ounce, and grain are the same as troy.

3. *Troy Weight.*

24 Grains = 1 pennyweight.
480 " = 20 pennyweights = 1 oz.
5760 " = 240 " = 12 oz. = 1 lb.

24 Grains	= 1 pennyweight.
20 Pennyweights	= 1 ounce.
12 Ounces	= 1 pound.

Gold being at £4 per ounce, 1 grain is worth 2*d.*

4 Grains	= 1 carat.
24 "	= 1 pennyweight.
20 Pennyweights	= 1 ounce.
12 Ounces	= 1 pound.
25 Pounds	= 1 quarter of a hundredweight
100 "	= 1 hundredweight.
20 Cwt.	= 1 ton of gold or silver.

Gold, silver, jewels, and precious stones are weighed by this table. It is also used in experiments in natural philosophy, and for ascertaining the strength of spirituous liquors. Diamonds are weighed by the carat of $3\frac{1}{8}$ grain.

Coal Weight.

16 Ounces	. 1 pound.
7 Pounds—one-fourth of ½ cwt.	. ½ a stone.
14 Pounds—one-half of ¼ cwt. .	. 1 stone.
28 Pounds or 2 stones . . .	. 1 quarter cwt.
56 Pounds or 2 quarters . . .	. 1 half cwt.
1 Sack or 112 lb. or 4 quarters	. 1 cwt. net.
20 Cwt. or 10 large sacks . . .	. 1 ton.
21 Ton 4 cwt.	. 1 barge or keel.
20 Keels or 424 tons	. 1 shipload.
140 Cwt. or 7 tons	. 1 room.

Avoirdupois.

ton.	cwts.	qrs.	lb.	oz.	drms.	grains.
1 =	20 =	80 =	2240 =	35840 =	573440 =	15680000
	1 =	4 =	112 =	1792 =	28672 =	784000
		1 =	28 =	448 =	7168 =	196000
			1 =	16 =	256 =	7000
				1 =	16 =	437½
					1 =	27·34
	stone.					
	1 =	14 =	224 =	3584 =		98000

Troy.

lbs.	oz.	dwts.	grains
1 =	12 =	240 =	5760
	1 =	20 =	480
		1 =	24

French Measure of Weight.

The unit of French weight is the "Gramme." It weighs ·03527 oz. avoir., or 15·43234 grains troy.

Milligramme	= ·015432 grain troy.
Centigramme	= ·15432 " "
Decigramme	= 1·5432 " "
GRAMME	= 15·432 grs. troy or ·03527 oz. avoir.
Decagramme	= 6·43 dwts. or ·3527 oz. avoir.
Hectogramme	= 3·21 oz. troy or 3·527 oz. avoir.
Kilogramme	= 2·6 lb. troy or 2·2 lb. avoir.
1 Grain	= ·0648 grammes.
1 Dwt.	= 1·55517 "
1 Oz. troy	= 31·1035 "
1 Lb. "	= 373·24195 "
1 Dram. avoir.	= 1·77184 "
1 Oz. "	= 28·34954 "
1 Lb. "	= 0·453 kilogrammes.
1 Quarter	= 12·693 "
1 Cwt.	= 50·780 "
1 Ton	= 1015·650 "

Equivalent in English (Avoirdupois).

	lb.	oz.	grs. (troy)		grs (troy)
1 Gramme				=	15·432
1 Decagramme				=	154·323
1 Hectogramme		3	230·7	=	1543·234
1 Kilogramme	2	3	119·8	=	15432·348
1 Myriagramme	22	0	323·4	=	154323·488

An English Ounce (Avoir.)	= 28·338	grammes.
" Pound "	= 0·4534	kilogrammes.
" Hundredweight	= 50·780	"
" Ton	= 1015·650	"

116. Chemical Facts and Figures.

We propose in the following series of articles to present the reader with a brief account of some of the countless substances known to chemistry that are of special importance in manufactures. This scheme may seem to some somewhat ambitious, but all we intend to attempt is a synopsis or sketch of the chief salts, acids, etc., the names of many of which are frequently to be met with incidentally in technical literature, but for the formulæ and preparation of which such elaborate works as Watts' great "Dictionary" are to be consulted. We shall give the common and scientific name, the chemical formula, the principles of the best method of preparation, and the chief *uses*, but not of course the properties, of each substance treated. We presume the reader to be acquainted with the rudiments of chemistry, and to understand symbols, and to such these papers may serve as a kind of dictionary of salts, etc. We shall notice such salts, etc., as are used in the arts, or medicine, or in the laboratory, and of those only such as are used extensively.

The arrangement we follow is simple: we treat the most important compounds of the chief metals first, in the order usually accepted as representing a natural classification of the metals, namely:—

1. The alkali metals: sodium, potassium, and the metal-like radicle ammonium.

2. The alkaline-earth metals: calcium, strontium, barium.

3. The earth metal: aluminum.

4. The zinc group: zinc, magnesium, cadmium.
5. The iron group: iron, manganese, cobalt, nickel.
6. The tin group: tin.
7. The chromium group: chromium, tungsten, uranium, molybdenum.
8. The antimony group: antimony, bismuth, vanadium.
9. The lead group: lead.
10. The silver group: silver, copper, mercury.
11. The gold group: gold, platinum, iridium.

Sodium Compounds.

1. *Caustic Soda,* sodium hydroxide, NaOH. Obtained by the action of lime on sodium carbonate solution.

$$\underset{\text{Lime}}{CaO} + \underset{\text{Sodium carbonate}}{Na_2CO_3} + \underset{\text{Water}}{H_2O} \text{ yield } \underset{\text{Calcium carbonate (or chalk)}}{CaCO_3} + \underset{\text{Caustic soda.}}{2NaOH}$$

Used in soap-making, and a great many processes in manufacturing when a powerful alkali is required; in constant use in the chemical laboratory.

2. *Common Salt,* sodium chloride, NaCl (crystals). Obtained by the evaporation of sea-water; also found as rock-salt.

Used with food; employed in the manufacture of soda ash, and therefore of hydrochloric acid; in soap making, in oleine making, etc.

3. *Soda Ash,* impure sodium carbonate, Na_2CO_3 (amorphous). Obtained by three methods.

(1) The Le Blanc method.—Common salt is converted into sulphate of soda or salt-cake by strongly heating with sulphuric acid, sulphate of soda being formed and hydrochloric acid given off.

$$(\text{A}) \quad \underset{\text{Sodium chloride}}{2NaCl} + \underset{\text{Sulphuric acid}}{H_2SO_4} = \underset{\text{Sodium sulphate}}{Na_2SO_4} + \underset{\text{Hydrochloric acid.}}{2HCl}$$

The sulphate of soda or salt-cake is then converted into the carbonate by ignition with a mixture of chalk and coal; the action here taking place is a double one, consisting first in the conversion of the sulphate into the sulphide, and then the conversion of the sulphide into the carbonate, thus:—

$$(\text{B}) \quad \underset{\text{Sodium sulphate (or salt-cake)}}{Na_2SO_4} + \underset{\text{Carbon (or coal)}}{C_4} = \underset{\text{Sodium sulphide}}{Na_2S} + \underset{\text{Carbonic oxide.}}{4CO}$$

$$(\text{C}) \quad \underset{\text{Sodium sulphide}}{Na_2S} + \underset{\text{Calcium carbonate (or chalk or limestone)}}{CaCO_3} = \underset{\text{Sodium carbonate (or soda ash)}}{Na_2CO_3} + \underset{\text{Calcium sulphide.}}{CaS}$$

The mixture of sodium carbonate and calcium sulphide thus obtained is termed "black ash." This is treated with hot water, the soluble sodium carbonate dissolves out, and the solution is separated from the insoluble calcium sulphide and evaporated to dryness (by the waste heat from the furnaces) and ignited, and forms the "soda ash" of commerce. The residue of CaS forms "alkali-makers' waste."

(2) The Ammonia-soda process, which is fast superseding the Le Blanc process.—Carbon dioxide is passed through a solution of common salt in aqueous ammonia. A double decomposition takes place. Ammonium chloride and sodium bicarbonate are formed, the latter precipitating as a white powder and the former remaining in solution.

$$\underset{\text{Aqueous ammonia}}{NH_4HO} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Sodium chloride}}{NaCl} = \underset{\text{Sodium bicarbonate}}{NaHCO_3} + \underset{\text{Ammonium chloride.}}{NH_4Cl}$$

The sodium bicarbonate is readily converted into the mono-carbonate by ignition, carbon dioxide, water and the mono-carbonate being formed:—

$$2HNaCO_3 = Na_2CO_3 + H_2O + CO_2.$$

The ammonium chloride liquor resulting from the manufacture may be distilled with magnesia to recover the NH_3, which is given off with formation of magnesium chloride—which again is distilled, and the hydrochloric acid is given off, and magnesia remains. This process, therefore, is theoretically perfect and wasteless.

$$\underset{\text{Ammonium chloride}}{2NH_4Cl} + \underset{\text{Magnesium oxide}}{MgO_2} = \underset{\text{Magnesium chloride}}{MgCl_2} + \underset{\text{Ammonia}}{2NH_3}$$

$$\underset{\text{Magnesium chloride}}{MgCl_2} + \underset{\text{Water}}{H_2O} = \underset{\text{Magnesium oxide}}{MgO} + \underset{\text{Hydrochloric acid.}}{2HCl}$$

(3) The Cryolite method.—The mineral cryolite occurs in immense deposits in Greenland. It is a double fluoride of sodium and aluminium, and has the formula $(NaF)_6 . Al_2F_6$. It is finely powdered, and ignited with ground chalk, and double decomposition takes place as follows:—

$$\underset{\text{Sodium-Aluminium fluoride}}{(NaF)_6 . Al_2F_6} + \underset{\text{Calcium carbonate}}{6CaCO_3} = \underset{\text{Sodium aluminate}}{Al_2O_3.(Na_2O)_3} + \underset{\text{Calcium fluoride}}{6CaF_2} + \underset{\text{Carbon dioxide.}}{6CO_2}$$

The ignited mass—from which the carbon dioxide is expelled by the heat—is treated with a small quantity of water; the calcium fluoride remains undissolved, the sodium aluminate dissolves, and through it is passed a current of carbon dioxide, when alumina is precipitated and the liquid consists of a solution of carbonate of soda—which is evaporated down and ignited, and yields commercial soda ash.

Soda ash is used chiefly in cotton bleaching and glass making, and is generally used as a source of an alkali, when the CO_2 which is evolved in neutralising an acid is no objection, and therefore is employed in a large number of processes in manufacturing.

4. *Common Washing Soda,* or *Soda Crystals,* sodium carbonate deca-hydrate, $Na_2CO_3 . 10H_2O$. Obtained by simply dissolving soda ash and crystallising out.

Used as an alkali when a purer and less concentrated product than that of soda ash is desired, as in the case of domestic washing.

5. *Crystal Carbonate,* or *Soda Ash crystals,* sodium carbonate di-hydrate, $Na_2CO_3.2H_2O$. Obtained by a process patented by Messrs. Gaskell, Deacon & Co., and consisting essentially of solution and crystallisation.

Used in place of common soda ash, being more soluble and pure.

6. *Bicarbonate of Soda*, sodium hydrogen sulphate, $NaHCO_3$. Obtained by saturating sodium carbonate with carbonic acid, or exposing crystals of carbonate of soda to carbonic acid gas.

Na_2CO_3	+	CO_2H_2O	=	$2NaHCO_3$
Sodium carbonate	+	Carbonic acid (solution of CO_2 in water)	=	Sodium hydrogen carbonate.

Used when a very mild alkali is required, and when a large amount of CO_2 is desired on adding an acid; hence it is largely used in medicine, and with tartaric or citric acid as a cooling drink.

7. *Glauber Salts*, crystallised sodium sulphate deca-hydrate, $Na_2SO_4 \cdot 10H_2O$. Obtained by purifying and crystallising anhydrous sulphate of soda or salt-cake.

Used in medicine, and in manufacturing when a neutral sulphate is required.

8. *Anti-chlor*, crystallised sodium hyposulphite, $Na_2S_2O_35H_2O$. Obtained by passing sulphur dioxide gas through a solution of a mixture of sodium sulphide and caustic soda, and crystallising the product.

$2Na_2S$	+	$2NaOH$	+	$4SO_2$	=	$3Na_2S_2O_3$	+	H_2O
Sodium sulphide	+	Sodium hydroxide	+	Sulphur dioxide	=	Sodium hyposulphide	+	Water.

Used largely in photography for fixing the image, owing to its solvent action upon salts of silver which have not been acted on by the light; also in volumetric analysis. It is also used to counteract the effects of bleaching powder—hence its commercial name anti-chlor.

9. *Phosphate of Soda*, di-sodium hydrogen phosphate, rhombic crystals, $Na_2HPO_4 \cdot 12H_2O$. Obtained by the following reactions: Phosphorus is burned with an abundant supply of air; phosphorus pentoxide (P_2O_5) being formed. This is dissolved in water, forming phosphoric acid, H_3PO_4; the liquid is kept boiling, and carbonate of soda is added until exactly neutral; the liquid is boiled down and the sodium phosphate crystallised out. Commercially, all the salts of phosphorus are generally obtained from bone-ash, which contains a large amount of calcium phosphate, $Ca_3(PO_4)_2$.

Used in calico printing, in the laboratory, and in artificial manures.

10. *Sodium Sulphide*, Na_2S. Obtained by reducing the sulphate by igniting coal.

Na_2SO_4	+	C_2	=	Na_2S	+	$2CO_2$
Sodium sulphate	+	Carbon	=	Sodium sulphide	+	Carbonic acid.

Used as a convenient source of sulphuretted hydrogen, H_2S.

11. *Borax*, crystallised sodium bi-borate, $Na_2B_4O_7 \cdot 10H_2O$. Obtained by purification and crystallisation of native borax found in Thibet and on the coast of California, etc.

Used in soap making, and in calico printing, and sometimes as a disinfectant, and as a blowpipe reagent.

12. *Soda Water Glass*, or *Soluble Glass*, sodium silicate solution, $Na_2Si_4O_9$, also $Na_4Si_5O_{12}$, but of variable composition. A product corresponding closely to the latter formula is obtained by igniting together 45 lb. of quartz, 23 lb. of anhydrous carbonate of soda and 3 lb. of charcoal, at about the temperature required to melt common glass. The carbonate of soda may be substituted by the sulphate (salt cake). By dissolving the product obtained by the former method in boiling water and digesting with precipitated silica, it is converted into $Na_2Si_4O_9$.

Used extensively as cements in building, and for hardening and preserving stone; in calico printing, in soap making, and in mural painting.

13. *Binarseniate and Arseniate of Soda.* Impure arsenates of soda, obtained chiefly by igniting white arsenic, arsenious oxide, As_2O_3, and caustic soda, and then adding some oxidising agent, as nitrate of soda—the product being arsenate of soda and a little arseniate, and sometimes unacted-on arsenious oxide and other impurities. It varies greatly in composition.

Used extensively in calico printing and dyeing, mainly to clean and fix the mordanted cloth previous to dyeing alizarine.

14. *Aluminate of Soda*, $Na_2Al_2O_4$; obtained by fusing cryolite with lime; or bauxite with soda and coal.

Used as a mordant in calico printing, for alizarine pink.

15. *Sodium Chlorate*, crystals, $NaClO_3$. Obtained by decomposing calcium chlorate with sodium chloride: $Ca_2ClO_3 + 2NaCl = CaCl_2 + 2NaClO_3$.

Used largely in calico printing for oxidising the colours after printing, especially for aniline-black. It possesses the great advantage over the potash salt of being much more soluble.

16. *Sodium Acetate*, crystals, $NaC_2H_3O_2 \cdot 3H_2O$. Obtained by saturating the distillate of the destructive distillation of wood with soda ash, purifying and crystallising out.

Used for the manufacture of pure acetic acid by distillation with sulphuric, or in some cases phosphoric acid; also in many chemical manufacturing operations to neutralise a mineral acid—the action being of course a salt of the mineral acid formed and acetic acid set free; also used in calico printing, and medicine.

17. *Tannate of Soda.* Obtained by neutralising solutions of tannin, such as catechu, with caustic soda. It is of variable composition.

Lately applied as a preventative for incrustation in steam boilers.

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY.

(44) In our preceding note (No. 43) on this subject we have already stated that the formation of carbonic oxide gas in the furnace is, although it is a combustible gas, a cause of loss of heat in the furnace. This will be obvious in considering that heat is required for the conversion of the acid into the oxide; and at the same time the heat due to the second atom of carbon is clearly also lost. It is only when the supply of air to the furnace is well and duly proportioned to the demands made upon its oxygen by the formation and combustion of the gases of the coal, that the carbonic oxide gas becomes a thoroughly valuable heating adjunct. It flashes into flame when at a high temperature it comes in contact with ordinary air, and it burns at a lower temperature than coal gas—carburetted hydrogen. A practical result of this is that the coal gases in passing along the flues are often cooled down by coming in contact with the carbonic oxide gas—that is, if the temperature be too low and the supply of air too limited to give the necessary current for flashing the oxide into flame; and the supply of air is too often very limited in furnace work. The result is that the carbonic oxide gas, in place of being ignited and made useful as a heating agent in the furnace in raising the temperature of the water in the boiler and in evaporating it into steam, is passed away by the flues into the chimney flue; and in passing through this it gets raised in temperature sufficiently, so that when it comes in contact with the open air at the upper orifice or exit of the chimney it is often flashed into flame, giving rise to the popular but erroneous notion that this is only the end of a terribly long flame passing from the furnace. From all that has now been said the young reader will see how important it is that all the conditions necessary to secure perfect combustion of coal with the consequent economy should be attended to. If one of the conditions be neglected loss is certain to be incurred.

(45) In our last Note (No. 39) on the subject of steam-raising or evaporation of water, we stated that irregular boiling was the rule, regular easy boiling the exception in practice. We then also stated that irregular boiling was well known to scientists and experimenters in the laboratory. In evaporating or boiling liquids in glass flasks, although the source of heat—generally a spirit-lamp—is constant, and therefore the number of increments of heat passing into the water also constant, the boiling—the result of this heat—is most inconstant and irregular. At one time the vapour bubbles pass freely away; at another (and the change is as sudden as it is annoying) they are retained in the mass of water till they reach a point of pressure at which they are freed with great violence, causing "bumps" or shocks sometimes so violent as to fracture the flask, or, if not, to violently shake it, while a mass of water is thrown up so that it is thrown out over the flask. The French scientists give a special name to these violent movements, terming them *soubresauts*. It was early discovered by scientists that by placing in it certain substances—such as pieces of cedar or cedar chips, iron and steel filings, pieces of cork, sand, etc.—the boiling was much more regular and the evaporation more rapid than when these substances were absent. The late Professor Faraday called such substances "promoters of evaporation." The late Mr. Charles Tomlinson, a practical scientist, instituted a very comprehensive range of experiments in connection with, and made elaborate investigations in the phenomena of, boiling, and also drew attention to the practical value of certain substances in water as aids to regular boiling and rapid evaporation, terming such substances as "nuclei." And this name he gave to them, inasmuch as they act as bodies round which the vapour bubbles readily cluster. But the moment they do so, or at least very quickly afterwards, the bubbles themselves form the surfaces of the nuclei, and rise rapidly through the mass of water above them, and pass off from the surface to the atmosphere if an open, or to the steam space if a closed vessel; and this rapid detachment of the vapour bubbles from the surfaces of the nuclei, to which in the first instance they are attracted, is in consequence of the pressure of the steam within the bubbles being greater than the force of the attraction just named. And the reason why such bodies termed nuclei act in this way will be now explained. The boiling water, considered to be—as Professor Tomlinson defined it to be—a supersaturated solution of its own vapour, forming bubbles, is attracted to the surfaces of the bodies or nuclei with much greater force than to the water which holds the vapour. And so long as the water only attracts the vapour, it has a tendency to hold or retain it so fast that its attractive force is greater than the pressure of the vapour held by the water-bubbles, and the natural tendency of the vapour-bubbles to rise upward through the mass of water above them. But the moment the

nuclei or foreign substances or bodies—such as pieces of charcoal, which Professor Tomlinson found to be the best nuclei—are introduced, their superior attractive powers upon the vapour cause the vapour-bubbles to rush to the nuclei, round the surfaces of which they cluster, and from which they are violently set free, as above explained. The mere bulk or volume of water in a vessel—say, a steam-engine boiler—has a direct influence upon the rate at which its vaporisation proceeds. If the water in one boiler is only half the depth of that in another boiler, both being heated in the same way and for the same length of time, the rapid evaporation will be altogether in favour of the shallowest mass of water, and this because the vapour-bubbles have a lower pressure put upon them by the lesser depth of superincumbent water; and the rapid vaporisation of boiling water met with in steam-engine boilers, in which the bulk or mass of water is broken up, so to say, into separate masses by the introduction of tubes passing through the mass of water, and through which tubes the heated gases and flame from the furnace are made to pass on their way to the chimney, act in the way above named, owing to the larger mass of heating surfaces which they present to the water. But now that the action of "free spaces" and free surfaces is understood, it is believed that such boilers owe their greater efficiency to their creating free surfaces—in brief, acting as nuclei. It is worthy of note that nuclei with surfaces absolutely clean or free from grease do not act in creating free surfaces, inasmuch as the water is attracted all over the surface; but where the surfaces are naturally greasy—and even what are considered clean bodies have more or less greasy surfaces—the water is repelled at various points, and the "free surfaces" are created, which act as promoters of vaporisation in the way already described. Did space permit, we could give a number of examples of the formation of free surfaces and how they act. But the rapidly decreasing space at our disposal compels us to limit our remarks, and to be content with noticing one or two of the methods by which the principle of free spaces or free surfaces is carried out, or can be carried out, in steam engine boilers. One of these methods is to place a series of projecting hemispherical bodies, called "cups," at intervals over the inside plates of the boiler immediately above the fireplace and under the flues. We should be inclined by preference to adopt angular or V-shaped projecting parts to run continuously along the boiler bottom plates. These could be rolled on the boiler plates, to avoid the large amount of riveting which would be required to fix detached parts. It is just possible that practice would show that the best nuclei would be obtained by having the angular corrugations to run transversely in place of longitudinally to the boiler axis. As yet the application of the principle of free spaces or free surfaces to boiler construction is in its infancy. When engineers become better acquainted with its practical value, there will be no difficulty in devising methods by which it can be adapted to boiler construction.

(46) We propose to utilise the remaining space at our disposal by drawing the attention of the student reader to certain points connected with the practical work of furnace and boiler management, in the raising of steam for motive power, on which the remarks given in the preceding papers on the subject of combustion of fuel and the boiling of water have the closest bearing. The process of combustion of fuel, which in its details has been already fully explained, would seem to be perfectly obtained when the elements necessary to combustion were supplied. But in practice it is not so. For example, the element of time must be attended to, and not be completely ignored, as so many do ignore it, to the great detriment of economical combustion. To promote and maintain combustion, so that none of the heating constituents shall be passed away to the open air through the medium of the chimney stalk, time must be allowed for the thorough combination of the elements essential to combustion to be completed. Those who know what good management of furnace and boiler is, know well what the evils are of "forced firing," by which the deficient dimensions of both furnace and boiler are sought to be made good. Forced firing in every case means waste of the coal constituents, evidenced not only by the visible product, at the chimney stalk, of black dense clouds, but also by the constituents not visible, yet which, if used properly in the furnace and boiler, would be valuable sources of heat: of these carbonic oxide gas is the chief. This "forced firing" is carried out by using excessive draught, and by too frequent and injudicious stoking or stirring the fuel in the bars. And another cause of loss is created by this forced firing, as the time is not given for that preliminary preparation of the fuel to which in a former paper we alluded as being termed by a high authority a species of cooking of the fuel, to render it more amenable, so to say, to that combination of the elements of combustion by which economical heating is secured. In this preparation of the fuel, heat is the great element, and as heat under the circumstances is obtained only from the combustion of the fuel itself in the furnace, the practical point to be attended to is to conserve the heat as it is produced, and not to allow it to be withdrawn or cooled down by lying or coming in contact with cooling or heat-conducting surfaces. In our next note we shall draw attention to the points of this heating.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER VIII.

At the conclusion of last chapter, in making allusion to the pressure exerted on the stones of marine structures, we stated that the actual facts exceed even the expectation of those who know something about this class of work. Let the pupil conceive of the effect of a pressure upon a body, even of the strongest kind, equal in amount to between two and three tons on every square inch of its surface. And yet even the maximum of these pressures named has been known to be exerted by waves. Calculate the surface of a large block of stone exposed to wave force (which may be considered as a compound force of wind and wave), multiply every inch—and even but a small block will give hundreds of inches—by the pressure on each inch, and the pupil will have some conception of the wild work on the structures reared by man which the waves of an angry sea, that may have received the stormy impulse of high winds over scores of miles of open water, may do. The marvel, indeed, is not that so much of the laborious and expensive work of man on sea margin or on lonely rock far out at sea should be destroyed, but that any of it can be reared at all, and when reared kept in existence.

Importance of the Study of the Pressures to which Stones are subject, or likely to be subject.

We have purposely here alluded to this subject of pressure exerted upon stonework, as it is one which closely concerns the practice of the stone mason. For although we have specially illustrated its importance by reference to two great sources of pressure, the pupil must not suppose that the effects of a powerful pressure are confined to works of the marine mason only. In structures on the "firm set land," with which the mind is apt to associate ideas of perfect stability, pressures, and those of a most potent kind, come into existence in a way often wholly unlooked for, and are exercised in a way as uncertain and as apparently capricious as those we have seen to be exercised by the winds and waves. In works of any extent or magnitude there are always sources of pressure the existence of which cannot always be predicated, and which are therefore not in the first instance provided for. In the well-conducted affairs of daily life no wise and prudent man ever trusts to a chance or contingency of danger or loss not coming into existence and acting prejudicially to his interests. He takes care, knowing that the chance or likelihood of mischief does exist, that it shall not injure him, simply because he provides against it, or, better still, gets rid of the chances against him. And if he does not absolutely know that they exist, or if they do in what direction they will operate, he tries hard to find out, if possible, all about them. A man forewarned is forearmed. Just so in the world, so to call it, of practical construction, be it of the mason, the carpenter, or the machinist. The wise and prudent designer and artificer tries his very best to provide against all chances or contingencies of loss or of evil to his structure. If he knows that a chance of loss or danger exists, the action of which is so remote that in the calculation of probabilities it is not likely to occur, he nevertheless wisely determines, since it *may* come into evil operation, to do his best that it shall not operate prejudicially. And in like manner he tries to conceive of possibilities of danger to his structure arising, none of which may show on the face of his work as he first designs it. What is likely to happen is, with the wise and prudent constructor, as carefully provided for as that which his knowledge and experience tell him will positively arise. No apology at all is needed either for the character or the length of these remarks; for as it is our duty to point out to the reader what, from their obvious character, may be called the open secrets connected with structures of stone, so it is no less our duty to point out the direction or probable direction in which the occult or hidden secrets or causes of danger or loss exist. What lies on the surface may or not be picked up by the pupil, but its acquirement is comparatively easy; it is another thing for him to imitate the conduct of the wise man, who does not conclude that all that exists is only all that which is seen. He looks below the surface, and this looking is invariably the result of thinking over the subject. One of the first, as it is in truth the most important, of all the lessons which the technical student has to learn, is the value of thought. The writer, who has had a wide and as varied as wide experience of work and of workers, does not hesitate to say that the great obstacle to the progress of working-men in their several callings is their lack of thought; or, to put it in a paradoxical way—which, like most paradoxes, conveys a vital truth—their determined thinking that no thinking is required of them.

In carrying on—for we have not, although some may think we have, interrupted—the consideration of the subject of contrivances to bind or bond blocks of stone together to resist pressure, we now come to notice the next class of appliances for securing bond supplementary to the ordinary methods of obtaining it, and which in preceding paragraphs we have illustrated and described.

The "Cramping" Method of Joining Blocks of Stone.—Cramps with Plain Ends.

This class of securing stones together is known as "cramping," the appliances being styled "cramps." These are constructed of iron, generally (almost universally) of the kind known as malleable, or more widely as wrought iron, and are of various forms and applied in different ways. A good idea of "cramping" and of the general form of a "cramp" may be obtained from an inspection of the sketches in fig. 55. The "cramping" is the bonding or tying together of two adjacent blocks of stone, *a*, *b*, by the "cramp," the upper surface or top of which is shown at *c c*. This is not merely flat, and of a certain thickness, let into a groove or depression cut in the surface of the two stones to receive it, and so that its surface be in the same level or line —technically called "flush"—with that of the stone surfaces. If so made, it would more properly be classed as a "dowel." But the ends are bent downwards, or "returned"—to use the technical term—in the manner shown at *h*, *i* being part of the horizontal piece which lies flat on the stone surface, as at *e*. The primary length of the piece of wrought iron is such, of course, as will, when the ends are returned, as at *h*, be the proper length which will give the "cramp" sufficient horizontal hold (as at *c c*) of

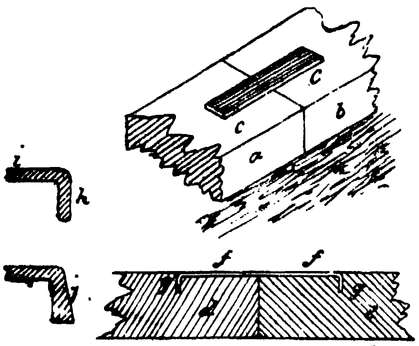


Fig. 55.

each stone, as at *a b*. In the lower sketch we give to the right hand a sectional view of two stones, as *d*, *e*, secured together by the "cramp" *f f*, with its two "returned" ends, *g g*, one of which is let into the stone *d*, the other into the stone *e*.

"Cramps" with Dovetailed Ends.

A much faster grip of the stones will be taken by the "cramp" if, in place of the "returned" ends being of equal thickness throughout, as at *i* in preceding figure, they are formed dovetail fashion, as at *j*. For it is clear that, while the "cramp," as *f f*, if made with "returned" ends as at *i*, could be lifted up by a pressure, or "prised out"—to use the technical term—by a sharp-edged tool acting as a lever, this could not be done with a "cramp" with "returned dovetail" ends, as at *j*, unless the stone was broken which rested above the sloping or bevelled side, at *j*. If the "returned" end was made with a double, or rather a true or complete dovetail (see "The Carpenter"), as in the lower sketch in fig. 56, there would be still greater difficulty in withdrawing the "cramp" from out of contact with the stones. This sketch in fig. 56 shows how the lower surfaces of the ends of the "cramp" shown in plan in the sketch at top of diagram may be formed, in order to get this greater grip of the stones. The plan in the upper sketch in the figure shows also a form sometimes given to the outline of a "cramp," by which it will be perceived that with equal length between the ends the horizontal contact with or grip of the stones is increased. It is obvious that cramps with dovetailed ends, as at *j* in fig. 55, and in lower diagram in fig. 56, cannot be let into the spaces or voids cut in the stones to receive them, inasmuch as the upper parts of the voids or spaces will be narrower than the width or thickness of the lower edge of dovetailed end of the cramp. Such cramps have therefore to be passed into their spaces in the stone from the sides or edges, at or near which the cramps are placed. But square holes may be cut in the stones to receive from their upper surfaces or

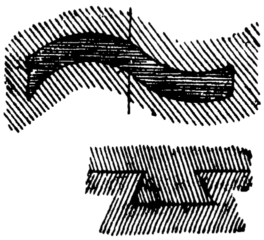


Fig. 56.

sides cramps having dovetailed ends of any width, by adopting the method next described.

Securing the Ends of Cramps, etc., to the Stones by Lead.—Various Methods of "Leading."

All the advantages of a solid iron dovetail grip by the returned ends may be obtained by "leading" the ends into the stone. A wrought-iron bar or stanchion is said to be "leaded" into a stone when the aperture or void in which its end is inserted into the body of the stone is made not straight-sided, but with sloping sides, as at *h* or *i* in fig. 54 (*ante*). To make the hold all the firmer, the end of the bar may itself be formed in dovetailed fashion, as shown in sketch at *g*, in place of being left straight, like the remaining part of the bar. The end of the bar *g* being inserted in the dovetailed hole in the stone, as at *i*, melted lead is then poured in, which envelopes or embraces the end of the rod *g*, and filling up the hole, *i*, in the stone, forms a solid wedge-like block of lead, in which the end of bar *g* is firmly gripped. To increase the "bite" or "grip" of the lead on the end of bar, the surface of this is often, and should be, chisel-notched, so as to form a series of saw-like teeth.

THE ALKALI MAKER AND HIS TECHNICAL WORK.

INDUSTRIAL IMPORTANCE OF HIS PRODUCTS.—THE MAKING OF SULPHURIC ACID, SODA ASH, CAUSTIC SODA, SODA CRYSTALS, USED IN A WIDE VARIETY OF PROCESSES.

CHAPTER IV.

Hydrochloric Acid (*continued*).

Manufacture. The first process has already been described (page 177), and consists in treating common salt with the proper amount of sulphuric acid, and heating the mixture as long as acid fumes are evolved. We have now only to describe how the gas so produced is condensed. This is done in high towers made of brick coated with tar, or still better of flags of Yorkshire stone clamped together by iron rods and fitted to each other by indiarubber joints which are not affected by the acid, and can be made perfectly air-tight. The construction of the tower

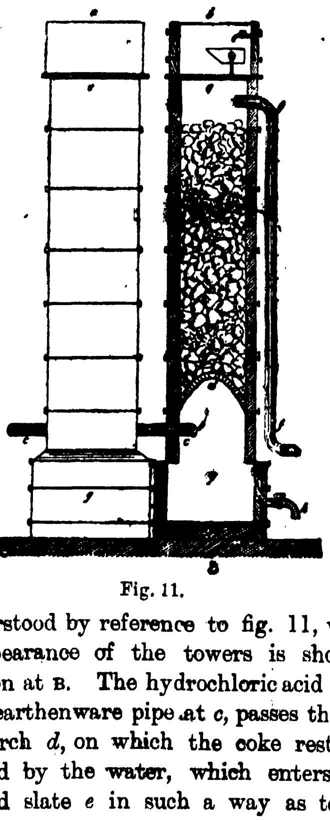


Fig. 11.

will be understood by reference to fig. 11, where the external appearance of the towers is shown at A and the section at B. The hydrochloric acid enters the tower by an earthenware pipe at *c*, passes through the open brick arch *d*, on which the coke rests, and is soon absorbed by the water, which enters through the perforated slate *e* in such a way as to moisten uniformly the entire surface of the coke. Any acid escaping absorption in the first tower is led by the earthenware pipe *ff* to the next, which is precisely similar in construction, and where further absorption occurs. By regulating the amount of acid passed up the tower and the flow of water passed down it, and also by attending to the number of towers through which the gas passes, it has been found possible to absorb all but a mere trace of the acid, which is allowed to pass up the chimney of the works, but must not exceed the limit allowed by the Alkali Act. The strong acid collects in the stone cistern *g*, and is drawn off from time to time by the tap *h*. The flow of water is regulated by an ingenious arrangement, the object of which is twofold: first, to make the stream of water on the coke intermittent; and second, to spread the water uniformly over the perforated slate *e*, and thus insure that the coke be uniformly moistened. The arrangement is shown in diagram in fig. 12. The water flows in from the tap *a* continuously, and is received in the box *b*, provided with a sloping side, *c*, and supported by pivots on upright rods at each side, *d*. By means of strips of lead nailed on at *e*, the box is so balanced that when empty it is in the position shown in the figure, but when full of water, the increased weight at *c* causes it to upset, thus spilling the water. When empty it regains the original position, until again filled (when it occupies the position indicated by the dotted line), when it at once empties; and so the alternate filling and emptying goes on continuously, and can be hastened or retarded by increasing or diminishing the flow of water from the tap.

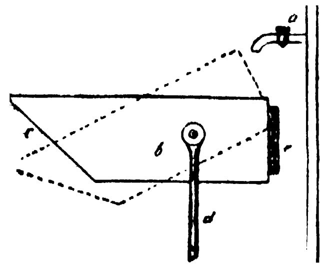


Fig. 12.

Properties. Pure hydrochloric acid is a colourless fuming liquid; but the commercial acid is always yellow, from the presence of chloride of iron, and contains besides usually arsenic, sulphuric acid, chlorine, etc. It is an excellent solvent for many of the metals, especially iron, zinc, tin, magnesium, etc., and is largely used for preparing solutions of these metals; but its chief use is for the
chlorine in order to make bleaching powder, the manufacture of which must now be described.

Manufacture of Bleaching Powder.

History. It does not appear that artificial means of bleaching were introduced earlier than the beginning of last century, and even then washing and exposure to light were the chief methods employed. But about that time improvements were introduced by the Dutch, and soon after extended to Scotland, where the process was further improved. But these methods were thrown into the shade by the discovery of Berthollet, in 1785, that chlorine (recently discovered by Scheele), possessed the property of destroying all vegetable colouring matters. Watt was shown this remarkable property by Berthollet, when on a visit to Paris, and on returning to Scotland he tried the process on the large scale at Glasgow. The bleaching was found to be perfect, but accompanied by so much injury to the cloth that the discovery seemed useless. Fortunately these defects were not irremediable, and by the joint labours of Henry, Berthollet, and Tennant, they were ultimately overcome, and bleaching by chlorine for certain classes of goods became quickly and widely extended, and is now universal. It was in 1799 that Mr. Tennant patented a process for the manufacture of dry chloride of lime, or bleaching powder, which has ever since continued to be the chief agent for bleaching by means of chlorine.

The preparation of bleaching powder is extremely simple, and consists of only two stages—

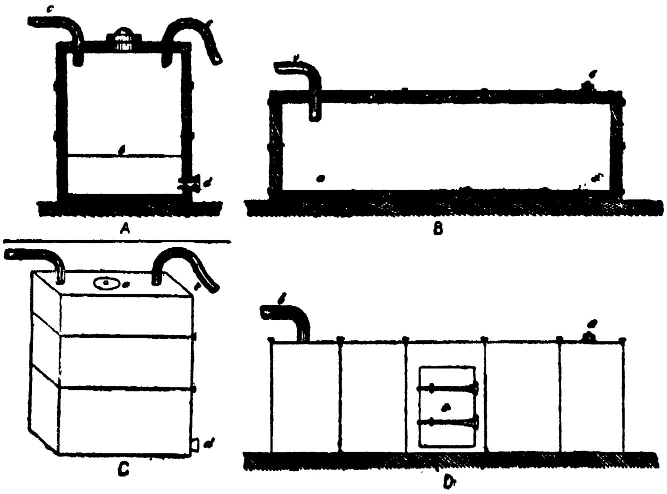


Fig. 13.

(*a*) the manufacture of the chlorine ;

(*b*) the absorption of the chlorine by lime.

Many ways have been from time to time in use for the preparation of chlorine, and these will be first considered, before passing to the means employed for absorbing it, which indeed are all very much alike.

A. Manufacture of Chlorine.

(*a*) From common salt, manganese dioxide, and sulphuric acid.—At first chlorine was prepared by the action of sulphuric acid on a mixture of salt and manganese dioxide. The materials were placed in a leaden still enclosed in an iron casing, and heated by steam. An agitator was placed in the middle and turned from time to time, to insure the thorough mixing of the contents. The reaction which takes place is represented by the following equation :—

$$MnO_2 + 2NaCl + 2H_2SO_4$$
Manganese dioxide + Common salt + Sulphuric acid.
$$= MnSO_4 + Na_2SO_4 + Cl_2 + H_2O.$$
= Manganese sulphate + Sodium sulphate + Chlorine + Water.

The evolved chlorine was led away by a pipe at the top of the still, and the waste products were drawn off at the foot. Nothing further need be said of this process, which is not now in use.

(*b*) From manganese dioxide and hydrochloric acid.—The above process was soon superseded by the use of hydrochloric acid and manganese dioxide alone, which for many years was universally employed. In this case the stills are made of stone flags, fitted together by indiarubber joints, and provided with openings for the supply of the materials, the exit of the chlorine, and the removal of the waste products when the reaction has ceased. Their external appearance and section are shown in diagrams A and C in fig. 13. *a* is the lid for admitting the materials, *b* a perforated stone shelf on which the manganese dioxide (in coarse lumps about the size of road metal) rests, *c* a pipe for supplying the hydrochloric acid, *d* a wooden plug for withdrawing when the waste products are to be emptied out, *e* the pipe for conducting the chlorine to the bleaching powder chambers. The stills are heated by steam, which is led by a pipe into the mixture of acid and manganese, and soon starts the reaction, which may be represented as follows :—

$$MnO_2 + 4HCl_2 = MnCl_2 + Cl_2 + 2H_2O.$$
Manganese dioxide + Hydrochloric acid. = Manganese chloride + Chlorine + Water.

A glance at this equation shows that *all* the chlorine in the hydrochloric acid is not obtained as *chlorine gas* by this process, but that one-half remains in combination with manganese as manganese chloride. For this reason, if for no other, the process is objectionable, and inferior to the previous process, in which *all* the chlorine in the common salt used is obtained as *chlorine gas*. Not only so, but the manganese is also lost, for when this method was in general use the waste product (chloride of manganese) was simply emptied into the nearest river and lost.

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER VII.

RESUMING our description of "Ground Plan" of house at p. 79, fig. 2, chosen as an example of working drawings, we find the "back passage" is at K K, with stairs, M, leading to the servants' part of the house in floor above, in the direction of the arrow at K. The space at L may be given to a water-closet; but as the pantry and larder are near this, it will be better to dispense with the water-closet altogether on the ground floor, as there is a water-closet in floor above (see fig. 3 and its description), and give the space to a closet, of which there cannot be too many in the working parts of a house, (see the paper entitled "The Domestic House Planner,) or to a "lavatory." The "kitchen" is at N N. The stairs to cellar floor (fig. 1, p. 337, vol. i.) will go *under* the flight M, which again lead to chamber floor (fig. 3), and enter from kitchen at right hand of M, at the point indicated by the "winders" at the extreme right-hand end of stairs, M

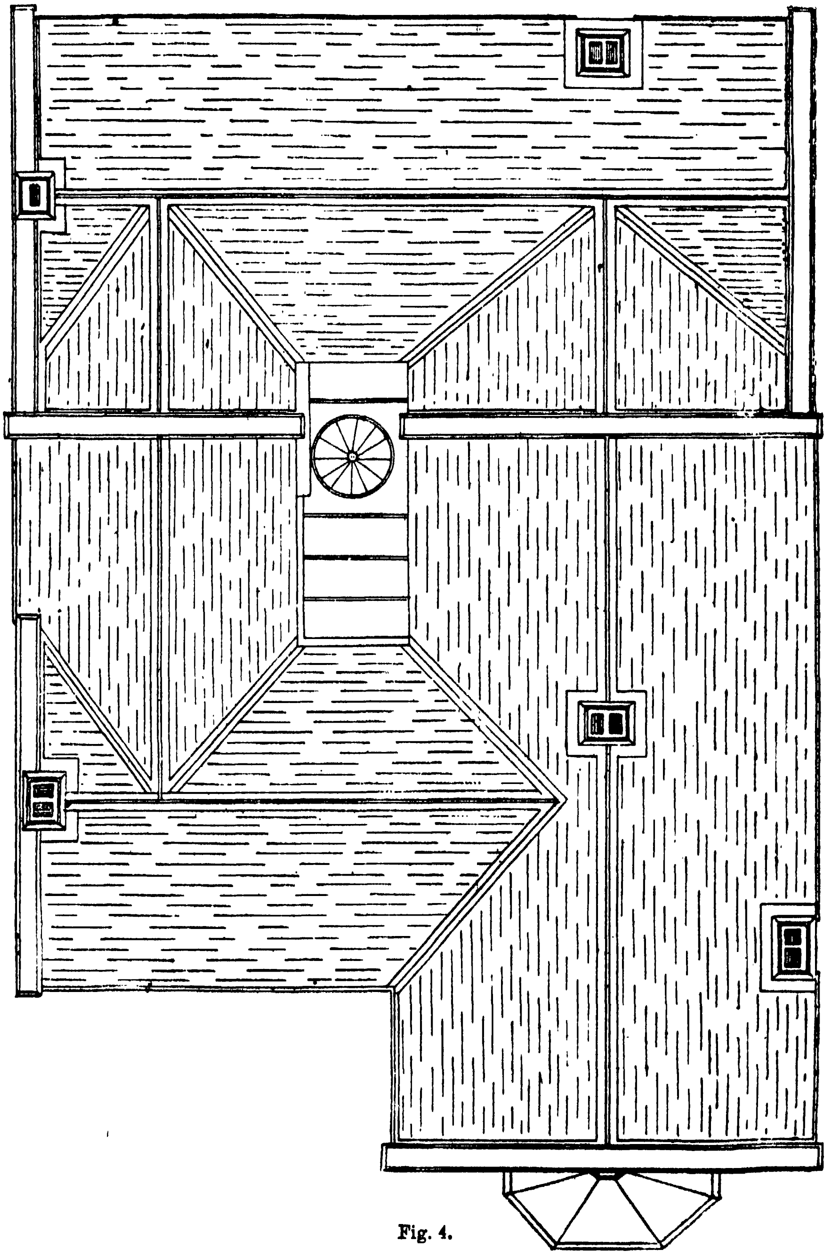


Fig. 4.

(for this term see the paper entitled "The Joiner," in the chapter devoted to staircasing and handrailing). The "scullery," entering from the kitchen N N, is at O O; P P the "larder," Q Q the "pantry" and china closet,—or L may be the china closet, according as this or a lavatory may be considered the more desirable, thus giving Q Q to "pantry" purposes only.

its window from the landing, F F, this latter is lighted by a skylight shown in dotted circles in the roof above, and in fig. 4. The "water-closet" is at N, the "bath-room" near it at K. The "back landing" of the domestics' or servants' part of the house is at L L, being reached by the stairs M M, leading from ground floor and entering from the point in the kitchen described in last paragraph nnder fig. 2. The

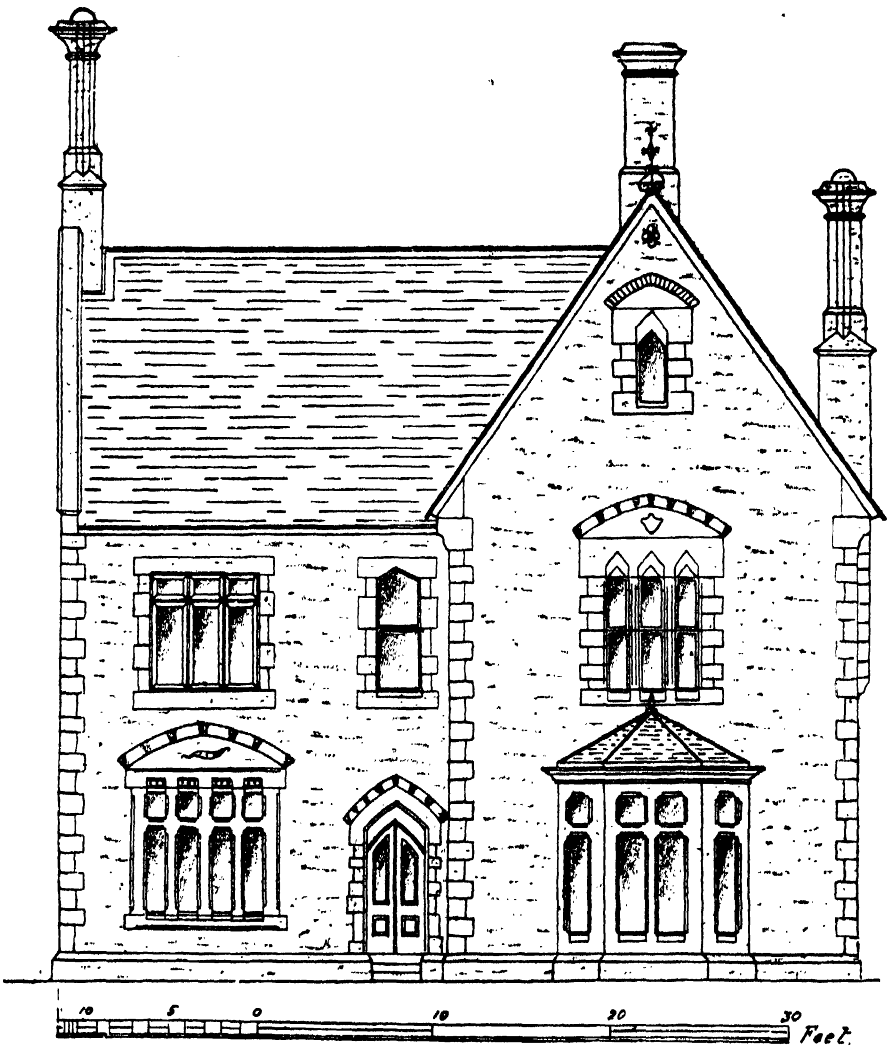


Fig. 5.

The Chamber Plan and Roof Plan of House.

Fig. 3 is the "chamber or bedroom floor plan"; the lines of longitudinal section (fig. 10) and of transverse section (fig. 9) are at A B, C D, respectively, as in fig. 2. The "stairs" leading from ground floor are at E E, F F the "landing," G G the "principal bedroom," H H "back bedroom," I I smaller bedroom, J a small "bed closet" at front end of landing. As this cuts off the light of "nursery" is at O O, the "servants' bedroom" at P P. Fig. 4 is the "ROOF PLAN."

The Elevations of the House.

Fig. 5 is the "front elevation," fig. 6 the "back elevation," fig. 7 the "side or west elevation," to right of lobby F in fig. 2, fig. 8 the "side or east elevation," to left of lobby F Q.

THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Work—The Principles and Details of its Practice.

CHAPTER VII.

Fig. 30 illustrates a mortise and tenon joint in which the face of the one piece, as *a b c d*, is oblique to the face of the other piece, of which the mortise hole is shown at *e f*. The drawing immediately below

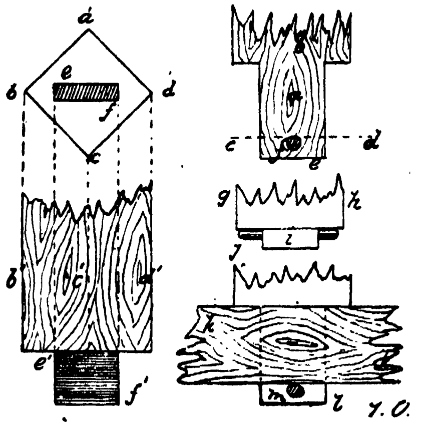


Fig. 30.

is a view of the side *b c d*, and *e f* the front face of the tenon. When the tenon of one piece, as *a*, passes right through the mortise made in the other piece, as *k k*, the tenon is made long enough to leave a piece, as *i*, projecting from the under side of the other piece

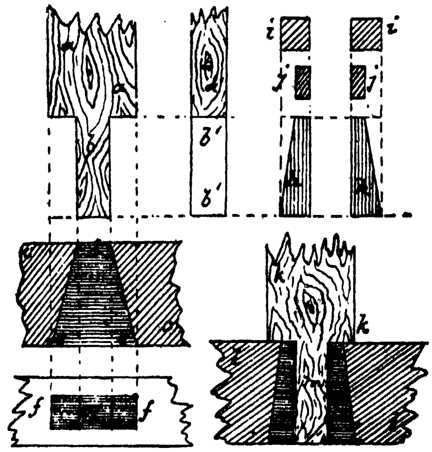


Fig. 31.

having the mortise cut in it; a hole, as *f*, is bored through the projection from side to side, as at *i*, and a pin *j* drawn in tightly through it, thus keeping the tenon in the mortise, as shown.

Another method is shown in fig. 31, in which the tenon *b* at the end of one piece, *a a*, is flat and rectangular in section, and of same breadth throughout, but the mortise in the other piece *c c*, to which *a a* is to be joined, is of the dovetail form, in which the narrow end or neck is at *d*, the base at *e e*, plan of this at bottom or lower edge of *c c*, as shown at *g* in edge view *f f*; *b′ b′ a′* is side or edge view of tenon *b* and piece *a a*; the tenon, as *m*, of piece *k k* is passed into the mortise, as at *l l*; and wedges are driven up, as at *o n*. The shape of those wedges is shown at *h h* in side elevation; section of the narrow end at *j j*, and of the width at *i i*.

Another modification of this joint, with dovetail mortise and rectangular tenon, is shown in fig. 32, and is known as the foxtail dovetail mortisė and tenon. In this the mortise is a dead mortise—that is, it is not cut through from surface to surface of the piece, but stops short, as at *c*, *e* being plan of neck or narrow part of the mortise which cuts across the whole breadth of face or edge of piece as shown. The tenon *a* on piece *b* is sawn across to a certain depth at its end, in two places, and into these saw draughts wedges, as *d*, are inserted. The whole are then forced into the mortise *c*, and driven up; and this causing the wedges pressing in the bottom, *c*, of the mortise, to be forced up into the tenon *a*, the sides of this are forced out laterally so as to fill up the spaces on each side. *a′ b′ d′* is an edge view of *b d*.

Fig. 12, Plate VII., illustrates the application of the mortise and tenon joint to the junction of a "king post" foot with a "tie beam" (for these terms see a

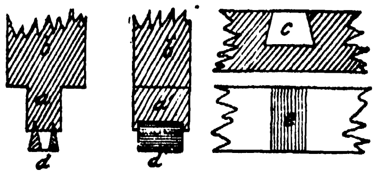


Fig. 32.

succeeding chapter upon Roofs). In this *a* is the king post, *b* the tie beam. The foot of the king post *a* is provided with a tenon, *c*, which goes into a mortise, *e*, cut in the upper edge of the beam. The termination of what are called the "struts" or "braces" are shown at *d e*; those being mortised into the sloping, butting surfaces at foot and on each side of the king post, *b* being the tenon. The mortise is shown in side view at *f*.

The application of the tenon and mortise to the junction of the foot of a "queen post" (see chapter on Roofs) with the "tie beam," is shown in fig. 6, p. 12, Chap. I., in which *a* is the queen post, *b b* the tie beam, *c c* the tenon formed at foot of the queen post; this being seamed by the wedge *d d*; *e* is end of a strut. The diagram to the right of same figure shows termination of end of the queen post of a single queen-post roof (see chapter on Roofs). In this diagram *f f* is part of the tie beam, *g g* of the foot of queen post, with its tenon *h* shown in dotted lines with wedge *i i*; *j* is part of the straining sill, *k* end of "strut" or "brace," with tenon *l* let into mortise in the butting face of queen post.

Joints used in Pieces both of which are Vertical in the Same Line.—Practical Points connected with this Class of Joints.

The joints used in forming a connection or junction between two pieces of timber, already illustrated, are all used where one of the pieces is vertical, and rests upon the other piece which is horizontal. We now illustrate joints used for the junction of two pieces both of which are vertical. This class may be looked upon as giving joints for extending the length or height of vertical pieces. Under certain circumstances the joints now to be illustrated under this head may be used in the junction of two pieces which are placed horizontally. But in such a use of them they are placed under strains which the joints are not the best calculated to resist, unless the pieces rest upon other pieces, or upon points of a building which give a solid support, if not through the whole of their length, at least for some distance on both sides of the joint. If the two pieces joined by any of the methods now to be considered and illustrated are used in circumstances other than this now named, such as the stretching over—technically called the "spanning"—of a void space, the joints are placed under severe strain, for which they are, as a rule, not calculated. Joints for this class of work are specially designed, and will in their place be considered. We proceed, therefore, to describe and illustrate the joints which are strictly those for use in lengthening out of a vertical piece by joining another vertical piece to it.

In fig. 33 we give an illustration showing the principle of the method in work of this class; it shows also the simplest form of joint used in it. The object in view is to keep the ends of the two pieces from sliding or being pressed out of contact with each other. If the end of each piece be simply squared off, and made perfectly flat—and this preparative method is necessary in all joints of this kind—the two may be kept in contact with each other merely by the dead weight of the upper piece, or by any weight pressing upon its upper extremity or top. But this contact is obviously dependent upon the stability of the two pieces. If either one piece or the other, as the top or the bottom piece, or both of them, be subjected to pressure calculated to cause it, or both, to get out of the line of stability, it is obvious that the one may be pressed more or less, or completely, out of contact with the other. Now, perfect stability depends upon the maintenance of the true vertical line of the two posts or pieces—that is, upon the two being what is technically called "plumb" (see "The Geometrical Draughtsman" for a description of what constitutes a vertical or "plumb" line, and what constitutes the difference between a line of this sort and a perpendicular—which may be two perfectly distinct and separate things, though often, and we may indeed say popularly, believed to be one and the same thing). Now, this retention of the strictly accurate plumb line in posts or pieces of timber plumb vertically is liable in all framework to be more or less dangerously influenced, and this by pressures or strains thrown upon the timber. The mere insecurity of the foundation on which the lower timbers rest may induce an unequal settlement, which will throw it "out of the plumb" or away from the vertical direction.

A side or lateral strain may from one cause or another be brought to bear upon the timber near to, or directly at, the "seat" of the joint which we are supposing to be formed by mere contact of flat surfaces square or at right angles to the length of face of the timbers, which pressure would rapidly tend to separate the two pieces. As we shall see in a future chapter, when we come to treat of the principles of framing, all framework is designed so that it shall remain perfectly stable—that is, that it shall retain the original form after due settlement or final adjustment of the parts. For when any disturbing element is not provided for, and strains or pressures allowed to act, causing even but a slight change in any one joint, as the whole parts are joined or connected together, this change may be communicated to another part. causing a change from its normal or safe condition; and as those changes set in in rapidly increasing ratio or proportion, a slight change at one part of the framing may cause a much greater change in a more remote and perhaps more vital part, and destruction of the whole may be the result. It is surprising how rapidly the total collapse of a framing follows upon the first change of a part of it from the true, stable or safe position. A crack or crink is heard, and fortunate are they who under framing hear it in time to get clear from under or off the falling mass. Joints of vertical timbers are therefore rarely made with merely squared surfaces in contact, unless in cases where the timbers are heavy and subject almost wholly to vertical pressures, lateral ones being very unlikely to come into play. But even in such joints with simple contact they often are, or should for safety be, provided with side plates of iron, or bound round with an iron hoop or strap securely fastened.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER V.

The Advantages of Brick as a Building Material, claimed for it in Preceding Paragraphs, only Obtainable where the Materials are Good and Sound.—Cheap or "Jerry" Work inadmissible.

In claiming, then, for brick such high qualities as a building material, it is of course to be understood that we refer to bricks honestly made and to brickwork honestly constructed. The bricks used to an enormous extent in the cheap and "jerry" built structures of modern times do not come within the scope of our observations; nor have such structures come within the range of our comparisons between brick and stone buildings. Those qualities or kinds of bricks made specially to suit the desire for cheap buildings are not, in truth, deserving of the name. Of these one may say, without much fear of being contradicted, that had the brickmakers of the day been capable of making such low-quality bricks as are now daily made, the bricklayers would not have used them —they would have been absolutely unsaleable. We venture to say that in none of the brick houses built about the period and during the reigns of the first Georges, or of an earlier period, as that of Queen Anne, will there be found bricks of poor quality, or bricks carelessly set and bonded. There has been of recent years a craze or rage which has led to a widespread revival of the architectural characteristics of what is called the "Queen Anne style." It would have been more to the purpose, and would certainly have indicated the rise of a higher morale, had there been as earnest an endeavour to imitate, in some degree at least, the honest use of good-quality bricks, and the as honest mode of applying them in construction, which characterised the practice of the bricklayers of Queen Anne's reign, and was observable also, as above stated, in the later reigns of the early Georges—up, say, to the end of the reign of the third George. At those periods the art of brickwork occupied a very high position in this country; and to have a due estimate of what it is capable of in giving good construction we must go back to those reigns. And it is chiefly those brick-built houses then constructed that, lasting almost in perfect condition to this day, afford us the examples by which we can compare brick as a durable material with the stones used in stone-built structures. Nor were the bricklayers of those early periods in our national history noted solely for giving good sound and honest work. They did admirable service also in showing to what an extent the material of brick was capable of giving ornamental and decorative, or in other words architectural, effect. With the introduction of so much material of the lowest possible quality, as we have seen, resultant upon the desire for cheapness of construction so widely spread now amongst us, all the higher uses of brick seem to have died out. There are, however, it is pleasing to be able to say, those who seem determined to revive the old custom of giving honestly done work with good materials. And with this revival, it is to be hoped, will come about the re-introduction of old, and also the devising of new methods of using brick, so as to give fine architectural effects.

Constituents of Bricks.—Their Influence upon their Colours.

As a practically useful conclusion to the foregoing paragraphs, we here append a few notes in connection with sundry points already treated of, or alluded more or less fully to. The first not only shows the constituents of certain bricks—and however various the localities in which they are made, they all, as a rule, present something like the same constitution—but some points also bearing upon colour, and the effect of certain ingredients and modes of burning upon this. The note is from the pen of an able Continental scientific authority, and is taken from *Dingler's Polytechnic Journal.*

"A brick manufactured in the neighbourhood of Stralsund exhibited on its surface a dark-red colour, while the interior was yellowish-white. The outer coating, of about 5 mm. thickness, and the inner portions, were examined with the following results:—

	Outer coating.	Inner portion.
Silica	63·71	71·25
Alumina	9·81	8·60
Oxide of iron	5·16	5·92
Lime	8·72	9·24
Magnesia	2·20	1·89
Sulphuric acid	8·49	0·61
Manganese	traces	traces
Chlorine	"	"
Alkalies and loss	1·90	2·49
	100·00	100·00

A still more characteristic [illegible] in the composition of the outer and inner part of a brick is shown by the following analysis of a specimen manufactured in Szegedin (Hungary). The exterior was of a dark purple-red colour, which reached to a depth of about 10 mm.; the interior was brimstone-coloured, very porous and light.

	Outer coating.	Inner portion.
Silica	45·73	56·07
Alumina	10·22	14·02
Oxide of iron	4·49	5·49
Lime	12·81	16·53
Magnesia	3·53	4·50
Sulphuric acid	19·58	0·74
Alkalies and loss	2·24	2·66
Water	1·40	0·39
	100·00	100·00

There is hardly any doubt that this large amount of sulphuric acid in the outer portion is derived from the gases of combustion, which, when coals are employed, will often contain considerable quantities of sulphur compounds."

Constituents and Properties of Fire-Bricks.

Professor (now Sir) F. Abel, chemist to the Government at Woolwich Arsenal, has made some valuable investigations into the constituents and properties of fire-bricks in use there. The following statement of these inquiries is given in *Iron.* The remarks are by the following analyses:—

Description of Firebrick.	Silica.	Alumina.	Iron Peroxide.	Alkalies, Loss, etc.
Stourbridge	65·65	26·59	5·71	2·05
	67·00	25·80	4·90	2·30
	66·47	26·26	6·33	0·64
	58·48	35·78	3·02	0·72
	63·40	31·70	3·00	1·90
Newcastle	59·80	27·30	6·90	6·00
"	63·50	27·60	6·40	2·50
Kilmarnock	59·10	35·76	2·50	2·64
Glenboig	62·50	34·00	2·70	0·80
Dinas	96·20	2·00	0·28	1·70

"Fire-clay derives its valuable properties from the presence in combination of two special constituents—silica and alumina—of which the former predominates, forming, in the majority of instances, about two-thirds of the whole; and its quality is enhanced in proportion to the absence of other constituents, the alkalies especially, which diminish its refractory power. Of these deteriorating elements peroxide of iron is the most detrimental, and indeed may be regarded as the chief cause of the wear and waste under heat of fire-bricks, etc. The district around Stourbridge has hitherto been most noted for the production of fire-clay goods; Newcastle also, and Dinas, with one or two other minor sources, have contributed to the supply. The last-named, Dinas fire-bricks, are considered the best, mainly owing to the small percentage of peroxide of iron—namely, as little as $\frac{3}{10}$ per cent., but partly to the presence of silica in excess, which is about 96 per cent.

"In Cornwall, some new deposits of fire-clay have been found, adjacent to the line of the Redruth and Devoran mineral railway, and with water carriage easily accessible. They are close to the surface, forming two considerable hills, in depth measurable not by feet only, but by tens or hundreds of feet, and can be "got" or "won" without need of mining or pumping operations. The clay is remarkably fine and free-working in its nature, rendering it easy of manipulation and treatment. Its composition is as follows:—

Silica	67·51 per cent.
Alumina	24·97 "
-	A trace.
Moisture and combined water	6·08 "
Lime	A slight trace.
Magnesia	0·64 per cent.
Alkalies	0·80 "
	100·00 "

"Fire-bricks made therefrom possess all the characteristics and qualifications for such uses: they have been tested in blast and other smelting furnaces, and found to possess powers of resistance and endurance under great heat in a very remarkable degree. The great freedom from iron probably conduces largely to this result."

The Strength of Various Kinds of Bricks.

We have said that there are on record no comparative experiments made to test the relative values or strengths of bricks and stones of various kinds and qualities. Even as regards bricks we have few experiments recorded showing the relative values of different kinds. The most complete set of recent investigations is probably that made and published by Mr. Harris. The bricks experimented upon were taken from various localities and countries, including the American States, and comprised examples of machine-made as well as hand-made bricks. The relative values, as regards strength, are calculated for dimensions as follows: length, 7 in.; breadth or width, $4\frac{1}{2}$ in.; thickness or depth, 3 in.: the two last dimensions are those usually adopted in practice, but the length is shorter by 2 in. than that of what may be called the "standard" brick, the length of which is 9 in. The reader will see, when we go into the subject of practical bricklaying, opened up in the paragraphs succeeding this, that the breadth or width of a standard brick being just one-half of the length, greater facilities are offered for securing a good bond between the bricks in a structure, than when the proportion of width to length is different, as in the brick above named, where the breadth is to the length as $4\frac{1}{2}$ to $7\frac{1}{2}$. Taking a London-made brick, the weight of which, at the ordinary dimensions of $9 \times 4\frac{1}{2} \times 3$ in., is 6 lb. 19 oz., the greatest strength is, in pounds, calculated, as above stated, for a brick $7 \times 4\frac{1}{2} \times 3$ in., 6100, least, 4126, and mean, 5064. Taking a Lancashire Oldham brick, the weight of which at the standard size was 8·31 lb., the greatest strength was 1193 lb., least, 898, mean, 982; the absorbing power, after twenty-four hours' immersion in water, was 9·27. A Nottingham brick gave as greatest strength 2142 lb., least, 1090, mean, 1583. A Birmingham brick, machine-made, gave as greatest strength, 3286, least, 724, mean, 2150 lb.; hand-made, 900, 421, 600. A brick of the same locality, a hundred years old—taking us back to the period we have already named as that of the best British brick-building—gave for greatest strength 4250 lb., least, 1160, mean, 1920. A Leeds in Yorkshire brick, machine-made, gave for greatest strength 4133 lb., least, 2616, mean, 3198; a hand-made brick, of the same locality, gave as greatest strength 1233 lb., least, 835, mean, 1038 lb. A Staffordshire blue brick—Tipton—gave as greatest strength 5553 lb., least, 2801, mean, 3975.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER IX.

ALIZARINE BROWN is generally made, like chocolates and maroons, from old colour, but if ordinary alizarine paste be used the following recipe may be adopted to produce good brown:—

Alizarine paste, 10%	18 lb.
Thickening	2 galls.
Red liquor, 20° T.	2 pints.
Red prussiate of potash	1 lb.
Acetate of lime, 20° T.	1 pint.

5. Alizarine Dyed Style.

Although less care is necessary in the production of the "colour" for printing in this class of work than in the case of extract alizarine colours, still, considerable care is required to produce the best results. Moreover, the red obtained by this method is much better than that which can possibly be obtained by printing the extract.

Of course, a great advantage which the latter has over the former is that extracts may be combined with a very much greater variety of colours than can dyed work. To understand this it has only to be remembered that in dyed work the entire cloth is worked in the dye-beck, so that any colours previously printed on the cloth require to be such that they are not injured by the dyeing process. The mordant is first printed upon ordinary bleached calico.

DYED ALIZARINE RED OR SCARLET OR TURKEY RED.

For a moderate shade of red may be taken:—Acetate of alumina at 13° or 14° T., thickened with starch or flour. It is then aged, either by hanging it up in the air for a night, or by quick passage (about three minutes) through a steam chest. By this process the acetate of alumina mordant is decomposed, or partially decomposed, acetic acid is given off, and alumina or hydrate of alumina is left on the cloth. It is then passed, open, through a bath consisting of about $\frac{1}{16}$ of an ounce solution of bin-arseniate of soda and $\frac{1}{16}$ of an ounce concentrated solution of glue per gallon. It remains in this bath ten minutes; it is then washed in cold water, entered into another bath, in the rope-form, about a fourth part stronger, for half an hour. It is afterwards well washed, allowed to remain for one night exposed to the air, washed again, and entered into the dye-beck, cold. To the dye-beck is added about six quarts glue solution to every thousand yards length of cloth. The pieces are run in this for five minutes, then 1 lb. of sumac, 4 oz. of chalk, and then the necessary quantity of alizarine added. The average amount of alizarine put in the dye-beck is about 15 lb. of alizarine paste, 10 per cent. This bath is gradually brought up to a temperature of 160° Fahr. in one hour. The goods are taken out, washed, and passed through a solution of glue and bin-arseniate in about the same proportions as in the first case for twenty minutes at 150° Fahr. They are then washed, dried, and passed through the preparing machine. The latter process, already described, is to saturate the cloth with dilute oil-emulsion; after passing through the emulsion the cloth passes between two heavy rollers, the top one covered with india-rubber, and the bottom one of wood or brass; then passed over heated tins to dry. The next process is to pass through the steaming apparatus for about two hours. Next they are soaped, at $\frac{1}{2}$ oz. of soap per gallon, at 130° Fahr., for ten minutes. Next they are passed into a bath at the same strength at 140° Fahr. for twenty minutes; then a similar one at about 165° Fahr. for ten minutes; then into another at 120° Fahr., which is kept constantly clean by a good supply of water and soap. This latter is called the clearing beck. Finally, they are washed in cold water, dried, and finished as required.

Imperfect "Whites."

In some cases the "whites," or those portions of the cloth that are unprinted upon, are imperfect —*i.e.*, they become slightly tinged with alizarine red. This is generally due to one of the following causes:—(1) Unskilful printing, as, for example, a bad doctor edge, failing to remove all the mordant from the smooth parts of the roller; the mordant consequently is printed upon the parts of the cloth that should be white. (2) Uneven drying after preparing, whereby, during steaming, the red "runs" into the white, or smears. (3) Dirty cloth.—In this case the goods are run rapidly through a machine similar to the preparing machine, in a weak solution of bleaching powder. The pieces are dried without washing, then soaped again through the clearing beck, washed and dried for finishing. It must be mentioned, however, that exceeding care is here necessary to adjust the strength of the solution of bleaching powder, so that, while it is sufficient to clear the whites, the clearing action stops before it injures the red. Indeed, it is highly undesirable to employ this process except when found absolutely necessary to cure a dirty white accidentally obtained.

Combination of Colours in this Style.

The combination of colours most extensively applied in this style are aniline black and alizarine red. In this case the course is exactly similar to that just described, except that along with red mordant is printed aniline black, and before dunging, the goods are, on account of the latter, passed through ammonia gas by simple rapid passage through a large box or room filled with the vapour. Alizarine black or lilac may also be dyed with alizarine red and pink; the same process exactly is gone through, the mordant in this case being acetate of iron instead of red liquor.

Dyed Alizarine Chocolates and Blacks.

For a black, iron liquor at 8 T., thickened with flour, is printed on, and then the goods are treated like alizarine red. For a chocolate, a mixture of 1 part red liquor at 3° T., and 1 of iron liquor at 8° T., thickened with flour, is employed. For lilac or purple, iron liquor at about 1° or 1½° T., thickened with flour, may be used. These may, of course, be applied separately, or in combination with red.

6. Resist Style.

This consists of designs produced by the action of a *resist*; either a chemical or a mechanical action taking place, or in some cases both. A "resist" is a composition printed upon certain parts of the cloth in order to protect those portions from the action of some process to which the cloth is afterwards subjected. It is generally applied to prevent the deposition of a colour or mordant upon certain parts, thus leaving them the original ground, which may either be white cloth or previously dyed cloth.

Resists may be divided into several classes, as follows:—

(1) *Resists for Alizarine Red.*

That generally used is limes or lemon-juice at 12° T., thickened with farina gum or calcined starch. This is printed on the cloth in the pattern required; the cloth is then "padded" (*i.e.* printed all over) with a plain or pad roller, with acetate of alumina at 2° T. It is next aged in the air, dunged and dyed, etc., in the ordinary way as already described, and those parts which the lime juice touches remain white, so that we have a white pattern upon a pink ground. A mordant for a dark red may be printed along with the lime juice, and then padded in pink mordant; and the effect is a white and pink pattern upon a dark-red ground.

Lime juice resists chocolates and purples in exactly the same way.

Another resist for extract alizarine colours is oxalic acid. A solution of oxalic acid is obtained by heating the crystals of the acid in gum gedda solution; this is printed on the calico either alone or combined with aniline green mixed with oxalic acid, or other colour that will not be injured thereby; also with dark extract red, of course without the addition of acid. About 3 oz. of oxalic acid to the gallon of colour is the average strength. Next it is padded with extract pink, aged in the air, steamed for 2¼ hours, and then soaked, ½ oz. to the gallon, for five or ten minutes at 130° F. In the case of combining aniline green, in this style, it is necessary to pass the goods through solution of tartar emetic, ½ oz. of the salt per gallon, at 130° F., in order to fix the green. Berry carmine yellow and aniline blue may also be combined in the same manner. In this style, by skilful combination, a variety of fine effects may be produced.

(2) *Resists for Pigments.*

This is a resist of which the action is both chemical and mechanical. A mixture of acetate of zinc and china clay, thickened with gum senegal solution, is printed on the cloth, and a light ultramarine blue (at about 4 oz. per gallon) is padded on, steamed for half an hour, and passed through hot water at 130° F., and finished. Those parts covered by the resist are white upon a pale-blue ground. Along with the resist may be printed a dark ultramarine blue, and after padding all over in pale-blue we have a dark-blue and white pattern upon a pale-blue ground.

(3) *Mechanical Resist—termed "Pasting."*

There is another kind of resist, called "paste," which is used for preserving or protecting reds. A combination of black, red, and pink mordants is printed on the cloth; it is then dyed and soaped in the usual way; next, a starch paste, about 1 lb. to the gallon, is blocked on the top of the red and pink, and pale green is padded on. The goods are then steamed, passed through a weak chrome solution cold, washed and dried. The starch paste throws the green off, or resists, and is itself readily washed off; and the result is a pattern in black, red, and pink upon a green ground.

(4) *Aniline Black Resists.*

Several resists have been proposed for aniline black. The best are sulphocyanide of ammonia and caustic soda. Either of these substances is printed on calico and dried; it is then printed (padded or covered) in aniline black, aged and soaped.

7. Discharge Turkey Red Style.

Turkey red cloth, or dyed alizarine scarlet, is the fastest and one of the most beautiful of coloured fabrics. It is not materially injured by dilute solutions of soap, alkalies, acids, chemic or bleaching powder, nor by light and air. It is, however, instantly discharged or bleached white when brought in contact with moist free chlorine. An application of this fact forms the basis of one of the most interesting and beautiful of the processes of calico printing—namely, the production of a white or coloured pattern upon dyed alizarine scarlet cloth.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XII.

The Pendulum and its History.

In the last paragraph of the preceding chapter we related that it was to the celebrated Galileo that the discovery of the pendulum is due. The cathedral of Pisa, in Italy, which Galileo doubtless often attended, was provided with large chandeliers suspended by long and strong cords from the lofty ceiling. Under various influences—chiefly that of draughts or currents of air, the strength of which, as they sweep through the interior of the grand and vast cathedrals of the Continent, many of our readers may have experi-

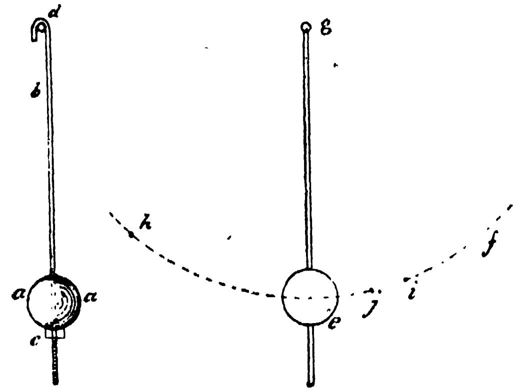


Fig. 3.

enced in their travels—those chandeliers had motion given to them as they were suspended. Galileo had observed, what thousands before him had seen but never thought of, that there was a singular degree of uniformity in their swing or sweep as they slowly went in one direction and returned in the opposite. Galileo was what would nowadays be called a "born engineer," and therefore began to think about what he had thus observed: the result of his thinking was the discovery of the pendulum—a discovery of which it is quite impossible to overestimate the value to man. A pendulum is, as every one knows, a very simple apparatus in itself, which swings to and fro as it is hung or suspended from a point. Its name is derived from the Latin word *pendulus*, and this from *pendere*, to swing.

Mechanical Principles or Features of the Pendulum.

It is in the peculiarities of the "swinging" that the value of the pendulum as applied to clocks or timekeepers, and all its modifications as met with in machinery, lies. Fig. 3 illustrates its general arrangement and those peculiarities. *a b c* is the pendulum, exhibiting what may be called the minimum of simplicity of mechanical combinations and constructions, for it consists simply, generally, of a circular weight, *a*, having the faces curved or forming parts of a sphere. This is screwed either simply on to the end of a rod, *b*, or a small nut, *c*, is used to raise or lower *a*. This is suspended at its upper extremity to, and swings upon, a rod or pin at *d*—a pretty fair copy of the suspended chandelier Galileo had observed in Pisa cathedral. Supposing the pendulum to be practically constructed and arranged as shown, and that the ball or weight *a* is taken hold of and carried up in the direction of the arc *e f*, till it reaches the point *f*, if then released from the hand the ball or weight, as *e*, will fall or descend through an arc of a circle the radius of which is *f g*, till it reaches the point *e*. But it will not stop here, as in the first instance, when it was at rest. In accordance with the laws of attraction of gravitation, already explained in preceding paragraphs, the movement from *f* to *e* imparts, so to say, a constantly increasing velocity, and this velocity in conjunction with the weight of the ball gives the property or quality known as "momentum," yet to be fully described in a future paragraph, but which may here meanwhile be defined generally as a force or power which enables the ball at *c* to travel up the hill, so to call it, from *e* to *h*, in opposition to the force of gravitation. As the motion from *f* to *e* was an "accelerated" one, so that from *e* to *h* is a "retarded" one, so that on reaching the point *h* in the weight, the power or force of momentum ceases, and the attraction of gravitation beginning to act, the ball falls from *h* to *e* with a constantly accelerated motion, and the force or power, so here to call it, of momentum, sends the ball "up the hill," so to say, from *e* to the same point *f* as before. Theoretically this action would go on constantly, so long as the integrity of the construction remained—as, for example, till this was destroyed by the wearing out and giving way either of the eye of rod *b*, or of the rod or pin *d*, on which it is suspended, or of both. But practically two elements or factors in the calculation come into play—namely, first, friction—at this very point of contact of "eye" with "pin" *d*, and second, the resistance offered by the air as the ball *a* sweeps to and fro through the paths *h e*, *e f*, and *per contrâ*. In the application of the pendulum to a clock these two factors are eliminated or practically got rid of by employing a falling weight; in its application to a timepiece a spring is used, the action of which through appropriate mechanical means counterbalances the effect of friction and of air resistance. When under the influence of a falling weight, or a spring, the extent of sweep, as from *e* to *h* in fig. 3, is the same as that of the sweep from *e* to *f*; but where a pendulum is simply suspended so as to be free to swing, yet only when under an extraneous force, as the impulse of the hand—when that force is withdrawn, the sweep of the pendulum weight *a*, or "bob" as it is technically called, becomes less and less, say as from *e* to *f*, then next sweep or swing from *e* to *i*, then from *e* to *j*, and so on, till in time it comes to rest, hanging as at *d b* or *g e*.

Isochronous Movements, or Equal Beats or Swings, or in Equal Times, a Feature of the Pendulum.

When set and maintained in motion the vibrations, or "beats" as they are technically called, are all equal for equal times—for that particular length, that is, whether the sweep or swing or the arc through which it moves be long, as *e f*, fig. 3, or short, as *e j*. It is this property which gives to the pendulum its value as a measurer and registrar of time. The young mechanical student may have at first a difficulty to see how the time taken by the ball or weight to fall from *f* to *e*, which we suppose to be twice the distance, as from *e* to *j*, can be the same as that taken in falling from *j* to *e*. The following will explain how this is, and also how some of the points are applicable to practice in certain classes of mechanical design. Let the student conceive of a circle as a polygon with an indefinite number of sides, each of which is a straight line—and which conception is scientifically accurate (see "The Geometrical Draughtsman"): he will see that the larger the circle the longer must be the straight lines which form the sides of the polygon, and that at any point in its circumference the circle will approach nearer to a flat surface than when the circle is small in circumference, and this made of lines which are therefore shorter. A straight-edge (see "The Building and Machine Draughtsman"), for example, laid upon the surface of a very large globe, the periphery or outside surface of which is of course a circle, will touch the globe surface for a considerable part of its length, and this touching surface will be reduced in proportion as the side of the globe is diminished or its periphery reduced, till at last a globe will be found with its circle so small that the straight-edge will touch or rest upon the surface of the globe at a single point only. And this the reader will perceive arises from the fact that the smaller the circle the shorter the lines of the polygon, and the quicker therefore do they turn or bend away from each other. We have just seen that in a large globe or circle part of its surface is flat, or nearly so, and that the more this line of surface is extended, or the further the globe is gone round, the steeper becomes the curve; in other words, the point *a*, fig. 4, is as much higher above *b* as the point *d* on the line *a c* is greater than *d e*. Simple as this point may now appear to the reader—too simple, as some may think, to be worth noticing here—it is nevertheless true that either to ignorance, or forgetfulness of it when understood, some grave errors tending to large losses have been made in machine designing—as, for example, in the case of pulleys and driving drums. The greater the arc, then, as *b a*, fig. 4, through which the pendulum ball *b* sweeps, and the higher the points terminating it, the steeper therefore is the incline, both near its beginning, as at *a*, and its ending at the point *f* on other side of *h b*, corresponding to *a*; the quicker, therefore, is its "drop" or descent from *a*, and the faster it moves through the space. So much the faster in proportion as the length of its sweep is greater, that if we suppose two pendulum balls to be so arranged that the ball *d* would drop from point *d*, and ball *a* from point *a* precisely at the same moment, the ball *a* would from its steeper or higher drop have at the start a so much higher velocity given to it as compared with the slow start of the lower or less steep drop at *d*, that the ball *a* would, so to say, overtake the ball *d* at a point below *d*, and that it would arrive at *b* at the same time as that from *d*, at this the lowest point. On going up the other side of the sweep or arc, the ball *d*, which started from the point *d*, would have a gradually retarded motion till it stopped at the point *g*, corresponding to point *d*; but the ball from *a* would go up to the point *f*, corresponding to *a*.

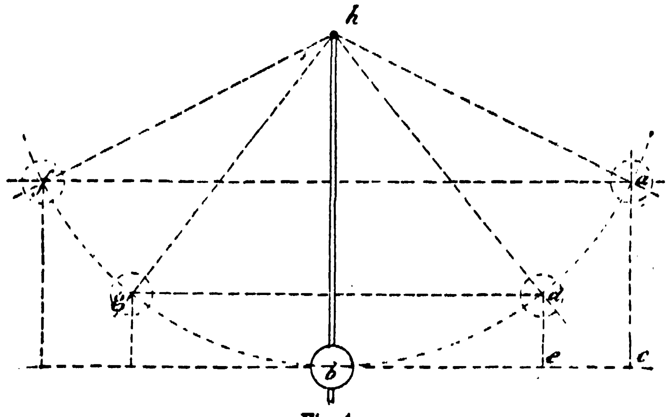


Fig. 4.

Time taken by the Swings or Sweeps of a Pendulum, or the Number of Beats in a given Time, dependent upon the Length of the Pendulum.

The above is true when pendulums are of the same length, no matter what the length of the arc through which they sweep, for the longer the arc the steeper are its sides or the higher its terminating points, and the quicker the drop or descent of the ball. But while in such cases the beats or the extent of the swings of the pendulum are equal in any one given length of pendulum, the youthful reader must not suppose that this is the case with pendulums of different lengths; he must bear in mind the distinction between the times due to the length of the rod of the pendulum, as *h b* (fig. 4), this length being measured from the centre, *b*, of the weight or ball technically called, as we have said, a "bob" at *a*, and the centre of suspension or "centre of oscillation," as it is termed the eye, at *h*. The time taken to traverse any given arc is dependent upon the length of the rod. The larger the rod the slower its swing, or the fewer the number of "beats" in a given time. In a clock each beat is known as a "click," caused by the movement of the escapement taking into the teeth of the first-motion wheel; and to beat seconds—that is, to begin and complete one swing exactly in one second—the rod must be thirty-nine inches and one-eighth long. To beat half-seconds the length must be one-fourth of this, or say nine inches and three-quarters; to beat what are called double seconds—that is, to give one beat in two seconds, the pendulum must be four times the length.

The youthful reader may here again be at first puzzled how there should be this great difference in the lengths of pendulums, when there is so little difference in the times of the beats. He may naturally enough suppose that a pendulum which gives one beat every second would, when required to give one beat in two seconds, be half, not one-fourth, as long. A brief inquiry showing how this is, will be valuable as bearing not only upon this particular point, but on others as regards "motion." We have just seen that as the length of the pendulum rod (technically the term pendulum is used to indicate the rod) so is the rate of its vibration or beat, and the reason why a long pendulum vibrates more slowly than a short one is simply this: that the bob *a* of the long pendulum *b a* (fig. 5) has a longer space (as *a c* or *a d*) to traverse than the "bob" *e* or "bob" *i* of the two shorter pendulums, as *f e*, *j i*, which have only to traverse the much shorter spaces *e h*, *e g*, and *i k*, *i l*, respectively. The reader may, in remembrance of what was said a few sentences back in connection with fig. 4, conceive this to be erroneous; and so it would be if with the longer traverse of the arc, as *c d*, there was a proportionately greater steepness in it than in the arc *h g* or *k l*. But a little investigation will show him that the cases as in *f g b d a* (fig. 4) are not identical with those in *c d*, *h g*, and *k l* (fig. 5). If those latter arcs were continued so as to form complete

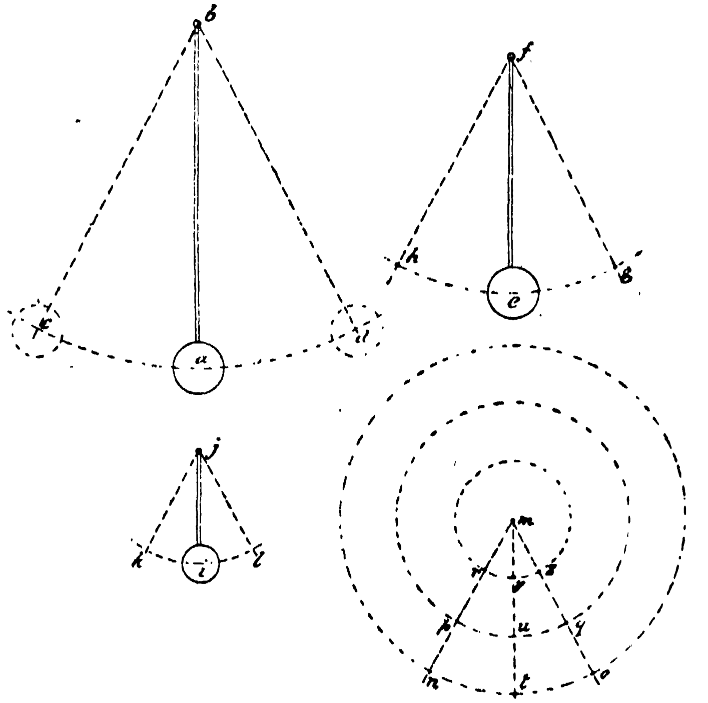


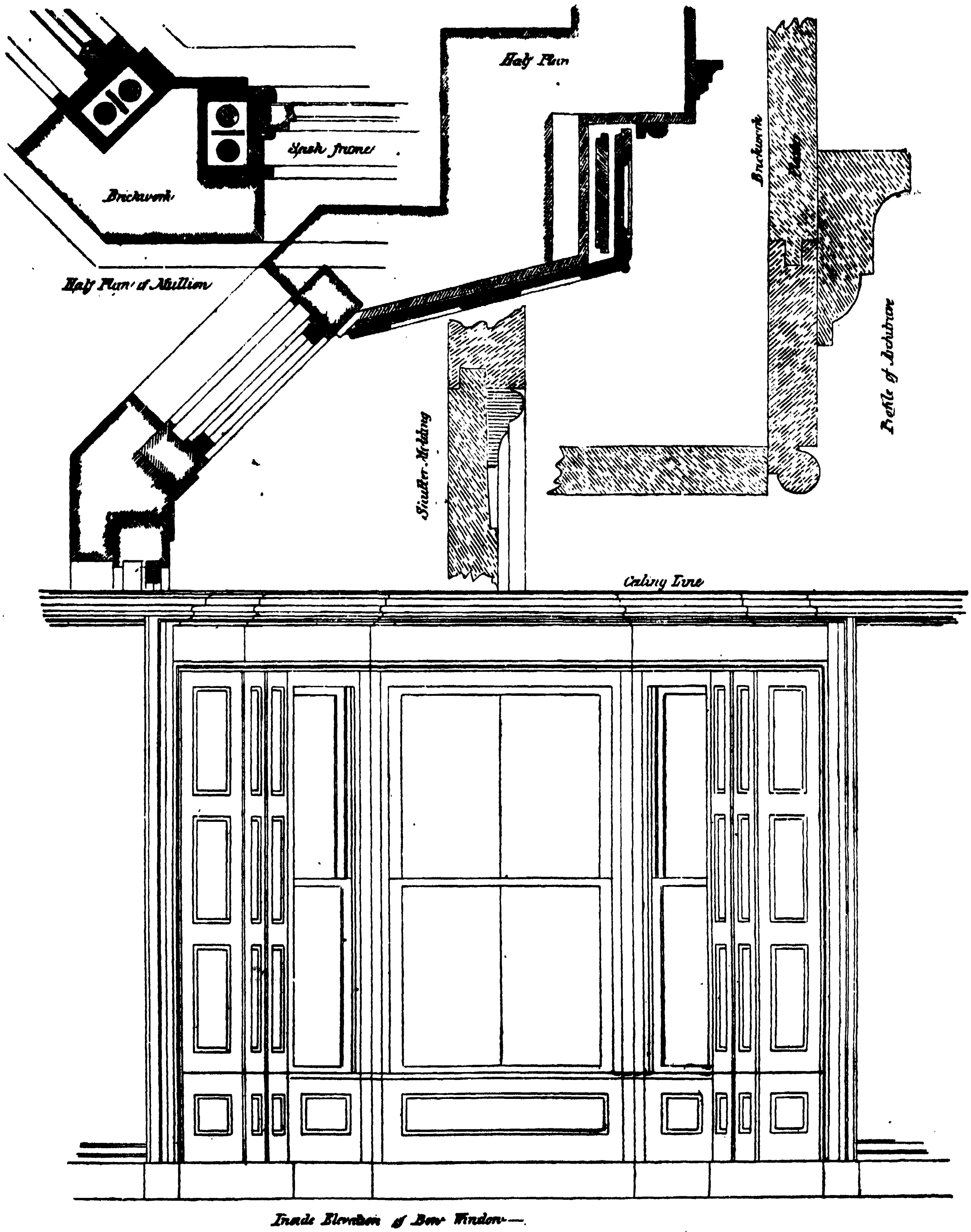
Fig. 5.

circles, the inner circles would be what are called concentric (see "The Geometrical Draughtsman"), being described from the centre *m* (fig. 5), common to them all, and this gives at corresponding points of the arc three concentric arcs, *m n o*, *p q*, *r s*, the inclinations as *n t*, *p u*, *r v*, are of equal angles, each being at the same angle, so that the "steepness" is the same in all, and the rate at which they start in all being the same, the only difference is the length of the incline or drop, *n t* being so much longer than *p u*, and *p u* than *r v*. Now, we have seen in a former paragraph the law which regulates the descent of falling bodies; and if the reader refer to this he will see how a body falls in two seconds a distance *not twice but four times* as great as that of a body in one second: hence the "bob" of the long pendulum, *m t*, fig. 5, which we suppose to beat double seconds, must be four times—not twice—as far from the centre *m* as the distance of the bob *u* from *m*, which we suppose to beat "seconds." The rods of pendulums are generally made of metal, and as this expands or contracts according to variations in temperature of the atmosphere, however accurately proportionated at first to give definite beats—the seconds' beat being what may be called the standard—this length will change or vary according to the thermometric condition of the atmosphere. In ordinary clocks a method is provided of adjusting the length of the pendulum so as to compensate for contraction or expansion of the metal of the rod, by terminating this with a screw, and providing it with a small nut, *c*, fig. 3 (*ante*), on which the lower part of the bob, *b*, rests. By raising this nut the bob is raised, and its centre carried of course nearer the "centre of oscillation." This shortens the pendulum, so that it gives a quicker beat than before the alteration; and this makes the clock, for example, go quicker. The converse of this gives a slower "rate" to the clock by lengthening the pendulum—that is, by dropping the nut. A great variety of what are called "compensating pendulums" have been from time to time introduced, some of them of a most elaborate and ingenious character. In all the principle is this: that different materials are employed, each of which has its own special rate of contraction and expansion under a rise or fall of temperature, and these are so arranged in connection with the suspending rod of the pendulum that they, counteracting each other in due proportion, give to this suspending rod what may be called a neutral condition, so that *it* remains always at one uniform length, therefore there is no variation in the time of its beat; if set for seconds it keeps beating seconds in all climates and changes of temperature. We have given certain lengths of pendulums as giving certain beats; to find other lengths the following rule may be employed. Put in another way, the times in which a pendulum vibrates or beats are as the square root of its length; and the number of vibrations in a given time—as a second, the usual standard, is inversely as the square root of the length. We have seen that a pendulum to beat seconds must be $39\frac{1}{8}$ inches long, represented by T: to beat in any required ratio to this number of beats in a minute, namely 60—as, say, to beat one-third more, or 80—taking x to represent the rates required or increased number of beats, we have the formula or proportion: As the square root of T is to the square root of x, so is the number of beats required to the standard beats of 60.

The application of the points connected with the operation of the pendulum to various mechanical movements might be noticed here *in extenso.* We have, however, space to notice one or two only. We do not here do more than very briefly refer to the use of the pendulum as a measure of time, although in this aspect it has been of such vast service to mankind that it is practically impossible to overestimate its benefits. But the application of the principle of the pendulum to what we call clocks was in itself a remarkable example of mechanical ability; and although we do not usually consider the clock as a machine—at least, that is not the popular conception of it—it is, notwithstanding, a machine, and moreover a very beautiful one, in which there is a perfect mechanical relation of all the parts one to another; and accurate movement of time-registering can be easily traced back to the primary source of synchronous or equal movements of the pendulum, in which all the swings, no matter whether those be short or long in extent, are taken in the same period of time. But the application of the principle of the pendulum to the watch or small timepiece—to neither of which was the pendulum with its "bob" and rod applicable—through the medium of the spring and the balance-wheel, was also a fine example of ability in applying a principle mechanically. For although the student may not at first sight see the connection between a pendulum of an eight-day clock, for example, which takes up great space, and the spring and balance-wheel of the watch, which take up so little that it may be, nay, as it has been, made but little larger than a pea, yet the two mechanical contrivances are the same in principle: the bob of the pendulum falls to its centre through gravitation, or it may be said to be pulled towards it.

"THE JOINER" AND "THE BUILDER" (see Text).

Bay Window Details. (See Plate CXII.)



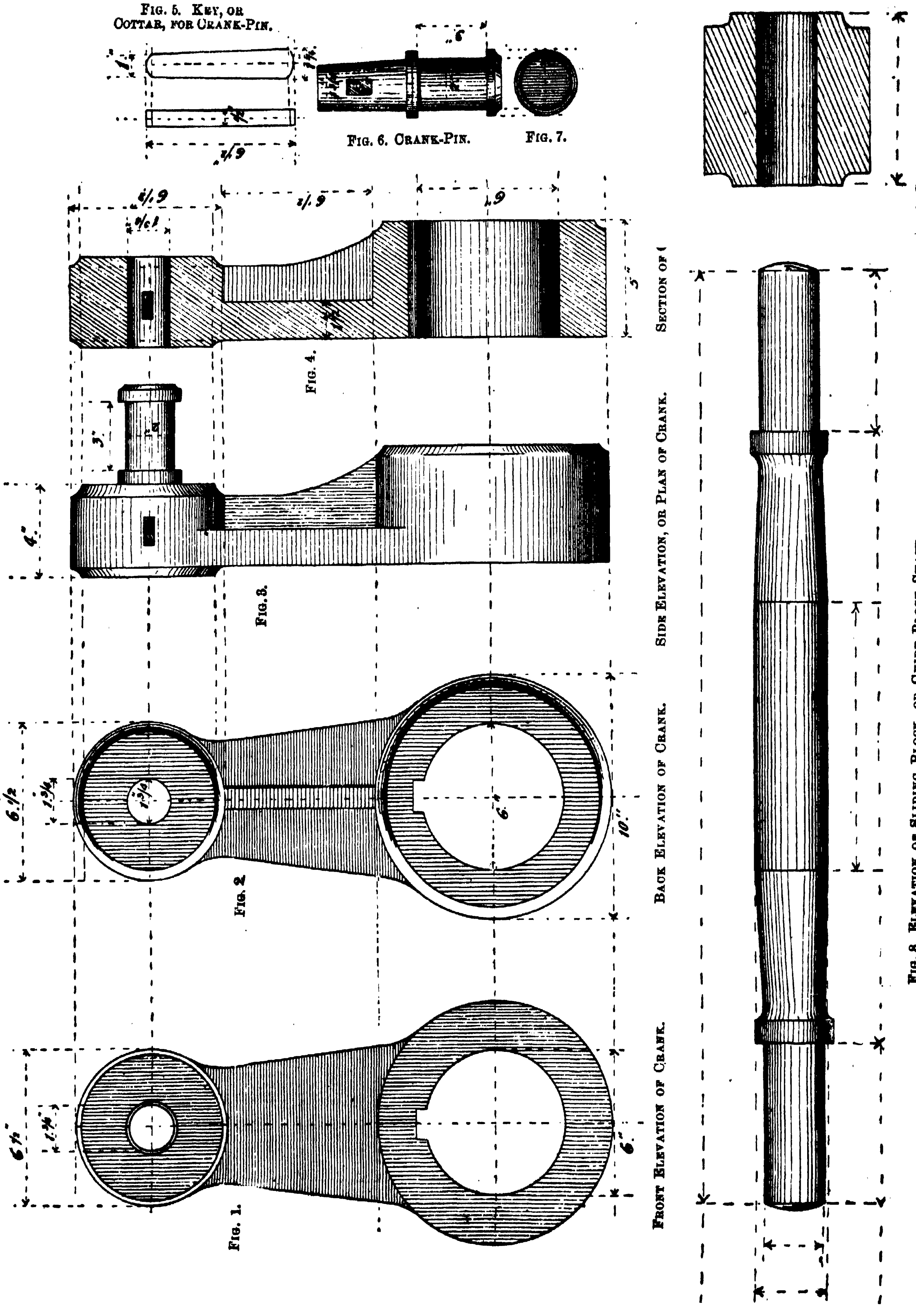


FIG. 5. KEY, OR COTTAR, FOR CRANK-PIN.

FIG. 6. CRANK-PIN.

FIG. 7.

FIG. 9. SECTION OF SLIDE BLOCK.

FIG. 4. SECTION OF CRANK.

FIG. 3. SIDE ELEVATION, OR PLAN OF CRANK.

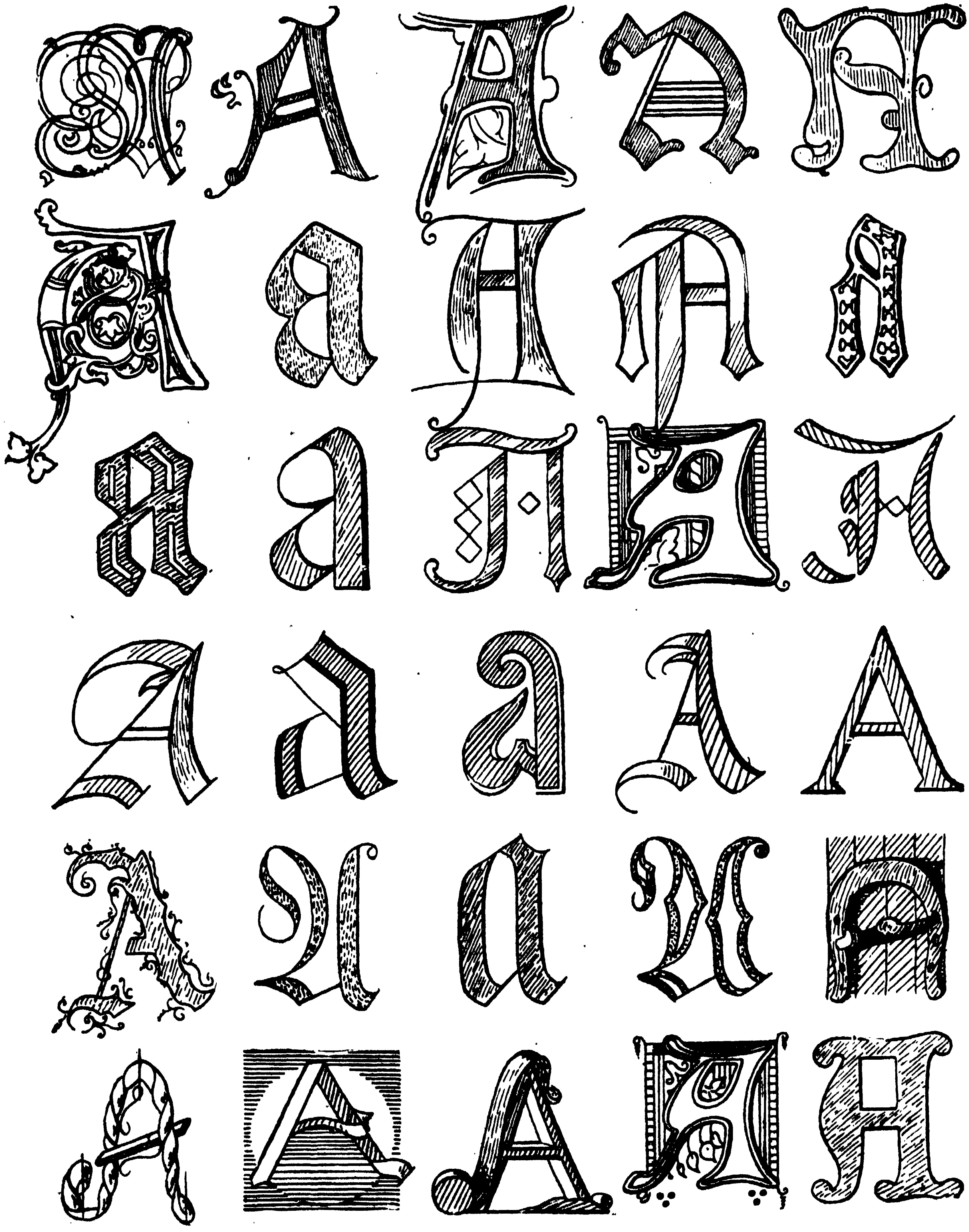
FIG. 2. BACK ELEVATION OF CRANK.

FIG. 1. FRONT ELEVATION OF CRANK.

FIG. 8. ELEVATION OF SLIDING BLOCK, OR GUIDE BLOCK SHAFT.

FORM AND COLOUR IN INDUSTRIAL DECORATION (see Text).

ORNAMENTAL LETTERING—SUGGESTIONS FOR CAPITALS.



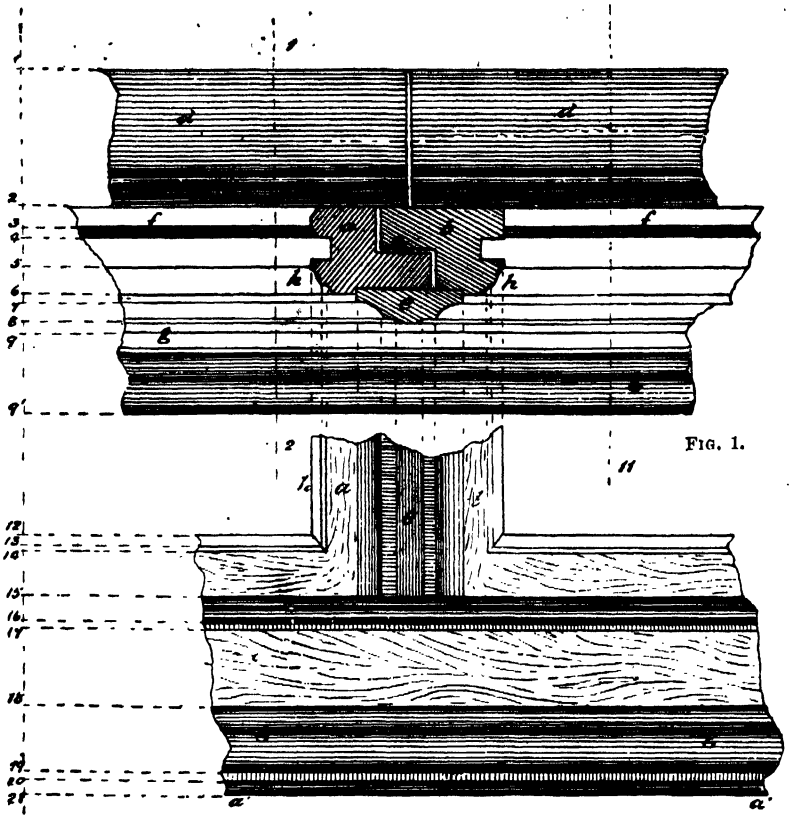


FIG. 1.

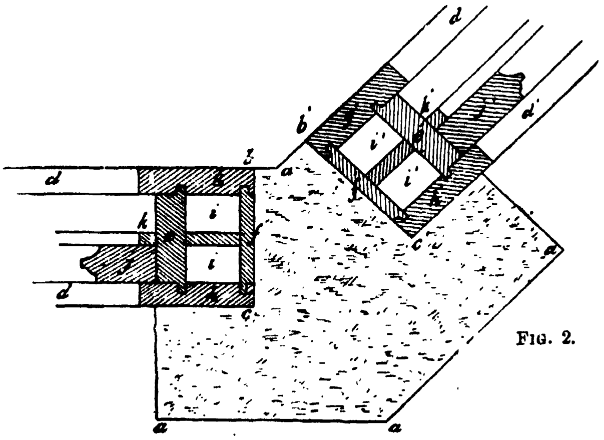


FIG. 2.

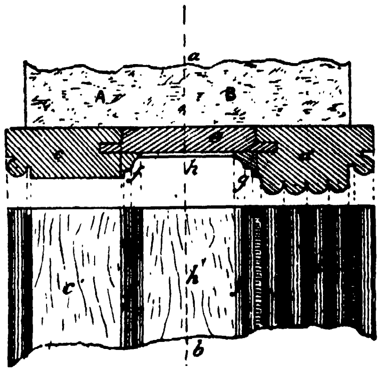


FIG. 3.

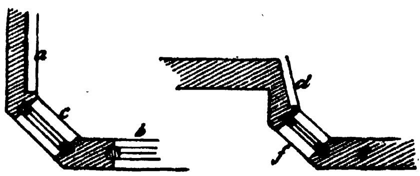


FIG. 4.

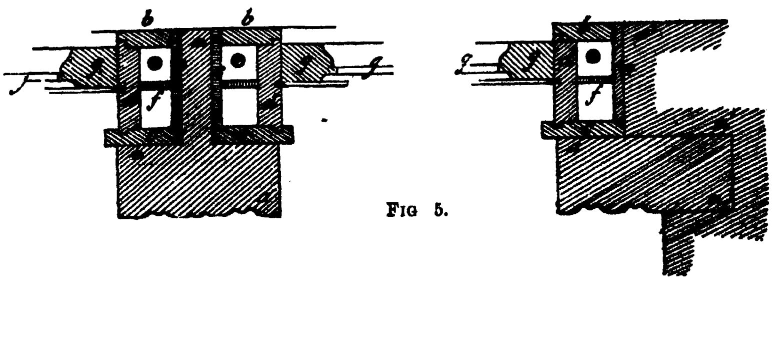


FIG 5.

Contrasted Elevation. Effect chiefly obtained by Foliage.

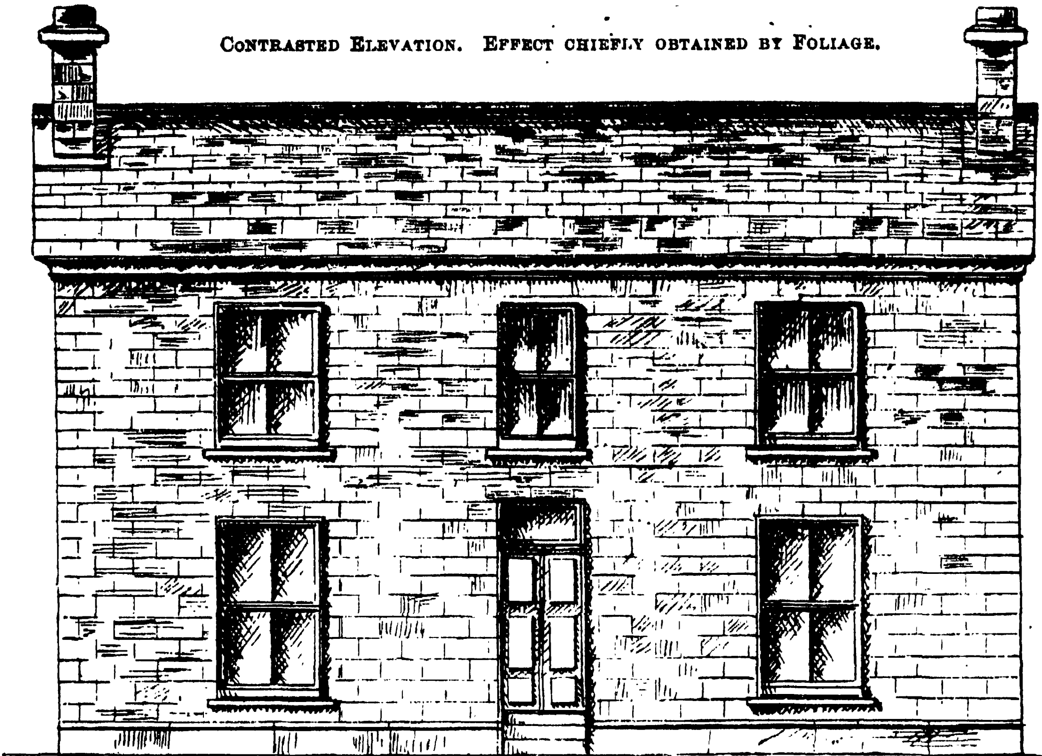


Fig. 1.

Fig 2.

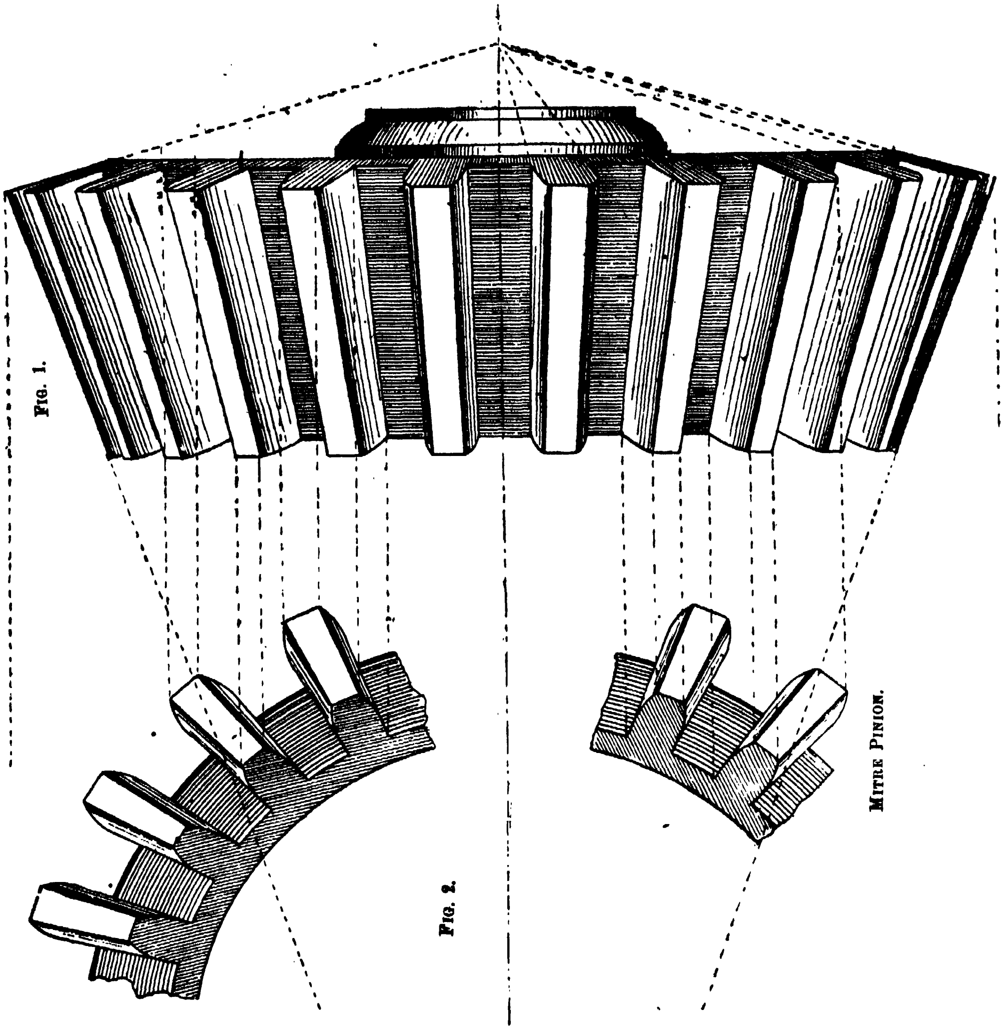


Fig. 1.

Fig. 2.

Mitre Pinion.

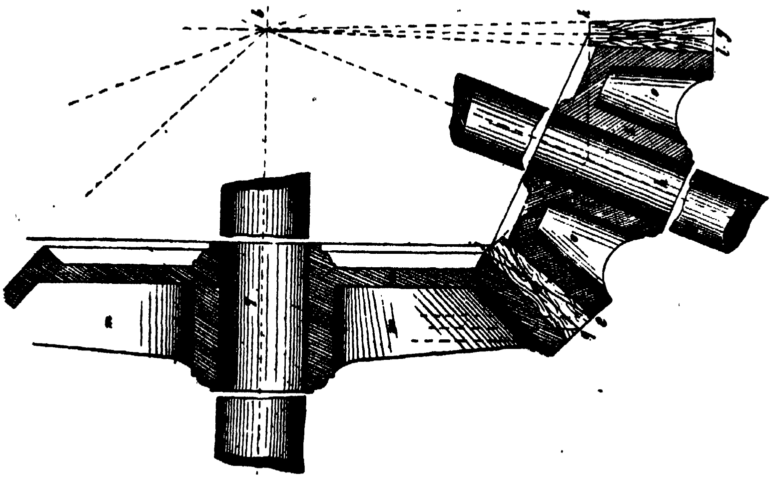


Fig 3

Bevel Wheel and Piston.

VARIETIES OF MOULDINGS. FIGS. 1, 2, 3, 4, AND 5, GOTHIC; FIGS. 6, 7, 8, 9, CLASSICAL OR ITALIAN.

Fig 1

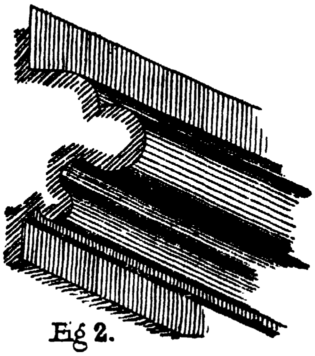


Fig 2.

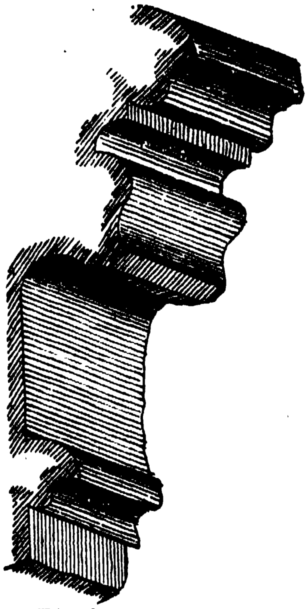


Fig 4.

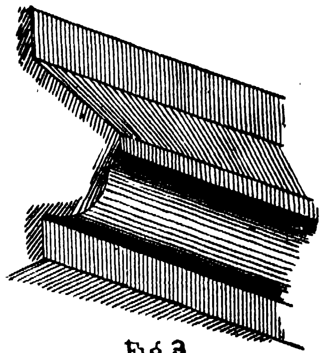


Fig 3.

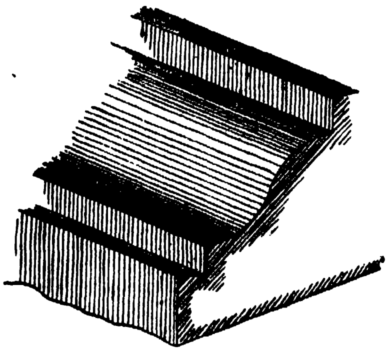


Fig 6.

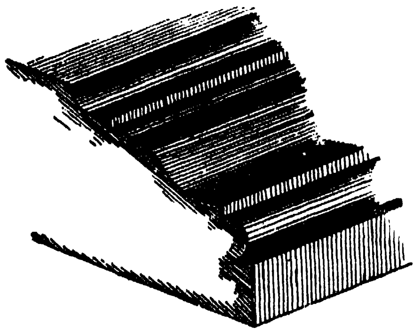


Fig 8.

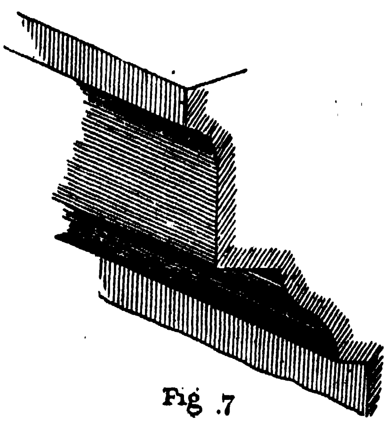


Fig .7

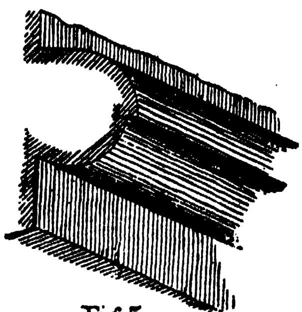


Fig 5.

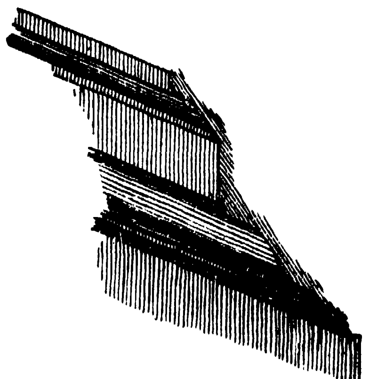


Fig 9.

DELINEATION OF SCREWS.

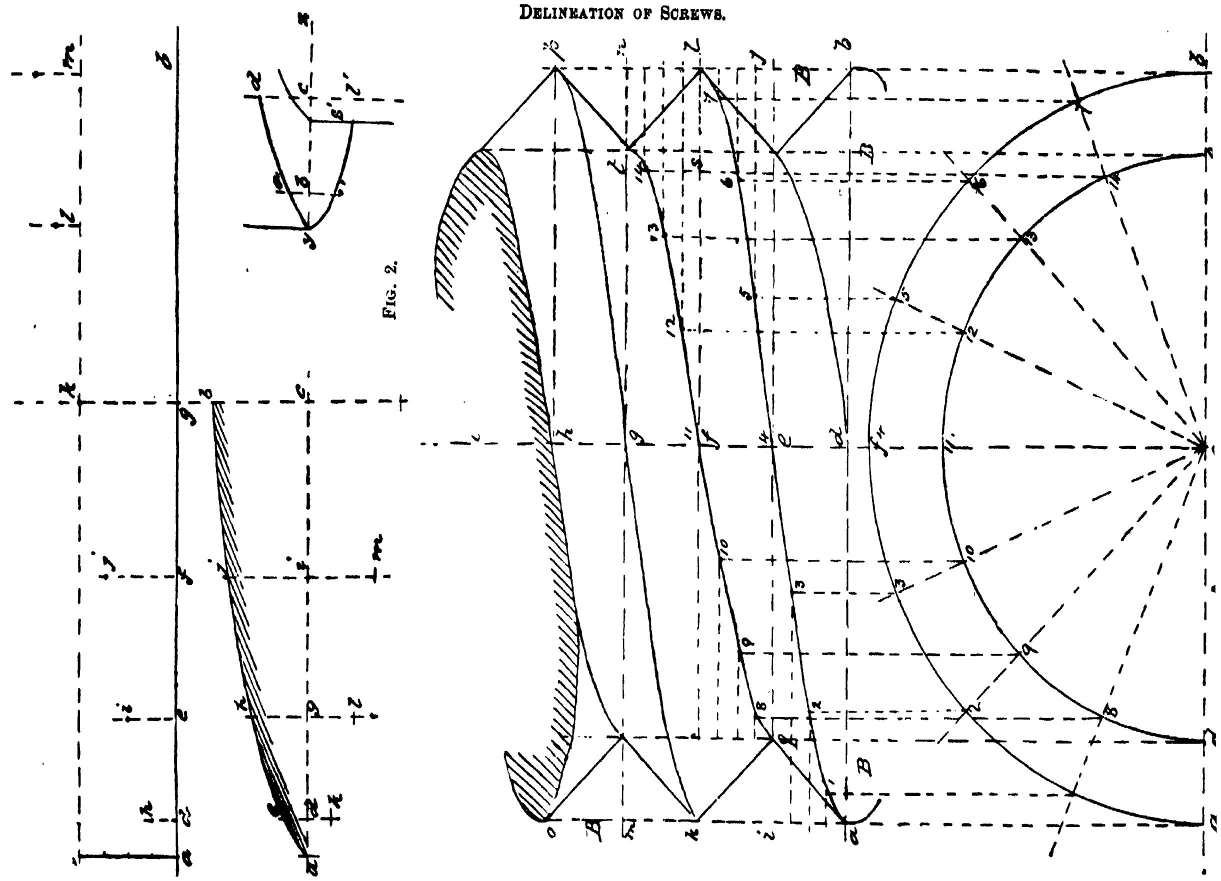


FIG. 2.

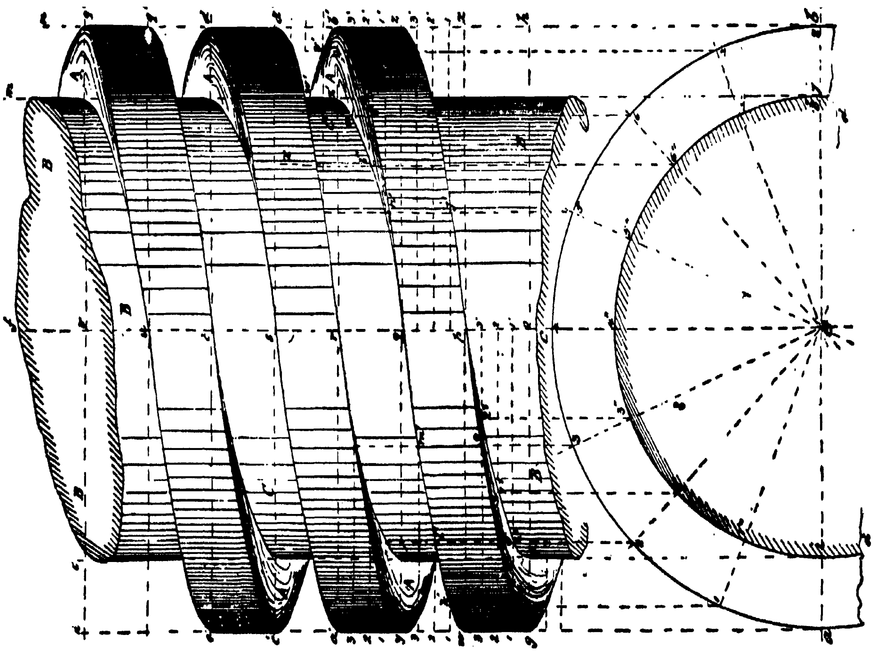


FIG. 1.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

The Technical Points connected with the Varieties or Breeds of Cattle—Their Breeding, Rearing, Feeding, and General Management for the Production of Butchers' Meat and of Dairy Produce.

CHAPTER IX.

At the conclusion of last chapter we gave certain points indicating a good animal, from the pen of an able authority; we now conclude them. A fine flesh-coloured muzzle, with nostrils well dilated, the neck, as said before, broad, deep and muscular; the shoulder-blades well set toward the rib behind, and yet stretching up finely towards the "crop," leaving no deep hollow between it and the ribs; chest deep, ribs well rounded, and stretching backwards towards the hook bone, so as to leave no very wide space there. The breadth between the "hook" or "hock" bones should be proportionate to the length from them to the point of the fleshy rump, and the tail well set-on; the fore-legs should be broad and muscular from this point upwards; the thighs well developed, and touching each other inwardly to near the hock; the skin covered with thick, soft, somewhat curly hair, and should be to the touch, when the animal is in a store condition, soft, elastic, and pleasant, but when the animal is fully fat (however soft the hair), the skin itself should be very firm, resistant to the pressure, like the feel of a strained, well distended air cushion. The bones should be as small as is compatible with the full, steady support of the animal. In the cow we everywhere expect greater roundness of form, a softer touch, wider hips, and more delicate outline. Both a graceful carriage and lively air are desirable. Such I conceive to be the perfect animal. Some one has said, "The perfect monster the world never saw"; but to this we aspire at our shows, and the "prize taker" is, or ought to be, the one which possesses the above points in the greatest perfection. However, practically, if there be a deep chest, a round rib, a broad loin, a mellow skin, and small bones, you have a beast which will repay your care, whatever faults may be found by the connoisseur in other parts of the animal's structure." The general form of a well developed and well fed animal ready for market approaches that of a rectangle, as shown by the lines in fig. 11 (*ante*, p. 128), the straight level back being a very prominent feature of the animal; to this we have already alluded.

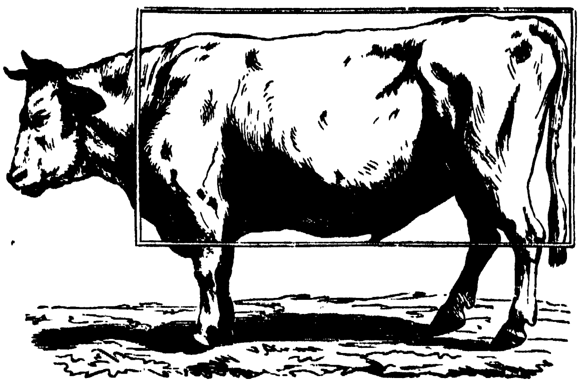


Fig. 12.

Fig. 12 shows a defective form generally, but chiefly in the dropping shoulder and rising rump. A very able authority draws attention to points in form too frequently overlooked. We have prepared three illustrations to indicate the chief of the points referred to. With regard to the size or bulk of the animal, to which we have already referred, Mr. Wells states that he fears that too great a disposition exists at present to overestimate its importance, independent of many disadvantages, such as the "difficulty of combining with it compact form and constitutional hardiness." Further, that it has not yet been properly investigated how much more relatively animals of increased size consume than smaller animals — a point, as he truly observes, of great importance. With regard also to levelness of form (see our preceding remarks in connection with fig. 11), our authority states that it requires a "watchful eye and a correct knowledge of the most desirable quality of flesh to prevent the levelly disposed animal being too loose, and the less even (level) one too firm." He objects also to the undue development of the brisket,—a point which is perhaps more a marked feature in the shorthorn than in any other breed—and which he looks upon or is disposed to consider as a superfluous appendage, and as adding to the offal, however attractive it may appear in the side view of the animal. In fig. 13

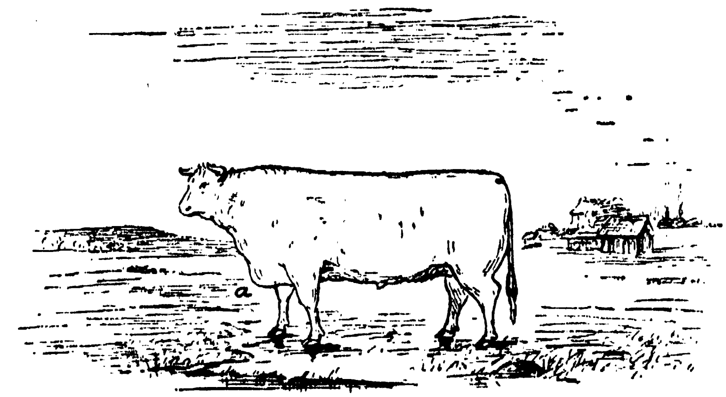


Fig. 13.

we illustrate what our authority deems a good point, where the point *a* of the bosom is not so deep as it often is seen—especially in the shorthorn breed; but is—as he thinks it should be, "full and carrying its width through the lower part of the chest, with sufficient circularity in the lower part of the pectoral ribs." In fig. 14, the point *a* of the bosom is deep and projecting, and deficient in the muscles extending to inside of arm, as is often met with, not—as it should be,—"well filled up by muscles inside the arm." This is opposed to the popular notion of a deep and projecting brisket or bosom, as shown in fig. 14 at *a*.

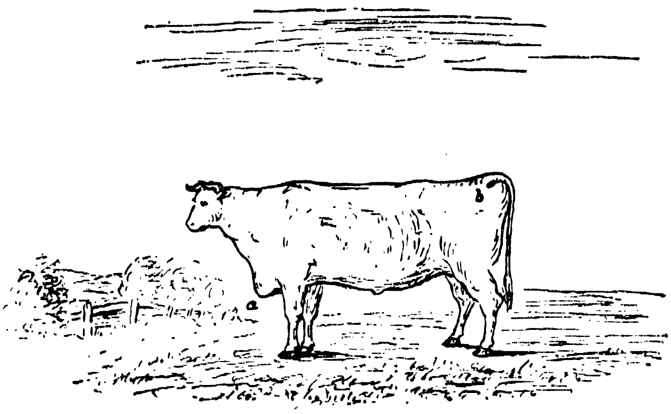


Fig. 14.

The setting-on of the tail and the general outline of the hinder parts of fattening cattle should be carefully looked at by the grazier. The illustration in fig. 13 affords an example of good form on this point. In fig. 15 the tail is set-on too low, as at *a*, and in fig. 14 it is set-on too high, as at *b*, in both cases giving very bad form.

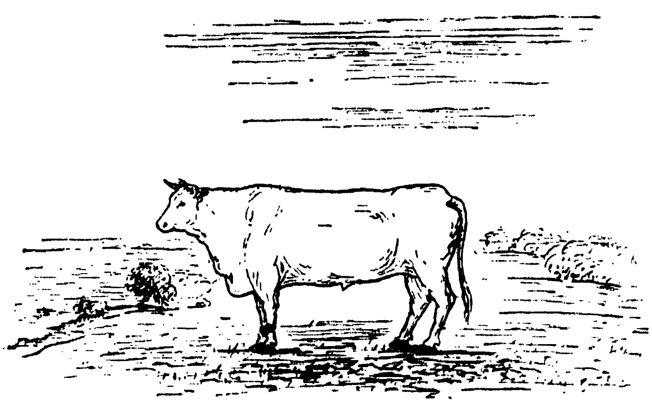


Fig. 15.

The Age of the Bull in Breeding.

In breeding, a point lost sight of too frequently is the using of bulls too young. A little consideration will show the importance of using bulls for breeding purposes which are matured, or old enough; the propagating depends to a large extent upon the full supply of blood in the animal, this being drawn to a large extent by the use of the animal in serving cows. Where this is drawn upon prematurely, it diverts so much from the nourishment of the animal, and therefore from its virile power. For "growth," as an able author in a contemporary journal well remarks, "involves a daily or continued increase of size and weight, which involves a gradual increase according to size in the consumption of food and the quantity of blood made from it; but as the propagation reduces this power to digest and form blood, and as all the blood young animals can make naturally is required, and used in forming growth, it is clear that all young animals have their growth suspended if used to propagate. This shows that it is injurious to use animals in propagating before they are well grown. . . . On the other hand, from the day an animal has done growing, its power to digest and form blood begins to exceed its requirement of blood for the regular process of nutrition. This excess of reserved power remains during the vigorous stage of animal life; and that this and cognate facts show the natural design that only mature animals are adapted to propagate their species seems to be clearly indicated and established." It is obvious that these remarks apply with equal force to the use of the female at too early an age. There can be no doubt that nothing is to be gained, but much is to be lost, by putting the heifer at too early an age to the bull.

General Remarks on Breeding.

On a subject so important as this, the reader will be prepared to learn that a vast deal has been written; and bearing in recollection the saying "Many men, many minds," that there is also very considerable diversity of opinion amongst those who are reckoned to be authorities upon it. Varied, however, as are the views held by those who have written on the subject, there are certain points held by all, for they are common to all, being, as it were, the vital principles upon which the art depends. At the same time, as different circumstances bring about different results, and what has been found useful to some may be so to others whose circumstances are similar, we may be able, in the following few paragraphs, to cluster together a variety of remarks and opinions which will carry with it some points of practical value to our readers.

Although the British grazier has much reason to be proud of what has been done in so improving the breeds of our fattening or meat-producing cattle that they are the best in the world, and are so held by all its best breeders, still, we must not lose sight of the fact that an improvement vastly more wide in its range, and productive of a still greater number of animals yielding butcher's meat of a good quality, would have been the result, had there been a more extensive adaptation of the principles of breeding, and as a consequence a more detailed and careful practical application of them. For while some readers may be surprised at the statement, it is nevertheless simply one of fact, when we say that all the great improvements in cattle breeding, rearing, and feeding have been carried out by a body of farmers and men of science very few in numbers as compared with the vast body practically connected with agriculture throughout the kingdom. This body of improvers have made up for the fewness of their numbers by the exercise of many qualities which are indispensable to success—great powers of observation, of perseverance and patience, in noting and recording facts generally, combined with a fair, in some instances a high amount of scientific knowledge of animal physiology and of food and feeding substances. They have, no doubt, as a general rule, been aided by the possession of capital; and in this last connection it is only right to state that the improvement of the British breeds of cattle has been greatly pushed forward by men of position, such as noblemen, landed proprietors, and those wealthy members of trade and commerce who, taking originally to farming as an amusement merely, have found in it a source of greater interest, have in more cases than one added largely to the general stock of knowledge, and have been successful in bringing a practical outcome in the shape of prize animals of greater or less merit. But although this be true of many, still on the question of capital it is here to be noted that not a few to whom the progress in breeding of British cattle has been considerably indebted, began their labour not possessed of, but greatly hampered and hindered by the lack of pecuniary means, yet who, by the exercise of all those qualities which insure success, have made, if not always fortunes, certainly handsome competencies. And from this fact encouragement may be had which should go far to incite many of the large body of farmers who, as we have just stated, have done as yet comparatively little in improving the British breeds of cattle. And if others who have gone before them, and many who are now their contemporaries, have succeeded not only in improving the breed of British cattle, but in ultimately making a competency, the same career is open to them if the same means are taken to secure its success. What can be, and what has been done by one, can be done by another. The first step to be taken, the first point to be aimed at, is to gain the conviction that progress is demanded, improvement in the cattle which they breed and rear. In any business, when the most of which it is capable is desired to be made of it, the very first step in the making is to have the conviction that improvement is necessary, and that improvement can be made. Satisfaction with things as they are never yet led, or will ever lead, to work which will and can make them better. All our improvements in the arts, all progress in the sciences, have had their origin in a dissatisfaction with what existed, and a conviction that a higher and brighter future was within reach, if only worked out. And if this be true—and it cannot be easily, if indeed at all disputed—of general business, it is no less true of the special business of "the grazier." Had the work of improvement in British breeds of cattle, which, as we have seen, has really been done by the comparatively few, been taken in hand by the comparatively many of British farmers, great as the improvement has been, a still greater—vastly greater, certainly wider—improvement would have been the result. The great mistake made by so many of our farmers who have not gone in for improvements in cattle has been in breeding with an utter disregard of the sire. Any bull has been, and is now through a far too wide area of country, thought good enough to use—and this even when they had originally cows from which good stock could have been obtained. But by neglect the good points of those cows have been so utterly lost, that no trace of them—or if any be left it is but of the faintest—can be met with in the mongrel race which is the ultimate result of this unfortunate system. Nor is this result long in being attained. "It is easy to descend," says the old classical proverb, and it is so in the case of breeding of cattle. While the establishment of good points is a matter of long and patient work, the loss of them is one of rapidity. And there should be, and indeed there is, not any difficulty in getting the services of a good sire. If a farmer or grazier is too poor to pay the price demanded, the principle of co-operation can be brought into use, and what the purse of one cannot, the purses of many can command. But the difficulty does not really lie here; it is in quite a different direction. Let the class of farmers and graziers we are now alluding to only determine that improvement in their cattle is a matter of importance, and it will go hard indeed with them if they do not find some means to carry it out.

Further Remarks on the Breeding of Cattle.—Modifications in the Law of "Like Begets Like."—Tendency to Diversity of Peculiarities.

If the class to whom in the above paragraph we have made special allusion as being able to do much in extending improvement in cattle, as butcher's meat producers, would but become convinced of the great truth in the art of breeding that "like begets like," or has an invariable, if it be an unequal, tendency to do so, we should not find so many poor mongrel animals in the market or on our farms. This principle of like producing like runs through all the departments of nature in which life is concerned, whether it be the life of vegetables or of animals. And this principle is wisely ordered by a beneficent Creator, for it gives that fixity of character in each class or family which enables man to know and to deal with certainty in his relations to it, but without which he would be, so to say, wandering ever in the mazes of a labyrinth out of which he would find no clue to guide or lead him. The fact that in the vegetable world, and specially perhaps in the floral kingdom, we find variations which in the latter case we call "sports," and in the animal kingdom abnormal developments—which may take the form of what may be called improvements, or, on the contrary, deformities—is not to be taken as evidence that the principle we have named, that like produces and begets like, is not correct or true. For those variations are changes only in degree, not in kind. We may have a "sport," variation or change in a certain flower; but, marked as the "sport" may be, the flower remains still the same, and is not changed into quite another flower. So in like manner, in the case of an animal we may find a variation in one which we may consider on the one hand to be an improvement, or on the other a deformity, and this may be very marked indeed. Still the animal remains the same as before; there is no change so great, no development so complete, as to change one flower or animal into another quite different: the carnation remains a carnation still, and does not become a violet; the cow still remains a cow, and does not develop into a horse. This fixity of family characteristics in created life is, as we have said, of immense value to man in all his dealings with it. In animal life he knows that he can trust with absolute certainty to this great principle, and that every animal will bring forth after its kind; and although changes or variations may come, still the great principle is so persistently operative that he knows there will be what may be called a fairly level uniformity of type and character. Hence, in all the wide variety of breeds of cattle existing throughout the world, we have the same general characteristics as to form, average size or bulk, feeding or milking properties, etc., etc. But this principle of like begetting like, while it affects the transmission of characteristics, technically termed "points," which are considered favourable, and therefore desirable to be transmitted from an animal to its progeny, the young reader must not overlook the highly important fact that the principle must be also operative in the case of abnormal developments, which are considered to be, and are, deformities; so that these, however undesirable it may be, often are transmitted from an animal to its progeny. This transmission of peculiarities from one generation to another, and which is known as hereditary, is so marked that an accidental or abnormal development in one animal, which is not only deemed ugly, but gives a characteristic feature to the animal the very opposite of that which marks the breeds of cattle generally, becomes transmitted from one generation to another till it constitutes what may be termed a new breed having this ugly or undesirable feature existing in all the animals of the breed. Those learned in the science and art of breeding can cite numerous, and in some cases altogether remarkable examples of the way in which new breeds or new herds are formed by virtue of this hereditary transmission of peculiarities. At first sight it would appear to be very unfortunate for the breeder that this principle of hereditary transmission, which is like begetting like, works equally in the direction of transmitting undesirable as desirable peculiarities in the animals. But, so far from being unfortunate, it is wisely designed to be the reverse; for if there were *no break in the continuity of the principle* of like begetting like, it is obvious that there would be but little, if any, opportunity to improve a given breed or herd. And, while the general characteristics of the family or class of animal are seen throughout the whole, each single member of that class may have, and generally, almost always, has, its own individual characteristics. We find the same existing in families of the human race: while there is a general or what is called a family likeness running through all the children, each child has its own individual characteristics peculiar to itself, making Tom different from Dick, and Polly from Jane. Very rarely indeed do we find two of the same family very like each other; still more rarely two so much alike that one may be readily and but too easily mistaken for the other. Such cases do now and then occur, but their very rarity as exceptions simply serves to prove the rule. This, what may be called somewhat paradoxically, yet quite truly, a variation or diversity in uniformity, runs through all the departments of natural objects. The youth may conclude that the leaves of an oak tree, for example, will be all alike, being oak; the blades of grass of the field the same; but he will be surprised to learn that there are scarcely any two, if indeed there be two, leaves or two blades alike. And this law of variation or diversity, which at first sight may seem to be quite antagonistic to the general principle that like begets or produces like, is of immense service to the breeder of farm live stock, as well, indeed, as in the cultivation of flowers.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER VIII.

AT end of last chapter we stated that Kenyon's "pistonless" indicator is best adapted to high-pressure engines. This does not by any means preclude the use of it to that for indicating the vacuum side of the piston—*i.e.*, when being used for indicating condensing engines. We have not had experience in it sufficiently to say whether it does operate as freely in case of this application as for the former purpose. We take the liberty of using on this point Mr. Kenyon's own words, knowing him to be a man of a good and sound mechanical turn of mind, who has to our own knowledge produced other inventions which have proved satisfactory.

"The 'No. 1' indicator has been specially adapted to indicate the vacuum on a large scale in engines or pumps working at low pressures. The tubes indicating pressures above 80 lb. will be made to indicate the vacuum when so ordered, and will also be made with scales to indicate any other pressures when required." The patentee strongly recommends the following, when an indication is to be made. "The tubes should be allowed to work some minutes before taking the diagram, so that they may become thoroughly heated." The indicators are made in two sizes, No. 1 and No. 2. The former takes a much larger diagram than the latter.

Indicators are subject to changes, as most other machines are when there is a demand for them, and hence competition springs up. The machinist sees an opening for the application of his ingenuity to a machine, and he at once embraces it, and thus sets to work either to dispense with some portion of it so as to simplify it, or else to add something to it in order that it can be better adapted for its purpose. At other times a completely new arrangement is adopted —*i.e.*, as far as regards the mechanical adjustment—but we must not allow ourselves to be drawn off the scent with an idea that the first principle is totally discarded; it may be only re-dressed—got up in a new fashion. But all new fashions are not improvements. In case of changes in the construction of machinery there is very often some decided improvement; and in that of indicators, all must admit that they have had their fair share of change and improvement. On that account we feel it to be more a duty to draw attention to many that are now in use, and to give outlines of the different ones of the present day. Those which have, as we may say, passed away, we have noticed by simply referring to them.

Thompson's Helical Spring Indicator—Short and Long-Stroked Engines.

We now advert to another maker's indicator—Thompson's. We do not see much in the arrange-

Richards. Those parts to which the pencil is attached are a little lighter, and the maker claims (what cannot be denied) that to remove anything which produces friction is a gain—*i.e.*, to produce a more correct diagram. Mr. Thompson also claims a further advantage for his indicator—which, in general appearance, is so much like those usually illustrated that we do not give a separate sketch of it. He has applied a different kind of spring, which he says is also an improvement. He calls the spring which he makes use of in the drum "helical." This spiral spring can be readily adjusted, so as to effect the return movement of the paper drum, thus allowing the operator to regulate it so as to accommodate it for the different speeds of the engine. When an indicator is attached to an engine of a short stroke (*i.e.* a short crank), the revolutions must be very numerous. To make this part just named clear, we shall give a comparison or two, for the benefit of those unacquainted with such terms as "cranks" and "strokes" of engines. An engine with a crank or stroke one foot in length, making a hundred revolutions per minute, would pass through two hundred feet. Another engine, with a crank or stroke of two feet in length, making a hundred revolutions per minute, would pass through four hundred feet per minute. In the former example the cylinder would be two feet in length or height, in the latter the cylinder would be four feet. In this way a short-cranked engine must make more revolutions to do the same amount of work. Therefore it is necessary to have the best provision in an indicator possible to meet such cases, in order that true diagrams can be taken from those running at high speeds. Those indicators of recent make have advantages over those of more remote date in that particular. Such changes are even necessary when longer-stroked engines are employed. Forty years ago, most engines with a five-feet stroke would not make more than about twenty-four revolutions per minute, or two hundred and forty feet per minute. Most of the new engines are running at very high speeds—about double that of forty years ago. Hence the necessity for the indicator to have been remodelled or altered, so as to be able to take diagrams as correctly at the high speed as they did in the days when half the speed of the engine was about the rule. Socket joints are employed in parts connected with the pencil arrangement, with the idea of lessening friction.

Hopkinson's indicator, fig. 6, is of another form in its construction, but it will be found to be much like the others we have described, excepting that of Kenyon. It has all the parts, (working parts,) with a little

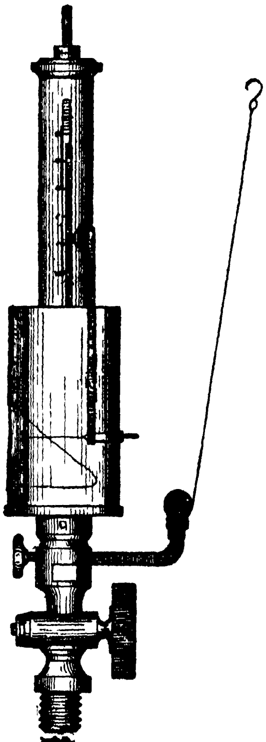


Fig. 6.

different arrangement. There is no material improvement about it over those we have described already, but it is only right to say that it has been very largely used.

Schaeffer and Badenburg's Double Piston Indicator.

We have to describe another indicator, which in its action much resembles all others, but with special

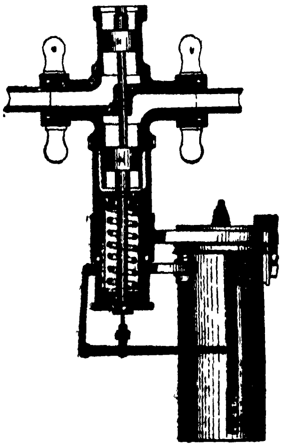


Fig. 7.

arrangements of a novel character, the object being to take two diagrams at the same time from the same cylinder and with the same indicator, and this constitutes the novelty of this indicator (Schäffer and Badenburg's patent double indicator, fig. 7).

In all steam-engine indicators used heretofore, the diagram taken only represents the result of one side of the steam cylinder, while in the double indicator a combined diagram, giving the result of both sides of the cylinder at one and the same time, or of the one or the other side singly, can be taken on the same paper; and that is performed by merely shutting or opening the steam cocks A and B, as seen in the diagram of the indicator. It will be seen from the sketch that two pistons, K, K′, are applied at the rod S. Also two taps are required; in short, it may be termed very truly a "double indicator" in its mechanism, as well as from taking two diagrams at one and the same time. By admitting the steam to the piston K by the tap A, it forces the piston rod up, and by opening the tap B on the opposite side of the piston, the steam acts upon the lower piston, K′—and in this way the steam forces the piston down. This work is done by the alternate rising

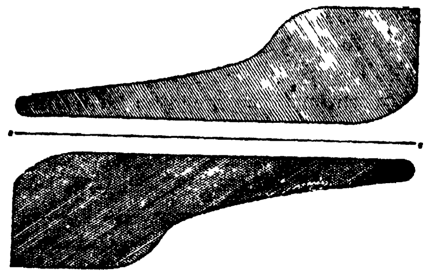


Fig. 8.

and lowering of the piston; and consequently the pencil is in operation, and thus the diagrams are formed on the drum. The larger the diagrams, the larger the drum will be required—*i.e.*, where the double diagram is taken on the same paper. The diagrams given below in fig. 8 will show how they are arranged when both are taken at the same time. This indicator is well calculated for taking diagrams off a high-pressure steam engine. From the diagrams it will be seen that one is above the atmospheric line, while the other is below it; this arises from the arrangement of the two pistons — they being so stationed that the steam acts on the top side of the one and on the under side of the other piston. It is driven up by the steam acting on K, (fig. 7), and is driven down by the steam acting on K′. In all high-pressure steam engines, the diagram, that part which is the effective force, is always above the atmospheric line when taken by a single indicating machine. It is the same with the double one when only one side is taken; but the other side must of necessity be under the atmospheric line. There is in all cases, with the high-pressure engines, what is called a "back pressure,"—*i.e.*, all the steam does not leave the cylinder in the same quick way as it does in the condensing engine. It cannot go below the atmospheric line unless something in the form of a vacuum could be introduced. If all the steam could get out at once (*i.e.*, when it had done its work on one side of the piston), the pencil of the indicator could only go as low as to the place it started from—the atmospheric line—and therefore in that case there would not be any back pressure. Take for granted that a high-pressure engine has always some back pressure when not in connection with a condensing engine, that is, when the line of the effective part of the diagram does not come to the atmospheric line. (See the annexed diagram, fig. 9.)

We propose to describe in a succeeding paragraph the elementary points of indicator diagrams; meanwhile it will be understood that the pressure which is upon the piston measures from the atmospheric line to the part of the diagram farthest from the atmospheric line. The pressure as measured from the parts

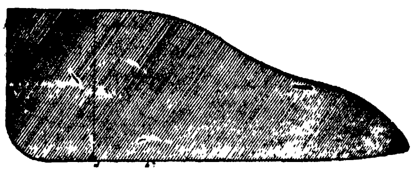


Fig. 9.

above named by no means gives a true record of the pressure of steam which is in the boiler. It may be an approximate to it, or it may be far from it. Much depends upon the circumstances of the throttle valve, or the lap which is on the valve, or the opening of the slide steam valve. It will further illustrate the way the diagrams are taken on the paper, by adding two diagrams, by the double indicator (in fig. 8), showing the position of each diagram to the atmospheric line. It will also be clear to the reader from the above remarks as to the back pressure. The line lying between the diagrams is the atmospheric line in this case; each diagram being about the same distance from the atmospheric line. It must not be taken for granted that it will always happen that the same distance will be precisely obtained. It ought, however, to be the same. Fig. 8 represents the double figure on one paper on the drum.

1 is the figure of one side of the piston, 2 is represented by being under the atmospheric line, 3 being the atmospheric line. The effective power is within the lines marked 1 and 2. The various points connected with the "diagram" taken by an indicator will be fully explained hereafter

Fig. 10 shows how an ordinary indicator can be applied to the cylinder of a steam engine by which a diagram can be taken from each end of the cylinder with one indicator and on the same sheet of paper. This can be done and completed in a very short time, and great accuracy can also be obtained. From the cylinder at each end a piece of gas pipe can be inserted (screwed in). This piping is brought from the cylinder at both ends. The indicator being midway, a tap must be fixed on each side of it so as to admit of the steam being cut off from that side. One tap on each pipe is quite sufficient. There is some advantage, after all, in having two on each side of the indicator, but it is so trifling that we shall not refer to it further. It is very important that the top and bottom of the cylinder—that is, each side of the piston—should have a diagram taken from it. In the first place, it is almost impossible for any practical man to set the valves of the steam engine correctly, so as to have the same quantity of steam on both sides of the piston. In the second place, the engine as a rule being more correctly balanced, steadier turning can be obtained and more evenness of strain secured. This can be ascertained by taking diagrams from both sides of the piston; and the same being done almost instantaneously secures correctness—*i.e.*, shows how much steam is applied at one and the same time to produce the amount of work which is then and there required. This arrangement may in material and labour be completed at a cost less than twenty shillings. For all practical purposes this may be considered perfection. This arrangement is best suited for a cylinder horizontally placed.

We have now described a few of the various steam indicators used for ascertaining power exerted in the steam engine, and also for examination of the position of the valves, and thus being satisfied that the steam engine is working to the greatest advantage in point of strain and economy; and have given sketches of those generally adopted, and explained their mechanical parts and their application to the cylinder of the steam engine. We have also pointed out to our readers the value of this little machine, when anything like a fair amount of knowledge is obtained of its working, and the dependence which can be placed upon its indications. With care on the part of the operator, the result shown on paper—the diagram—will be the true position of the working parts of the steam engine. From what has already been given in preceding paragraphs, the reader may be enabled to form a general idea of the working of the indicator, and how it gives a graphic record of the peculiarities of its operation; and he may also have some conception of what certain forms of diagrams indicate—that is, in how far their form shows the peculiarities of the action of the steam inside the cylinder.

THE JOINER.

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER VIII.

AT end of preceding chapter we stated that when a panel is to have mouldings round it at top and bottom as well as at sides, the arrangement known as "stuck-on mouldings" and "flush panel" was adopted. This is illustrated in fig. 6, Plate XI., the upper diagrams to the left showing in section and in front elevation in the lower drawing the stuck-on mouldings for a "flush panel" (see fig. 1, Plate XI.), and the opposite drawings to the right in same relative positions the stuck-on mouldings for a "square panel" — that is, with sunk or recessed faces (see fig. 2, Plate XI.). In both cases in fig. 6 the moulding is worked in separate pieces, and cut to the requisite lengths to reach from end to end and from side to side of panel; the four pieces—two sides, and one top and one bottom piece—"mitring" at the corners, as shown in the lower diagrams at *h* and *i*. Where a "flush panel" is employed, as at *b b* in upper diagram to the left, *a a* being the style, the inner surface of which is flush with inner surface of panel *b b*, the moulding *c c* is "stuck on" so as to cover part of the surfaces of both style and panel, as shown. Where a "square panel" is used, as *d d*, to the right, with a recessed or sunk surface below surface of style *e e*, the moulding is "stuck on," or secured to the panel only; the top and side mouldings "mitring" at the corners, as shown at *i*; *j j* is part of the "style," *i i* of the "top rail."

Chamfered Styles with Square Panels not Moulded.

When "square" panels are used, and the work generally plain or cheap in style, no mouldings are given either to the styles or panels, as in the arrangements illustrated in figs. 3 to 7 inclusive, in Plate XI., but some degree of ornamentation is secured by chamfering the margins of the "styles" and the "rails" at sides and at the top and bottom of the panel, as shown in fig. 54. In this *a a* in the diagram to the left is the "lock style" of a door, *b b* the "lock rail"; the other side of this outside the room being shown at *a′ a′ b′ b′*. When we come to the subject of doors, their different forms, details of construction and fittings, we shall again refer to this diagram, giving it meanwhile simply to show the mode of ornamenting the panelled part, with cutting the corners or margins nearest the panels of the styles, as *a a*, and "rails" as *b b*, as shown by the shaded parts.

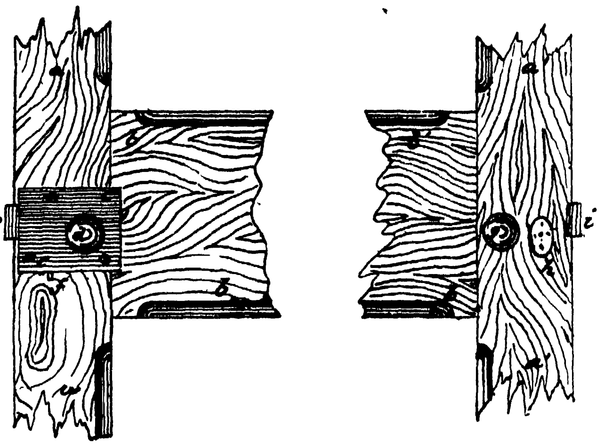


Fig. 54.

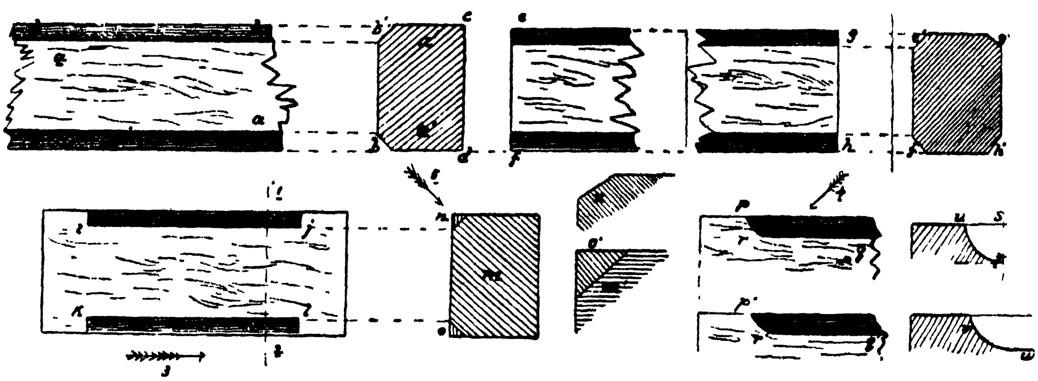


Fig. 55.

Flat Chamfers—Stop Chamfers—Chamfered Work—Varieties of Chamfers.

This will be an appropriate place to illustrate the kinds of "chamfers," and also some points connected with panel work not yet noticed. In fig. 55 we illustrate at *a a b b* in elevation what is called a "plain chamfer." This is simply taking off the "arrises" or corners at one of the faces *a a*, as at *b b*, shown at *b b* on inner corners of piece *a′ a′*. When the other face, as *c d*, is left square, the chamfer is called a single plain chamfer. When both faces are chamfered, or all the corners, as at *e′ f′ g′ h′*, are cut off in elevation at *e f g h*, the chamfer is called a double, or double-faced plain chamfer. In the plain chamfer the bevelling is done along the whole length of piece, stopping only at the ends, as *e f g h.*

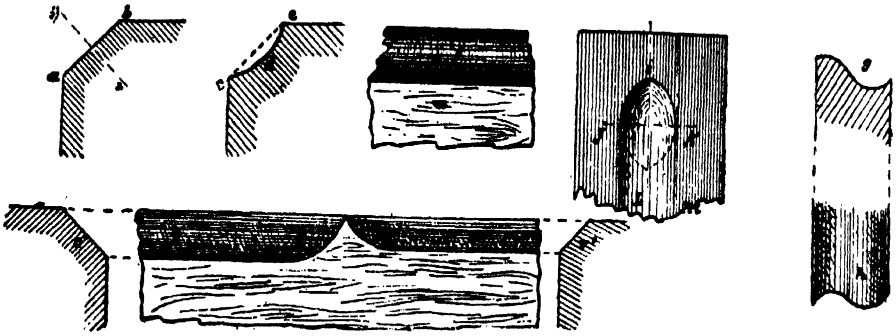


Fig. 56.

What is called a "stop chamfer" is that in which the bevel or taking off of the corner or arris does not extend along the whole length of the piece, as in preceding diagram, but stops short near one end, or near both ends, as at *i j k l* in fig. 55; cross section as on line 1 2 looking in the direction of the arrow 5, as at *m n o*; *o′* shows the shoulder or end at *n* formed by cutting off the chamfer square at the ends; at any part between *k* and *l* the corner or chamfer shows as at *x*. In place of cutting off the end of the chamfer square, as at *j* or *l*, giving a flat shoulder, as at *n* and *o′*, the chamfer is run up to meet the edge, as at *p*, by a curve, as at *r*. This curve may be sharp, like the quadrantal curve as at *s t u*; or flatter, as at *v w*.

Chamfered Work continued.—Curved Chamfers.

In place of the face of the chamfer or bevel being flat, as shown in section at *a b*, fig. 56, it may be curved, as at *c d e*, front or side elevation of which is at *f*; *g* shows another section of a chamfer face, more easily made when the chamfer is a plain, not a stop chamfer; *h* is side view of *g*. The front view of a stop chamfer, where it terminates near the end of the piece, is shown at *i j k l m*. A piece may be stop-chamfered with chamfers of two different sections, as *o p* of section as at *o′*, and smaller stop chamfer *q r* section at *r′*. It may be as well here to give illustrations of a rail, such as that of a staircase or a railing enclosing the well hole of a staircase at side of landing. In fig. 57 we give at *a e* elevation of rail square at ends, at base or lower part *g*, at top or upper end at *f* and in the centre *h*; the heights being, *e* to *d*, 6 inches, *d* to *c*, 11 inches, *a* to *b*, 11 inches, and *b* to *a*, 4 inches. The stop chamfers are at each corner, *i j*, *k k* being two contiguous ones. These are cut deep, so as to leave but very narrow parts or faces, as at *q* and *r*, between the two chamfers, the faces of the chamfers being flat, as at *p q*, or they may be curved as at *r* (section); the chamfers, as *s t*, may be cut so deep that they meet at a sharp or knife edge, as at *s* and *t* on the line *t*, shown in cross section at *u*.

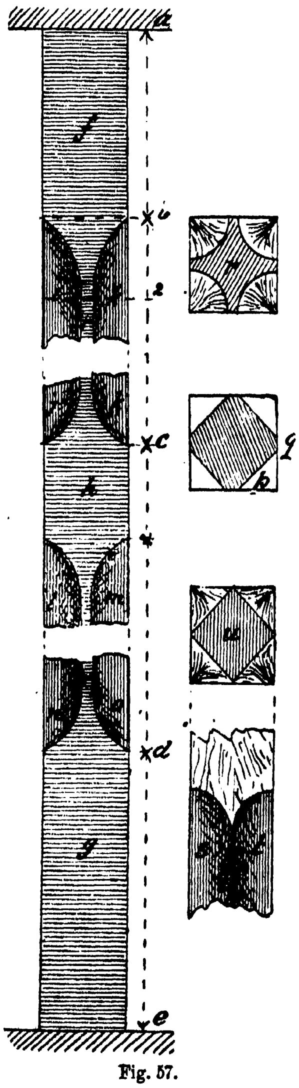


Fig. 57.

Different Forms of Panels.

We conclude this part of our paper by giving some illustrations of panels. In fig. 1, Plate XI., we give a "flush" panel for a front or entrance door, in which in front elevation *a*, *b*, are the two rails, *d d*, *e e*, the styles, *c c*, *g g*, the panel with stuck-on mouldings all round and mitring at corners; *g h* is a vertical section in line 3 4. In this the recess between the style and panel is one side only. Where there are recesses on both sides of the panel *b b*, fig. 2, Plate XI., and the styles *a a*, the panel is known as a "square" panel. In this figure the lower diagram is front elevation, that on the left is a section on line 3 4. In fig. 3, Plate XI., we illustrate different forms of panels. In the upper diagram, *a a*, the styles, carry one "square panel," which is not flat, as in fig. 2, on the inner side, but tapers to the centre, which is thickest to the sides, where it may be either square, as at the right hand, or finished with a moulding, as on the left.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER XIII.

At the end of last chapter we referred to figs. 47 and 48 as showing the way in which the Greeks used the honeysuckle. The student will find this form in other styles, and especially in the Assyrian; but he will always be able to distinguish the Greek honeysuckle by the length, beauty and regularity of its leaves, and the intrinsic beauty of its curves and form. It would weary the student were we to describe the peculiarities of each plate: what we would recommend him to do is, as soon as he gets a new copy, to compare it with the one just finished, and note all the differences in the arrangement; let him carefully compare the plate before him with the honeysuckle in fig. 54, and note the different way it is used. He will find the Greeks did not limit themselves to number, while in the Assyrian honeysuckle they are limited to seven, as shown in the illustration of the latter in fig. 4, p. 230, vol. i. (*ante*), in the paper entitled "Form and Colour in Industrial Decoration." This may be contrasted with the Greek anthemion in fig. 5, same page.

We place before the student in fig. 50, p. 86 (*ante*), a bunch of grapes; and in fig. 49, p. 85, the blocking in. The vine and its fruit has figured largely in ornament, as well as in literature. The student has already drawn the leaf (fig. 42, p. 17 *ante*); both fruit and leaf are drawn from examples grown in the open air. The student will find the leaf of the hothouse grape much larger than the one in our example—different both in shape and size; we hope he will now be able to draw them with ease.

The student's next example is preparatory to the one immediately following, and we need only say that he is now entering on a new order of line, and he cannot be too careful in mastering all its details. Having carefully drawn fig. 51, p. 135 (*ante*), he will finish his drawing from the following one, fig. 52, p. 136, observing that all the lines flow harmoniously. The examples that follow will become more complicated.

It will be unnecessary at this stage of the student's progress to do more than merely ask him to draw his examples or copies correctly; for by this time he ought to be able to do so. We here only direct his attention to a new form introduced—namely, the "scroll" (see figs. 53, 54, pp. 172 and 173 *ante*, and figs. 1, 2, Plate VI.). These forms rarely occur in Egyptian ornament, although the student may find some development of its peculiarity in that style; but the Greeks use it in a most beautiful way, as indeed they do all their ornament. In the Roman ornament the student will find it more fully developed, and assuming an importance in their decoration which it never reached before. Now, as the scroll forms an important feature in ornament, let the student here "get it off by heart," so to say, as he has done his alphabet, that he may draw it well and correctly, without any break or bend, but let every line run correctly and harmonise with all the others. This he should do without a copy, and not rest satisfied until he has mastered it, and can draw it easily and with satisfaction to himself, as it will form, if one may use the phrase, one of the letters of his alphabet of art.

The next example of the scroll, in fig. 55, block line, which is the blocking of the drawing in Plate L., forms part of the decoration of a Greek vase. The student will observe how beautifully it is arranged, how well each part agrees with every other part, and how accurately it is balanced. When he has drawn it very correctly, we would recommend him to draw it from memory, and not look at the copy until he has quite finished it, then compare it with the copy, and if it should be wrong, put it away and draw another, and then compare the second drawing with the copy, and also with the first drawing; by this means he will measure his progress. The student may here think this a slow process. Well, we hope he will take our word for it, but we recommend it simply to hasten his progress; and from this stage we would very earnestly recommend him to draw all his copies from memory, so that he can produce them at will whenever he may find use for them. In fig. 56 (57 is the blocking), we give a "scroll" taken from a cast of part of the "Choragic" monument of Lysicrates.

In figs. 58, 59, and 60 the student will find a drawing of the acacia leaf with a small block shape, which he will be enabled to draw now to the containing size without any instruction. In the next example, Plates L. and LI., the student will draw the leaf referred to above (see figs. 37 and 38, p. 367, vol. i., and fig. 45, p. 18, and fig. 46, p. 19)—namely, the acanthus leaf. This leaf is found extensively in Greek, Roman, and Renaissance ornament; in the Greek it is drawn with sharp points, while in the Roman it is more rounded. The student will find examples of it in subsequent plates in all the styles referred to above; he will then be able to note the different treatment of the same leaf in different countries. We have in England an extensive flora: surely we ought to be able to find some leaves that we could treat decoratively, without always falling back on this acanthus; and the object of these examples and remarks is to direct the student's attention to the desirability of establishing a national style which shall be as distinctly known to be English as the Greek is Greek.

In fig. 55, and in the drawing in fig. 55A, the student will find another mode of using the "anthemion" or honeysuckle, referred to in figs. 47 and 48. He will observe that only one-half is here used, and also how beautifully it is bound together by ornamental bands. This example is from the painted decoration of a Greek vase, and there is another illustration of Greek vase decoration, also painted, in figs. 1 and 2, Plate VI.

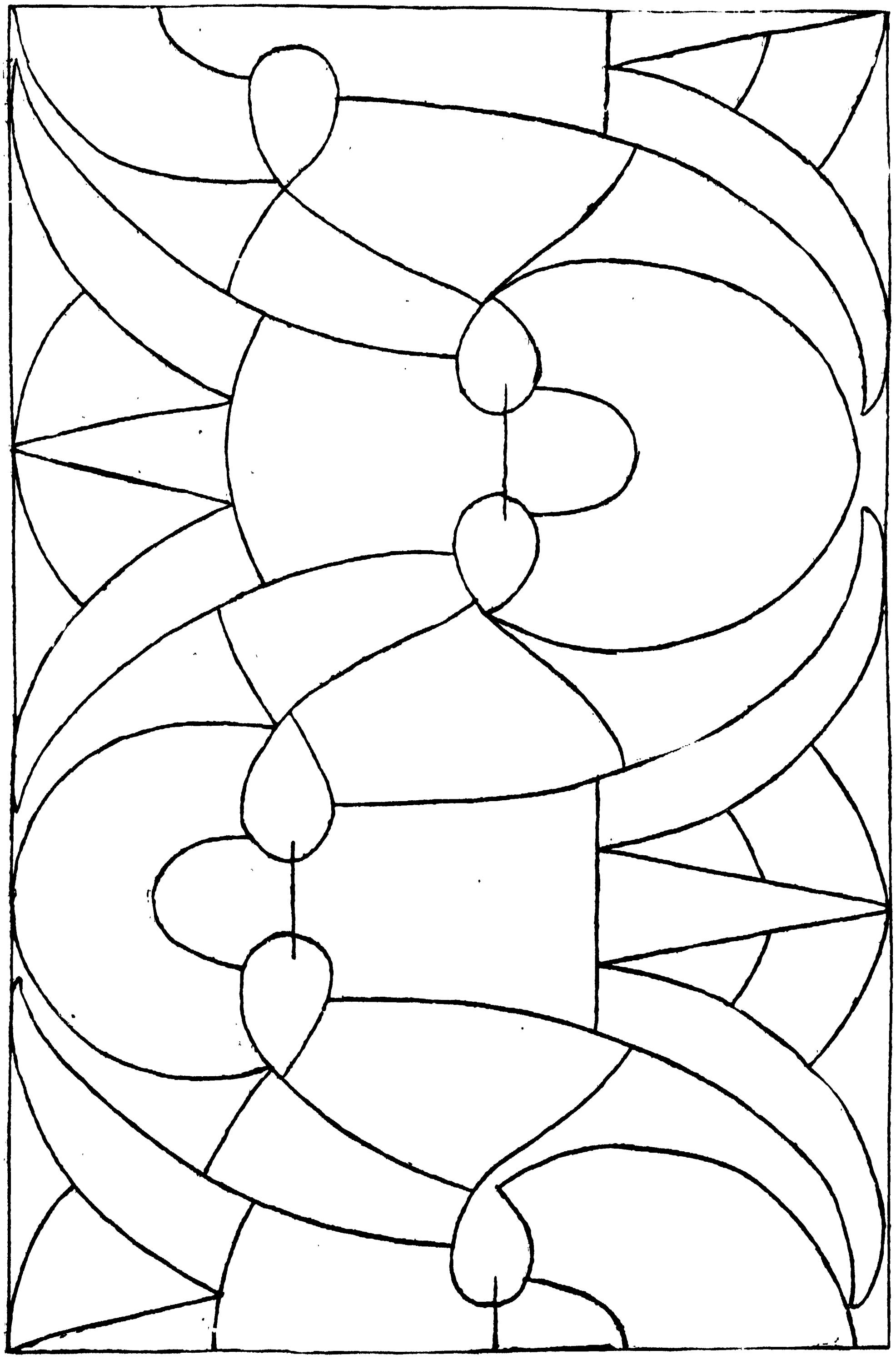


Fig. 55.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

117. Bessemer Steel Castings.

IN our last note, No. 112, p. 176, we took up the points connected with the condition of the metal in the ingot after solidifying and cooling; noting particularly the theory or speculation or fact—which latter some maintain it to be—that there is a redistribution of the elements or constituents of the steel, this going on while the ingot is solidifying and cooling. We have seen what the two authorities who have specially experimented in relation to this question have done; we now, as promised in last note, proceed to refer to what other authorities think about this question of ultimate condition of ingots. But before entering upon this let us here state that the young reader should not entertain the notion that we are giving too great a prominence to this the general question of Bessemer or even Siemens steel—for certain points are common to both in the matter of quality fitted for castings. Practically we cannot give too great a prominence to the subject of this series of our notes on technical points, for to a very large extent the great question of the future use of the new steels—especially those made by the Bessemer process—is bound up with it. And the wide extent of this question may be conceived of when we consider that metal construction affects almost, we might say absolutely, every branch of technical work; for if this be not in any one branch of it connected with the actual making of machinery, appliances and tools, there is no branch which does not require one or other or all of these to a greater or less extent. It is not, therefore, any easy thing to limit the importance of the subject of Bessemer steel castings, to which we have devoted several, and as some of our readers may have up till now had the idea, too many notes. After what we have said, those of them who have come to the latter conclusion will, we trust, see that the number of our notes in this special department of technical work is amply justified by its eminently great importance. The attention, moreover, we have given, and purpose still further to give to it, is also in a measure further justified by the fact that we endeavour, while giving its special points, to draw the attention of our youthful readers to certain principles which, while they affect and are illustrated by this special subject of steel castings, affect a very wide range indeed of practical technical work. In this connection the writer of those notes bears in mind one of the leading characteristics of the TECHNICAL JOURNAL, which its conductors have in view—namely, that while technical details of special subjects are carefully stated and expounded, their young readers will be induced to think them out for themselves, and to deduce from them principles which will not only be specially applicable to this particular case in point, but to all or a very wide range of work. Our notes have, therefore, a wider range of utility than might be anticipated from their titles alone. And this habit of thinking out subjects is one so vitally necessary to all true progress in work of any kind, that its exercise cannot be too earnestly insisted upon, and its value illustrated by examples which may flow out from or be deduced by the practical exposition of points connected with every or any special branch of technical work. After this practically useful and suggestive digression—if this indeed it be—we now proceed to gather up the points still remaining to be considered of our special subject. And first as to the theory or speculation that the quality of the ingot ultimately obtained is rendered unequal—that is, that the steel is not homogeneous throughout—in consequence of the redistribution of its elements or constituents which takes place during and in consequence of the action of solidifying and cooling. And here we draw attention to what is said by Mr. Adamson, now so well and widely known as the energetic chairman of the Manchester Ship Canal Company, and in technical circles equally well known as an able mechanic who has had a great deal to do with the practical use of ingot or the new steels of the Bessemer and Siemens processes. Referring to the experiments of Mr. Snelus, a description of the leading points of which has occupied our attention in a preceding note, Mr. Adamson pointed out the fact that the analysis showed a very uniform distribution of the manganese throughout the ingot; this he attributed to its (manganese) specific gravity and that of the steel itself being very nearly identical, showing a difference in the maximum of from 0·1 to 0·2 only. But in turning to the phosphorus and sulphur—the two great debasing elements in iron and steel—constituents in the ingot, analysis showed that their presence gives very varying quantities in two different parts of the ingot. Dividing this into two parts, the upper and the lower ends, the analysis shows that the upper end or top contained the phosphorus and sulphur constituents in greater quantity than did the lower end or bottom part. Mr. Adamson, still bearing the specific gravity point in view, comes to the conclusion that this condition arises from the great difference there is between the specific gravity of the steel and of the two debasing constituents phosphorus and sulphur. The specific gravity of phosphorus might be taken at 1·77, that of the steel itself of the ingot being about 7·85. "It is," says Mr. Adamson, "not unreasonable from his point of view to come to the conclusion that the tendency of the lighter alloys was to rise to the surface." The same could be said of the sulphur, which followed the same law; this having a specific gravity of 2·0. Whether this be or not the true theory of the difference between the two ends of an ingot, Mr. Adamson asserts that this difference does "at any rate" exist, to the decided detriment of the uniform quality of the steel, and to the annoyance and loss occasioned thereby to the user of it. To those of our readers who have been in the habit of reading or hearing discussions on scientific points, it will be nothing at all unexpected, our stating here that this theory of Mr. Adamson's is by no means agreed to by other authorities on the subject. Reasonable as this theory looks at first sight, it all depends upon the *condition* in which the elements or constituents of sulphur and phosphorus exist. Before the phenomena affecting their specific gravity could be displayed, it is obvious that this specific gravity could only attach to phosphorus and sulphur in their normal condition. The eminent authority—and there is no greater on this and steel metallurgy—Sir I. Lowthian Bell, Bart., saw this point, and at once pointed out that in place of having to deal with phosphorus and sulphur as free agents, or free in condition, they were, on the contrary, present in the ingot as phosphorus and sulphur united with iron; and though no doubt these metallic compounds were forced, so to say, to take the form of phosphides of iron, and metallic iron, which had a different specific gravity from that of the steel itself, yet it was not to anything "like the extent supposed by Mr. Adamson," thus holding that his "line of argument was entirely untenable." On the same theory of Mr. Adamson, Mr. E. Riley, F.C.S., another great authority in metallurgy, said that Mr. Adamson argued purely on mechanical principles. Those could not decide the point; and Mr. Riley, while agreeing with Sir Lowthian Bell as to the phosphides of iron, instanced the case of tungstate of iron, which had a specific gravity of about 17·5, yet it formed with iron of about 7·4—considerably less than half its specific gravity—a most perfect alloy, the two seeming to have the greatest chemical affinity for each other. Yet after "melting and cooling, the difference between the top and bottom was extraordinary, the top having a specific gravity of 9·9 and the bottom of 11·5." Here, continues Mr. Riley, "they had an exaggerated case which did bear out the principles to which Mr. Adamson had called attention." Sir Frederick Abel, the celebrated director of the Chemical Department of the Government establishment at Woolwich, believes with Sir Lowthian Bell that it is of the "utmost importance" that many experiments should be made to establish the important fact pointed out by the experiments of Mr. Stubbs and Mr. Snelus to which we have made reference—namely, that there is in the process of cooling of steel in large ingots, a redistribution, as it were, of some of the impurities or debasing constituents. Sir Frederick drew pointed attention to the comparatively great fusibility of the phosphides and sulphides of iron as a circumstance likely to bring about what may be called "the liquation" of those debasing constituents or impurities. This great fusibility would, as Sir Frederick points out, promote the elimination of those compounds, passing them away from the parts of the ingot first solidified; so that he was not surprised to learn that the upper part of an ingot was "really considerably richer in sulphur and phosphorus than the lower portion." Mr. Riley, who certainly has had large experience of steel in its new forms, believes that this theory of liquation so well accounts for the phenomena or peculiar and varying characteristics in ingot steel as regards uniformity of constituents, that he is inclined to ask whether, in view of all the "theoretical and absolute experiments," they might not consider the theory conclusive. Sir Lowthian Bell also thinks that in all probability liquation does take place; but he thinks that a "redistribution of the elements comes about independently of this liquation." We have still some other points to refer to in this most important question of metal making and working.

118. Belt and Pulley Gearing.

In our last note, No. 91, p. 73, we gave a number of details in connection with the speed or velocity of pulley driving, and concluded it by stating various points in connection with this which would fall to be considered in our series. The first of these was the arrangement or distribution of the belting in relation to the machines to be driven and to the driving power. Before, however, going into this point, it will be as well further to dwell for a brief space on the advantages to be gained by driving at high speeds when belt-and-pulley gearing is employed. The distinctive characteristic between this and "positive," that is toothed-wheel gearing, is that while the latter must of necessity be driven at slow speeds, the greater the power to be transmitted, and the necessarily heavier all the parts, the slower the speed which can be got safely out of it. But in the case of belt-and-pulley gearing, the conditions are so different that, as we stated in last note, a system of running at low speeds, whereas it sometimes is adopted, is so in a thorough misapprehension of what those conditions are or should be. That those conditions are numerous the young reader will have perceived from what has already in previous notes been given on the general subject, and the hints we have thrown out as to what remains yet to be considered. But numerous as they are, many of them are what may be called minor details; and the conditions which may be said to be the chief or principal are but few,—such as large diameter of pulleys hung to or carried by light shafting, light and slack-running belts, and high speeds.

One characteristic of modern machines is their being so much more highly "speeded," as the technical phrase is—that is, made to run or do their work very much more quickly than even in times not so very remote from the present. This is particularly the case with textile machinery. Speed at the ultimate end of a belt-and-pulley connection—that is, at the machine to be driven—being required, the more quickly we get up that speed the better; and this brings out to the best advantage the chief condition of the belt-and-pulley system. In our last note we put the speed of the main driving pulley or drum at 3000 feet of rim surface velocity per minute. This in the practice of some goes up to as high a speed as 3750 to 4000. We alluded to the "factor of safety" in belt-running as 3000—making thus the maximum that which with others is the minimum speed—but experience would seem to show that a much higher speed than 3000 might be placed as the factor of safety; for which, however, we should say that the more correct term is "factor of economical running." There are some examples to be met with of a belt or running speed very much higher than the above named maximum: 7200 feet per minute has been given to a belt twenty inches wide, and running on a drum or main driving shaft of engine fourteen feet in diameter. The driven or small-diametered pulley was in this case four feet in diameter; but this was too small for the belt, which, through the centrifugal force of the pulley, jumped and ran now and then uneven. By reducing the speed to 6000 feet per minute the belt ran most satisfactorily. By increasing the diameter of the driven or small pulley to six feet the same result would have been attained. In cases where the driven or small pulley is not over four feet this authority puts the factor of economical running at 6000 feet per minute. This is considerably over "a mile a minute" (5280 feet), — a speed of belt-running which is conceded by the majority of machinists who have had large and varied experience as the best speed to be adopted for the main driving belt. With well proportioned pulleys 10,000 feet per minute may be run, which is, however, far in excess, of what is actually required in practice; but this practice is generally so exceedingly varied in its circumstances and details, that it is very difficult to decide what is the factor of economical running: what may in one case be shown to be a good factor, may in another case be greatly exceeded.

The piston speed and corresponding speed of crank shaft, or number of revolutions it makes per minute, being determined and known, the diameter of the driving pulley must be so proportioned as to give the required F s. p. m. (foot speed per minute) to its rim surface, as named above. Of course the other points have to be considered, but these are chiefly matters of detail. Nevertheless they must be attended to, as they will exercise their own special influence on the system generally. By duly proportioning the pulleys in accordance with the conditions demanded by the system, we shall get the larger diameters which will enable us to effect a saving of power; we shall have straps working easily, reducing tear and wear to a minimum, reducing that drag and strain upon the shafting and bearings which ill-proportioned pulleys and speeds produce, and which is in itself a prolific source of loss of power, to say nothing of the cost incurred in repairs, etc., etc. We shall presently refer to the method of taking off the power from the main driving shaft of the prime motor to the various parts of the factory or workshop in which the machines to be worked are placed. But we have one or two points connected with the proportioning of pulleys, etc., in order to obtain the high speeds which we see is or ought to be an essential feature of the belt-and-pulley gear system. An important point is the length of the belts, or in other words the distance between the shafts. This distance some determine by a hard-and-fast rule, such as making the distance from centre to centre of shaft ten times the diameter of the smallest or driven pulley. But it may be said with some degree of certainty that varying circumstances of machine location and driving will necessitate modifications of any definite rule such as this—which may, however, be said to be so far determinate that it may yield a general principle to be followed in adjusting lines of shafting. All distances should be avoided that necessitate the tightly bound belting which, as we have seen, throws such severe and costly strains upon the shafting and bearings. The distances between shafts should be such as to let the belts run with that easy sagging motion which pleases the eye of the practised machinist, and which the young machinist will, by close observation, soon get also acquainted with. While, then, a definite hard-and-fast rule applicable to all cases is not likely to be attainable, its modifications may lead to what may be called average distances, covering a wide variety of practice. While the too short distance is to be avoided, as involving too tightly wrapped belts, so on the other hand are too great distances. Those will involve such a heavy sag or drag weight on the belt, and this on the shafting and bearing, that considerable loss of power will be the result; and this undue weight or sag induces the unsteady, varying, flapping motion in the belt, trying to the mechanism—a motion very unlike the gentle snakelike motion which it is the aim of all machinists to secure in long belts or where the distance between the shafts is great. This peculiar wavelike—so otherwise to call it—movement may be taken as a safe test that there is no more strain put on the belt than is necessary to transmit the power. In forgetfulness or ignorance of this the true condition of belt-working, some adopt means—such as the use of clamps—by which the belt is put on the pulleys in a state of extreme tightness, which throws a most prejudicial strain upon the belt and the shafting and bearings. All such expedients, if used at all (and their avoidance on the whole would be the most prudent procedure), should be used most judiciously. Tightening or tension pulleys are also sometimes used, to give the belt a better grip, as is supposed, of the pulley; but good design and laying out of the gearing throughout will be found to be the best way of making all such expedients unnecessary. For main or driving belts the distance between the shafts being from twenty-five to thirty feet from centre to centre, belts having a sag—that is, a drop or catenarian curve from the straight line drawn from pulley to pulley periphery—of four up to five inches work well. With a distance of fifteen feet, which is a good one for small-diametered pulleys with narrow belts, a sag or drop in the belt of one-and-a-half up to two inches will be found satisfactory. Where with large diameters of pulleys and broader belts the distance from shaft to shaft goes up from twenty to twenty-four and twenty-five feet, a sag or drop of from two-and-a-half up to four inches will give good results. As a rule generally to be accepted, it may be stated that long belts give much more satisfactory results than short ones. The capability of belts to transmit power from the prime mover, as the steam engine, to the machines which it is employed to drive, is in proportion to the pressure of the positive or true weight of the belt on the arc or part of the surface of the pulley with which it comes or works in contact; one belt which is longer than another must of necessity have greater weight than the short one, and having greater weight must have greater adhesion, or as we may put it, greater tractive or dragging power on the pulley surface. And as this defines or decides its capability to transmit power, it may be taken as a rule that this power-transmitting value of belts is in the ratio of their relative lengths. It is obvious that the same rule applies in relation to the width or breadth of the belt; as where we have two belts of the same length, but of different breadths, the broader is of necessity the heavier, and gives, therefore, the greatest amount of power-transmitting value. Belts should therefore be made sufficiently wide or broad; for if too narrow the tension must be increased by tightening the belt, or by using a tension pulley, both of which expedients should be avoided, if possible; and by careful attention to such details as we have named, securing the wavelike motion of the belt to which we have already referred, and this by a proper adjustment of the sag of the belt. The young reader will of course understand that the sag or drop of the belt is on the lower side of the pulleys, the shafts of which are in the same horizontal plane. And in designing the motions, the direction of motion of the belt should be from the upper surface or part of the rim of the driver pulley to the upper surface of the driven. In shafts not lying on the same horizontal plane—that is, in which one shaft is placed above the other—this direction should not be vertical, but the centre line of the one shaft should be in advance of the centre line of the other, so that the belt will be at an angle or oblique to the lines of shafting. This angle should, however, never exceed that of 45°. In all cases, in proportioning the main driving power to the machinery to be driven by it, we should strongly recommend that a considerable margin of available power, whether of steam, water, or gas, should be given. This reservoir of power excess will be found of great value, should at any time more machinery be put down, which can thus be done in the cheapest way possible; while the having an excess or margin of working power will at all times be valuable, as it will prevent the necessity of over-driving or over-working when higher speeds or greater power are required. And though some young readers may not see the analogy existing between the two, it is nevertheless an axiom that an over-driven steam engine is as liable to be "done up" as an over-worked man or horse. Easy, steady working is always economical working.

119. Recent Researches into the Nature of Friction.

In a reply which we lately gave to a correspondent who had made an inquiry as to some experiments which had recently been made in connection with this subject of friction, we promised that we should, in a brief series of notes in the present section of the TECHNICAL JOURNAL, draw attention to the principal points established by those experiments. That promise we now address ourselves to redeem. Those experiments on or researches into the nature of friction are all the more noteworthy for two reasons. First, because they come before the world of practical mechanicians impressed, so to say, with the stamp or seal of the body—the Institution of Mechanical Engineers—best calculated from its position, and from the eminently practical and scientific character of its members, to institute experiments, and to give forth declarations deduced from these—a subject of vital importance to all engaged in the designing, the construction, and the use of machinery of all kinds, in which motion required for the infinite variety of mechanical and industrial work is the chief feature. The second reason why the experiments a description of which will form the basis of our notes are so noteworthy, is that they will greatly tend to set at rest certain points in connection with the nature of friction which have for long exercised the minds of men who were not satisfied with the long held and generally received theory on the subject. And while some may assert that these points, which will be presently specified, cannot be cleared of the doubts connected with them by the results of one set only of experiments, such as those which have been instituted by the Institution of Mechanical Engineers, it is only right to state that those experiments have been gone about and carried out in such a way, and have been so under the careful supervision of perhaps out of sight the best men in the mechanical world, that there is the best reason for deciding in favour of the conclusions which have been drawn from them. Moreover, while accepting those conclusions, it by no means follows that the experiments are final, and not to be repeated: on the contrary, there is every reason to believe that what has been done will give a great impetus to the further investigations which may be made either by the same body or by another body equally competent. Meanwhile, if no other benefit has accrued from those experiments than this, they have set men thinking upon a subject which for a long course of years was somehow set aside from the region of thought and investigation, as one which, being settled on all points, did not require to be in point of fact further thought about at all. And the value of this impetus to thought appears to be all the greater when it is recollected, which we have already alluded to, that the theory long held generally was deemed, to say the least of it, doubtful by many, who could not reconcile the facts of their own experience or the deductions of their own minds with the points of the established theory of friction. All this is the more valuable when we call to mind the danger which arises to mechanical, or indeed to any progress, from finality of effort or purpose, which rests contented with what has been, and does not admit that better might yet be done. To understand as precisely as is possible with what may be given in the short space at our command the value practically of the deductions made from the experiments of the Institution of Mechanical Engineers, it will be necessary to glance at the chief points of the theory of friction which has so long dominated the minds of the great body of our mechanics. This theory had its origin in, and was based upon, a most elaborate series of experiments, instituted by and carried out more than half a century ago at the expense of the French Government, by the able scientist General Morin, well known also for investigation in other departments of physical science, and whose name has thus become inseparably associated with, and who is indeed generally accepted as the author, or, as some would call him, the discoverer of the laws or theory of friction. It is right, however, to state that other experimenters on the subject had been in the field before Morin; and of these the most celebrated was Coulomb, whose investigations were conducted in such a manner as to have entitled him to the designation of the ablest of all the experimenters who had taken up the subject. The experiments of Morin, however, were conducted in such a way, and the mechanical details of the apparatus employed were so ingeniously designed and so accurately adjusted, and the theoretical skill with which the various points were dominated and those got rid of which tended unnecessarily to complicate the subject and to introduce elements of error—and, still further, the admirable way in which the practical deductions were stated, taking all those points as a whole—were such that the subject of friction was at once placed in so complete a way before the mechanical world that it was considered as settled; and the deductions of Morin, with his tables of results, and the coefficients of certain conditions of working, accepted as a rule by the whole body of machinists throughout the world. It is only due to the memory of so distinguished a scientist as Morin to state that, like all truly scientific men, he with all due modesty disclaimed any idea that he considered his researches and deductions therefrom as having finally and definitely settled the question of friction. He looked upon what he had done—marvellous as at the time it really was—as a mere contribution to the full investigation of the subject, which he trusted others following in his steps would prosecute; only claiming for them that in following those investigations up and out, he had taken every care and omitted no precautions to make their results as precise and as definite as he could. It is with a purpose in relation to our younger readers, and for the matter of that in relation to some of them who cannot with any truth claim to be young at all, that we note as above this example of Morin, to which numerous others can fortunately be added, of the truth that science properly so called is always modest It is only the pseudo-scientific man who claims with all calmness finality for any investigation he may make or theory he may put forward—who is dogmatic, asserting that what he says must be right, simply, as it would appear, because it is he who says it. After him the deluge! From what we have already stated, it will be seen that, widely as the deductions or "laws" of friction formulated by Morin were accepted as those which regulated the phenomena of friction, there were those who doubted the accuracy of these—if not all, certainly one of them—inasmuch as they could not make certain facts which their own experience had offered square or fall in with the requirements of those "laws." Further, that some, at least one of the deductions of Morin, could not be made to coincide with what *their* common sense told them was likely to be more accurate, or in consonance with the facts of their experience. These views, antagonistic as they were to certain of the deductions of Morin, did not detract from his true scientific celebrity; for, as we have seen, he at all events, whatever his followers might have done, and actually did, claimed no finality of settlement of the question of friction. If the experiments had done nothing more, they had done much when they set people thinking, investigating for themselves, in order to find out, were this possible, if such things were so. And it is this spirit which has led to the investigation and experiments an epitome or condensed statement of which it is the purpose of a few succeeding notes to give.

120. Ensilage Crops suitable for the Process.

At the conclusion of last note, No. 109, p. 144, we stated that we should draw attention to some crops which have been recently proposed to be added to the list of stock-feeding crops—a by no means large list—and this with a special view to the ensilage system. Of these, the two first we name have this special value attached to them: that, while affording good produce as green-cut food for stall-feeding, or for ensilage, they can be grown upon soils so exceedingly poor that, for the ordinary crops of the farm, they are practically of no value; and also upon odd corners of the farm which, either from their size or position, or the poverty of their soil, are usually left uncultivated and given over to weeds and such like. The first of these crops is Spurry—*Spergule arvensis*. This crop is almost wholly, at least is comparatively, unknown to English farming. It plays, however, an important part in certain districts of Continental farming. We have more than once elsewhere alluded to the exceedingly poor soils from which the small farmer of the Continent contrives, with patient labour, to wrest prolific crops. Those soils are, in the majority of instances, so very poor from a cultural point of view, that the term soil can with little accuracy be applied to them. They are chiefly almost pure sand, as light, shifting, and sterile as the sands which drift on the seashore, or are raised in clouds as the wind sweeps over the sand-hills or the dunes which skirt it for miles along the dreary coast. Those soils—which in many instances, as for example in the district of Belgium known as the Campines, constitute almost the whole of the soil so called by farmers—are brought under cultivation and made fertile not merely by the careful addition of manure, but by the wise adaptation of certain crops which lend themselves to the improvement of the soil or sand in which they can be and are grown. Amongst those crops spurry has a high reputation in this direction, and is largely used. It grows—and grows well—in those almost pure sands, yielding a large produce of leaves and stems. These afford a good supply of food for cattle, and in this way add to the stock of manure, which in turn being given to those poor soils, adds to, or rather gives to them, a new quality. In another system of cultivation the spurry produce is itself used as a direct manure by being ploughed or dug into the soil in its green condition. Or part of the produce may be cut green for cattle food and part used thus as green manure. And green manuring plays an important part in the cultivation of the poor soils of the Continent. Even in cases where the spurry is cut and used, the roots left in the ground tend not only to consolidate its shifting, movable, sandy particles, but add also to the fertility of the soil. And as these poor soils are thus gradually made richer and fertile, more valuable crops succeed the spurry, till they form part of the regular rotation course of the farm, and are made to produce that wide variety of crops for which Continental farms in certain districts are, as we know, so celebrated.

In this country we have a vast acreage of poor, sterile, sandy soils, of the class above described, to which the Continental system here briefly described could be easily and, beyond all doubt, profitably applied. We have, at all events, one instance recorded where the crop we have alluded to has been grown for the special purpose of ensilage, and with very successful results. This was done recently by Lord Walsingham, the spurry being grown upon a sandy soil so poor that it was valued at only a rental of one shilling and sixpence per acre; which is about the nearest approach possible to being valueless.

The second of the two crops of the class so valuable for being grown in poor soils is the Jerusalem Artichoke. The value of the root or tuber of this plant is becoming daily more and more recognised. All kinds of live stock are fond of it; and for dairy purposes it possesses a special value, as it tends to increase the flow, while to a considerable extent it adds to the richness, of the milk. And not the least valuable of its characteristics is the ease with which it can be grown in poor soils. So generously does it yield, for the little cultural care it gets, that it has been jocularly remarked of it, "that it will grow on a public road if it only be broken up and allowed to remain at rest." Certainly no odd corner of a farm, no stretch or patch of land which is looked upon and treated—or rather, utterly neglected—as if "good for nothing," but what will grow a crop, and a good crop, considering the circumstances, of Jerusalem artichokes. It may, further be said that after the first crop has been planted no further cultural care is demanded from the farmer. It may be grown year after year without manure, and the stirring of the soil which is given in the taking up of the tubers of one crop appears to be all the culture required for the next. So free and liberal a grower and producer is it, that a supply of fresh tubers as seeds or "sets" for a succeeding crop is not absolutely required; for the small tubers and parts of tubers which even the most careful "taking up" of the last crop will allow to remain in the soil will be quite sufficient to act as the seed for the succeeding crop. This freedom of growth is indeed just one of the objections to the Jerusalem artichoke as a crop forming part of the rotation of a kitchen or vegetable garden, for it is difficult to keep the plants down in succession or rotation plots where they are not wanted to come up. Hence we have always relegated the crop of artichokes to that piece of land in the garden which, for its position or its soil, is looked upon as an odd plot or corner of no great cultural value. Most large gardens have a plot or plots of this kind; and in such places we have grown fine crops year after year without giving any manure and very little cultural care, and it was difficult to say that the last crop was a whit less in value than the first or any preceding crop taken off the land. We have had occasion to inspect many farms in different parts of the country, but we do not remember having come across one which had not at least one patch or piece of what was called, and quite properly, "useless" land. In many farms we have seen considerably more than one patch of such; and we do not hesitate to say that we never yet came across corners of this kind but what were capable of yielding with literally the very minimum of farm labour, paying well for feeding purposes, valuable crops of Jerusalem artichokes. From an ensilage point of view, it is the stem and leaves only of the plant which are available. It it proposed—and the proposal, from what we know of the plant, we can heartily endorse—to grow the Jerusalem artichoke for its leaves and stems—especially its leaves cut in a green and thoroughly succulent condition. We have never tried, and therefore cannot say definitely, what effects this cutting away of the stems of the plants will have upon the tubers. But from what we know of the habits of the plant, and the freedom of its growth, we should be inclined to say that, as the stems and leaves will be cut for ensilage purposes at a very early part of the season, the roots will take a new start, and by the end of the season will have produced, if not a positively good, yet a crop of tubers which, whatever their value, will be so much to add to the value of the ensilage produce. And even if the plants be cultivated solely for this, without any regard to the root or tuber production, we believe that their cultivation will pay. Analysis shows that the stem and leaves are in point of nutritive value but very little lower than the roots or tubers themselves—and the nutritive value of those is more than twice as great as that of swede turnips or of mangolds.

Of the plants suggested by authorities fitted from their experience to give good counsel to farmers for trial under the ensilage system, the plant known as Sorghum or Sorglio, *Sorgium saccharatus*, has been recommended. Our older readers will remember how, on its introduction several years ago into certain parts of the Continent, it was thought that it would give our farmers a new and a valuable feeding or forage plant. It was tried in various parts of the country, but although much lauded by some, it did not take the place in our available crops it was fully hoped it would have done. Nevertheless it is a plant well worthy of the ensilage user; and it is just possible that it was introduced before its time, and that the system of ensilage is just what is necessary to enable the farmer to avail himself of the undoubtedly large yield of green food it produces. It is a species of sugar-cane, its habitat being North China. It is, like the maize, a very handsome plant, growing, like it, tall; producing in a short time a large amount of rich-looking stem and leaves, from which, by cutting down, a succession of feedings may be obtained.

The plant can be grown in a wide variety of soil—heavy, tenacious clay soil being, however, excluded; the deeper the soil and the finer the tilth, the better the crops produced, and like the maize, being somewhat of a gross or greedy feeder, it does well with liberal manuring. It is best grown in drills, say eighteen inches apart, and the plants singled out to twelve inches or thereabouts in the drills. May is the best month for sowing; six pounds of seed to the acre are required, and this should be softened by steeping in water for a day before sowing. The plants may also be propagated by seed-bed plants; the seed-bed sowing being done in early April, and the plants taken out and transplanted in June, or even in the first part of July if the land cannot be got ready or freed from a preceding crop sooner than this

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY.

(47) In heating, as when the first process of combustion—the volatilisation of the hydrocarbons—is effected, the gas produced is of greatly increased bulk as compared with what may be called its cold condition. Suppose now that cold air—the air necessary to supply the oxygen required in the process of combustion—is admitted to the furnace. As it comes in contact with the volatilised coal constituents, which in increased bulk are thin and light, there can be no proper mingling of them with the denser and heavier air; and the result is that the gas and air are passed into the flues or tubes of the boiler in a cold state, cooling there, while the temperature is too low to allow the gases to be completely flashed into flame, so that a large percentage of the heating constituents are sent into the open air through the chimney. The remedy for this untoward condition of things is to have the air heated to a sufficiently high temperature. When the heated air, in consequence of the same or nearly the same tenuity or lightness as the volatilised constituents of the coal, comes in contact with these, they mingle at once; and being of the proper temperature, they flash into flame, and thus are highly useful in heating the boiler flues or tubes, and are therefore not wasted by being, as before, passed unconsumed into the open air. But another benefit is derived from this system of having the air heated: the flashing into flame of the coal gas creates such a heat as to cause the combustion of the carbonic oxide gas, one of the products of coal combustion, and which, when the temperature is low, is passed into the open air through the chimney unconsumed. Special plans for heating the air in order to obtain the benefits thus named may perhaps in the not very remote future form part of every well-designed and worked furnace and boiler system. But meanwhile much of the benefit is attainable at no great cost by simply lining the interior of the furnace with a refractory material, such as firebrick.

(48) We have in a preceding note (46), while drawing the attention of the student reader to various points connected with the furnace and boiler of a steam-raising system for motive power, shown the evils arising from the "forced" firing of furnaces, inasmuch as time is not given for the necessary combination of the elements of combustion to be carried properly out, nor time for what we have seen to be necessary—namely, the preliminary preparation, or "cooking," as it has been termed, or extra heating, of the fuel calculated to give the most perfect combustion. For all these essentials in the securing of economical firing ample space and large area of grating for the furnace are absolutely essential. Thus, a boiler of ample dimensions, giving abundance of steam and water space, would alone secure that economical working of the system of steam-raising which is largely missed in so many establishments, in which, to save a first cost, and under erroneous notions of what combustion and evaporation are, furnaces and boilers of straitened spaces and confined dimensions are the features. With an alteration alone in the extending of the area of fire grate, and of the interior space of furnace, admitting of their slow firing, even a too straitened boiler could be made much more efficient than in conjunction with a confined furnace it now is. The great advantages to be obtained by ample space in the furnace interior are scarcely recognised by the profession, but indications now abound that this will not much longer apply. The researches of Mr. F. Siemens, than whom few have had such an experience in the practical application of heat in furnace work, will have great influence in spreading more accurate knowledge as to the value of wide spaces, in which the radiant heat of flame can give its best development. Objection is made to the increased dimensions of furnaces, as these will only give increased external area, or surfaces from which heat will be radiated to external objects, and thus be lost. But Mr. Siemens has conclusively proved that the heat produced in the interior of a well-arranged furnace increases in a much quicker ratio than the ratio of increase in the size of the flame or of the furnace interior space; for flame radiates heat from every point of its volume, unlike solid bodies, which radiate only from their surfaces. We have shown that a certain amount of air is necessary to promote and obtain combustion, but care should be taken not to admit too much. The efficiency of a furnace, as far as regards the combustion of the fuel, is generally tested by the temperature of the gases at the point where they leave the furnace and enter the chimney stalk—any increments of heat which pass this point and could have been used for evaporating purposes being obviously lost, as they are simply passed into the open air. If we admit air at the normal temperature of 60°, and the temperature of the gases as they escape from the furnace is found to be 500° Fah.—a temperature which engineers are careful never to exceed, but, if possible, to reduce—it is obvious that there must have

been taken from the coal as much heat as would raise the air at 60° to 500° (equal to 450°). As we must have draught in the chimney in order to pass the air necessary to combustion through the fuel and the flues or tubes of the boiler, a certain waste of heat cannot be avoided in this direction. This unavoidable waste may in round numbers be equal to 2000 heat units, which, being deducted from the total amount due to the combustion of one pound of coal, gives us the number of units of heat left for steam-raising purposes. Air is supplied to the furnace through the interstices or open spaces left between the fire bars. Those air spaces are in area generally calculated to be one-third of the whole area of the fire grate, which is virtually the area of the bottom of furnace. The volume of oxygen required to complete the combustion of 1 lb. of coal is in round numbers 2½ lb. This is obtained in 12½ lb. of common atmospheric air. As a rule, from 18 to 24 lb. of air is allowed for each pound of coal. The bulk of 13 cubic feet of air gives a weight of one pound. So far as the mere process of combustion itself is concerned, it does not matter whether a small or a large weight of coal is burned in the fire grate of a furnace, for the same units of heat are obtained from each pound of the fuel. But in respect to the economical combustion of the coal, it matters very much indeed whether you have heavy or light firing, large or small weights burning in the grating. Thus, with a small weight the necessary amount of air required by it will be supplied at so low a velocity, as it passes through the air spaces between the fire bars, that ample time is allowed for the perfect combination of the elements required for combustion. But in the case of the heavy firing, with the large mass of coal in the grating, the volume of air required is so great that a very much higher velocity of the air is demanded. This brings about the evils which we have already noticed. In regard to the boiler, the best ideal of it is that which an able engineer of the Manchester school gave when he placed a frying-pan on a kitchen fire, and said, "There you have the best theoretically perfect boiler you can have—large horizontal surface of metal heated by the fire on one side, and a thin large surface of water being heated on the other." Horizontal or bottom-heating surfaces are reckoned to be of twice the effective value of vertical or side surfaces. This ideal boiler being, however, constructively weak, and one taking up much space, to save space and obtain strength we double up and fold round the flat pan, and give it the form of a cylinder, either with flat or hemispherical ends, and this is the simplest form of shell boiler. But if we require more surface to be exposed to the heated gases and flame of the furnace, without increasing the space to be occupied by the boiler, we run a flue, or two cylindrical flues, right through the water space of the boiler from end to end, and we thus have the modern "Cornish," or with two flues the "Lancashire" flued boiler. Or if, still requiring more heating surfaces, and still keeping down the space, we multiply the internal flues, reducing their diameter, and run through from end to end of the water space a number of small-diametered tubes, we then have the tubular or locomotive type of boiler. In these cases the flame and heated gases of the furnace are run through the interior of the flues and tubes, their exterior surfaces being covered by by the water in the water space of the boiler. But if, conversely to this, we pass the water into the interior of the small tubes, and allow the flame and heated gases to play round the exterior of the tubes, we have the type of the boiler known as the "tubulous." These four—the shell, the flued, the tubular, and the tubulous—are the types of all the varied and ever-varying forms of boiler being almost daily introduced. Heat is not communicated to water, as in the case of solid bodies, by radiation and conduction, but by the process called convection, meaning literally one of conveying. This process has been fully explained when we were considering the conversion of heat into mechanical force and explaining the process of boiling of water. As the particles of water nearest the heated bottom plate of the boiler get warmed, they rise upwards through and communicate some of their heat to the surrounding water, colder particles rushing in to supply their place. This, in briefest fashion, explains the process of convection heating. The efficiency of a steam-engine boiler is tested by the weight of water at or from the temperature of 212°—the ordinary boiling point—changed or converted into steam by the heat units obtained from the combustion of one pound of coal. Space prevents us from going into the details of the subject: suffice it to say that the result of perfect combustion of one pound weight of coal is equivalent to the work of evaporating water from the boiling point, or changing it into steam to 14·87 lb., or in round numbers, 15 lb. It may be held that boilers are undoubtedly good which can evaporate or change into steam 11 lb. of water by the combustion of 1 lb. of coal. In many instances, the effective work obtained is far below this. It is, however, only right to note that, while we find that in practice a large number of the units of heat created in a furnace are somehow passed away absolutely unused, it is not altogether just to look upon this loss as one which by a better system could be wholly avoided. A percentage no doubt could; but it should be remembered that a considerable amount of heat is unavoidably lost in working the furnaces, which may, however, be said to be usefully employed, in carrying out the process of combustion itself.

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.—TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER II.

WE concluded the preceding chapter by pointing out that some fail to see the connection between the results in a sanitary sense arising from the condition of the poorer classes and that of the higher. It will be well, therefore, to point out the general bearings of this relationship between the one class of society and the other, in this matter of what is now so widely known as the sanitary condition of the people.

If the lives of the poor and needy are looked upon by their wealthier brethren with indifference, and if in the calculations of daily business their happiness and comfort are ignored, we may safely conclude that, notwithstanding other claims they may present—as advancement in the arts and sciences—their rank in the scale of true civilisation is not so high as they may wish to make it appear. Tested by this standard—which, by the way, is clearly founded upon the dictates of Christianity—it is somewhat painful to contemplate the position that we, as a nation, occupied at one period of our history. For years, the number of which may be easily reckoned by scores, one class lived in plenty, and were surrounded by luxuries and comforts; the other, afflicted with penury, and subject to all "the ills that flesh is heir to," were allowed to drag out their miserable existence, separated by a barrier hopelessly irremovable from the circle of humanity in which dwelt their luckier fellow-men. Such was the unhappy position of the two great classes, the base and the apex of society, that the rich and wealthy cared no more for their poorer brethren than for the beasts of burden that ministered to their wants or gratified their sense of luxury; nay, if the truth were told, not so much: the animal that bore his master to scenes of gaiety and dissipation might be pampered and caressed, while its keeper and the class he sprang from would only be suffered to "come between the wind and his nobility" because of his being useful in his day and generation. We do not refer to this period of our nationality as that of a time remote, when barons bold and their meanest serfs were alike subjected to influences most hostile to the principles of health, when the plague and pestilence walked the land, involving all, rich and poor—the prince in his palace, the baron in his dingy castle, or the vassal in his miserable den—in one common and destructive fate; but as of a period very closely connected with that in which we live, and the incidents of which may be remembered by living men. We have certainly begun a new era in the history of civilisation, but we cannot plume ourselves as to its having been long commenced; it takes no great stretch of memory to recollect how long it is since the various means were taken for alleviating the position of our poorer classes, and carried into practical operation. The poor and miserable have only recently begun to be considered as members of the body politic, and sanitary economy is but a science of yesterday. It is, however, gratifying to think that a beginning has been made,—that although the time has been short in which we have been working, the amount of labour has been comparatively considerable. The spirit of interest is awakened, the principle of exertion vivified; and our chief care now should be, that its practice become more and more extended, until the causes of disease, which are so rife and foul around us, may be grappled with and removed, till the loathsome graves which are now throughout the land "thick as the leaves in Vallombrosa" may be less frequently met with; and thus by labour most gratifying in its results, and by exertion the motive for which is the highest and purest that dwells in man, let us clear ourselves of the stern disgrace that so long has been connected with our nation's name, and of the weight of responsibility which we thereby most assuredly incur. But although we have begun the good work, and have upturned some of the sod which covers the field of labour, with a view to its thorough cultivation, we should not overlook the fact that all the labour we have done is but as one item in its aggregate amount; that the evil we have removed is but one atom of the mighty mass before us. An earnest and close consideration of the whole subject displays to us the fact that rather than pride ourselves on the good we have effected, in having removed many of the evils surrounding us, we may rest assured that the festering mass of evil before us has scarcely been surveyed in all its horrors, or its amount estimated. The misery which yet surrounds us, the deaths continually taking place, the disease ever prevalent, the vice and wretchedness resulting from these—may well incite us to greater efforts in the cause of humanity. And it may be, perhaps, to some, a more deeply inciting motive to exertion than the mere passing claims of humanity, to be told that the misery which exists, caused by the neglect of obvious sanitary arrangements, *must* be paid for; that every death—even of the meanest member of society—involves the loss of a certain amount of money, which must in some shape or other be drawn from the survivors who are able to pay; and this, whether collected in the name of poor rates or prison rates, or on any of the numerous pleas by which money is obtained, either for supporting wretchedness or endeavouring to prevent crime. If it be true that a "wrong to the individual is a wrong to the state," it is equally so "that shortness of life," from whatever causes, "among individuals, is a heavy calamity to the community at large." "The more closely," says an able writer, "the subject of the evils affecting the sanitary condition of the labouring population is investigated, the more widely do their effects appear to be ramified. The pecuniary cost of noxious agencies is measured by data within the province of the actuary, by the charges attendant on the reduced duration of life, and by the reduction of the periods of working ability—a reduction by sickness. The cost would include, also, much of the public charge of attendant vice and crime which come within the province of the police, as well of the destitution which comes within the province of the administration of relief. To whatever extent the probable duration of the life of the working man is diminished by noxious agencies, I repeat a truism in stating that to some extent so much productive power is lost; and in the case of destitute widowhood and orphanage, burdens are created and cast either on the industrious survivors belonging to a family, or on the contributors to the poor's rates during the whole of the period of the failure of such ability."

Sanitary Improvements not necessary only in the Houses and Districts occupied by the Poorer Classes.

It is a mistake to think that sanitary improvements are only required in the squalid dens of vice and misery—alas that they should be so rarely met with there!—but if their introduction served no other end than that of the example set to others, as an inducement to exert themselves in their position, we think it clear that it is the duty of those who are alive to the interest of humanity at once to do so. Numbers who are totally unconcerned about the matter, indifferent as to the daily loss of life going on around them, are not in the main hard-hearted; they require a stimulant to exertion; "they have never been roused to a sense of the surpassing value of life and health": let them become aware of this, and other feelings than those of indifference will result. And the best way, we take it, to rouse this "sense" is by setting a good example before them. Let efforts, in any walk of life or branch of business, be made continually before parties indifferent to them, the effect of daily sight or contact will suffice to awaken curiosity, stimulate inquiry, and ultimately prompt to the like exertion. And so with the details of sanitary economy: the more they are efficiently carried out, the more widely will their influence be felt, and the higher in the ranks of a true civilisation will those classes rise whose condition under what has been too long, and still is to far too wide an extent, their normal position, has been of a greatly degraded and degrading kind.

Much yet to be done in the National Work of the Sanitary Improvement of Districts and their Domestic Buildings.

So much has been done lately in the wiser course of national life, just alluded to, that many are under the impression that there remains little to be done in the way of sanitary work. This is a grave mistake, and gives rise to gravely evil consequences, moral as well as physical. We have said that the public were startled by the too true descriptions of the condition of the dwelling-places—to call them houses would be to totally misapply a term which properly conveys ideas of healthy comfort—of the very poor. These examples of existing circumstances were not confined to the rural districts, as some for purposes of their own, the existence of which, however, they would have been ashamed to admit, asserted or wished to assert that they did: they were to be met with equally in our towns and cities as in our country hamlets and villages. So startled was the public mind with this painful exposure of a condition of matters physical and moral existing in our midst, which spoke but little, if indeed at all, in favour of our boasted civilisation, that it seemed at one time as if the public were determined that such sanitary horrors should no longer exist amongst us. No doubt, as we have seen, something was done in the way of cure, especially in some of those districts which were favoured by the presence, not only of philanthropic but earnestly-minded business men. But much as was done in the way of cure, little was effected in the way of prevention. It would have seemed but a common-sense way to have dealt with the evil, which all admitted to be one grievously and injuriously affecting the welfare of the whole community, in such a way that it should not be perpetuated. If houses popularly so called, but which were in no way deserving of the name, had been allowed year after year to be built, in districts ill drained, ill supplied with water, and from which disease was never absent, it would have seemed but an ordinarily prudent, business-like mode of dealing with the subject—to say nothing of the higher and nobler motives which urge men to all good work—that a determination should be come to that for the future no such houses, no such districts, should be permitted to exist amongst us.

But this was not so; and although, as we have seen, much was done at the time in the way of cure for evils then existing, no proper steps were taken in the way of peremptorily preventing their occurrence in the future. So that to-day we find ourselves surrounded with a condition of matters which, if the evidence of scientific men and the appeals of philanthropists are to go for anything valuable, is just as bad, in its physical as well as in its moral aspects, as anything which existed at the time when the public were for the first time startled, not from their apathy—for they had never given any thought to the subject—but from their ignorance. Surely it is time, in the history of our social and national life, that no more "Bitter Cries" should arise from any district of any town or city in our otherwise highly favoured country.

As showing the harm, physical and moral, which arises through sanitary evils as they exist so potently around us—and as indicative of what their characteristics are, we might here give pictures, so to call them, painted by able hands, of facts as they exist around us. But neither the space nor the scheme of our papers admits of this being done. Nor, indeed, is it necessary in one sense to do so; inasmuch as we can have but too ample stores of information on the subject by consulting the pages even of our daily journals. Few of our readers, for example, can be ignorant of the evils existing amongst us as displayed in the pages of that remarkable work but recently issued, which gave voice to the bitter cry of "outcast London," which has so startled society, and to which we have but just alluded. The two parts of the sanitary question, the moral and the physical, cannot be too frequently dwelt upon by, or too forcibly impressed upon, the public mind, seeing the large amount of indifference with which the public view the subject—and seeing how far this apathy permits the evils to be simply perpetuated, created as they are from day to day, in districts in every town, in quiet spots in every county.

We have said and hinted enough, but not given a word or hint more than enough, to suffice to show the importance of the subject of sanitary reform. It is one which carries consideration of truly vital interest to us as a people; and while we should regret if the reader conceived that we were not gratified at what has been done in the way of remedying sanitary evils alike in town and in rural districts we should be doing him and ourselves an equal injustice if we gave the impression that little remains to be done. The evils are so gigantic, the instances in which they exist are so numerous, that the mere amount of time required to get rid of them is in itself a most potent reason why their removal should be earnestly begun at once. And more than the removal of present evils is required at the hands of the community. Means, as we have seen, are necessary to prevent their recurrence in the future. And those will not be taken—seeing they must be under legislative sanction if taken at all—until the public mind is educated up to the proper point at which they will be urged to be no longer content with talking about, but only determined to effect thoroughly, completely, and once for all, sanitary reform in all its departments, and this under the guidance alike of a wise and sound social, and a precise and definite sanitary science.

We have thus glanced at the importance of our subject, and given some of its leading characteristics. In dealing with its more practical details, we shall consider them under several heads, which will be taken in what we may call a natural sequence. This will lead us, in the first place, to note the practical points connected with the site and soil constituting the foundations of houses—thereafter taking up the subject of drainage and sewage of the houses to be built upon the sites—and presuming the houses to be so built, we shall next consider those points which tend to make the houses healthy and comfortable to live in; these being treated of under the heads of ventilation, warming, and lighting.

And, first, as to points connected with the soil and the site. What we have to say on this is chiefly based upon a paper on the subject which the writer gave some few years ago in one of our leading scientific journals.

"The foundation of a house" is, as a workman graphically said, "everything,"—and truly he was not far wrong, for unless that be sound, the superstructure, however good, will not be safe; and this saying of the workman is specially true in the sanitary aspects of the question. Indeed, it may be said that some of the most grave sanitary evils—if these two words be not, indeed, contradictory, as a good thing, which sanitary is, cannot be evil—arise from defective foundations. Let us see how this may be and is. The foundations may be said to consist of two things: the soil or ground upon which the building stands: and the foundation in a constructive sense—that is, as part of the wall, which is popularly understood to be the foundation proper. The soil on which the house is to stand is generally natural, or, as it often is, partly natural and partly or wholly artificial, the latter being what is known as "made soil,"—a source of many evils, as we shall presently see.

Of the many causes which render houses so unhealthy, there is perhaps none which is so certain in its effects, and yet so difficult to be dealt with, and withal so insidious in its forms of attack and methods or ways of development, as damp. And from these peculiarities, especially that referred to as being so insidious, it is one which should be most carefully guarded against, all the more that its effects are not immediate, and so calculated to strike the inhabitants or their medical advisers as others,—as, for example, the evils arising from defective drainage, this latter making itself known by at least one of the most potent of the senses, that of smell.

Damp, unless it be of so decidedly bad and highly developed a character as to show itself in its usual and melancholy signs upon the walls, gives, on the contrary, no indication of its presence in this way; it works, but works in many cases unobserved, silently — if the phrase may be allowed — doing its mischief, and this unknown to those subjected to it.

THE GEOMETRICAL DRAUGHTSMAN.

HIS WORK IN THE CONSTRUCTION OF THE FIGURES AND PROBLEMS OF PLANE GEOMETRY. USEFUL IN TECHNICAL WORK.

CHAPTER VII.

CONTINUING our description of fig. 25, given at end of last chapter, we proceed to say to the pupil: Place one of the edges of the square on the line *a b*, so that when a set-square *c* is placed on the edge, its side, as *c*, is coincident with *a b*; then, keeping this ruler perfectly steady, draw the set-square along till its side, which was in coincidence with the line *a b*, passes through the point *c*; it only remains to draw a pencil along this side, and any number of lines parallel to *a b* may be drawn thus. It is evident that this side of the set-square always

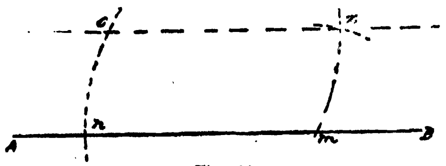


Fig. 26.

makes in every position the same angle with the side of the ruler along which the square is drawn. Any two positions of this side are then always parallel, as making corresponding equal angles.

Another method of drawing a line through a point *a*, which is to be parallel with a given line, is with the ruler and compass. From the point *c*, fig. 26, as a centre, with any convenient opening of the compasses, describe an arc of circle *m x*, which cuts the straight line *a b*, to which we wish to draw a parallel. From this point *m*, with the same opening of compass, let us describe an arc of circle *n*. With the distance in the compass, *c n*, describe from the point *m*, as centre, an

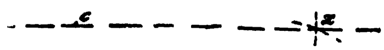


Fig. 27.

arc of a circle which cuts the arc of circle *m x* at point *x*. Join *c x*: this gives us the parallel line required.

In this construction we suppose that the straight line *a b* is given, and that the points *c*, *m*, *x*, and *n* are in the same situation as $c\,m = m\,n = c\,x$. In a case in which the straight line *a b* would be indicated only by two of its points, *a* and *b*, and we could not draw or complete the line, we may employ a construction as simple as the preceding: thus, from the point *c*, fig. 27, as centre, and with an opening of compass equal to *a b*, fig. 26, describe the first arc of a circle; then from the point *b* as centre, with a radius equal to *c a*, describe a second arc, which cuts the first at *x*. Join *c x*. This straight line is parallel to *a b*, fig. 26. From the construction, the quadrilateral *a b c x* has its opposite sides equal; it is then a parallelogram; *c x* is then parallel to *a b*.

A third method is with the protractor. We merely mention this process, which is easy to understand. It consists in drawing a straight line passing through the point *c*, and meeting the straight line *a b*, and in leading through the point *c*, by means of the protractor, a straight line, making with the latter an angle equal or supplementary to one of the two angles which forms this straight line with *a b*.

To draw a straight line terminated by two points, one of which is at *b*, between which there is an obstacle.—From the point *b*, fig. 28, as centre, describe with any convenient radii arcs of circle which intersect at *m* and *n*. From these points *m* and *n*, as centres, with

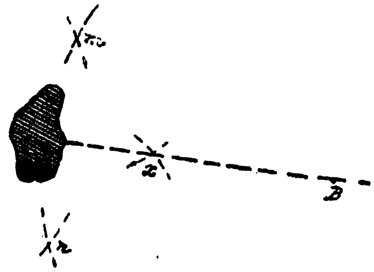


Fig. 28.

the same radius, describe two arcs of circle which .... intersect at *x*—the point *x* belongs to the straight line *a b*. We can thus obtain as many points as we desire of this straight line. The construction is easily proved. The line or arc *m n* is in short the common arc of two circles having their centres at *a* and *b*. Now, we know that the line of the centres is perpendicular in the middle of the common arc; therefore the point *x*, at equal distances from the points *m* and *n*,

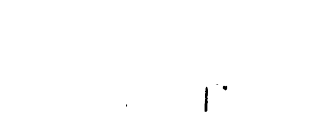


Fig. 29.

belongs to the perpendicular raised in the middle of the line *m n*—that is to say, the line *a b*.

Problems connected with Lines.—To Raise or Draw Lines Perpendicular to other Lines.

To raise a perpendicular in the middle of a straight line, A B, on which there is drawing-space both above and below the line, as in fig. 29.—From the points A and B as centres, with some arbitrary opening of compass, we describe two arcs of circle which intersect at x. With the same opening of compass, or with another, we construct in the same manner a point y. The two points x and y, from their construction, are equidistant from the points A and B; the line $x\ y$ is then perpendicular in the middle of the line A B. Where there is only space above the given line, we adopt the same constructions, but on the same side of the straight line A B, fig. 30. It is besides evident that the farther

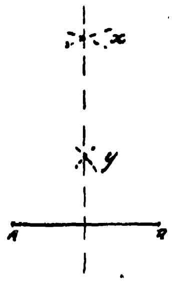


Fig. 30.

apart the points x and y can be made, the better the perpendicular wanted, $x\ y$, will be determined. It is a general principle, when we wish to determine a straight line by two of its points, to get the latter at the greatest possible distance from each other. The pupil will perceive that this construction is applicable to the dividing of a line into two equal parts, the operation being known in the technical language of geometrical drawing as "bisection." By extending the operation we can divide a straight line into two, four, eight, etc., equal parts. In dividing by the same construction the half into two equal parts, we have the quarter, and so on. We will give further on a

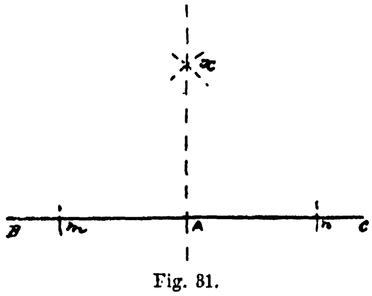


Fig. 31.

construction or problem for dividing a straight line into any number of equal parts.

To raise a perpendicular to a straight line at a given point of this straight line.—We assume two positions —first, where there is drawing-space on the straight line to right and left of the point given; secondly, where the point given is situated at one of the extremities of the straight line, and the latter cannot be prolonged.

To raise at the point A, fig. 31, a perpendicular to the straight line $b\ c$. Starting from the point A, with any convenient opening of the compasses, set off on the straight line $b\ c$ two points $m\ n$, which will be thus equidistant from the point A. The perpendicular through the point A to the line $b\ c$ will be then perpendicular in the middle of $m\ n$; and we recur to problem in fig. 29, with this difference, that here the middle, A, is known. It is sufficient, then, to determine a single point x, which will be done as above, in describing from points m and n, with the

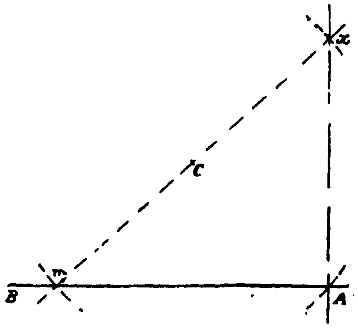


Fig. 32.

same convenient opening of the compasses, two arcs of circle, the intersection of which will give a point x, and $a\ x$ will be the perpendicular wanted. In the second of the above cases or positions we see that the preceding construction is evidently at fault when the point a is situated upon or towards the extremity of the straight line $a\ b$, on which we wish to erect a perpendicular. We easily perceive the construction which belongs to this case by remembering what we have already stated, that every angle inscribed in a semicircle is a right angle. Let us take any point whatever (C, fig. 32) and from this point as centre,

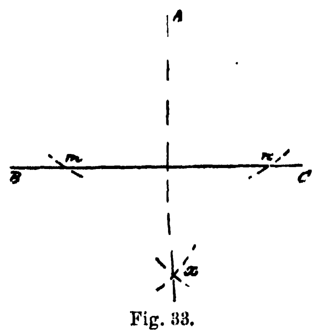


Fig. 33.

with an opening of compass equal to C A, describe a circle which will cut the straight line A B at a point m. Join this point m to the centre C, and prolong the straight line m C to its meeting at x with the circle which has just been described. Draw the straight line A x; it is the perpendicular required. The angle m A x is a right angle, because it has its summit on an arc m A x, equal to a semicircle, the line m C x being a diameter.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER IX.

WE concluded our last chapter by stating briefly that what had been given in preceding paragraphs would convey to the reader no fair conception of how the indicator showed the peculiarities of the action, or "behaviour," to use an engineering term, of the steam inside the cylinder. This latter is called technically the "reading of indicator diagrams," or "figures" as they are often called. But although these general ideas of the indicator, its mode of working, and of the reading off of its indications or recorded diagrams, may be obtained from what we have already given, still more explicit statements on these points will be required in order to make our paper as complete as we desire

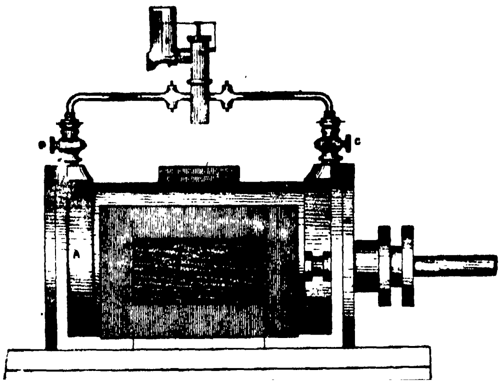


Fig. 10.

it to be. But complete as it may be, still it is not to be expected that from consulting our pages one unacquainted with a steam engine can gain all the knowledge of its working equally with one who has been accustomed to its use and is in daily connection with it. From papers written in a plain style, and descriptions given clearly, much valuable information can be obtained, and thus be a great help to those intending to put such knowledge into practice. Still no writer would be so proud (*i.e.* so ignorant) as to assert that the information derived from his pen would be equal to the practical testing of a personal experience in the working of the engine, even though we may give to some writers credit for the clearness which they give to their matter. Much depends upon the turn of mind or the aptitude of the reader in taking possession, so to say, of the information communicated. The difficulty of imparting knowledge may not always rest with the writer; the task of receiving it rests with the reader. We shall now at this stage present our readers with some paragraphs in connection with

The Forms and the Reading off of Indicator Diagrams or Figures.

At the outset it will be necessary to draw the attention of the reader to some points connected with the action of the piston in the cylinder, which some who are advanced in knowledge of the steam engine may at first sight conclude to be altogether too elementary in character, but which on further consideration they will, we think, see are essential to be known, and if known, to be remembered in all inquiries into the working of indicators and the "reading off" of their "figures." Although there have been a large number of peculiar forms of steam prime movers or engines introduced, some of which might well be designated as the eccentricities of mechanical genius, still the normal or general—so general that it may be said to be the universal form of steam engine—is that in which the cylinder and piston, as in fig. 2 (*ante*), are the principal and essential features. As steam is the impelling or propelling power which acts on the piston, and as this action is controlled, influenced and directed by the arrangement of the "ports" or channels by which the steam is admitted first to act upon the piston, and by the "valves" which control, that is, cover and uncover those ports, it is obvious that the efficiency of the engine depends upon the relation which all those parts bear to one another, and the mechanical perfection of their make and adjustment. And as the practical result of this relation is exhibited, so to say, within the cylinder, they may be said to be occult or hidden. To make them to be as it were seen, or visibly displayed, to the steam engine user, is the office of the indicator, and the figure or diagram which its operation affords. This last is practically a graphic illustration of what goes on inside the cylinder; and on the work there done depends, as we have shown, that of the engine as a prime mover useful in turning or driving machines of various kinds, or of doing special work itself directly, as in the driving of the locomotive or the propulsion of a steamship. The motion of the piston, *d i*—see fig. 2 (*ante*)—is in a right line, which may be parallel to the horizon, as in the horizontal engine; at right angles to it, as in the vertical or upright engine; or oblique to the horizon, as in the diagonal engine. This motion of the piston within the cylinder, *h g*, *g h*, is taken alternately in two directions, each of which is called technically a "stroke," one being the "forward stroke," and the other the "backward," or perhaps more frequently the "return stroke." What is technically a "revolution of the engine," which is another term for a complete rotation of the crank and crank or driving shaft of the engine, is made up of both the forward and the return or backward stroke—the forward stroke sending the crank or turning the crank shaft through one half of its circle of rotation, the return or backward stroke sending the crank round or through the other half of its rotation, thus completing it, and giving what is called a "revolution." And this is a term synonymous with a "complete stroke,"—the forward, and the backward or return strokes, being in this sense only half-strokes. In taking the "forward stroke" in the direction of the arrow c, fig. 2 (*ante*), the steam, which enters at the port towards the end *h* of cylinder, expands and drives or pushes forward the piston *d i* from the end *b b* to end *g g* of the cylinder; the impelling or propelling power—which is the equivalent of what is called its "energy" (see for this term the paper "The Student's Introduction to the Principles of Mechanics"), although the terms power and energy are not precisely equivalent or synonymous—exerted or put forth upon the piston during this forward stroke, or what may be called its working intensity, is in proportion to the space, which is the equivalent of the volume, of steam passed through by the piston, and to the intensity or energetic force of the steam—that is to say, a mean of its varying conditions, these not being uniform. In taking the "backward" or "return stroke" in the direction of the arrow *b*, fig. 2 (*ante*), which extends from the end *g g* to that at *h h* of the cylinder, the piston *d i* exerts two influences on the steam which is present in the cylinder, on the side *h h*, *d d*: first it sends it out or drives it before it, passing it out to the atmosphere through the exhaust port; and secondly—this dependent upon the way in which the exhaust port is controlled—by compressing the steam, or, as it may be popularly described, squeezing it up against the end *h h* of cylinder, in the enclosed space between this end and the side or surface *d d* of the piston. And the result of this squeezing, or compressing, is technically called the "back pressure" existing in the cylinder, and is a feature which closely affects the character of the diagram or figure given by the indicator. In doing during the return stroke this dual work of part expulsion or driving out of the steam from and part compression of the steam within the cylinder, the piston exerts on the steam an amount of power, force, or energy, proportionate to the space or volume of steam through which it passes and the mean or average intensity of its pressure, which, as we have stated above, is known as the return or backward stroke, or a back pressure. In the two strokes—or properly speaking, half-strokes, as a revolution is only a complete stroke—we have first in the forward stroke an excess of power, force, or energy, exerted by the steam on the piston; and conversely, in the return or backward stroke, a force, power, or energy exerted by the piston on the steam; and it is the excess of force or energy exerted by the steam during the forward stroke over that of the piston, which constitutes or gives the effective power of the engine during the period in which the two half-strokes are being done—in other words, effective power during one revolution or complete stroke. And this is equal to the work done by the piston and its always associated piston rod, connecting rod, crank, and crank shaft, in overcoming resistances exerted by the work to be done—this work performed or resistance overcome by the piston and its associated members being *minus* the back pressure above noted.

Some Points connected with the Forms and the Reading off of Indicator Diagrams or Figures (*continued*).

In fig. 2 we gave a popular description of a diagram showing the working of a steam engine cylinder under what may be called theoretical conditions, the figure or form of which may be taken as represented by the lines *g l*, *m*, *n*, *o*, *p*, *h*, and as giving a diagram representing the highest effective work which can, so to say, be got out of the steam. But this is never

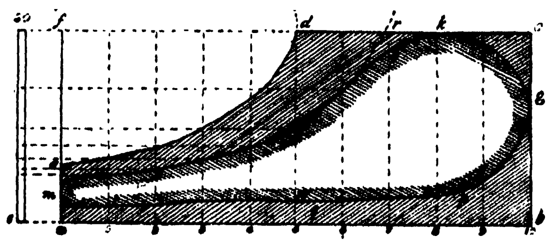


Fig. 11.

practically obtained: certain defects in workmanship, others which may be said to be inherent in the steam engine, and some arising from defective adjustments—all of which will be hereafter named—give rise to defects in working, and which being mirrored, so to express it, in the diagram afforded by the indicator, constitutes its great value to the steam engine user. Thus, taking *a b*, fig. 11, to represent the "atmospheric line," the atmospheric "pressure" being assumed to be 14·7 lb. per square inch, or 2116·3 lb. per square foot, at the level of the sea. In very precise and definite calculations, the true atmospheric pressure is to be ascertained by the barometer for the given locality. The height from *b* to *c* is to be set off from the scale which is adopted in constructing the diagram to represent the pressure at which the steam is to be admitted to the cylinder, be it 30, 50, 70, or 100 lb. per square inch; and represents the rise of the pressure of the steam on entering the cylinder from the lowest or atmospheric pressure point up to that point above it due to the steam pressure employed, be it 30, 50, 70, or

100 lb. per square inch. The line *c d* represents the pressure as it is continued to the point *d*, at which the valve cuts off the supply of steam, which no longer enters the cylinder. And the curved line *d e* represents the gradually lessening pressure caused by the expansion of the steam as it expands from *d* to *e*, to fill up, so to say, the increased capacity of the cylinder. From what has been said on Mariotte's law of expansion in second column of p. 354, vol. i., it will be seen that the point *d*, on the line *c f*, which represents the full length of stroke of the cylinder, represents the pressure at the end of the stroke. This, according to the law above named, will be just one-half of the pressure at the beginning of the stroke, at point *d*, or at the middle of it. When the steam is cut off, as at *d*, one-half of the stroke of the piston, as the capacity of the cylinder into which the steam passes beyond point *d* has been doubled in relation to the amount of steam, this is of course equal in volume to that which filled the other half of the cylinder from point *c* to *d*. Still referring to the diagram in fig. 11, the line or distance *e* to *a* represents the amount of sudden drop from the final pressure at *e* to that of the atmosphere, where the exhaust port is opened by the valve; while the steady continual resistance of the atmosphere to the passage of the steam from the cylinder is represented by the line *a b*, which is the atmospheric line. But this theoretically perfect diagram is very much modified by the actual, and as we have observed, often unfavourable circumstances under which the engine works, as well as the carelessness in adju tment of parts so often met with in steam-engine construction. In place of the figure or diagram represented by what may be called the symmetrical form in fig. 11 at *a b c d e*, it may be as in the internal figure, which is an irregular curve in its outline throughout. This change in the diagram may be brought about by various defects in adjustment of the engine, etc. Thus, the curve from *g* to *k* may be brought into existence in the diagram by the gradual opening of the port, in place of a sudden or quick one at the commencement of the stroke; and this because the piston may have actually gone through part of its stroke before the full pressure of the steam acts upon it. Then again, the curved line from point *k* to *l* is produced or caused by the too gradual closing of the port, or from other causes, such as leakage or cooling of the steam. The curve from *d* to *e*, which is the theoretical or perfect curve, is that of a hyperbola, shown by the dotted curve on upper side of line *c f*; and it varies from this true curve, as shown by the corresponding line *l m* in the actual diagram in fig. 11 as contained within the perfect or theoretical diagram. And the nature of the actual curve, as from *l* to *m*, depends upon the degree to which the steam is cooled in the interior of the cylinder from radiation, etc. Hence the value of "steam jacketing" or of "cleading" the cylinder, in keeping up the curve *l m* to the true curve *d e*. Remarks on this principle of steam jacketing, and how it is practically carried out, will be hereafter given. The theoretical straight-lined drop in the diagram from point *c e* to *a*, fig. 11, when the exhaust port is opened, is by its too gradual opening the cause of the diagram taking the curved form as shown in the internal diagram at the point *m* joining the line *l m* with the line *a b*. It will be observed that the complete curved line extending from *m* to *k* is that curve known as a "curve of contrary flexure," the part *m* to *l* being concave, *l* to *k* convex, the point of the contrary flexure, that is where the change of direction of curved line begins, being at *l*. This peculiar curved line is the effect of what is called the "wire drawing" of the steam—that is, the mechanical effect produced by the passage of the fluid through passages, channels, or openings more or less confined, and which may be popularly described as throttling. To this and its effects we shall again refer in noticing other causes of defects in diagrams—which expression is synonymous with that of defects in the working of the engine.

Some Points connected with the Forms and the Reading off of Indicator Diagrams or Figures (*continued*).

In the last paragraph but one we gave some remarks on what may be called the behaviour of the steam in the engine cylinder in relation to the forward stroke and the backward or return stroke. Certain parts of the cylinder—or, what is the same thing and more apposite to our present purposes, of the indicator diagram—which, as we have seen, is a mirror, so to say, of what has gone on in the interior of the cylinder—afford areas or surfaces which represent the work done or energy expended or given out by the forward stroke, as, on the other hand, they give areas which represent the loss of working power or energy in the backward or return stroke. Areas indicated by the diagram are calculated by the use of what are called "ordinates" (see "The Geometrical Draughtsman"). The length of the diagram, as *a b*, is divided into any number of equal parts, generally ten. From these points lines are drawn at right angles to *a b*, joining the line *c f*, which represents the length of stroke, and these lines are called "ordinates." The reader will see in fig. 12 points, as *m*, *n*, *o*, *p*, upon the curved line, and these measured from where they cut the atmospheric line, represented by *g h*. These indicate the various and varying amounts of the pressure of the steam at the points, as *n*, *o*, *p*, the actual pressure of which is 50 lb. to the square inch, represented by the line *g h*—this pressure uniform to the point *m*, along the straight line *m* of the perfect or theoretical diagram. (See fig. 11 and its description in preceding paragraph.) At the point *m* the steam is cut off, and the points *n*, *o* and *p* represent the reduced pressures as the steam expands—namely, 25, $16\frac{2}{3}$, and $12\frac{1}{2}$ lb. These, it will be observed, are all marked on the "ordinates," as *j n*, *k o*, and *h p*, drawn at equal distances along the atmospheric line *h g*. It may be noted here that the letters given in this diagram will supply the place of some which are unfortunately omitted from the diagram in fig. 2, p. 353, vol. i. The points *n*, *o*, *p*, it will be perceived, are coincident with the vertical scale drawn parallel to the end *h p* of the diagram, and which scale is in any proportion of equal parts considered most convenient, —the distances, as *j n*, being either measured from the scale *a b*, or the lines carried across from the points as shown at the parallel to *g h*, the point at which they cut the scale giving the amount of pressure for that particular point in the diagram, as at *n*. The number of lines, or "ordinates," on the line *h g* depends upon the distances or intervals on the line; this is usually ten, as in fig. 11, giving the nine ordinate lines. It will be observed that the "ordinates" give or enclose spaces or areas, such as *i g l m*, which may be called

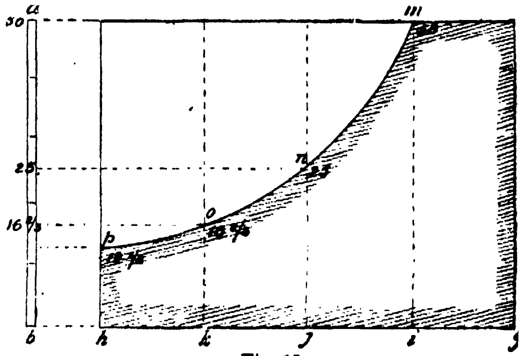


Fig. 12.

the area of initial or primary pressure of steam. In the last paragraph but one we explained briefly the points connected with the phenomena of the steam action within the cylinder, as of the forward stroke, and the return or backward stroke of the piston. The diagram, or indicated "figure," given in fig. 11, is supposed to be taken with the indicator screwed into the tap at top or cylinder cover; and in this the upper line, or the curve from *m* to *g* through *l* and *k*, represents the line traced by the piston during its "forward stroke," and the space or "area" *a m l h g b a* the force, power, or energy given out by the piston during this forward stroke. The bottom line of the curve in fig. 11, as *m n g*, is that traced by the piston when the steam is passing from the cylinder by the port, or during its backward or return stroke; and the "area" *a m n g b a* represents the work, power, or energy lost in expelling the steam, the piston pressing on it during this return stroke. Consequently the "area" *m l k g n m* represents the amount of actual or effective work done by the steam within the piston; and the peculiarities of the curve giving or enclosing this area indicate the defects or otherwise influencing this effective work. The ordinates drawn from the atmospheric line, *a b*, fig. 11, at any point, as at 5, give in the distances 5 *n* and 5 *l* the difference between the atmospheric pressure—which is practically the line of no pressure, or as it may be called the zero line of the diagram—and the effectual. If the indicator were attached to the end of the cylinder opposite to that at which it was attached in giving the diagram in fig. 11, the diagram resulting would be theoretically the same; and practically, if the valves be properly set, the two diagrams, one taken from one end, the other from the opposite end of the cylinder, will represent pretty nearly the pressure of the steam at that corresponding point. In this case the whole height of the ordinate from 5 to *l* represents the total or complete pressure on the one side of the piston during its forward stroke, when the steam is pushing or propelling it—in other words, doing work —at that point in its progress forward, or of its stroke; the part 5 *n* represents the amount of resistance offered by the steam at the same point of its stroke as it is escaping through the exhaust port, and offered partly by its compression against the cylinder end; then the part between the two points where the curve cuts the ordinate, 5 *l*—namely, the distance *n l*—represents the effective pressure on the piston at the point 5 of its stroke, that is, free from all resistance of exhaust or compression. And the condition here shown to exist at any one "area," as bounded say by the points 5, 7, *o*, *l*, obviously applies to the corresponding changes as to pressures on all the areas bounded by all the ordinates with their connecting points of the curved line of diagram. The area of the whole gives a representation or measure of the force developed by the piston during its forward stroke. The areas of diagrams, or similar areas of irregular figures, are estimated by what is called the "trapezoidal rule." This is based on the supposition that the curved line, as *m l o k g*, fig. 11, is made up of a series of straight lines,—just as a circle may be considered a polygon with an infinite number of sides of straight lines. By dividing the space by a number of equal distances, as in fig. 11, we have a series of points through which, at right angles to *a b*, we draw "ordinates" as shown, the number of which must always be one more than the number of the intervals or equal spaces into which the line *a b* is divided, this number of spaces being, as we have said, generally ten in indicator figure work. Of course the end "ordinates" are included, as *b c*, *a f*—these, in fact, bounding the figure right and left, as the line *c f*, representing the full length of the stroke of piston, and the atmospheric line *a b*, bounding the top and bottom of diagram.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER VII.

Great Neglect amongst Speculative Builders as to what is really required by Families of Different Classes of House Occupants.

AND on the point last stated (p. 92), it may be said that in but too many of the houses " built to speculative order " a very great ignorance of what really are the necessities and requirements of the families for whom, strange to say, they are said to be specially built, is shown to exist, if the plan or internal arrangement of the houses is to be taken in evidence. Or if this ignorance on the part of the builders does not exist, then their position as builders is still worse, for they show that they wilfully neglect giving what they believe nevertheless ought to be given. Many amongst us sigh for a higher class of domestic architecture, higher alike in sanitary position, in convenience of living arrangement, and in constructive taste. But they will sigh in vain so long as the present system continues, of planning and building on what we have called the stereotype system, in which street after street, district after district, in our cities, and isolated buildings such as cottages and the like in suburban and rural districts, are perpetuated, and perpetuated in endless repetition of internal arrangement, and in sombre sadness of external appearance. We cannot here use the term architectural style or design, for of this there is none in those too-frequently-met-with buildings.

Principle upon which the Plans in this Paper are given.

Our plans are given on the principle that the young architect or builder is called upon to design a special plan to meet the *special circumstances of his clients or employers.* These circumstances it is his duty closely to consider, and to study how best he can meet them. The plan he may hit upon as the result of this may be so good, and so well suited to the circumstances of that particular client or employer, that he may repeat its building in another or in the same locality, should he be called upon for a design by some other client. But it by no means follows that the circumstances of this other client are the same. His wishes or his family necessities may demand something quite different, and to the points of this demand the young designer must or ought to pay the strictest attention. And as to the repetition in the same locality of the external style or design, there can be no valid objection—although sameness, at least in one locality, is to be deprecated. Still the style may be followed in many instances, and yet variety may be obtained by the different arrangement of the plan necessitated by the requirements of different clients or employers. The young architect or builder may thus in time, as his practice extends, get up what he may call a series of representative plans and designs, suitable for different classes of society. It is such representative plans and designs that the drawings we are about to give illustrate. They are simply suggestive plans, showing the style and class of accommodation required by different classes in varying situations in town, suburban, and rural districts. They are not only open to criticism, but are given with the special view that the young architect or builder *should* closely criticise them—so carefully study them, that he may either approve wholly of them as good, or be able by his study to show how they could be made better designs by his improvements in them, if not indeed to decide that in accordance with the results of his study they are more or less decidedly bad. To this end we give plans more or less defective, in the hope that he may be able, by a close study of them, to show in what point or points their defects lie.

Importance to the Young House Planner of Studying and Taking Sketches of the Plans of Houses already or being Built.—His Sketch- and Note-book.

To the study of the designs which will be presented to him, we would earnestly impress upon the young architect or builder to add a diligent inquiry into the peculiarities of plan of such houses within his easy reach as may be building or built. He ought to take every opportunity of closely examining their arrangements, as also those of every plan which he may meet with in works he will find in most of the technical libraries. Knowing the class of inhabitants for whom such structures are raised, and having, or endeavouring to have, a pretty accurate acquaintance with their household necessities, he should endeavour to see in how far the plans of houses he meets with are likely or not to meet those necessities. Not content with merely observing, and that closely, the peculiarities of plans he thus meets with, he should, whenever opportunity offers, take sketches of the plans. And this opportunity will, if he so wishes it, be found much more frequently than he may at first deem likely. And if to those he adds sketches of his own, showing how the originals may be modified and in his estimation improved, he will in course of time possess a collection of hints on planning which will be found to possess a high practical value, and, for the matter of that, a pecuniary one in his own practice, whenever he fairly advances to that important period of his life at which he earns his own living, if not actually by the sweat of his brow, at least by the arduous labours of his brain.

Study of Style and Sketching of Designs also Important to the Young House Planner.

If to all work of the above-named kind the young architect or builder adds a careful examination of the external characteristics of the houses the plans of which he studies, he will be able to become practically acquainted with the peculiarities of the different styles by which their external features are characterised. But further, he will thus find examples of the methods by which the styles can be applied so as not only to be appropriate to the plan, but so that they bring forward its peculiarities more prominently. A well-designed house—meaning here by the term design both its plan or internal arrangement and its elevations or external character—is always one in which the style and the plan are well wedded: fairly and fortunately matched, so to say, no incongruity or disturbing element being observable between them. If to the study or observation of peculiarities of style of external design he gives the same careful consideration he exercised in the case of plans, and fills his note- or sketch-book with sketches of those peculiarities, he will possess a still more valuable record, which he will find to be in constantly recurring use and of great value in his practice.

Practical Purposes to be secured by the "Plans" to be given in this Paper.

In one sense, although from the limits of our pages of necessity of a less complete or comprehensive character, the various plans, elevations, sections and details which go to make up the present series of papers, under our special heading, will practically represent the sketch-book which we have in the last two paragraphs supposed young architects or builders to have become possessed of by the diligent practice we have recommended. And we trust that a careful perusal and study of what we purpose giving in the chapters to follow, will show how useful a place such matters will find in the ranks of technical literature. For they propose to afford an effective picture, so to say, of what the features of the domestic architecture of the present day are. But, further, they may be looked upon as a mine, so to call it, from which materials can be dug to help those who are beginning the practice of the art, or who at an earlier stage are simply commencing to study its peculiarities. Still further, they may also serve as suggestive hints to those who are already actively engaged in carrying out works and projecting others which are to follow them. To the first two of the above classes it is impossible to overrate the importance of any work which gives to the young practitioner or the student of architecture a wide variety of hints as to what has been done and is being daily done in the way of planning out the internal arrangements of houses, or of adding to these the beauty and adornment of architectural design and ornamental detail. Nor to the practical man, who is actually engaged in the work of execution, is a "note-book," so to call it, of the kind less valuable, although it is valuable, perhaps, in another direction. For although he may see much to condemn in the plans and designs which our pages give—and we have distinctly stated that some will be specially given as defective, and all for the closest criticism—it should not be forgotten that the means of suggesting what should "not" is just as valuable as that which suggests what ought to be done. Indeed, it often happens that suggestions of the highest value are derived by many from this very source—the *mistakes* of others. A point this often overlooked, but none the less valuable and true. We thus improve our own work by the mistakes and errors of those who have gone before us. It will be observed, therefore, that we make—as indeed we have clearly pointed out—no pretensions to perfection in the plans and designs we give. If we did, and if it were possible—which it is not—for us to succeed in reaching it, our papers would no longer be what they profess to be; and in so being much of their practical value rests. This consists in their being not merely a picture, so to say, so far as its limits extend, of what domestic architecture at the present time now is, but a series of hints and suggestions open to and inviting the criticism of the young architect and builder; and by this criticism improving his own practice by altering what we give, if bad, or approving of them according to certain principles laid down for his guidance if they are good.

Arrangement or Systematic Classification of the Different Kinds of Domestic Structures.

In arranging the various plans and designs which make up our papers, the reader at all acquainted with the subject will at once perceive that several plans or methods were open to choice. But this, in place of rendering the task an easy one of fixing upon the arrangement to be adopted and that possessing all the best features, made it, in point of fact, just the more difficult to arrive at. For the arrangement of a subject like ours involves various points of importance. There must be, so to say, a logical or consistent classification, this rising out of what may be called the natural connection of one set or class of houses or designs for houses with another. The general principle being decided upon, the details of classification must next be considered. And as the ramifications of the examples in the same style are pretty numerous, sub-classes come up which require notice. It follows of necessity from all this that there must be, in a well-arranged plan, ease of ready reference and a consecutive course of study open to the young architect or builder. Another point falls to be considered. It is probable that our papers will be glanced at by a class of readers who have no practically technical or business interest in house planning or designing, but who, nevertheless, have a great interest in the subject generally; and in many cases specially, inasmuch as they may be contemplating the building of a house for themselves, or of speculating in building many for others. The ready reference and consecutive treatment which will be useful to all classes of readers will, we hope, be secured by the arrangement which after mature consideration of the whole circumstances of the case we have concluded to follow.

Arrangement or Classification of Plans adopted in our Papers.

Taking the various classes of domestic structures as a whole, three great divisions come up before us: first, houses in "Towns"; second, those which are only connected more or less directly, but still partially, with the towns near which they are situated; and third, those distant from towns. The second class we designate as "Suburban," and the third "Rural." These great or leading divisions are again cut up, so to say, into a pretty wide variety of subclasses. Thus, in the second division we have, first, the large "Mansions," involving great expenditure in their construction; second, the "Villas"; and third, the "Villa-cottages" or "Cottage-villas," the extent and cost of which varies exceedingly; and lastly, we have the "Cottage" pure and simple, of no pretension as to size or decoration. All these three, again, may come within another range of sub-classes: such as the "Detached" or isolated houses or cottages —a style almost universally adopted in the case of superior structures which have their own grounds; and second, the "Semi-detached" houses—that is, those which are built in pairs—a plan adopted in structures of less cost than the preceding. Finally, the "Cottages" pure and simple may be built either as detached, semi-detached, or in groups of three, four, or more, or in long rows or streets, or in squares or quadrangles.

In the first division, namely, the "Town houses," there are but comparatively few examples met with of the sub-classes of the second division above named —that is, the "detached," or the "semi-detached." As a rule, the houses are built in straight-lined rows, in terraces, or in curved-lined crescents or quadrants; while the "square" is a favourite arrangement for the superior houses, a central garden being surrounded by straight-lined rows of houses. Of the middle-class houses, and those designed for the working-classes the straight-lined rows, or streets, or terraces, is the prevailing method of arrangement.

The Adjuncts or Outlying Structures or Buildings of Certain Classes of Houses form part of our Subject—Stables, Cowhouses, Dairy Buildings, Piggeries, and Poultry-houses.

While, however, the plans and design of the house form of necessity the main feature of our series of papers, we have deemed it necessary to pay some attention to certain points of importance connected with houses of certain classes. Thus mansions have, even in suburban districts, as a rule, a pretty large extent of ground attached to them; while in rural districts the extent of ground is often very large indeed. Again, many of the less costly structures, such as villas and the like, have in suburban districts, if of lesser extent, still in many cases somewhat extensive plots of ground attached to them. It is scarcely necessary to say that in rural districts the garden and the ornamental grounds form a distinguishing feature. It was at first thought desirable, therefore, to give a few hints as to the best method of setting these out. And as the love of flowers is not the least marked peculiarity of the day, conservatories and greenhouses were proposed to be described. But editorial arrangements, and what was of greater importance, the interests of the reader, demanded that larger space should be given to all the subjects now named than could be found in the present papers; and this inasmuch as their importance required full and systematic treatment. A paper has therefore been given under the title of "The Garden Architect," to which the reader is referred. But the large mansions and villas above named have frequently considerable spaces of ground attached to them, other than those given to garden and ornamental purposes, such as small paddocks in which a cow or two may be kept. And of course horses form part of the *ménage* of wealthy people—the owners of such places being "carriage people" as a rule. Accommodation is therefore required for those animals, and this we have also gone into, in the way of giving plans of stables and cow-houses; while to make this department fairly complete—at least comprehensive—designs for poultry-houses and piggeries have been added. Nor has the washing accommodation been lost sight of, some suggestions as to laundries being given. These are all essential features of domestic architecture, which the young architect and builder must not overlook.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER X.

At the end of last chapter we stated that proportional compasses gave only accurate measurements for a time. When inaccuracy in the length of the legs takes place, the marked or index figures no longer indicate the accurate proportions. In view of this, some draughtsmen purchase those forms which have no index lines or figures engraved on them. And as the adjustment and consequent engraving costs money, the plain compasses are of course cheaper than those adjusted and engraved. But even in this case, and when the adjustment is specially made by the aid of the scale, as we have above explained, the greatest attention is necessary on the part of the draughtsman to keep the compasses in accurate adjustment. The points do not wear equally—far from this; and so unequally that the right-hand point of, say, the short leg or end will wear faster out than the left-hand point—supposing the instrument to be invariably, at least regularly used with the set-screw, for example, nearest the draughtsman; the reverse may be the case as regards the points of the other leg or end, the left-hand wearing faster than the right-hand point. In fact, nothing can be predicted as to the condition which the points will relatively assume, the circumstances being so varied and varying. One thing is obviously clear, that the draughtsman should attend to: which is, that each leg or half of the compasses be exactly the same as the other; so that when the instrument is closed, the points of the two legs at each end shall coincide with each other with absolute precision. After a long use, moreover, another source of error in the accurate adjustment, even if this is done specially by hand trial and scale, is the central stud or screw. This through long usage gets so worn, or by some kind of usage more or less rough gets so strained, that on tightening the screw after the proper adjustment of the slide has been obtained, a slight "jar" or "giving" of something will be felt. This always indicates a greater or less amount of mal-adjustment, or of change in the first or accurate adjustment obtained. So that extreme accuracy of proportion between the lines, and the maintenance of this proportion throughout a drawing—reduction or enlargement as the case may be—which takes long time to execute, is not always or often obtained with proportional compasses which have been a long time in use. They are, however, useful for a wide range of work, and should form part of the "set" of instruments of all draughtsmen who look forward to having this wide range in their business.

Description of Appliances and Instruments continued.—The Straight-Edge for Large Drawings.

Arcs of circles and divisions of various kinds have frequently to be taken and laid down on a large boarded surface previously prepared, or upon a "drawing floor" of such size and extent as to be incapable of being described or laid down by any of the instruments we have as yet described. For ordinary work on the large scale, where extreme accuracy is not required, the "straight-edge," which is a long narrow strip of wood with parallel sides perfectly straight, or so-called straight-edges, may be used. Thus let *a*, fig. 14, be the point at which a sharp pointed "sprig-bit" or awl is inserted, this being stuck into the straight-edge at any desired point, and projecting through to the board or surface below. Then let a line, *b c*, be run across the centre of this to each side of the straight-edge; then take the required distance to be measured off, or the radius of the arc or circle to be described, and set it off from the line at *a* accurately, as say to *d*; across the face of the "straight-edge"

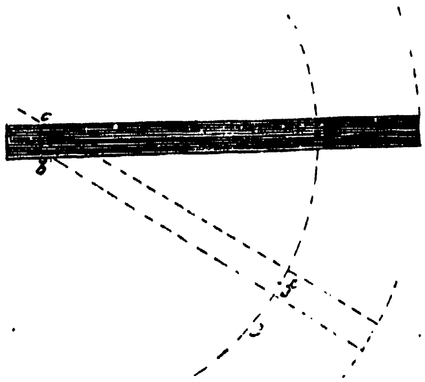


Fig. 14.

draw a line parallel to *b c*, and in the centre of it, so as to project but a little way below the lower surface, pass through a sharp-pointed sprig-bit,—this will describe or scratch out the arc or circle in the floor or board. The line, as *b c*, drawn through the point *a*, which may be considered as the "joint" of this extempore pair of compasses, as it may be called, is only drawn to insure perfect accuracy in measuring the distance from the centre *a* to the point *d*, which defines the length of the radius of the curve or circle. In ordinary work, in setting out distances greater than can be done by ordinary drawing instruments, the radius may be measured simply from the point *a* to *d*. Where the drawing floor, or board on which the large circle or arc of circle to be described is chalked, the line of curve may be made more visible by inserting a pencil in a hole made at the point *d*.

Where large arcs or circles are to be described, or distances set out with more perfect accuracy than can be done by the straight-edge as just described—the instrument called the "beam compasses" is used. The principal parts of this are illustrated roughly in the diagram in fig. 15. This instrument is made of a central rod or "beam"—hence the name—not too long, as it is apt to bend. It is made square at its upper part, but sloping to the edge on the under side, as shown in the section to the right, at *b*, to which a scale of ivory or of box-wood or other fine-grained wood is secured; this scale, for the ordinary artificers' work of masons, etc., being of the ordinary kind of equal parts of feet and inches, or if necessary a decimal scale for surveying plans, etc. Along the bar *a a*, *b b*, a box, *c c*, of brass is capable of sliding easily, and of being secured at any point by means of the set-screw as shown at top. This box carries a "vernier" scale, *e*, and also a pointer or leg, *f*. A second brass box, *g*, also carrying a "vernier" scale, and a pointer, is secured to the bar by the screw *j*, the box being kept close to the extreme end, and prevented from sliding altogether off by the ledge as shown in the drawing. The pointer is capable of a slight lateral adjustment, so as to approach to or recede from the other pointer by means of a slow-motion screw

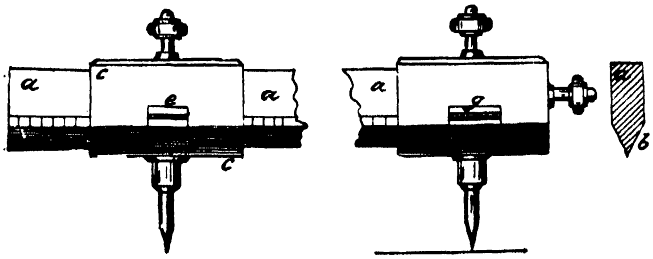


Fig. 15

actuated by the button at the end of the box *g*. To adjust the instrument with the scale on *a a* divided into feet, inches and tenths by means of the button, turn the slow-motion screw till the box *g* moves so that its "zero point" coincides with the "zero point" or "0" of the scale of the beam *a b*, at the end nearest the adjusting button to the extreme right, in which position it is to be secured by the screw of the box *g*. The box *c c* is next to be moved along the bar *a b*, till its "zero point" coincides with the distance required, say 11 feet 6 tenths; and supposing that the distance is actually 4 hundredths more than 11 feet 6 tenths, then by the button adjust the box *g* till the division of 4 coincides with the fourth tenth in the scale of the bar *a b*. By means of the "vernier" scales and the slow-motion screw worked by the button to the extreme right, a great degree of accuracy of measurement can be obtained by this instrument.

Pencils and Crayons.

We conclude this department of our paper by adding to what we have said in a preceding chapter a few remarks upon the appliances used by the draughtsman in executing architectural and mechanical drawings. We have seen that in the practical work of the architect, drawings—chiefly ornaments in detail—are required to be executed by the aid of the hand and eye only, and for these no instruments are required or permissible. The work, in point of fact, is precisely that of the "Ornamental Draughtsman"—which see. The architectural draughtsman may, for this class of drawings, use the different grades or degrees of hardness of the ordinary drawing pencils—as "B" (black), "H B" (hard black, or lighter black), "F" (fine), or "H" (hard). But some prefer the use of the chalk or black crayon, especially for finished drawings of ornamental work. The chalk or crayon is held, for working with, in what is called a "crayon holder." This is of metal, in the form of a circular tube of small diameter. The ends of this are split up into two or more pieces for a short length. These ends, through the elasticity of the metal, open up or spread out, affording spaces into which a crayon can be inserted. The spring ends—so to call them—of the holder are then brought together, so as to close in upon the crayon and hold it fast by a ring sliding on the central tube. When the crayon is wished to be released the spring ends are made to open up by pulling back the ring.

We may here say that after the chalk or crayon is roughly pointed by means of the knife, the finest point can be put to it by rubbing it down on fine glass or emery paper—much better and much more quickly, and with less chance of breaking, than by a knife. The cleanest way of using the glass paper is to gum or glue it down to a piece of cardboard, doubled up in the centre so that one half can be folded over the other half, on which the glass paper is gummed. By this means its blackened surface can be covered up when the glass paper is not being used, and thus prevented from soiling other objects. Minor contrivances such as this the draughtsman will find useful; and "little" as such may be considered by some, a thoughtful student will not despise or think lightly of anything calculated either to aid his work or keep it clean and all things orderly in its execution. The value of method and order cannot be overestimated by the student desirous to excel.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XIII.

We referred at the conclusion of last chapter to the fact that the spring of a watch and the pendulum of a clock depended upon the same principle; and that as the bob of the pendulum falls to its centre through gravitation, or is pulled towards it, so the spring of the watch takes the place and gives (so to say) the power of gravitation; and as by this the accelerated speed of the bob, drawn down (so to say) to the centre, which virtually is the centre of rest, as in the case of a pendulum which has ceased to move or swing, carries it beyond it, so the spring which gives the moving force to the balance, and sends it so far past the centre through the force stored up in it, brings it back again through the action of its own little or hair spring. And thus the balance-wheel, as may be seen by examining a watch in movement, is found to vibrate or oscillate on its centre alternately to and fro, and its vibrations or "beats" are all taken or given in the same instants of time. And any one possessed of an accurate ear can easily tell, by listening for some time to the beats of a watch, by those being "synchronous" or otherwise, whether the watch is in good order or the reverse.

But although the principle of the pendulum receives its most striking and practically useful exemplification, and in its ordinary form of rod and bob, in the mechanism of the clock, it has been applied, although in less important manifestations, in larger mechanisms. Although the ordinary steam-engine "governor" depends for its action also upon another principle or law—namely, that of "centrifugal force," hereafter to be explained—and this therefore takes it away from being strictly an example of the pendulum principle, which many conceive and state the steam-engine "governor" to be; nevertheless it is true that the ordinary governor, illustrated in the papers under the title of "The Steam Engine User," is in one sense a pendulum, in so far that when the centrifugal force, which drives, so to say, the balls from the centre of rest, ceases to act, or lessens in degree, the falling of the balls towards the centre is brought about by the action of the law of gravitation, which gives also the phenomenon of the pendulum or of the suspended plummet. But in the case of the governor the force stored up in the descending balls is not allowed to carry them so far in the opposite direction, the very nature of the contrivance demanding a prevention of this. The rise or motion outwards from the centre of rest caused by the centrifugal force generated by the rapid rotation of the central spindle to which the balls are by their jointed rods connected, and the fall or motion inwards to the centre of rest caused by the force of gravitation, are in the most ingenious manner (elsewhere in another paper illustrated) availed of by the machinist, and made or compelled to do good service—to put it more correctly, to insure that uniformity of speed, or of its working, which is essential to the due performance of the work of the various machines which the engine drives. The great defect of the pendulum governor is its want of sensitiveness, or that peculiarity which would enable it to transmit, so to say, its controlling or regulating power to the engine; or conversely, which would enable the engine to affect the governor immediately on the change in the conditions of speed. To gain this sensitiveness—which the old or ordinary form of governor lacks through the fact that a certain time is required for its changes in position to take place—and to make the governor act, if not positively coincident with the cause which necessitates action, at least as quickly as possible after it begins to operate, a very large number of governors have been invented. The majority of these have been on the principle of the pendulum, or rather on the combined principle of centrifugal force and gravitation force, with added mechanical contrivances, such as springs, heavy weights, etc. But although some of those forms have been used, the great majority of steam engines are still regulated by the old-fashioned water-wheel governor, the contrivance having been adapted for and applied to that motor long before the steam engine supplemented, as a rule with few exceptions, the older motive power.

Swinging or Pendulum Motion, exemplified in Certain Classes of Machines.—Defects of Certain Adaptations.

In industrial machines "swinging" motions or movements are frequently required, and all act on the principle of the pendulum; and the accuracy of the results obtained in the working of the machine, or this part of it, depends upon the way in which the principle is applied. And it may be questioned, in many cases in which swinging motions are used, whether the adjustment of the parts is made with due relation to the principle of the movement. In many cases, indeed, it is not far from the truth that those who use these swinging movements are not even aware that they do depend upon and are in fact exemplifications of the principle of the pendulum. In the portable threshing machine the principle of the pendulum is exemplified in the straw shakers, which perform the office of carrying forward the threshed straw from the beater drum to the free delivery end of the machine; and at the same time act, so to say, as sieves—the grain which has not been threshed out by the beaters being shaken out by the motion of the straw shakers, as are also the short lengths of straw, etc. (See the series of papers "The Agricultural Implement Maker.") It is but too well known that, with all its admirable working capabilities, the portable threshing machine is a most wasteful user or absorber of power, the mere driving of the machine empty taking an enormous percentage of the effective driving power. The cause for this has been, as may be easily guessed, most anxiously looked for by machinists, but it has not yet been discovered. At the discussion which followed the reading of a paper on threshing machines by Mr. Worby before the "Institution of Mechanical Engineers," some remarks were made by the well-known mechanical authority Mr. Vaughan Prendred, referring specially to the subject of straw shakers in relation to this pendulum action, which are worthy the attention of our readers interested in this class of machinery. And possibly the reader may conclude from what he there peruses, that if more attention had been paid to this action of the straw shakers, and the parts duly proportioned to and in accordance with the law or principle of the pendulum, some of the power which is so largely lost in the working of threshing machines might have been saved. It is not too much to say, that amongst the earliest makers it is questionable whether the fact was at all known to them that the really ingenious straw-shaker movement was dependent upon this principle, and indeed a practical exemplification of the pendulum law. The instances are numerous in which machinists exceedingly clever in making mechanical combinations giving very beautiful motions do bring out contrivances, yet all the while are profoundly ignorant of the law which they illustrate—ignorant or careless of the fact, indeed, that they illustrate any law at all. But with all the ingenuity of those movements, it often happens that there are grave defects which would not exist if the machinists had known the law upon which they depended. It is only by understanding the true point that errors are got rid of. In examining the wide and ever increasing range of machines, the reader will find many exemplifications of the pendulum principle, or may have occasion himself to adapt it to some mechanism of his own. If so, he will be all the more likely to make that adaptation perfect if he studies closely the phenomena of pendulum action, and the law or rule deduced from these.

Motion of Bodies down Inclined Surfaces.

The fall or drop, or to use the popular expression, the "rolling" or "sliding" of a body down an "inclined plane," is governed by the same laws as those which govern the fall of bodies falling freely from a height. The results practically are, of course, affected by friction and certain mechanical considerations, which in calculations must be taken into account. Neglecting those influences, the time which a body takes to roll down the full height of an inclined plane is in the proportion of the length of the plane to its vertical height at its upper or higher end, or what would be the extent of fall of the body if allowed to drop and descend freely. The velocity of the body down the plane is to the velocity due to a free descent of the same height as the length of the surface of the inclined plane is to its height—*i.e.*, at the higher end. The velocity of the body down the inclined plane is therefore equal to that with which the body would fall if allowed to drop freely from the same height, and it reaches the end of the inclined plane with precisely the same velocity as would be attained by a body falling freely from the same height on reaching the ground or level of the lowest point of inclined plane. The times taken for the descent are as the velocities; and the spaces through which the body passes are as the squares of the times.

Inertia an Important Property in, or Characteristic of, Bodies, Substances, or Masses of Material.—Definition of the Term.

With weight, or the heaviness of a body, or its gravity, the mind always associates the idea either of an ease in moving, or, in the converse, a difficulty to move a body, or, in other words, to set it in motion. This motion, or change in the place it at the time occupies, every one knows intuitively must be produced by force of some kind, or power as it is often designated popularly; and this he knows will require to be great just in proportion to the weight of the body, as he also knows intuitively that it will be easier for him to lift, or to move along, a light, or what he considers to be a light, body or object than a heavy one. This mental conception as to weight increasing the difficulty to move an object or set it in motion, together with an infinite variety of circumstances which he sees around him every day, convey to the ordinary, or, as we may say, to the uneducated, mind, this other conception, which he at once decides to be the true statement of what he might call the natural fact—namely, that the natural condition of bodies, or of masses of matter, is that state which is so universally known as "rest," or a continuance in the same position it occupies or is made to occupy. While one of this class has no difficulty in understanding that, before a body can be set in motion, some force or power must be used and applied to it, as no body, he well knows, can begin to move of itself only, yet he might, and very likely would, have a difficulty to understand how it is that when a body *is* set in motion, it has no power, or rather no capability, in itself to cause this motion to cease, and so to stop itself, and that unless something intervenes, or some force comes into existence, the body will continue to keep in motion. Thus, while it is quite true that a body would continue in a condition or state of perpetual rest—that is, remain in the same place without changing it in the slightest degree—if no force external to it or power was applied, it is equally true that, once set in motion by a force, it would continue in a state or condition of perpetual motion, unless the original force, or some other force, was applied in order to stop it. Motion, therefore, is as natural a condition of matter or of bodies as rest; and whether the one condition or the other exists, or is continued, depends entirely upon the action of something outside of or external to it; and this, whatever be the source of it, we call force, whatever that force may be. That which determines the continuance of a body in a state of rest, or if it be in motion the continuance of that motion, may itself be, and often is, called a force—that is, the "force of inertia." We shall see presently that this term, "force of inertia," gives rise to false conceptions of what inertia is, and how it acts, which have hindered more or less mechanical progress with many, and given rise not seldom to grave errors in practice. The important points dependent upon or raised by this generally received definition of inertia will be gone into in a future paragraph, when we come to consider the term "*vis inertia*," freely translated as above in the term "force of motion," so often and so erroneously used. But as any force by which man sets a body in motion is adapted by or created, so to say, by him—as he adapts the force of falling water, of rushing wind, or creates a force by boiling water and raising steam—and as these adaptations must be special, we see another reason why the popular mind associates with all bodies the idea that their natural condition is that of "rest," and it is this which seems to have given the very name to the law of the force we have just named that of inertia. The name is derived from the Latin *iners*, *inertis*, and those from *in*, and *ars*, art, signifying something apart from power or force, which art is. So that when we speak of an *inert* body or of *inert* matter, we mean to convey the idea that it is destitute of the power of moving, or that is difficult to move, it being at rest. Now, the reader will see that the term inertia, thus derived, involves only the idea of a body at rest, and its tendency to remain in this condition, and takes no cognisance of the converse or opposite condition, in which motion is supposed to be the condition of the body. The force which causes or influences the continuance of this motion in the science of mechanics is known by another name, which is described and discussed in a future paragraph.

Erroneous Conceptions of the Property or Characteristic of Bodies known as Inertia arising from its General or Popular Definitions.—Proposed Accurate Definitions.

It is therefore a matter of some regret that the term "inertia," which designates alike the force which enables bodies at rest to resist being set in motion, and bodies in motion to be made to be at rest, should be such that in its real meaning, and also (which is more to the purpose) its popularly, we may say universally, received meaning, denotes or conveys the idea of rest only, or, as is popularly expressed, of "inert" matter.

As, therefore, "inertia," or the law of inertia, is confounded, and is almost in all cases popularly seen to be, with the word or term "inert," two totally different things, some authorities have proposed to designate the law or state of inertia by the word "obstinacy"—the "law of obstinacy of matter." Let us again look at the inner meaning of this word. It is derived from the Latin *obstinare*, and this from *obstare*, signifying to "stand before." The student will thus perceive how much more definitely and precisely the term "obstinacy of matter" explains the law we are now considering than the term "inertia." For matter, or a body in its two conditions of rest and motion, has, as it were, a power or force, or a something which "stands before" a body, either to make a body at rest change its condition into that of motion, or the opposite—namely, to change the condition of a body in motion to that of rest. The inertia (to use the received term) of a body may, therefore, be said to be the "persisting" of a body to remain either at rest *or* in motion. And this term "persisting" is generally understood to be synonymous with obstinacy, and the derivation of the word itself throws further light on the point. "Persist" is derived from the Latin word *persistere*, and this from *per*, by or through, and *sistere*, to cause to stand or remain fixed, and this last from the word *stare*, to stand; literally, therefore, to "persist" is to stand by and not to leave a thing to itself.

There is a French definition of inertia in which a word is used which gives perhaps a better conception of what the condition is than even the word obstinacy. This French word is "indifference," which in that language and in ours is spelt in the same way, and means precisely the same thing. French scientists define inertia still, however, using almost the identical term to denote this condition; the word in French being the same as ours, except that it is spelt with a final "e" instead of an "a" as with us—thus, *inertie*. Inertia, therefore, under this French definition, is the indifference of matter either to a state of rest or a state of motion. That is, that when at rest it will persist—here the definition uses the very word we have done, *persistere*, to persist—in that state till a cause external to it moves it or puts it in motion; or, if it be in motion, it will "persist" in that motion till a cause external to it stops it.

Illustrations of the "Inertia" or "Indifference," the "Obstinacy" or "Persistency," of Matter to remain in One Condition, whether that be of Rest or of Motion.

Every one knows the result of the common "trick," as it is called (although every one does not know the reason or cause of it) in which a coin being placed in the centre of a card, and this placed upon the top of the finger of one hand, and a fillip or smart stroke given to it by the finger of the other hand, the card is seen to fly away, but the coin to rest upon the finger-tip. This is simply in virtue of the inertia, of its "obstinacy" to move; the result would be different if we used, in place of a card and coin, the surfaces of both of which are pretty smooth, two flat bodies with rough surfaces. We should then bring another force into play—that of friction; although a stroke or fillip could be given to the lower body so dexterously strong as to overcome this, and give the same result as before. Of course the term "friction" is used here in a relative sense; it existing, though in a less degree, between the smooth surfaces of the card and coin. It is the inertia or obstinacy of matter which makes it so difficult to railway porters to set carriages in motion which have been at rest on the rails, or for a horse to start a heavily-loaded lorry or cart.

One knows intuitively that the heavier the body or mass of matter the greater will be the force required to put it in motion; but in the converse of this, or such cases as the above, one does not so intuitively or naturally take in the conception of the opposite truth, that if a body takes a certain force to put it in motion it will take an equal force to stop it when it is in motion. To stop instantaneously the motion of a heavy grindstone which has been moved in the first instance by the arm, will require the exertion of as much physical force as was necessitated to make it revolve. Examples of inertia, or the indifference of matter either to rest or motion, are as readily met with, illustrating the tendency to keep in motion of bodies once set in motion. Many will occur to the reader: a cannon-ball rolled along a long sheet of smooth ice, a top with finely-pointed pin spinning on a highly polished metallic surface, are examples of the tendency to continuity of motion when friction is lessened, and the resistance of the air—which latter element acts frequently as a very retarding and stopping force.

The ruptures in and breakages of materials and objects arising from their being subjected to sudden strains or pressures owe their existence to the inertia, indifference, or obstinacy of matter. If a careless servant, supposing that a water-jug standing on the floor is quite empty, lifts it by the handle with the swiftness or velocity which she deems due (and this is decided intuitively) to the fact of its being empty, the almost certainty is that she will lift the handle but not the jug, this being left behind, or, if raised only a little, dropped on the floor and probably smashed; but the severance of the handle from the body of the jug is almost certain. In like manner, if a schoolboy wishes to break or sever a piece of cord, string, or band in pieces, he brings his two hands, round which the two ends are twisted to "get the grip," near each other, and then quickly and forcibly separates them, so as to give the cord a sudden jerk which may be sufficient to break it in two. The strength which would resist a steady pull is not sufficient to resist a sudden wrench. So, if a man be hauling along a heavy weight by a rope, if he be doubtful of the strength of this he will wisely put the strain on gradually and slowly; so also in the raising of a weight by means of a "crab" or winch, a weak rope may do the work if the strain be put on gradually, while it would be sure to give way if the strain were quickly put on, or "with a jerk," to use the common phrase. It is in this way that the iron anchor chains are so much more to be depended on, in enabling a ship to ride out a gale, than hempen cables. For the mere weight of the chain causes it to hang down or belly concavely (the "catenarian curve," from the Latin word *catena*, a chain); so that, if a wave or the wind drives back the vessel, the chain is gradually hauled on, so to say, and brought to the straight, thus throwing the strain on it gradually; whereas, in the case of the hempen cable, this is, as a rule, in a straight, tightly stretched line from ship to anchor, so that, when the vessel is driven back by wind or wave, the strain is put on suddenly, and the cable may give way. If iron wires be used to resist strains which will, as a rule, be suddenly thrown upon them, they will be better able to resist those if they be not hauled or screwed up too tightly, but have a certain amount of play or "give and take." Giving way at the first shock of the strain, this will be gradually pulled up, through the greater strength given to the wires by the strain being gradually put upon them. In all those and in similar cases the action of the law of inertia has been humorously described by saying that the atoms or particles in the part of the object which has been jerked off, or torn, or broken away, have not had time to give notice to the further and next neighbour that a call was about to be made upon their strength; unitedly, they could resist the strain, and far more; separated, they could not. This humorous statement of a physical fact, the reader will remember, is aptly illustrated in the saying, "a threefold cord is not easily broken." The young mechanical student will perceive the value of such facts when applied to practical work.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

The Technical Points connected with the Varieties or Breeds of Cattle—Their Breeding, Rearing, Feeding, and General Management for the Production of Butchers' Meat and of Dairy Produce.

CHAPTER X.

We stated that the principle of "like begets like" is of immense importance to cattle breeders; for while it may give the breeder, as it often does give him, an objectionable feature in an animal, he takes care not to repeat it and run the risk of making it hereditary. It, on the other hand, may give him a valuable feature in an animal, which it is his pride and care to get transmitted to other animals. It is in this way that the different breeds, with all their well known and valuable qualities, have been created, and by which they are by the high-class breeder constantly being improved. The improvements consist in getting rid of those points which are against, and cultivating, so to say, the development of those others which are in favour of, the laying-on of meat at the points where that is of the best quality; and this in the quickest time, with the least consumption of food. What those points are, is of course determined by experience, and is based upon a long course of patient observation. This law of diversity or variation in peculiarities of animals is therefore of the highest value to the breeder, and the watching its developments and the recording these constitute not the least interesting part of the study of the scientific grazier. And some of the examples of its operation are as puzzling as they have been unexpected. The tendency to diversity or variation is not always shown, nor does it exist, in the same degree or strength, so to call it, in the animals of both sexes or of the same breed. As a rule the tendency is apparently strongest in the male, though exceptions to this are numerous enough; while, so far as the female is concerned, the influence of the male in giving its characteristics to the progeny is exceedingly marked. So powerfully does this principle of variation operate at times, that even in the case of two animals possessing superior points, and from which a still higher range of good points or quality might be reasonably expected, the reverse is the case, and the progeny exhibits decided marks of harking back to the original condition of deficiency in excellence. The tendency to be perpetuated, or the strength of the hereditary principle, varies with the different "points," but of those colour is the one in which it appears to be the strongest or most decided. The tendency to "hark back," as it is sometimes called—to which allusion has just been made, and which has also been designated as the law of reversion—presents some singular developments, which often puzzle the breeder and disappoint his expectations. And although we have stated that colour is one of the points which has apparently the strongest tendency to be perpetuated, it is very curious to note how many examples have been met with in which the tendency to revert to some original and generally objectionable colour or marking is very decided.

Remarks on Breeding continued—"Line" or "In-and-In" Breeding.

In an early paragraph we pointed out the general features of this system of breeding. There are, however, other points which deserve notice, not merely because they have a special bearing on this, but because they have a bearing more or less direct on the opposite system, or that of "cross-breeding," on which a special paragraph remains yet to be given. From what has been stated regarding the law regulating the transmission of animal peculiarities, the uniformity of the hereditary principle, and that of variation, which gives rise to diversities in those peculiarities, the general principle of the "in-and-in" system of cattle breeding will be seen to be confirmed in the saying "like produces or begets like." If, then, we have certain qualities existing in any given animal or breed of cattle—which peculiarities may be conveniently, and in practice are, distinguished by the term "blood"—it follows that the purity of that blood, or in other words the peculiarities of the animal, can only be maintained by preventing all admixture of other blood or of other peculiarities. Thus, if we have an animal or breed possessed of what we call perfections, or consider as such, there seems to be no other way of transmitting those perfections to new animals than by using animals which possess them, and thus keeping up the purity of the breed, or by frequently returning to animals possessing the blood which gives those perfections. If an animal is of a different breed, possessing those peculiarities which it derives from what we call its blood, the chances are, to put the point in the least dogmatical way, that this animal will bring into the strain or new progeny the characteristics of this blood, influencing more or less according to circumstances, but still always influencing, the blood of the original breed, and changing its characteristics. And this influence of the "cross" here supposed arises of necessity from the same law of hereditary transmission which dominates the "cross," and under the operation of which it in common with all breeds is placed. The principle of the in-and-in system may be familiarly illustrated by supposing that we have a stream of water possessing certain characteristics which give the title of pure to it: the length to which this stream extends does not *per se* influence the purity of this water; that remains so long as we keep it by itself, preventing access to it of all water which if allowed might join it or come to it from lateral or side sources. But if we did admit to the original or main stream any one side stream, we could no longer assert that the quality of the water was the same,—still less so if in place of one side stream we admitted several streams. It might be perfectly true that, as some might say, the original water was improved by the admixture with it of another water or of others,—that would obviously be a matter of opinion,—but the fact would still remain as incontrovertible that it was impossible to assert that it was the *same* stream or quality of water. In the system of "in-and-in," or as it is otherwise called (from the circumstance that the animals are the same), "line" breeding, it is of course essential that we start with a pure-bred animal—that is, one possessing the blood we desire to perpetuate. But it is a point of extreme importance in breeding to know that the goodness of the stock, or rather the continuance of the purity of the peculiar blood or breed to the animal from which the stock is to be raised, depends greatly upon the first conception of the dam or mother.

The First Law or Principle affecting the "In-and-In" System of Breeding.

The reason for this brings us face to face with the first law affecting the "in-and-in" system, or what appears to be so well established that we may give to it all the authority of a law or rule which has few exceptions. This law or rule may be thus stated and illustrated. Supposing that we have a heifer or cow of a certain blood or breed, as a shorthorn, and that from her good points or qualities it is desirable that we should have stock from her. Supposing, further, that the sire we employ is himself of another breed or blood, with points different from those of the heifer; and that a calf is the result. This progeny may or may not possess the distinctive characteristics of the sire or bull; but the point of the law is this,—that supposing we raise other calves from this same cow of a certain pure breed or strain, and employ, not as before, sires of another breed or breeds, but of the same breed or strain of blood as the cow herself,—we shall find that the calves resulting from fruitful intercourse will have the distinguishing characteristics more or less well defined, not of the sires then employed, but of the sire through which the first calf was obtained. In other words, although in the later instances both the sire and the cow were of the same pure breed or blood, the resulting progeny would not be pure, but an impure breed or mongrel—that is, it would breed or "hark back" to the first sire. This peculiar result may not always happen, and the characteristics of the first sire may not reappear in the progeny of the second or third or succeeding sires; but it does happen so frequently, and the exceptions are so rare, that they only prove the rule, and give the fact all the authority of a law, the actual and practical result of the operation of which is that the cow so dealt with becomes after her first calf a cross, and is no longer a pure-bred cow. This is stated by an eminent authority. "When a pure animal of any breed has been pregnant to an animal of a different breed, such pregnant animal is a cross ever after; the purity of her blood being lost in consequence of her connexion with the foreign animal." The case is analogous with that of the stream of pure water before alluded to: this may be contaminated by the admixture of an impure stream flowing into it; and however other pure streams of the same quality as the original water may be mixed with it, the contaminating taint of the impure water crops up from time to time, more or less pronounced, but it will be always present. The young grazier will see the important bearing of the rule or law now enunciated and explained in his breeding practice; and a due consideration of it will make the fact clear to him, that it is not enough to have heifers or cows of pure blood or breed to commence breeding with. To insure success the breed of the sire must also be attended to, and if he be of a different blood or breed, although good of its kind, he will influence future progeny obtained by sires of the same pure blood as the heifer or cow. Hence the practical value of the advice we gave in a preceding paragraph, to avoid the use of sires or bulls of doubtful or of no pedigree, or one of different breed from the breed of the heifer or cow.

Second Law Influencing the "In-and-In" System of Breeding. —Influence of the Male and Female on Stock.

The relative influence of the male and the female on the character of the stock or animals obtained from them is a point of importance in considering the "in-and-in" system of breeding. While some of the points connected with the discussion of the general subject of breeding are marked with a very considerable diversity of opinion, both of scientific and practical men, this point of the relative influence of the sire or the dam upon their progeny receives amongst practical men what may be called a fairly complete consensus or agreement of opinion. At first sight it would appear that there would be an admixture more or less complete, or in other words a blending, in the progeny of the peculiar characteristics of the sire and the dam. This is not so, however; but it appears to be a kind of fixed rule—which may be taken as the second "law" affecting the "in-and-in" system—that in each animal the sire and the dam contributes its own influence in the formation of certain parts of the structure or living organism of the calf, and in the development of certain qualities.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

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121. Recent Researches into the Nature of Friction.

IN our last note, No. 119, p. 215, we opened up this most important subject; and in order that our young readers might know how the question stood at a period preceding the researches we proposed to record, we stated that we should glance briefly at its position as formulated by Morin, and which, as we have seen, was accepted as a rule with few exceptions by the general body of machinists throughout the world. The phenomena of friction were ranged or classified under two great divisions: first, the friction of bodies at rest—or what was called the "friction of quiescence"; and second, the friction of bodies in motion—or simply the "friction of motion." There was also another division or classification, dependent upon the condition of the bodies, whether those were solid or liquid; and these were ranged under distinct "laws," as those of "solid friction" and of "liquid friction." These were not seldom mixed up, so to say, and confounded with each other, as if they were one and the same thing, giving rise to a confusion of ideas and consequent inaccuracy in results, which made in the minds of many the general subject of friction, complicated as in its simplest aspects it is, still more complicated. And this unfortunate result was all the more to be deplored, as it was rendered still more complicated by a forgetfulness on the part of those just alluded to of the fact that the results of any experiments are practically worthless if the conditions under which they are made are either overlooked or not considered of importance. In more than one of the papers on various points of physical science given in our Journal, we have taken occasion to point out that, so far from the conditions under which experiments or trials are made being of no significance, they are on the contrary of vital importance,—so much so that, if disregarded either through ignorance or indifference, any experiments or trials made are of no real value. All this tended to put the whole question of friction on a most uncertain and unsatisfactory basis; and the mechanical world will be placed under no small obligation to those who have recently been making researches into the nature of friction, if these tend to get rid of the accumulation of errors and of crude conjectures which have in the course of time got clustered round the subject. At present the late experimenters have contented themselves with the recording of such facts as are truly entitled to the name—that is, things which actually exist, not merely being supposed to do so, as many things called facts really are. No attempt has been made to found a theory, or to formulate laws upon those facts made known by the experimenters,—this work will doubtless follow,—meanwhile the facts are of the highest value, and will materially, and we believe rapidly, modify the practice of machinists in the lubrication of moving bodies. Referring to the classification of the varieties of friction, we may note that certain points of that known as the "friction of quiescence" have given rise, especially in the minds of young readers, to some considerable confusion of ideas, and consequent uncertainty as to the points connected with the "friction of motion," which is in practice that with which the machinist has chiefly, if not indeed alone, to deal. It is, in truth, not easy for the youthful mind to comprehend clearly what is meant by the friction of bodies at rest or in quiescence. With the very word friction the idea of rubbing between the bodies, or the dragging or moving of one body over the other, is so insuperably associated, that the mind cannot readily comprehend friction as existing at all between two bodies at rest. In one sense the phenomena, so called, of friction between two bodies so placed, might strictly be defined as the result of the law of (the attraction of) cohesion, or that which keeps the molecules (see "The Technical Student's Introduction to the Principles of Mechanics" in text) together. But in solid bodies this cohesion must be overcome by some external force tending to break up or disturb the relative position of the molecules. But with this breaking up, which is equivalent in one sense to the destruction or doing away with the original integrity of the body, the youthful reader will not readily associate the idea of friction as he popularly understands it; although there will be the friction as he understands it—there will be rubbing between or dragging of the one molecule over the other in the very act of breaking up the body, or in destroying its cohesion. But the young reader may conceive of two bodies, one simply placed or resting upon the other, their surfaces being placed in contact more or less complete. Thus placed, he would not define the two as constituting one solid body; on the contrary, he knows at once that there are in reality two solid bodies, the division between which is the line of contact of their surfaces. And he has only to lift the upper or superimposed body vertically from the other to destroy its apparent single solidity, and obtain two bodies; and in lifting up the upper body, he knows at once that he has had only the attraction of gravitation, in other words the weight of the body, to overcome. But if he attempts to change the apparently one single body into the two bodies of which it is composed by shoving the upper block along the surface, by exerting pressure at one end, or by dragging it over the lower surface, he knows intuitively, or rather he feels, that he now has something more to oppose than the mere weight of the body. He has now something which resists the pushing or shoving or dragging motion—and to this something he gives the name of friction. And he also intuitively knows, or comprehends in popular language, that the resistance given to the pushing or dragging of the one body over the surface of the other is dependent upon the condition of the surfaces. The rougher these are, the greater the power he requires to exercise in order to move the one over the surface of the other; the smoother the surfaces, the easier the movement. We talk of smooth surfaces, but there is no such thing as absolute smoothness. All bodies are rough in their surface, and a body is called smooth only as considered relatively to another which is less smooth. The smoothest surface, as the finest edge of a cutting instrument examined by a microscope, displays protuberances, the spaces between which are hollows: the smooth edge, so called, is seen to be rough and jagged like a saw. Friction arises practically from the protuberances of one surface entering into or engaging with the hollows in the other; the less pronounced those inequalities are, in other words, the smoother the surfaces, the more easily is the one body moved over or along the surface of the other—that is, popularly expressed, the less the rubbing or friction. But it is only by moving the one body upon the other that one becomes sensible of the fact that the difficulty of movement exists—or that different bodies, in varying conditions of surfaces, present different facilities for or obstacles to movement. Popularly, as we have said, it is difficult to conceive of friction as existing between bodies absolutely at rest or quiescence—which of course exists, otherwise there would be no permanence in the stability of bodies in contact, subject as they would be to movement on the slightest disturbing power coming into existence. General Morin found that the friction of quiescence is subject to causes of variation which are not met with in the case of friction of moving bodies. Further remarks on this most interesting subject must find a place in a succeeding note, as the space of the present one is now exhausted.

122. Belt-and-Pulley Gearing.

This subject, in its general aspects carries, with it much that is of an interest to the general machinist of a wider character than that connected merely with its special details of shafts and bearings, with their pulleys and attendant belts. In our last note upon it we took up sundry points connected with the length of belts, their breadth, and the speed at which they are, or should be, run,—all as affecting the economical working of belt-and-pulley gearing. This economical running is further affected by the way in which the power is taken from the main driver drum or pulley or crank-shaft of prime mover, steam engine or otherwise, led to the different localities of the machines, and distributed, so to say, amongst them. Let us glance briefly at some of the ways of leading off the power. Each belt in its drag or tension obviously acts as a power tending to strain the shaft or give it a tendency to get out of the straight line, and this in the direction of the dragging power. It is a judicious mechanical arrangement to oppose a strain acting in one direction by a strain acting in the opposite direction,—making those strains equal, if possible, so that the two strains or forces will be neutralised, and the shaft, for example, left free, if not otherwise subjected to an injurious strain. If the transmitted power is communicated to the range of pulleys all on one side, the strains will obviously be all acting in one direction; but by arranging the machines to be driven on both sides of the driving or lying shaft, it is obvious that the strain will be thrown on both sides of the shaft. The equality of the strain will of course depend upon the way in which the machines can be distributed on either side of the central shaft, in relation to the power which they require to drive them. And it is difficult at times so to dispose of the various machines that this balance of strain, desirable from a mechanical point of view, can be obtained. That it is not, indeed, always an easy thing to do to give a central position to the driving or lying shaft, one may judge from the frequency with which arrangements are met in which the shafts are ranged along the sides or on one side of a building, the machines being on one side of them, and in which case the strain or pull is all in one direction. This point of strain distribution is one which is worthy of being carefully studied in connection with belt-and-pulley gearing, for much of its economical efficiency depends upon it. To gear a factory or workshop with belt-and-pulley gearing, so that it gives out its best characteristics, demands on the part of the machinist greater care, more accurate calculations, and a wider range of experience, than to gear the same place with toothed-wheel gearing. Much of the prejudice which exists in some quarters against belt-and-pulley gearing has doubtless arisen from the cases in which it has been so ill carried out that they contrasted unfavourably with the like cases in which toothed-wheel gearing had been adopted. There are certain ways of doing mechanical work which have a great attraction for many minds, as they possess the feature of simplicity in a marked degree. No doubt this is what always should be aimed at; but it should be considered whether the method in question is in its practical working simple, and not merely so in what may be called its primary idea or principle. And the every-day working of a system or method is after all its best—indeed, from the true point of view its only test. For the simple method may involve in its working so many difficulties, or chances of creating these, that it may ultimately be less valuable than a more complicated system. We have an illustration of this in the system of driving machinery, however extensive, in the case of a cotton factory, through the medium of *one* long endless main or driving belt only. Now, in this there is beyond doubt a "sweet simplicity," when we think of it as against, and compare it with, the system which has several belts by which the power of the engine or main driving pulley is taken off to several lying shafts, from which, again, the machines of the factory are driven. But a little examination will show that this *one*-belt system is anything but simple in its practical working. In the first place, its principle is directly antagonistic to what may be called the common-sense principle of the distribution of risk of loss inherent in or attached to all methods of doing work or carrying on a business. It is this which affects so seriously the question of what every user of steam-engine power in the driving of extensive machinery knows but too well, not only by name, but by the serious losses which are involved in "break-downs." When, for example, the engine driving the machinery of a cotton mill breaks down, the result is disastrous, as even in its simplest manifestation a money loss of considerable amount is sustained, not only in repairing the engine and damaged gear, but in the complete stoppage of the work of the mill. It is losses such as these, and all the business inconveniences which they carry along with them, which are leading machinists up to the adoption of a system by which the chances of such losses are minimised; this being reducing the risks of a total break-down of driving power by dividing it amongst two or more engines. Some of our ablest mechanicians, not content with giving a separate and distinct engine to each floor of a mill, or to each class of machines to be driven in a workshop, have advocated the giving of a separate engine to each machine, if requiring great power; or, at the least, one engine to a number of machines requiring each less power. There is, of course, as in nearly all mechanical questions, much to be said on both sides of this question; but the general principle is sound, and applies to the "one driving belt" system we have specially alluded to. In this system, which has met with its chief exemplifications in the United States of America, the engine is placed in the centre of the basement floor, the main driving pulley being at one side of this; or otherwise, the engine the fly-wheel of which constitutes the main driving pulley may be at one side,—in both of these cases the main driving pulley being at one side of the basement apartment. The driving belt is carried up at a high angle—80° or 85°—to a drum on a lying shaft, placed under the ceiling of the second floor of the building, and, being passed round, is led round pulleys which command machines at one side of the room, from thence to the other side, where it is passed round another set, and finally to a drum close to the wall under the ceiling. From this it is passed vertically up to a drum on the third floor of the building, in which it is passed round other sets of pulleys; and so on through all the floors, till it finally passes over a drum placed near the wall, and vertically over the main driving pulley in the basement floor, to which it is led. Where there are several floors and numerous lying or line shafts to be driven, one may conceive to what a great length the belt extends, which practically is one endless belt,—in some cases three to four hundred feet long being met with. When the mere weight of a length of a belt like this is considered, the difficulty of adjusting the tension, passing as it does round or wrapping so many drums or pulleys, and the necessity of having so many joints either laced or riveted—each being an element of chance of breakage, and which is simply equivalent to the break-down of the whole—it will be perceived that the sweet simplicity of this, the one-belt system, disappears quickly under the influence of practical working. By far the best, because the most economical as it is the safest system, distributing as it does the risk of break-downs and minimising the chances of these, is to locate the lying or line shafts in the centre of each floor, and take the power from the main driving pulley, which we suppose to be the fly-wheel, also by a separate belt. This has its own position on the pulley, independent of its neighbour belt, and separated from it by a flat unoccupied space on the pulley face or periphery, also boxed in; and being centrally placed in the room, the pulleys fixed on its shaft can be arranged to take off the power to the various machines right and left of it. And if those be judiciously disposed, the strain on the shaft may be equalised. As the engine is placed on one side, the strain on the line shafts on the different floors will of necessity be on one side; but this will be greatly neutralised by the judicious arrangement of the driven machines in each floor or apartment, disposed on both sides of the lying or line shaft. The length of the driving belts for the line shafts will, of course, increase as the height of the different floors increases, and the angle at which they run will vary also, of course. The best condition of running, as regards length, etc., cannot be secured on all the line shafts on the different floors. Still this independent system, affording as it does also opportunities to balance the strains upon the shafts, will be found much more satisfactory in working than the one-belt system, in which all the machines to be driven are disposed on one side only of the driving shafts.

123. Bessemer Steel Castings.

In our last note under this head we concluded by referring to the theory of liquation accounting for the redistribution of the debasing elements of sulphur and phosphorus in the cooling of the metal of the ingot. Whether this theory will be still further corroborated by the results of the wider experiments which Sir Frederick Abel deems essential, remains to be seen. The point to be decided is one, as we have said, of great practical importance. In connection with the effect of getting rid of the occluded gases from ingots, as adding greatly to the value of the steel, Mr. Adamson has some very suggestive observations. Much as this cause of inequality in the ingot steel has been discussed, Mr. Adamson thinks that it has not met with such a "thorough explanation" as might have been expected as the result of so much interchange of views of so many different and, it goes without saying, differing, practical authorities. After all that has been shown in regard to the process of mechanical stirring introduced practically as a part of the Bessemer process by Mr. Allen, and, as we have seen, proposed at a very early stage of its history by Sir Henry Bessemer himself, Mr. Adamson doubts whether after all we get with this "mechanical admixture a thoroughly sound ingot." Mr. Adamson readily admits that the views of Mr. Allen are sound, and that his practice moreover bears out the value of this process based upon them,—that they seemed to get by it a metal which had assumed a new condition, "approximating to that of the more carefully prepared hard tool steel." But while admitting this, and readily, Mr. Adamson—and we confess we think with sound scientific reasoning—points out that there are other conditions under which Bessemer steel is placed when being cast which must affect its ultimate value when cast. In more places than one in the pages of the TECHNICAL JOURNAL attention has been called to the great importance, to the youthful student of mechanism and mechanical subjects, of attending to all the conditions under which work is done, and to which materials are subjected. Hence the value of the remarks made by Mr. Adamson in connection with the important subject of our note. The conditions of "casting" the ingot—a process which follows the mechanical admixture of the steel by the process of Mr. Allen—must have an influence of some kind in the ultimate condition of the ingot. It is difficult to get rid of this assumption, or rather of the fact which it involves. The mere casting process must bring about certain changes or conditions of the ultimate ingot—cannot avoid doing so; and Mr. Adamson does well to endeavour to trace out—and this he does with great mechanical and scientific acumen—what those changes are. The conditions of the process of *casting* the ingot must not be confounded with those under which the metal is mechanically *mixed* in the teeming ladle by the process of Mr. Allen. They are totally distinct, and must be kept so if a right view of the ultimate condition of the cast ingot is to be obtained. Mr. Adamson points out that the conditions of the "casting process," even after that of mechanical admixture has been completed, must of necessity "give rise to such differences of action in cooling as could not be touched by any mechanical agitation of fluid metal." In tracing out these "differences of action" he assumes that he is dealing with an ingot twenty-four inches square in cross section; and that the steel which is to form it is run into a cold iron mould. The effect of this mould will be to "chill" (a note may yet be given on the process of "chilling" cast iron, so largely introduced in the mechanical arts) the outer portions of the steel poured into the ingot, so that the interior portions become encircled, so to say, or, to use the technical term, "hidebound," by a skin or envelope of hardened metal. Now, Mr. Adamson conceives it to be "utterly impossible" for the metal in the interior of the ingot to remain solid unless there was a departure of the metal from the top, or a curvature from the sides of the flat or square ingot itself. It was well known to those who had examined carefully large numbers of ingots that a much sounder ingot was obtained from the square or rectangularly-sided ingot than from a circular or rather a cylindrical one—which latter has, of course, to be cast in a mould circular in section. But while Mr. Allen contended that his mechanical mixing process gave an ingot solid throughout, Mr. Adamson, *per contrâ*, contends that this solidity is only apparent on examination, and that in reality the metal is so far from possessing this characteristic, that it is in a condition to which he gives the name of "porous homogeneity," the "diminished contact of atoms which were distributed throughout the whole mass giving rise to a porous ingot." The difference in condition between the hard chilled metal forming the skin of the ingot, produced by its coming in contact with the cool metal of the mould, and the hot and in the first instance partly liquid metal of the interior of the ingot, must give rise to contraction, with all its mechanical effect. This contraction in an ingot 24 inches on the side—that is, two feet square in cross section and five feet long (a size commonly adopted in practice)—was, at the high temperature of ingots, equal to about a quarter of an inch per foot. But Mr. Adamson submits that half of this contracting power is lost in consequence of the action of the hard hidebound skin or envelope of the ingot. This he estimates, in the case of the ingot of size above named, to be equal in effect to a $23\frac{3}{4}$-inch square ingot as against the 24-inch, or the full size of ingot; and with a length of ingot of five feet, this difference would be equivalent on the total amount of bulk to about 988 cubic inches. This difference of nearly a thousand cubic inches between an ingot actually obtained, and its theoretical, or what might be called its natural or normal bulk, if subjected to no opposing conditions or influences, must, Mr. Adamson contends, produce an ingot anything but solid. With this difference, it is, he says, "utterly impossible" to have a solid ingot. To make his contention more clear, Mr. Adamson puts the case in a proportional or arithmetical way. The want of solidity in a 24-inch square ingot arising from the influence of its hidebound skin in the mould, is equal to a solid bar $5\frac{1}{2}$ inches in diameter, the length equal to that of the ingot, which we have seen was assumed to be 60 inches or 5 feet long. Mr. Adamson, in pointing this out, asks for any one to conceive of the porosity of the mass of the ingot when minus or deprived of a mass of metal equal to a bar $5\frac{1}{2}$ inches across in section and 6 feet long. He therefore concludes that it is "utterly impossible" to get a solid ingot—solid throughout—under the influence of a hidebound skin, unless the ingot was diminished from the top or broken up from the bottom; and Mr. Adamson believes that solid ingots will only be obtained when other means are discovered and adopted of treating the metal than that only of the mechanical mixing process of Mr. Allen. That Mr. Adamson is right we have little hesitation in saying. No one who is at all conversant with the phenomena—and some of them are exceedingly curious and puzzling—of the casting or moulding of objects in ordinary cast iron, can come to any other conclusion than this—that the conditions of the operation or process of casting or moulding must, of necessity, bring about changes of condition more or less decided in the ultimate or finished product. And it is impossible to see why the process of steel ingot casting should be exempted from some at least of the many causes which in ordinary casting or moulding are but too well known to bring about prejudicial conditions in the finished product. The whole question is one of great importance, and will no doubt yet obtain that full investigation which its importance to the world of mechanical construction demands.

124. Ensilage.—Crops Suitable for the Process.

In last note, No. 120, page 217, we gave a description of the crops suited for the ensilage system; that department of the subject we now continue. The Lupine or Lupinus is a plant recommended to ensilage practitioners as producing forage well suited for the system. This is another crop which has a high reputation on the Continent, not merely as a highly nutritive cattle food, but as being, like the spurry, specially valuable in bringing poor sandy sterile soil into cultivation and fertility. As a food, the researches of our own agricultural chemists and the hints of our practical men have shown that it possesses a very high value. For sheep, as a crop to be eaten down, the lupine is particularly valuable; and as a green-cut food for stall or horse feeding it is also of high value in the rearing of calves and the feeding of cows.

Having so far dealt with crops available for soils of a dry, sandy nature, we have now to name another, which is at least worthy of a trial in poor soils of a totally different character—namely, wet and marshy or moss lands. This plant is the Tussac grass (*Dactylis cæspitus*), and of which it is worthy of note that, in addition to the valuable characteristics which it possesses as a crop most useful in bringing damp, partly moss or marsh land, into good heart for general arable culture, it has alsomost valuable feeding properties. Tussac grass, although so completely a new thing to many of our readers that this will be the first time they have seen the name, is nevertheless no new thing to agriculture. Much more thought of at one time than it is now, and most strongly recommended for its many good qualities, it affords an example of what seems to be a feature of farming—a peculiarity common to other industrial arts—namely, that a product or process held in high esteem at one time gradually ceases to be used and followed till it becomes so seldom employed that it is but a mere tradition in the history of the art. The plant, like ordinary grass, is an evergreen; it is a handsome plant in its growth, reaching a height of from three to four feet, and is striking in appearance from the length of its leaves, which will reach often to five and even seven feet. The roots are thick, solid, and matted; and in this way the plants are most useful in draining the marshy, wet, or peaty soils in which they grow so luxuriously. The plants are very hardy, standing frost well; and what makes it appear to us as a plant peculiarly valuable for ensilage purposes, they improve in productive quality by being cut down for food. One thoroughly practical authority, who years ago devoted much time to this grass, states that cutting the crop as a green food, he obtained a weight of fifty-one tons per acre. The best way to cultivate this tussac grass is by transplanting: the young plants being raised in a seed-bed, the sowing being done in a well prepared patch of good—say garden—soil, in a well sheltered position, to admit of so early a sowing that plants may be ready for transplanting in March, and which may be carried on up to May at intervals, as other work will admit. Some idea of the handsome dimensions the plants attain to may be derived from the distances at which they are set from each other, this varying from three to four feet according to the character of the soil. Taking readily to wet soils, they may be planted in such without previously draining them; and from the succulence of their abundant leafage and the size and solidity of the roots they make, the cultivation of the crop is itself a great help to the more complete drainage of the soil which may follow thereafter. In mossy, peaty land, a piece of soil some eighteen inches square is cut out, inverted or turned upside down while dry, and the plant dropped in. To give the plants a good start, some stimulating manure, such as guano, should be placed in the holes. Taking it altogether, we should be inclined to strongly recommend this plant to the attention of the small or the amateur farmer, whether he designs to grow it for ensilage or for stall feeding or soiling purposes. To the small farmer it is of vital importance that he makes the most not only of his good soils, but also that he has none which is not yielding something; and there are few farms on which there is not a patch or patches of poor soils, either sandy and so sterile as to grow scarcely anything upon them, or so damp and marshy that nothing but poor aquatic weeds flourish on them. And for soils of both of these kinds we have pointed out crops which, while bringing them into good cultivation, will yield at the same time fair, and in many instances good crops, suitable for ensilage or for soiling. In the case of the amateur farmer we should counsel him to try this tussac grass. It is one of the useful features of his farming life that it affords him opportunities to make trials of new things, in order to be of service to others less fortunate than himself, who also do not possess the means, however strongly they may have the inclination, to try new processes or introduce new plants. Moreover, by making these trials, and other trials such as we have here and there in these pages pointed out, he will derive that pleasure which is one of the charms of amateur farming—of seeing new things he never saw before, watching their development, and helping forward the best way of gaining all the advantages they may offer.

We have now glanced at the leading crops which have hitherto formed the staple produce for the ensilage process; have noticed those which in a few instances have been tried, but which are recommended for more extensive, and indeed general use; and have in conclusion named what may be called quite new plants, which we have seen possess some claims to be considered good for ensilage as well as for soiling purposes. To render these notes as practical as possible, and to serve the double purpose of completing our paper on ensilage, and of giving information useful generally on the ordinary modes of cultivating and using forage or live-stock food plants, we have also given brief notes on the cultural characteristics and the methods of growing them of the various plants we have drawn the attention of our reader to.

We cannot, or in the interests of our readers ought not, to omit some notice of the use of leaves of plants, such as mangold leaves, for ensilage purposes. And this may afford us the opportunity to point out that in a new process it is just as desirable to learn or know what it will not do as what it will. So far as the physical characteristics of leaves of various plants such as those of all the root crops are concerned, there is nothing in the nature of ensilage to prevent their being applied, and successfully, to its work. Ensilage will preserve such leaves; but the point is, Is it worth while to preserve them? We have seen that in the case of one crop—the Jerusalem artichoke—good anthorities point out that it is a plant worthy of trial in the ensilage system; and here it is the leaves and stems only which are available. To apply the ensilage system to the preservation of the one true "leaf crop" we possess—namely, cabbages—appears to us to be what a high authority says is simply a "waste of force in our climate." For our readers will see more fully explained in a future part of this work, in which we give some remarks upon cabbages as a most valuable crop for milch cows more especially, that it is a crop which can be kept and kept well naturally, so that to use an expensive silo for its preservation is or would be what it is said above to be —a waste of force. But there are other leaves which cannot be so kept, and it is worth while to know whether the ensilage system could be used for them in a paying sense. Of these leaves we place first the mangold and the kohl rabi: of the latter it is worth noting that in nutritive value they are actually, weight for weight, slightly higher than the actual roots. The point is, whether, seeing the great bulk of leaves required to make what may be called a "good weight" of food, the ensilage process of preserving them would pay.

Now, on this head it is but right to see what evidence we can obtain in connection with it. That many farmers on the Continent adopt means to preserve mangold leaves, is some proof that the process is worth attending to, and that it pays to do so. And it is here very suggestive to observe—and indeed it bears most closely on the question now under consideration, as to whether it will pay to apply ensilage in this direction—that the method of preserving those leaves is neither more nor less than the "silo" in its original form, and which in its improved character is the base of the modern ensilage system. The old or original silo is, as we have seen, simply a pit; and the preserving of mangold and other leaves, as adopted exclusively on the Continent, is simply the "pitting" of them. Some years ago attention was strongly directed in the agricultural papers to the importance of this method of preserving the leaves of root crops, as a means of supplanting the food of live stock as obtained from the usual sources. In our next note we will give a description of the method, as given by a practical authority who at the time we have above referred to gave great attention to the subject.

125. Dimensions to be given to the Various Pieces or Members of Floors of Different Classes according to the "Bearing" or the Distance from Wall to Wall.

[The members in columns 2, 3, and 5 belong to the largest size of floors, termed "double-framed floors"; the members in columns 3, 4, and 5 to the medium class, or "framed floors"; the member in column 4 to the smallest class, "single floors"; the member in column 5 is sometimes added to this class. The table is arranged from one given in the standard work, Tredgold's "Carpentry."]

1. Distance from wall to wall or "bearing."	2. Girders 10 ft. apart, with 10 to 12-in. bearing on walls.		3. Binders 4 to 6 ft. apart, 4 to 6 in. on walls.		4. Joists 1 ft. apart.		5. Ceiling joists 1 ft. apart.	
Feet.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth
30	16	14						
28	16	13						
24	15	12						
20	13	11	13	7½	3	12		
18	12	11	12	7	2½	12		
16	12	10	11	6½	2½	10½		
14	11	9	10	6	2½	9		
12	10	8	9	5½	2½	8	6	2¼
10	9	7	8	5	2½	7½	5	2½

126. Farm-yard Manure—Number of Pounds of Fertilising Constituents given to the Land, in Dressings of Twelve, Sixteen, and Twenty Tons to the Acre.

Farm-yard manure is the only manure at command of the farmer which contains *all* the constituents necessary to feed plants with. The "dressings" or weights applied per acre vary according to circumstances, and to the farmer's notions of economy or otherwise. Referring to Note No. 106, p. 110, it appears that it takes an application of twenty tons to the acre to restore the fertilising constituents taken out of the soil by the crops therein named. The following shows the number of pounds of each of the constituents, in the order named in the above note, restored respectively by dressings of twelve, sixteen, and twenty tons of farm-yard manure to the acre.

Nos. in Note 106.	Weight.		
	12 Tons.	16 Tons.	20 Tons.
1	201	35	108
2	268	67	144
3	355	59	180
4	67	12	269
5	89	16	358
6	100	20	447
7	387	84	165
8	449	112	220
9	561	140	275

127. Weight in Pounds of Round Iron per Foot of Diameter, from 5⅛ up to 6 inches. (*See* Note No. 66, vol. i., p. 341.)

5⅛ inches diameter = 68·76 lb.; 5¼″ = 72·15; 5⅜″ = 75·63; 5½″ = 79·19; 5⅝″ = 82·83; 5¾″ = 86·55; 5⅞″ = 90·36; 6 inches diameter = 94·24 lb.

128. Weight in Pounds per Foot of Square Iron, from 5⅛ inches on the Side or Square, up to 6 inches. (*See* Note No. 97, p. 110.)

5⅛ inches square = 87·55 lb.; 5¼″ = 91·87; 5⅜″ = 96·30; 5½″ = 100·8; 5⅝″ = 105·46; 5¾″ = 110·2; 5⅞″ = 115·05; 6 inches square = 120·00 lb.

129. Scantlings or Dimensions of Pieces of Timber of the Thickness of 5, 6, 7, 8, 9, 10, 11, and 12 inches required to make one Cubic Foot of Given Lengths. (For table of thicknesses of 2, 3 and 4 inches, see Note No. 8.)

Pieces of 5 inches in Thickness				Pieces of 6 inches in Thickness.				Pieces of 7 inches in Thickness.				Pieces of 8 inches in Thickness.				Pieces of 9 inches in Thickness.				Pieces of 10, 11, and 12 inches in Thickness.				
Width or Breadth of the Pieces in inches.		Length of the Pieces in feet and inches.		Width or Breadth of the Pieces in inches.		Length of the Pieces in feet and inches.		Width or Breadth of the Pieces in inches.		Length of the Pieces in feet and inches.		Width or Breadth of the Pieces in inches.		Length of the Pieces in feet and inches.		Width or Breadth of the Pieces in inches.		Length of the Pieces in feet and inches.		Width or Breadth of the Pieces in inches.			Length of the Pieces in feet and inches.	
ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.		ft.	in.	ft.	in.
5	5	5	9	6	6	4	0	7	7	2	11	8	8	2	3	9	9	1	9	10 in. …	10	10	1	5
5	6	4	10	6	7	3	5	7	8	2	6	8	9	2	0	9	10	1	7		10	11	1	4
5	7	4	1	6	8	3	0	7	9	2	3	8	10	1	9	9	11	1	5		10	12	1	2
5	8	3	5	6	9	2	8	7	10	2	1	8	11	1	7	9	12	1	4	11 in. …	11	11	1	2
5	9	3	2	6	10	2	5	7	11	1	10	8	12	1	6						11	12	1	1
5	10	2	10	6	11	2	2	7	12	1	8									12 in. …	12	12	1	0
5	11	2	8	6	12	2	0																	
5	12	2	4																					

THE PRACTICAL NOTE-BOOK

OF

INDUSTRIAL SCIENCE FOR HOME STUDY.

(49) In Notes Nos. 28 and 40 we named some of the properties of aluminium, which in many respects may be said to be a remarkable metal, and for which uses may yet be found at present not anticipated, numerous as have been its applications. The melting point of the metal is about 1300° Fah. or 700° Cent. It fuses or melts very slowly indeed, and is valuable on account of its extreme indifference to atmospheric effects, as it does not vaporise or oxidise even under the high temperature of the blast furnace. In large masses it may be said to be altogether untouched by oxidation of the atmosphere. It is not acted on by nitric acid or aqua fortis, which is an active agent in the solution and practical destruction of so many metals, markedly of silver and copper. Yet, curiously enough, it gives readily to the action of a solution of soda or potash.

(50) In reference to the flashing point of illuminant oils, on which we have given a few brief notes, it is the ease with which those of poor quality pass off combustible vapours, and the low temperature at which the oxygen of the atmosphere combines with these combustible constituent of the oil, bursting into flame, which constitute the source of danger in the use of the oil in domestic lamps. It would be comparatively difficult to make a lamp explode if full of the oil by simply blowing the lamp out,—an action which is full of danger in the case of a lamp nearly empty, or in which there is a large vacant space. In the latter case, through long burning the body of the lamp gets comparatively hot, the vapour from the oil in the lamp rises with all the greater facility, and fills the upper part of the chamber, which thus becomes a reservoir of highly explosive gas. On putting the lamp out by blowing down the glass chimney, the flame or air so intensely heated is forced into the reservoir, and the necessary combination takes place, the vapour flashes into flame, and such a pressure is created that the body of the lamp, generally of glass, bursts. Dangerous as would be the casting about of splinters of glass, that does not constitute the true danger. This lies in the fact that the vapour flashing into flame sets fire to the liberated oil, and this with the pressure is simply scattered around in the form of a spray and sheet of living fire, which, if it settles on the body of any one near, means generally death of a most painful kind. The only true way to extinguish a lamp is to put a cap on the chimney-top, when, the products of combustion being prevented from escaping out, and being themselves inimical to free combustion, the flame is generally extinguished. As the value of the oils increase, the temperature of the flashing point rises, and the higher it goes the safer are the oils in use. We have seen that crude paraffin oil, with a specific gravity of 0·849, flashes into flame from the heat of a lighted candle placed a certain distance from the oil at 74° Fah. only; another specimen, of specific gravity 0·891, had, under the same conditions, a flashing point of 89° Fah. Crude naphtha of specific gravity 0·881 flashed at a temperature of 78°. Another specimen, of specific gravity 0·881, flashed at 90°. Refined paraffin oil of specific gravity 0·809 had a flashing point of 134°. Another, of specific gravity 0·814, flashed at 138°; while fine kerosene oil, specific gravity 0·801, flashed at 118°.

(51) To the many features of aluminium already named, which give a special character to it, may be added the facility it affords for the making of alloys with other metals. Of those, the most striking form the series known as aluminium bronzes, the base being copper, so much used by mechanics.

(52) Flooring surfaces formed with cement as a substitute for stone are now employed in a wide variety of instances, forming by far the most effective floor to resist fire and the dangers of damp. But they present this disadvantage—especially felt in offices and other apartments in which work is done—that they are very cold and uncomfortable as compared with a boarded or wooden floor surface. But this can be very easily obtained in conjunction with a cemented base or lower fire and damp-proof floor. Portland cement concrete lends itself with singular facility to the formation of boarded yet solid fire-proof and damp-resisting floors; for the joists, battens, or narrow sleepers to which the flooring boards are nailed can be imbedded in the cement concrete before it sets, and when it does set they will be as firm as if screwed down. Or the under edge of the joists—they may be made very light, as they have no cross strain to bear, only one of impression—may have a groove run along it, either rectangular or swallow-tailed in section, into which the cement will pass and form a "key," securing the joist to the body of the cement floor. This is better adapted to asphalte floors; simply imbedding the joists in the mass will do for the Portland cement concrete flooring system.

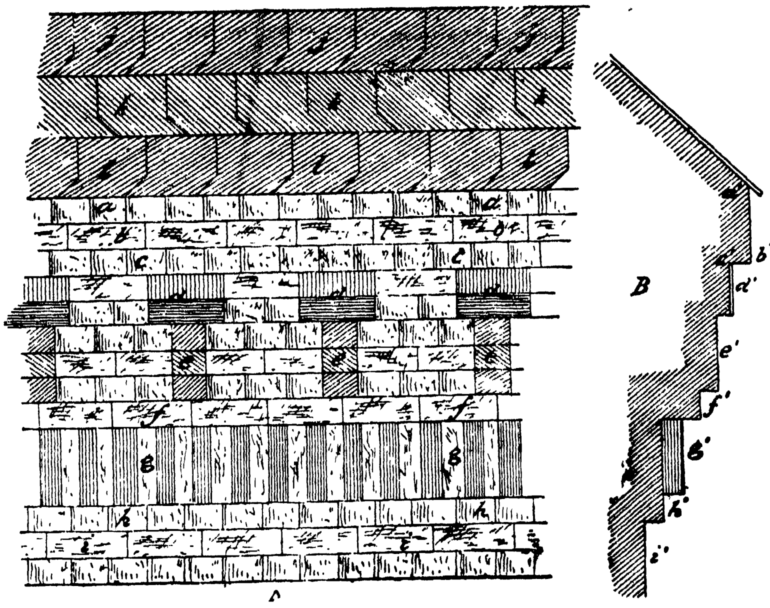

FIG. 1.

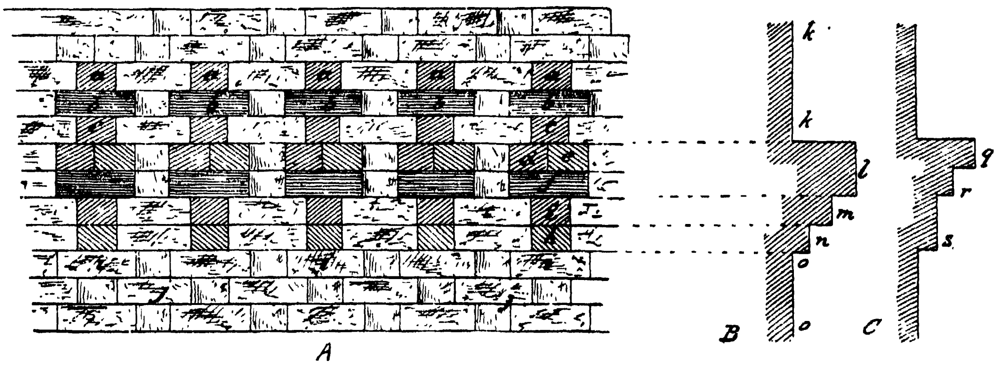

FIG. 2.

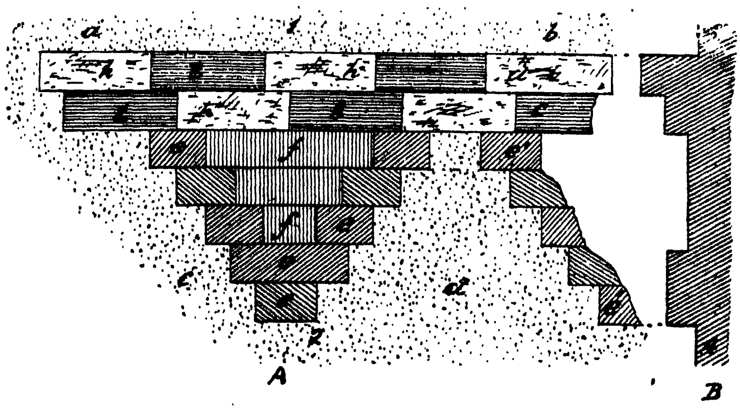

FIG. 8.

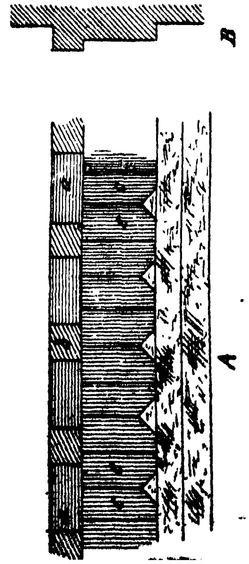

FIG. 4.

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ORNAMENTAL BRICKWORK.

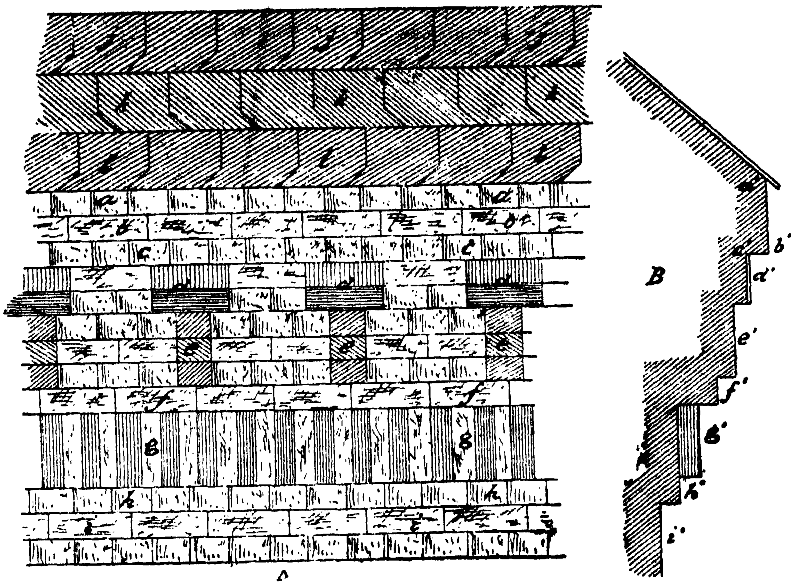


FIG. 1.

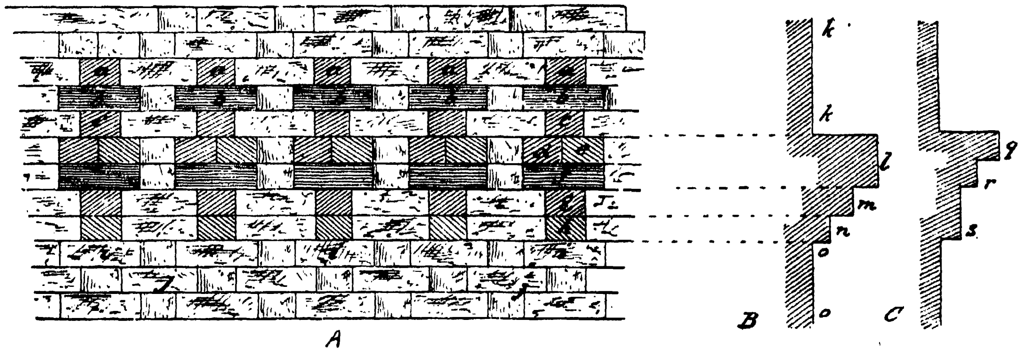


FIG. 2.

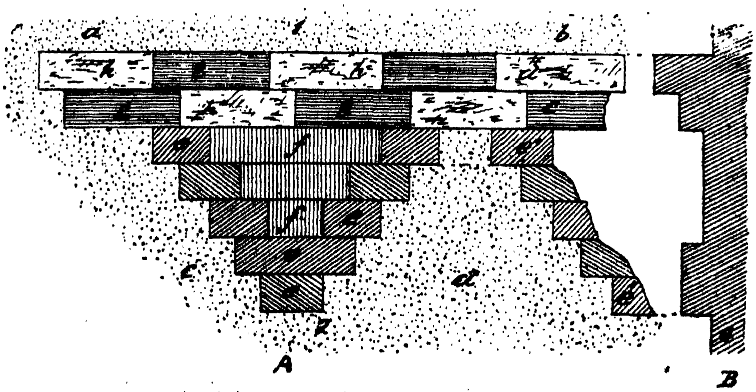


FIG. 3.

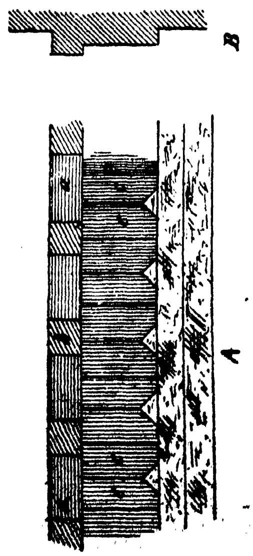


FIG. 4.

DEVELOPMENT OF SURFACES AND SECTIONS OF ARCHES.

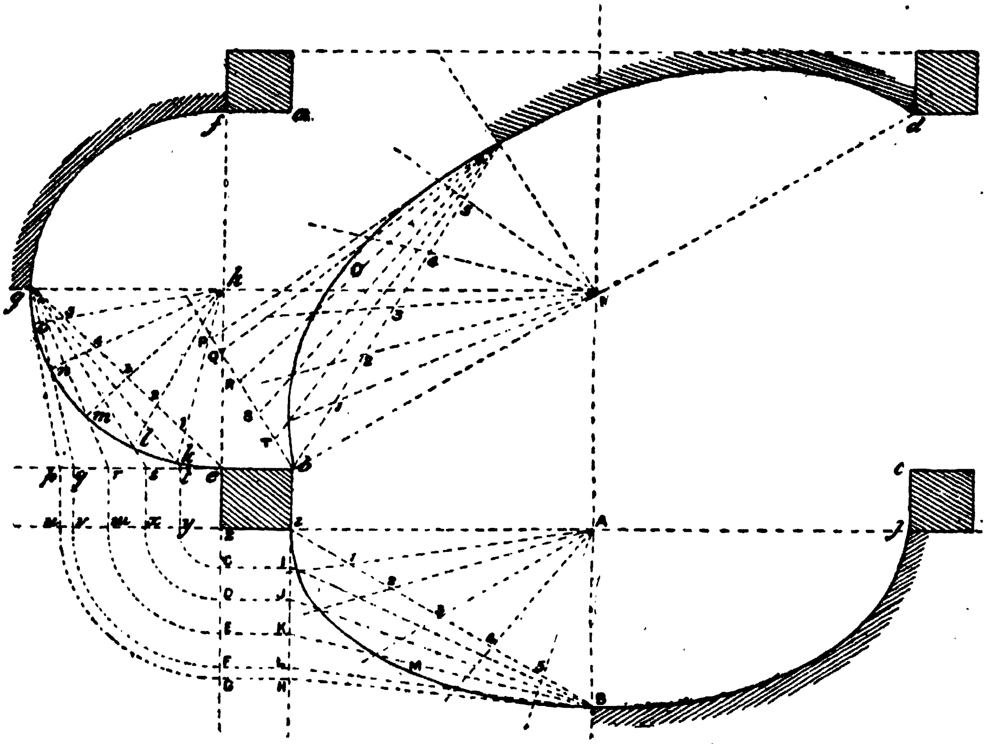


FIG. 1.

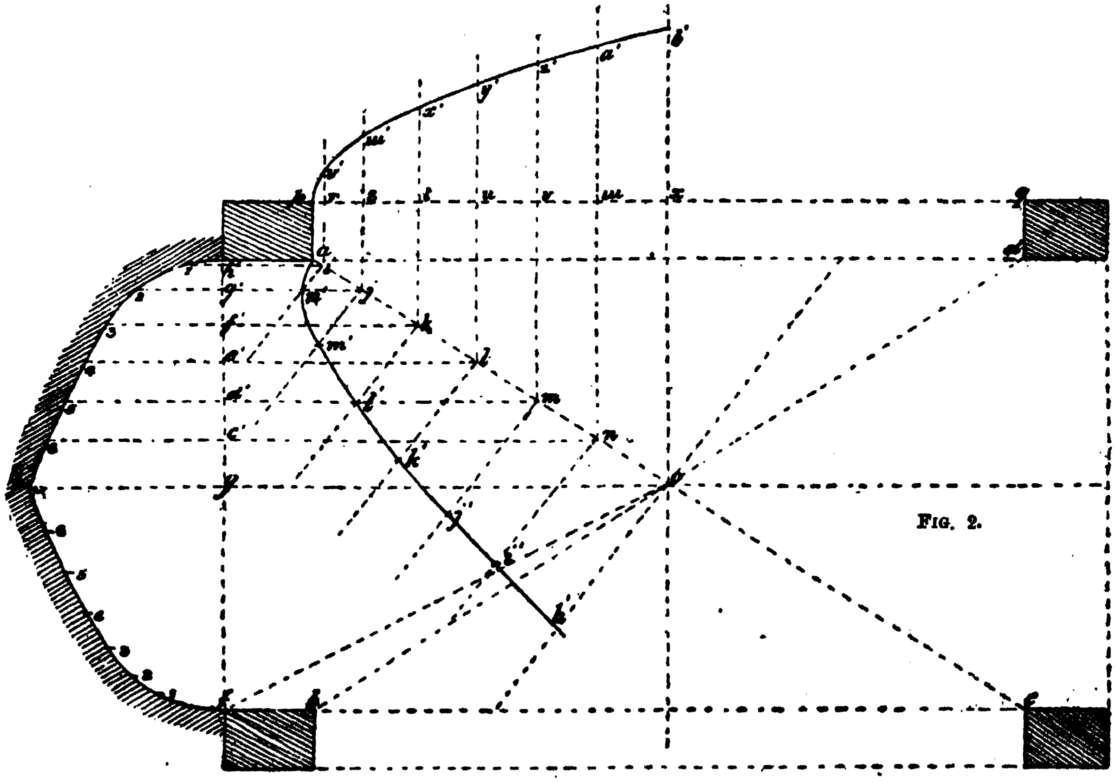


FIG. 2.

THE BUILDING AND MACHINE DRAUGHTSMAN (see Text).

SKEW WHEEL OR

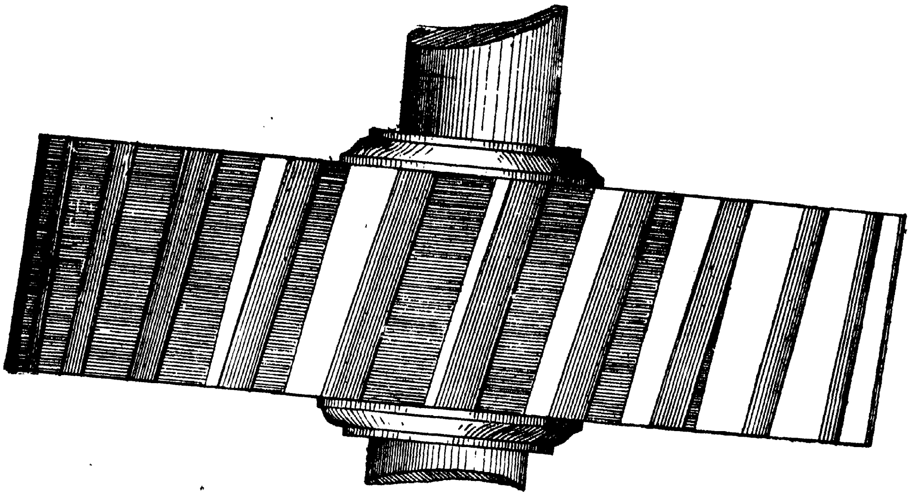


FIG. 3.

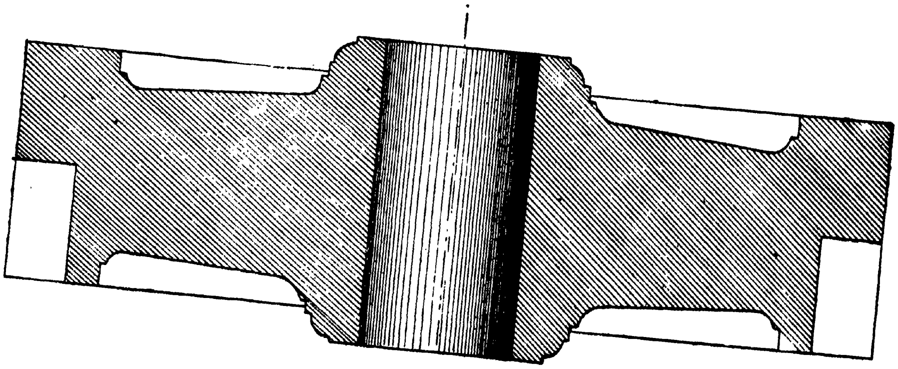


FIG. 2.

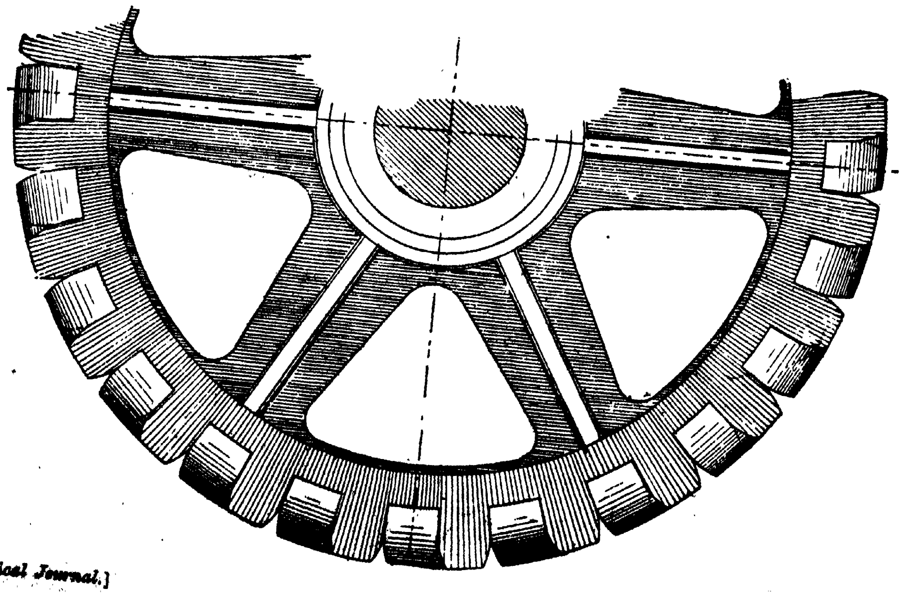
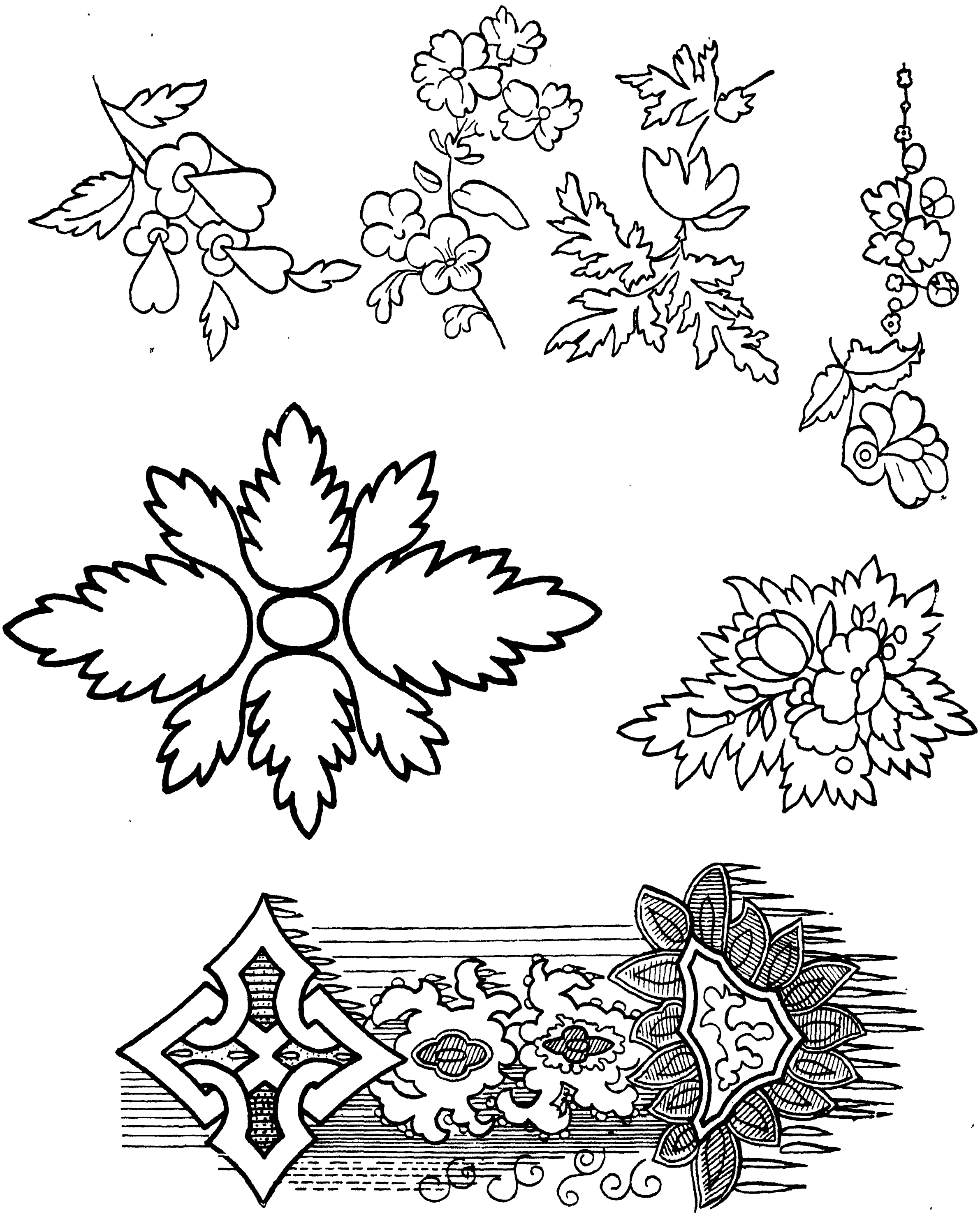


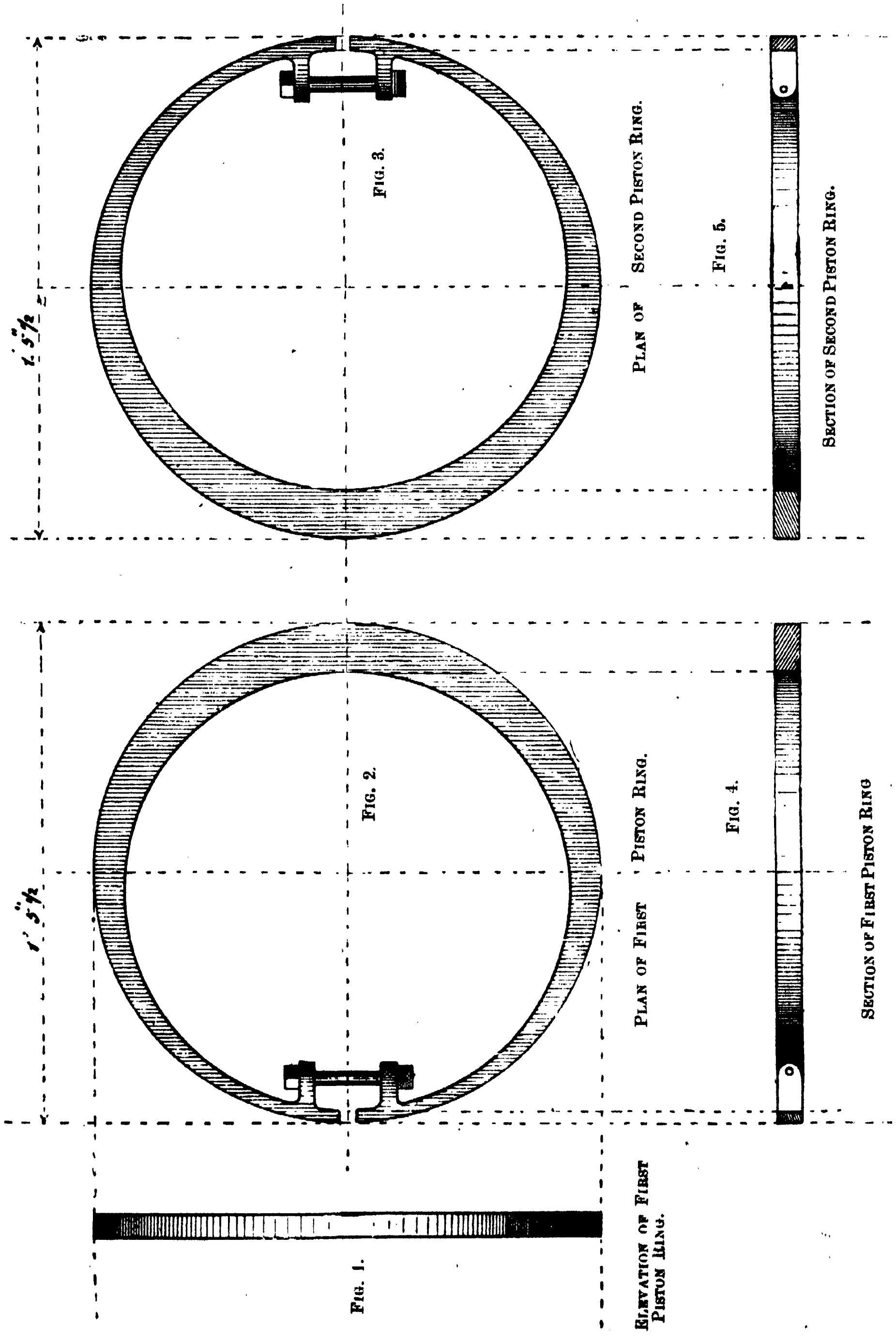
FIG. 1.

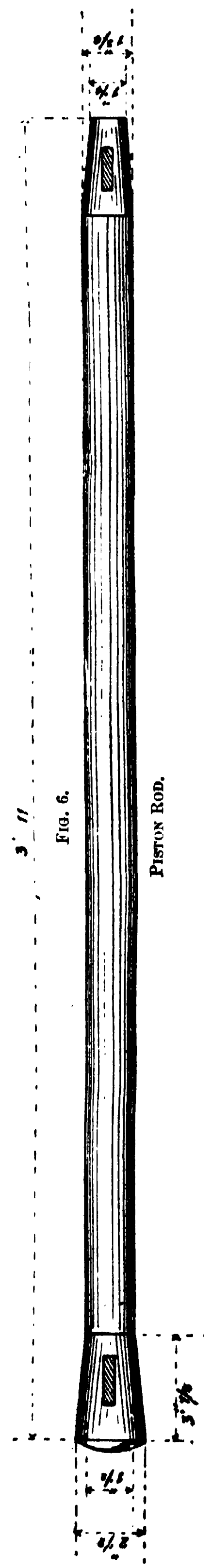
FORM AND COLOUR IN INDUSTRIAL DECORATION (*see Text*).

CONVENTIONALISED FOLIAGE, ETC.

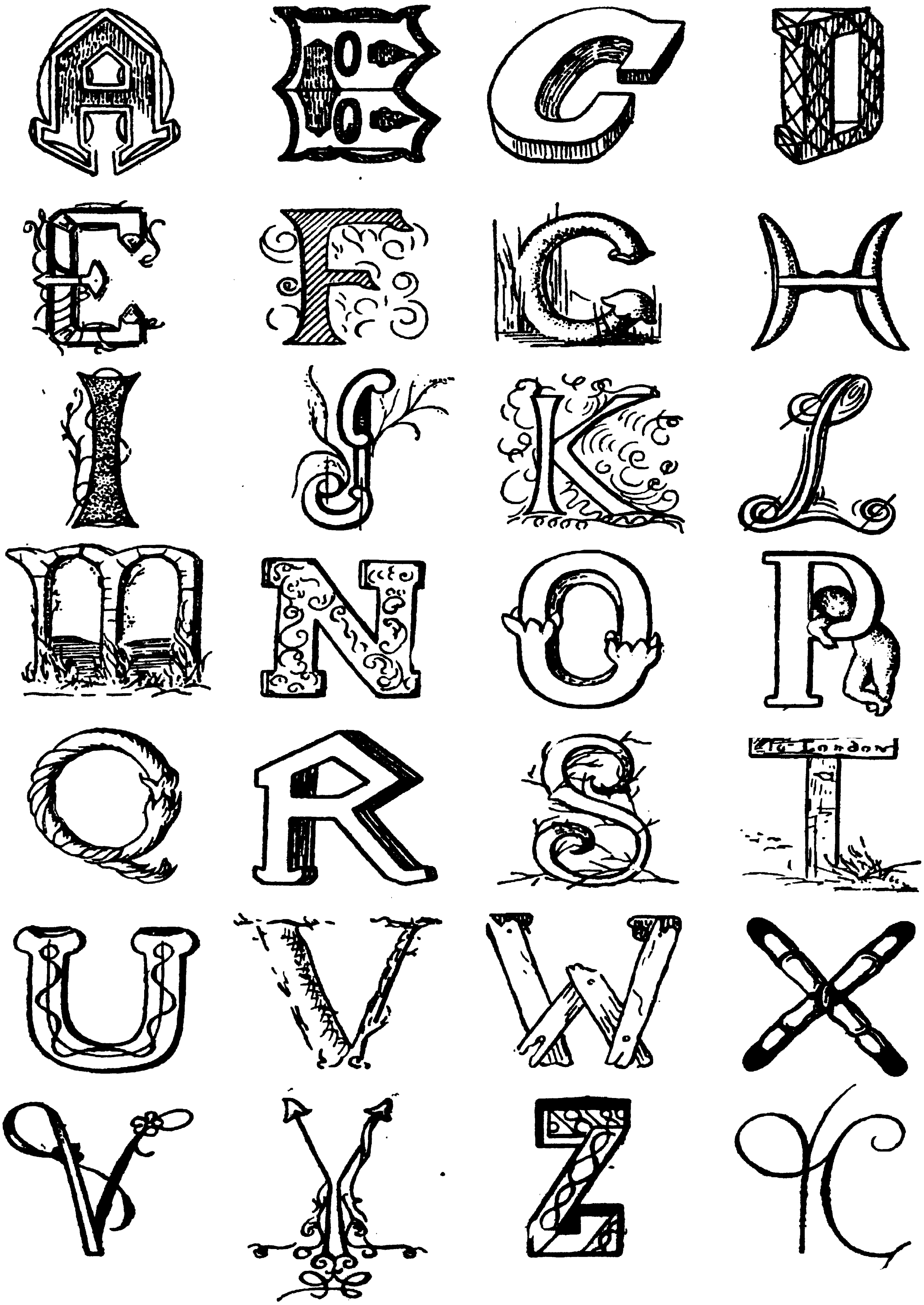


DETAILS OF PISTON RINGS (See Plate LXXVIII. for Piston Details). Scale 2 inches = 1 foot.





ORNAMENTAL LETTERING.—SUGGESTIONS FOR CAPITALS.



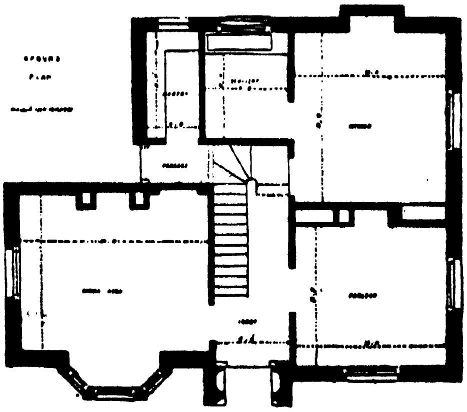
THE DOMESTIC HOUSE PLANNER (see Text).

ELEVATION AND PLANS OF VILLA COTTAGE.

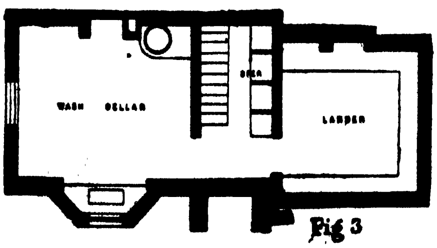
FRONT ELEVATION.

Fig 1.

(Scale in Fig. 2, Plate CXXX.)



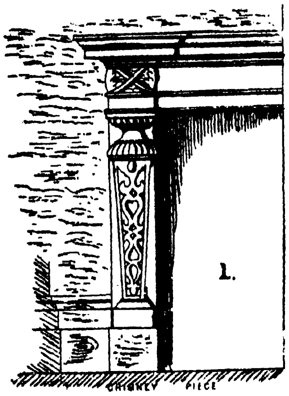
GROUND PLAN.

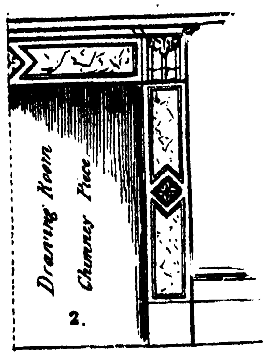


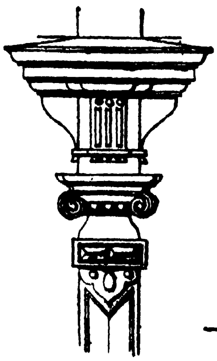
CELLAR PLAN.

Fig 3

Details Exterior and Interior.—Style Elizabethan.







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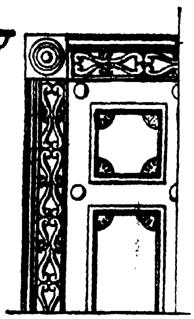

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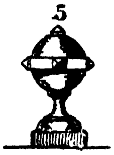
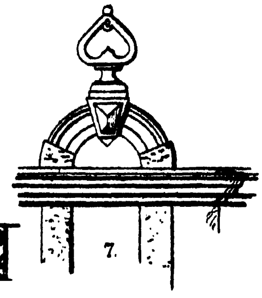
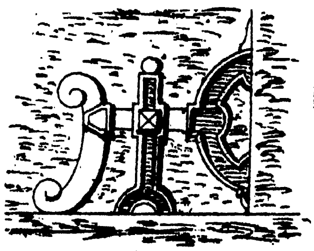


FINIAL

PIERCED PARAPET



PART OF PARAPET



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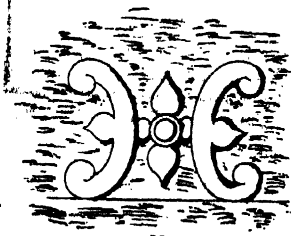

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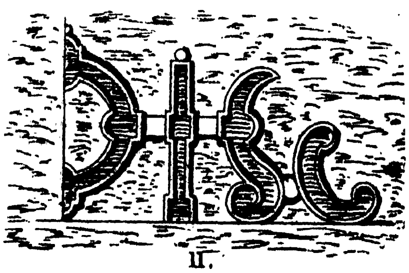


11.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XIV.

IN the preceding chapter, in detailing certain facts connected with the "indifference," "obstinacy" or "inertia" of matter, we pointed out their value to the student in practical work. Even in the everyday duties of life he may learn a lesson from them—the lesson of doing all work in a quiet, steady way, the very opposite of that "jerking," nervous style which some have, invariably suggestive of breakages, upsets, and all sorts of untoward accidents. We know of some master mechanics who judge very much as to what a man is likely to be worth from the mere way in which he handles his tools and "goes about his work."

A Popular Error in Connection with this Law in its Application to Machinery.

The law of inertia may be said to be exemplified in action in every machine with which the mechanic has to deal, which the individual workman employs. Some of its special exemplifications are very curious, as showing how much effective work is done by exceedingly simple means; one or two instances of this will presently be given. But it is not only in a great variety of machines that the law or property of inertia which matter possesses when in mass is exemplified; for those machines cannot be put in motion, or, if in motion, stopped in their action, without this property being called into play. The points involved in this statement, simple and incontrovertible as it is, are of much practical importance to the mechanic, and a neglect or ignorance of them has given rise in the past, and with many yet in the present, to grave mechanical errors, which have resulted in great loss. We have pointed out that the observance of natural phenomena led to their application in the doing of mechanical work long before the laws regulating those phenomena were known, and that it was the number of facts which the practical man had accumulated which gave the scientific man the natural form through which, by a process of inductive—sometimes, however, deductive—reasoning, he discovered the law which explained all those facts or phenomena. But even after the laws have been discovered or enunciated, mechanics do not always understand them; and frequently the very fact that they have closely observed the phenomena which exemplify them, gives to them certain impressions which, however erroneous, act so powerfully that grave errors in practice arise, and are so difficult to be eradicated from the mind that it takes the lessons of loss of many years, and much scientific exposition from those who know accurately, before these errors are got rid of. The law of inertia, or the property possessed by matter to which this name has been given by our physicists, affords a striking illustration of this statement.

In attempting to move heavy masses—say, to put a heavy ball in motion or roll it along a surface—it would be observed that it took a much greater amount of bodily exertion or force to set it in motion or to make it begin to roll, than was necessary to keep it rolling when once fairly started. And conversely, when once it was fairly set rolling and had a certain amount of force, so to say, stored up in it, if it were desired to stop its rolling, it would be found that it likewise took a greater force to stop it than was required to keep it rolling. This force required would, almost of necessity in the early stages of the collecting of mechanical phenomena and of the attempts to formulate a law which accounted for them, convey the idea that the matter possessed a force or a power which imparted to it the capability to resist its being moved, or, when in motion, being stopped. It was only at a later period that more accurate observation of phenomena, and an accurate process of inductive reasoning based upon these, led to the formulating of the correct or accurate law of inertia. This, as we have stated in preceding paragraphs, shows clearly that matter *per se* is, to use the French definition, as indifferent to motion as it is to rest. In other words, that, whatever be its condition, be it of motion or be it of rest, its tendency is to keep or remain in that condition unless acted upon by some force or power exterior to it; that it has neither what may be called the force of stability-inertia, nor the force of motion-inertia. Yet it took long before this was thoroughly comprehended; and there are many mechanics who do not now comprehend it. So that it came to be considered that matter possessed a force of inertia, and it was so propounded in many text-books, the term "vis inertia" being the learned name given to it. To how large an extent this erroneous conception of the property of matter known as inertia dominated the minds, and consequently the work, of mechanics, need not be here inquired into. Suffice it to say that it did dominate long and powerfully, to the great detriment of mechanical progress. As soon as mechanics got hold of the fact of the "indifference" of matter either to rest or motion, a rapid and a great revolution in mechanical practice came about. No one has stood for some time watching with close attention the working of one of the large and powerful reversing-geared steam engines used in first-class iron and steel works in the rolling department, without seeing at once that if the old notion that there was such a property in matter as the "force of inertia" had prevailed, no engine could have been thought of, far less constructed, which proposed to give reversed movements so rapidly following one upon another as the movements of the engines alluded to give. Juster views of this property of matter have also, in other departments of mechanical work, given rise to great improvements in working.

It is scarcely matter of surprise, however, that the erroneous conception as to the nature of inertia alluded to above, which gave rise to defects in machine working, was held by so many mechanics. For many of the phenomena of matter or of bodies are really, to the ordinary mind, so startling that it is not easy to do otherwise than conclude that matter possesses in itself an active principle which is brought to bear so as either to resist being moved when at rest, or oppose being put to rest when in motion. But the thoughtful student, however tempted to form and hold this conception of inertia as an active power in matter, must, if he desires to progress in mechanical knowledge, rest assured that it is entirely erroneous; that, so far as matter is concerned, it is equally indifferent whether, as in the case of the pendulum, the bob is hanging vertically at rest, or sweeping down one arc with an accelerated motion, or going up the opposite arc with a retarded motion. It is the force external to it that is to be considered in relation to the body, not the body by itself alone.

Illustrations of the Property of Inertia exemplified in Various Machines and Mechanical Movements.

We have said that some of the applications of this property or law of matter known as "inertia" are curious from their simplicity. When the flour-dressing machine, with sifting surface of material made of silk, was introduced, it worked well at first, but the interstices of the silk got rapidly clogged up with the particles of fine flour. The difficulty was overcome when some one thought afterwards of giving a shake, or shock, to the cylindrical inclined cage as it revolved. This could be done in more ways than one, the simplest of all being to give a small projecting part or protuberance to a part of the shaft, which as it came round, and in contact with a fixed point, would cause the shaft to rise in its bearings. So adjusted to allow of this rise, in passing from the fixed point the shaft would fall or drop, the amount of drop and consequent shock given being dependent upon the extent or height of the projecting part. Precisely the same effect could be produced by an eccentric keyed on the shaft working against a fixed point, for a protuberance on the shaft itself is virtually an eccentric (see "The General Machinist"). We find this principle of shock, as calling into play the property of inertia, applied in a wide variety of mechanical work. What is called "shogging," sometimes "jogging"—a movement applied to many purposes, as in certain modes of screening coals, and the sifting or separating of corn in the thrashing machine—is virtually dependent upon the property of inertia; the sudden reversal of motion from one direction to another giving, as it were, a shake to the materials. We have a good exemplification of the application of the principle in the straw shakers of the thrashing machine. In one arrangement of these, while they are hung from, or attached to, vibrating bars or pendulums, and have a lateral motion to and fro in a horizontal direction, they have at the same time an up-and-down motion or a vertical one given through the agency of cranks: as the cranks come down to their lowest dead point, dropping or falling, a shock is given to the straw shaker, which tends to shake out the small or short pieces of straw and any grain which has remained in the ears, while this, in combination with the two movements, keeps the straw "jogging" on in the same direction till it is finally passed away free from the machine. If the movement of the straw shakers were only the pendulous to-and-fro one, the passing of the straw from the inner to the outer end would be but a very slow process; theoretically there would be no passing of it, for the shock inertia occasioned by the change of motion at one time causing the straw to go forward would be neutralised by the next change, which would cause it to go a like distance backwards; but by the up-and-down crank motion the various shocks produced, or callings into play of the property of inertia at different periods, give precisely the result arrived at.

But if shocks, shaking or jogging is for some objects purposely and specially called into play by the machinist, this is but comparatively seldom required. As a general rule, the accuracy of work in machine design and construction is, in the contrary direction, displayed by the absence of all shocks in their actual working. For the student may take it as axiomatic,—that is, a statement which cannot be denied, being absolutely worthy of all credence (from the Greek *axioun*, to think worthy),—we say that it is axiomatic that where shocks or "jars" are found to exist in, or are created by, the working of a machine, it may be decided without any doubt that those are defects which arise either from bad design or construction. The working life of a machine is practically determined by the fact as to whether it works smoothly and noiselessly, or with shocks or jars and noisily. What may be called the natural life of materials of which the machine is constructed is virtually a very long one. That is to say, what is called the "wear and tear" is, when reduced to the minimum which good design and sound construction can alone give, very small in amount indeed. We see this exemplified every day in mechanical work: there are machines which, constructed years and years ago, are working now smoothly and steadily, and as efficiently as the week in which they were set to work; while others of precisely the same class, made by makers of quite another class, have been laid aside as worthless long ago. We have alluded to machines working noiselessly, and this quietness of motion is about as good an evidence, and it is certainly the most obvious and the most easily understood proof, that a machine is well made as any at command. Shocks and jars are always accompanied by noise; and the employer or user of a machine, though no mechanic, has in this proof a good way of deciding whether his machine is well designed or constructed, or the reverse. It is a positive delight to a well-trained machinist to witness the working of a well-designed and constructed machine, such as a large factory engine or a marine steam engine. These may be of vast proportions, of many hundred horse power, yet they go on working so smoothly, that if the eyes be closed, there is scarcely any ear evidence that one is standing by a machine the moving parts of which are alike bulky and ponderous. A painful contrast is but too often provided in the experience of the observant machinist, in some small fussy engine which, in its noisy, jarring working, "knocks itself to pieces," to use the graphic phrase, in a period all too brief to be satisfactory to its user and purchaser. And yet there is scarcely any comparison to be made between the size and the weight of the moving parts of the two machines. In the good—the true—machine, tons may be moved and changed in position scores of times in the hour, and be kept in motion for years of working time without injury; in the bad—the false—machine parts of but a few pounds in weight may be injured in a month or two. Hence it is the object of all good, and we may say conscientious, engineers and machinists, proud of their work, so to design their machines that all the parts shall be so related to each other that a "balance" between opposing forces shall be secured; and not only this, but that all the individual parts shall be constructed or made with such scrupulous care, and with such perfection of workmanship, that all the evils arising from shocks, jars, rough and noise-creating movements, shall be avoided. In other words, that all means be taken to prevent the property of matter we are now considering—inertia—from being manifested where it is not required. So prejudicial are all those manifestations of this property to the working life of a machine, that where shocks, or shogging or jogging movements, are part of the work of the machine, the able machinist takes care in its design and construction to arrange so that the inherent evils of shocks to the general life of the machine are counterbalanced.

All this attention to the development and manifestations of the property of inertia in machine work is essential to be given in every case. It is but too often ignored in that class of work known as "cheap," the product of an unhealthy trade competition or an equally unhealthy desire on the part of purchasers, who will have work done at the lowest price. It may be ignored in such cases, which are chiefly those where bad working can somehow or another be put up with, however costly in the long run it will prove to be. But attention to this point above stated *must* be given, cannot possibly be avoided, in the case of machines which are to run or be driven at high speeds or great velocities. A badly made locomotive, for example, would not be cheap at any price; simply because it would not, could not do its work for a day. A shock or jar which happened at each revolution of a shaft or each throw of a connecting rod, or each movement of a link, might, so to say, be "put up with," would or might not cause a breakdown, if the shaft revolved or the link moved twenty times a minute; but it would be simply ruinous to the working integrity of the machine if the revolutions, and therefore the shocks and jars, were increased to hundreds in the minute. Why, the youthful student will see when he comes to examine what is said in the general paragraph on "momentum." For, as we have already said, it is inherent in all works treating on the principles of mechanics, that in the very earliest parts terms have to be employed and phenomena alluded to the explanation of which cannot be given till at a later part of the work; so that the student has to wait for an explanation of those, in the meantime taking them for granted. In all high-speed machinery it is therefore absolutely demanded of the machinist, as a duty which he dare not ignore or overlook—could not if he would, for the simple reason that his machine would not do its work if he did overlook it—that he should balance the parts of the machine, and construct it in every detail, even the most minute, so that all shocks and jars, all manifestations of the property of inertia, shall be avoided thoroughly. As even our most youthful mechanical students will know, a striking peculiarity of steam engines—and the same may be said of productive machines, such as those in the cotton manufacture now constructed—is the very high speeds at which they are driven or "run." A high-speed engine has thus, of a working necessity, to be so designed that in the perfect balance of all its parts there shall be an utter absence of that "hammering," as it is graphically called, the evil effects of which in "knocking" to pieces, rapidly, of machinery, every sound mechanic fears and endeavours to avoid. The bearings of shafts have also to be made with a special view to the new circumstances of a great number of revolutions in a given time. The weight of parts, by judicious construction and accurate calculation, must be reduced to a minimum, and their increased momentum met by counterbalancing. All this is necessary—keeping to the example of a steam engine—when we consider the new conditions of speed at which it is run, In Watt's time, and for very long after, the speed of piston was two hundred and twenty feet per minute, and all sound engineers of the period looked upon any departure from this, the orthodox speed, as a grievous error in engineering. Now speeds of double this are quite common; and in some instances speeds not far from, if not quite up to, treble this are to be met with. When the student remembers that the direction of motion of the piston is changed at every stroke, he will have some conception of what the effect of "inertia" would be on the main shaft, and through it on all its connected shafts and machines, as in the case of a factory, if this were not provided for. The space taken up by what we have said on this subject will not have been given in vain if the youthful student will note especially the practical value of what has been said on the subject of inertia. Interesting in itself as the property is in all its manifestations, he will perceive how wide are its applications in mechanical work. Its importance may, indeed, be argued on the ground that it is primary, and that it underlies or is the cause of existence of a wide range of mechanical work, providing for working contingencies in which other laws of nature and properties of matter, and their manifestations in phenomena, are also brought into use by the machinist in designing and constructing. What those are we now proceed in due sequence to show. And first as to momentum, which will take precedence of the subjects which will yet make up the matter of our pages.

Glance at the Discovery of the great Law of Attraction of Gravitation.—Important Lessons to be derived from this by the Student.

Before passing on to the consideration of the other points of the general subject, it will be interesting here to glance at the points connected with the history of the great law of attraction of gravitation discovered by Sir Isaac Newton. Of the great law of "attraction," that of the attraction of "gravitation" is taken conventionally as the leading department—is, indeed, that on which all forms of attraction so called depend—so that the term "the law of gravitation" may be said to be synonymous with that of "the law of attraction." It is impossible to overestimate the importance of this law of attraction. It is one of the two (and, as we shall hereafter see, the only two) great laws, or natural influences if we may so term them, upon which depend the whole of the infinitely varied and endless phenomena, and of the no less infinitely varied states or conditions in which matter exists in the universe. But this brief glance at the discovery of the law we here propose to take will not only be interesting, but should afford to the student some exceedingly suggestive considerations—to which, as greatly influencing his future career, it will, we think, be well that he should give heed.

It is scarcely necessary to say that it is to Sir Isaac Newton, the greatest philosopher of modern, we may say with safety of all time, that the discovery of this great law of attraction is due. Every schoolboy is familiar with the legend or tradition that it was the falling of an apple from a tree to the ground which gave Newton the conception which ultimately led to that sublime discovery. Be this true or not, it is just as probable that not one circumstance, but several, of the phenomena of nature happening daily around him led his thoughts in that direction which resulted so marvellously. Newton, proceeding from the lesser, took up the consideration of the grander phenomena of nature, and conceived the idea or speculated upon the notion that the very same force, or "something," which caused a stone—or an apple, to keep to the old tradition—to fall to the ground, was that which kept the moon circling continuously in its orbit round "the great globe itself, and all that it contains." It is right to state, and it is somewhat calculated to upset the popular notion of the "apple" tradition, that other scientific men before Newton had speculated on this conception. But they had gone no further than mere conjecture or supposition, however roundly they may have declared that the fact was so, simply because (after the fashion then but too existent, and not quite died out amongst ourselves) *they* had said that it "was so." But Newton belonged to—headed, in fact—quite another class, namely, the race of thinkers who, combining thought with action, have done, or have led to the doing of, all the practical work of modern art and science. Not content with conjecture, using it only as the suggestion of a path which might lead to something practical, he went beyond all his predecessors in hypotheses, and endeavoured to find facts which would prove his conjecture as to the influence, force or cause which compelled the moon to keep whirling round the globe. If his conjecture was right that the "influence" or "something"—to which, the reader will note, no name could then, when Newton began his researches, of necessity be definitely given, as nothing definite was then known of it—which made or compelled a stone to fall to the ground when left free in air was the same something which acted upon the moon, then it followed that a stone held in a sling with its cord or string, or a stone tied to a cord and whirled rapidly round the head, held the same relation to the body of the operator or to the whirling force of the hand and arm, which the moon did to the earth or our globe,—and it followed also as a matter of course that the cord represented the force, and the line of direction in which that force acted, exerted by the earth upon the moon.

THE ROAD MAKER.

His Work in the Laying-out of Roads in Rural, Suburban and Town Districts, their Construction, Repair, and in the Choice and Use of the Various Materials employed.

CHAPTER V.

Roads on Peat Bogs and Soft Yielding Soils.

When proper means are taken, roads of great excellence and uncommon durability may be made over peat bogs. The latter-mentioned property is imparted by the elastic nature of the ground.

The first operation in making a road over a peat bog is to make large open drains, at a considerable distance from and parallel to the intended site of the road on each side. When, by the operation of these drains, the surface has somewhat subsided, from the escape of the water held by the peat soil, other drains should be made along each side of the intended road. The whole of the peat excavated from the drains should be thoroughly dried, as for fuel; and when the surface of the site of the road has become firm to the tread, any hollows should be filled up with dried peat, and the unbroken surface covered to a depth of several inches with dried peat—first with pieces the size of bricks, and then with small pieces the size of hen's eggs—until a form of cross-section, the same as that recommended for the surface of the soil for roads on McAdam's principle of construction, is attained. Our young readers might at first suppose that this use of peat was very much like restoring the surface to its original condition; but in answer to this we draw attention to the fact that a remarkable property of peat is, when it has been thoroughly dried it will never again absorb water, and this renders that earth, on being completely deprived of water, an excellent material for forming the foundation of roads over bogs. When covered with dried peat, the road may be spread with broken stone in every respect in the same manner as recommended when treating of McAdam's system of road-making.

Peculiarity of a Road on a Soft Yielding Soil, as a Peat Bog, compared with a Road over Rock.

Roads made upon peat bogs, in the manner pointed out above, are remarkably pleasant to travel upon, and, without sensible increase of the force of traction in the draught of loads, of all others the most durable, arising from a degree of elasticity possessed by no other description of soil.

It may here be remarked that, whilst a road made upon a peat bog is the most durable, that made upon rock is the least so, and the deficiency of durability is in proportion to the hardness of the rock. This want of durability of roads upon rock is occasioned by the resistance of the hard bed to the material of the covering of the road pressed by the weight of the traffic crushing such material into small particles; so that, however favourable the firmness of a road upon rock may be to a small force of traction upon it, it is the most expensive to maintain in good working condition.

Roads carried over Morasses.

When a road is carried over a morass that cannot be thoroughly drained, the surface soil should on no account be removed, but the surface should be kept entire, and any hollows in it should be filled up with stuff to be obtained elsewhere than from the site of the road. The surface should then be covered, to a depth of several inches, with concrete, composed of six parts, by measure, of gravel, and one part of Portland cement, before the application of the broken-stone covering.

Piling, in some instances, has been resorted to in carrying roads over ground liable to be flooded, and the road in such event raised on a timber platform to a height beyond the reach of the flood. Such an alternative is necessarily very expensive, which nothing short of no other route being attainable, or some other instance of the greatest necessity, can justify.

Footpaths or Sidepaths of Roads and their Fences.

An important department of road construction is that of the foot- or sidepaths; and in close connection with this is that other—scarcely less important—namely, the fences by which the road is bordered, marking it off and making it distinct from the fields, gardens, or other property which bound it on both sides. These two are dependent one upon another, a footpath not being complete unless it is provided with a fence of some kind or another. This fence is in old roads very often the ditch by which both the road itself and the field skirting it is drained. This may seem to be an odd sort of fence, as the results of "tumbling into a ditch" on a dark night would be by most people considered likely to be, if not more awkward in some senses, at least more decidedly and immediately unpleasant, than those from straying into an adjoining field. At the worst one might only lose his way for a while. We shall in due course illustrate the various forms of fences where this particular form of "fence"—so called, we presume, on the principle of *non lucus a lucendo*—that is, being considered a fence for the reason that it is not one in the true sense of the term, forms at least part of the general arrangement. In connection with footpaths and their fences the subject of drains for the road surfaces is very closely connected. Indeed, so intimately are the three subjects, foot- or sidepaths, fences, and drains, concerned one with another, that they might in one sense be very appropriately considered as one subject or great division of road work, the three separately being taken as subdivisions. In whichever way considered, they will at all events form the subject of special paragraphs, to the various points of which we now address ourselves.

Fig. 4 illustrates the form of fence we have alluded to—namely, a ditch, *a*, acting as the drain in old roads

Fig. 4.

to both road and adjacent field—bounded on one side by the footpath, part of which is shown at *b*, and on the other by a mound-wall of soil, *c*, crowned generally by a quickset hedge, as shown, or by small shrubs and trees of various kinds. This form of fence, so called, was so very general at one time that it may be said to have been the only kind in use. But that the notion of protection was more on the side of the proprietor or user of the field than on that of the user of the road, is from the very nature of the arrangement obvious enough. The main object of the mound-wall *c* was to prevent the animals which might be grazing in the field from getting out of it and being lost on the road. And so far as the users of the footpath *b* were concerned, it is also obvious that they might, if they could, keep from falling into the ditch; but that if they fell in, the best thing for them to do was to flounder out of it again, taking the side from which they fell into it. For if they tried the other side, the mound *c* with its topping hedge clearly prevented egress in that direction. Fence to the footpath there was in this arrangement clearly none; and it is curious to note how long this fence but in name was quietly accepted in such a wide area of the country, and is in some districts more or less "remote from cities" still accepted for what it in reality only professes to be, but is not. We shall see as we proceed that more advanced notions have tended gradually to supersede this form of drain-fence—for in reality the ditch was the outlet for the drainage of the field, and for such water as might or could find its way from the footpath *b*, and over it often, in very wet weather, from the surface of the main road beyond it.

Although this form of ditch fence is still to be found bounding the roads in many districts, it is only right to say that these are chiefly "cross" or "accommodation" roads—practically parts in which there is but little traffic. And even here the gradual spread of advanced knowledge in farming, to say nothing of that of road-making, has led, and is daily leading, if not to the actual doing away with the ditch fence even in the most remote of roads, at least to its great improvement. The damage done to both the road surface, and also to a considerable part of that of the field and the crops which it bears, by such high mounds of earth-wall as *c* in fig. 4, is now widely known. These mounds are, or were, often so high of themselves that they shielded the road from the sun and prevented largely the drying effect of winds upon its surface. But this was not the only evil they brought about, for even this was greatly added to by the high mound being as a shield made still higher by the hedge by which it was crowned. But if the road suffered, so also did part of the field and its crops. Nor was the actual loss of land occasioned by this system a point of little or no importance. Such portentous-looking affairs were those mounds of land that, not crowned with a hedge only, or with small shrubs or trees, they were not unfrequently of such huge dimensions that they bore easily aloft on their tops trees by no means to be despised for their height and girth, and for the consequent bulk of their timber. This necessarily implied not only some height, but a wide base—so wide that in an extensive farm the doing away with these huge mounds gave what was in fact no contemptible area of cultivated land.

Where ditches as drain outlets and drainage water-carriers, whether of road or field or both, were retained, as at *a* in fig. 4, in place of the improved forms of drain presently to be described and illustrated, they were so far, and indeed vastly, improved by doing away with the huge wall mound, as at *c* in fig. 4, or at least lowering its height and narrowing its base to such an extent as to form but little more than a broadish base or foundation (*b*, fig. 5), this being often separated from the ditch by the escarpment,

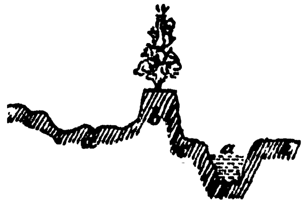


Fig. 5.

c. But still, in this case the footpath *e* was in much the same condition as at *b* in fig. 4, so far as a fence to it was concerned—it being, as before, still open to the ditch. Further improvement—and a decided one, moreover—was however made by inverting the order of the primary arrangement at *a b c*, fig. 4, so that a fence, generally of quickset, as *d d* in same figure, was put between the ditch or drain, *e f*, bounding the field *i* and the footpath *f g*. This decided improvement resulted in giving to the footpath a suitable fence, and it is to be met with very extensively throughout the country in various districts.

THE WORKMAN AS A TECHNICAL STUDENT.

HOW TO STUDY AND WHAT TO STUDY.

CHAPTER VII.

Distinction between the Work purely of the Theorist, and purely of the Practical Man.

THE theoretical man may be compared to him who tells us that there is a district in a wild country which possesses such rare treasures that it is "worth a king's ransom" to get to it; and not only tells where it is, but points out the direction along which the shortest road to reach it lies. But there are difficulties in the way, between the spot upon which the theorist stands and that to which he wishes us to go. The path, or rather the ground over which the path has yet to be made, is rough and rugged, and its soil treacherous. There are hills to be crossed or penetrated, as best we can; valleys to be crossed or bridged over somehow; forests and jungles to be got through; bog, marsh, and quicksand to be traversed. If the impassable road is not made passable, the much desired district can never be reached. But how to make it so the theorist knows not; he knows there are practical difficulties in the way, but he knows little of their nature—the first essential to get rid of them—still less of the methods by which they are to be dealt with, without the aid of which they cannot possibly be got rid of. It is one thing to know of the existence of a treasure, to be absolutely sure that it does exist; but quite another thing to get at it, and when it is reached, to get possession of it. The practical man may be compared to him who, in such a case as we have supposed, steps in to the help of the theoretical one. Following the guidance of the theorist, who points out the direction, the practician lays out the line of the road which both are so desirous to have made, as both wish to reach the district in which the treasure lies, or by the theorist is declared with all solemnity to lie. Bridges span valleys, tunnels bore through mountains, deep cuttings split up hills, rocky ridges are cloven, quicksands and bogs made solid, marshes drained, and the thousand-and-one things done which have to be done before the district can be reached. The impassable way is at last made passable, demanding not only all this work, but the continued exercise of the forethought, the energy, and the skill which the practical engineer alone possesses to the full. At the same time, all this work demands appliances or mechanism in wide variety, all more or less complicated, in all of which the ability in design and the skill in construction of the accomplished machinist is essential.

The Combination of Practice with Theory the Cause of the Marvellous Progress in the Arts and Sciences witnessed of Late Years.

The combination which we here suppose of the theoretical and practical man is but the type of that which has of late years characterised the arts and sciences. It is met with more and more frequently as men become wise and perceive clearly the bond which binds both in the links of a common chain. This combination has done much in the past, and it is destined to do more in the future, if men will but keep its principle in view and persist in giving it life in action. And it will be well if the principle of "give and take," the conjunction of abilities and skill which forms the very backbone of the union now so largely and so happily exemplified by men of theoretical and of practical science, could be extended to the classes of practical men who work in common, but not, unfortunately for our national welfare, in unity of spirit or a community of interests. If to the combination of the theorist and the practician we could add the true union we have indicated of capital and labour—the two confederations of the thinkers and the workers would beyond a doubt add much to the material wealth and prosperity of the country we are all so proud of—a prosperity, we firmly believe, which would be as startling and satisfactory as has been that of the past half-century—a period, moreover, which would to a large extent be free from the chequered features of the past, alternations of bad with good times. Although the periods of depression have been short, and although the loss to the nation arising from them has been but a trifle compared with the larger gains of the period of prosperity, still there is but little doubt in the minds of all who are competent to judge from practical experience in the daily work of the trade, that a large proportion of the losses incurred would have been avoided, had the combination we have above alluded to existed, as it is hoped it will some day exist. The hope cannot be too speedily realised, for on its realisation depends much of the future prosperity of our industrial processes and trades. Prejudices must be admitted to exist, and this is the very first step in progress to be taken,—the prejudices must be met and overcome. And amongst those which many of our working men keep with such tenacity, is one most potent for evil—that theory in science is no good—practice is the only thing to "go." If to what has been already said be added much of what will be given in succeeding chapters, any of this class who may peruse our pages will have abundant reason to be convinced of the error of their belief. The practice of his daily work, which brings him his daily wages, could not be carried on without the theory or the science which he makes so light of, deems so worthless. And the more he studies the subject of our industrial processes—such, for example, as the iron and steel making—the more clearly will he perceive the dependence of the practical upon the scientific men; the very material he uses owes its value in practice to what science has indicated to be necessary to its production in a condition fitted for constructive purposes. This does not lessen the value of the services of the practical worker, however, but rather, on the contrary, increases it, and gives to it a greater dignity, while it enables it to exercise a wider field for its ability than without science labour could have possessed. We have already referred to the increase of practice which science has brought about, the number of new branches of industry which it has created; and nearly all if not every department of manufacture the details of which it is the chief object of this work to explain and illustrate, affords the most striking examples of how science can revolutionise trade, give to it an enormous development, and do more for it in a quarter of a century than centuries of previous work were able to do.

Rapid and True Progress in Technical Work dependent upon the Complete Union between Practice and Science.

Where true progress in any department of technical work is to be made, the union between theory and practice must be perfect and complete. Theory may at times by the practical man be placed in a very subordinate position, if its teachings be not wholly ignored and its claims to consideration thought lightly of, if not denied: so the theorist may at times deny, or affect to deny, the right of practical men to give an opinion upon any point under discussion, or positively assert that they possess not the capability to do so. But this happens comparatively seldom when real work is to be done, and a solid determination is arrived at by both that it shall, if possible, be effective. It only exists in ordinary times of fair and plain-sailing work, when an established practice is being quietly carried on, and no improvement seems likely to be made, or may be desired to be made. Prejudices on both sides exist, and it is only when the necessities of a common interest become clearly apparent that those are set aside and the work required to be done is by both parties carried out with a quiet acquiescence in each other's ability. But it not seldom happens that the prejudices are so strong that progress is greatly retarded—sometimes altogether for the time stopped. As to which of the two, the theorist or practical man, is more influenced by prejudices, some, as may be readily supposed, lean to one side, some to the other. But if the actual facts be taken, not only as gathered from past history, but from the circumstances of daily life, we fear it must be conceded that practical men are most given to the creation and perpetuation of prejudices.

Great or Startling Innovations leading to Great Improvements in any branch of Technical Work frequently made by those in no way practically connected with the Special Branch.—Lesson to be learned from this Singular Fact.

It is a singular fact, which has puzzled many to account for, that any great or startling innovation in the established practice of any particular branch of industrial work — which innovation as it is worked out effects a large saving in established systems of work, or possibly brings about a wholly new system —is very frequently made by some one not actually concerned in the business. But the reason for this seemingly anomalous condition of matters is not far to seek. And it lies in the distinction between the practical man, whose business it is to follow up the work of the particular branch of industry in question, and the theorist who has nothing more than a scientific interest in it—circumstances of one kind or another, and which often very curiously present themselves, causing him to give close attention to its details. In the one case the practical man may have no inducement to make a change in his system of working. He may be perfectly well satisfied with its results. He knows in the most satisfactory of all ways that it "pays," by the fact that he is accumulating money every year. He may or may not admit the correctness of the views of the theorist—nay, may positively agree with them. But he naturally concludes, even granting their accuracy, that a doubt may reasonably enough be held that however correct the theory, it may not work out in practice. And seeing that before the theory can be tested he may have to erect an entirely new plant, new buildings, new machinery, as a practical man he thinks twice before he runs the risk of this, and what is in other ways attendant upon the adoption of a new system. And that there is a risk in all new things the most of business men readily enough decide. But there is also the other side: the practical man may wholly disbelieve in the new views of the innovating theorist. It is not possible for a man of any observation to carry on a business or a process practically without watching its progress and noting results; and the consequence is that he forms opinions and draws certain definite conclusions. These may be entirely erroneous; still he believes in them, and can bring forward from his own experience a great array of facts, or what he deems to be such, in support of them. And what a man has been for a long time in the habit of doing, and of finding the pecuniary results to be on the whole satisfactory, more especially if others his predecessors have carried on the same for perhaps a longer period, one need not be surprised at learning that he firmly believes no improvement can be made upon, at least in the direction to which the new theory points. The theorist may assure him that, profitable as the old system is, the new one will be more profitable still; but established practice is naturally conservative, and such wise saws as "let well alone" and the like come up to fortify him in the belief that with all its faults—if he will admit that it has some—he is safer and surer with what he already possesses.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER VII.

WHEN the blowing-room department has performed its share of preparation of cotton, which is an important one, the position of the cotton is such that it is easy to be removed, *i.e.*, without sustaining any disarrangement in its transit from the lap machine into the next room adjoining the blowing room. We must inform our readers that in this case the blowing room is always conveniently situated with respect to that room which requires the cotton next after it. Cotton mills are remarkable for such a system of arrangement that neither time is lost nor extra labour required. Cotton while in its loose condition (*i.e.*, while free from twist) is easily disturbed or entangled, and such entanglement leads to what is most objectionable in every kind of work—namely, "waste." Not but that the entangled cotton could be re-worked; but we must, like all other business men, use all lawful means to prevent losses. In working up cotton a second time, let us keep in mind that such cannot be done without additional power from the engine, and also additional wages. The two additional expenses do not alone constitute the evil done. Another very important consideration for the mill owner to take into calculation is that if cotton be twice operated upon by one class of machinery it is more detrimental to its proper condition than would be possible for an inexperienced individual to conceive. Experience only convinces the mill-worker of the fact. It is necessary to allude to this matter of working the material a second time, for the cotton in every machine in the preparation room would betray it. It at all events shows itself in one particular way—that of more waste being made in each operation, by more breakages of the slivers, more liability to lick, *i.e.*, *to* catch, the rollers, and thus the sliver, in whatever condition, is sure to break down. It gives a softness to the cotton, which, as we have said, is a cause of breakage, and extra waste is sure to be made. In a cotton mill, as we have said before, every possible means should be adopted for convenience, so that each machine shall be so arranged as to take up in rotation the material as it leaves the machine preceding; and this principle is carried on throughout all the mill processes.

The Card or Carding Room—The Carding Engine.

Having in preceding chapter taken up the work of the "blowing room," and drawn attention to the points connected with its economical management, we proceed now to that of the "card," or "carding room," in which the next process through which the cotton passes is carried on, by the aid of what is called the "carding engine," or very generally the "carder," or even simply the "card."

In former times the carding machines required a considerable portion of the room which was allotted for them and the preparatory frames before anything could be transferred to the spinning room. Though the cotton as it leaves the lap machine is in a form different to that which it was in as it left the bale, still it is in such a condition that it would appear impossible, to those unacquainted with the processes which it has to undergo, to use it for the later operations. It is, however, in such a condition as to be convenient for carding purposes. We now proceed to give an account of the carding engine. The carding engine has undergone so many changes within the last thirty years, that even experienced men doubt whether any very extensive changes from the present condition of it can be made. We are not sure, neither would any man venture to say, that its present state means perfection. Without referring to any changes from time to time as to the improvements in carding engines, we shall satisfy ourselves by describing them as they are, and with one or two of the important alterations which have been introduced, and which have, in some degree, made them "automatic." The principle of labour-saving has been one valuable auxiliary to the workman in ways too numerous to be mentioned; however, we will refer at the present by saying that certain means have been adopted by which the most objectionable part of labour has been dispensed with. The most unhealthy portion is performed by machinery, and in a most satisfactory manner. We believe that it would be a task too difficult to accomplish, to get workmen now to perform such employment as that of grinding the cards,—indeed, we should be sorry to see the system of hand grinding renewed,—and in addition to the grinding by hand of the cards, there is also a class of cards where another unpleasant piece of labour is practically dispensed with.

Before describing the carding engine and its construction and manner of working, we will draw the attention of our readers to a fact which might somewhat startle them. We have described the opening machine and the scutcher, also the lap machine, as all being intended to free the cotton from (comparatively speaking) all superfluous matter. They do certainly perform that part of opening and freeing the fibres of cotton from the heaviest part of material which the cotton contains, and so far it is dispensed with; but experience proves that there still remains a considerable portion of waste matter, which cannot be utilised for finished yarn, and which has to be separated from the good usable cotton, and so far freed from it in the process of carding. When we fully describe the train of operations which the cotton has to undergo while being acted upon in the carding engine, it will at once be apparent to the reader how so much more useless material can be arrested, not only in sand and dust, but in useless fibres. If an inexperienced man could examine the cotton as it leaves the blowing machinery, he would be ready to hazard an opinion as to the impossibility of the further necessity for any cleaning operation whatever to follow. The carding engine is no more intended than the scutcher for cleaning only, but for that of advancing the condition of the cotton for further treatment. There is more waste or inferior material disposed of in the carding than in the former processes of opening and scutching. We may say that more than one-third of the loss in the production of yarn made is from the carding.

when the drum revolves. Opposite to the band *a* there is a small drum or roller B, likewise spirally covered with carding-cloth, and called a "doffer." The carding-cloth is put on the two drums in the same direction; consequently where they nearly touch the teeth must be in opposite directions. As the two drums revolve in opposite directions (as shown by the arrows), the same working against one another would take place as between the drum and its case, were it not that the doffer revolves much slower than the drum (about 16-32 revolutions of doffer to one of the drum), and therefore may, in regard to the latter, be considered to be almost at rest. In *m* and *n* (fig. 4) are shown on a large scale two such pieces of carding-cloth with their teeth in opposite directions, as were mentioned above, and in *o* is shown one of the double teeth as like those set in leather to form the carding-cloth.

The cotton is led slowly but continuously by the grooved rollers *c* to the drum, and between the

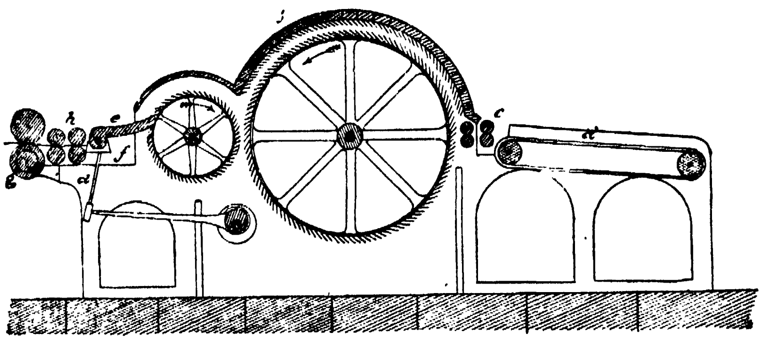


Fig. 3.

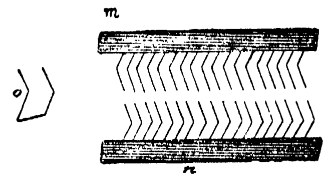


Fig. 4.

Illustration and General Description of the Carding Engine or "Card."

Carding has been called the mother of spinning, because the quality of the rovings depends essentially on it. Because, besides cleaning and opening, the principal object in carding is to make the fibres as parallel as possible, the operation is gone through twice, in two machines differing but slightly from one another. These machines are called "breaker carding engine" and "finisher carding engine."

In the breaker carding engine, which is represented in fig. 3 in vertical longitudinal section, the cotton from the endless band of the first scutching machine, or the "lap" from the second, is led by a double pair of grooved rollers *c* to the carding-drum or drum A. This drum is somewhat over a yard in diameter and in length, makes 90 to 120 revolutions per minute, and its circumference is covered with carding cloth. The upper part of the drum is covered by a concentric case, *b b*, consisting of small lids, and also lined with carding cloth, but the teeth of which are in an opposite direction to those of the drum. The teeth of both parts are close to one another, but do not touch

teeth of the latter and those of the case is drawn out and deposited on the doffer, whence it is conveyed to a comb, which vibrates rapidly up and down, attached to the bent lever *d e*, and is drawn out as a thin spongy band, called a "web" or fleece, and is either wound round a drum, or else led away by a trumpet-mouthed point. The machine represented in the figure has the latter arrangement. It consists of a flat hopper made of tin or brass, through which the cotton in sheets of about a yard wide is pressed into a narrow band, and is taken off by the rollers *g*, between which and the hopper a double pair of rollers, *h*, are placed. The band or ribbon of corded cotton is technically called a "sliver."

The Drawing of Cotton Fibres.

Though the drawing out or stretching of the "slivers" is not in practice combined with the breaker carding engine, we nevertheless give a short explanation of the process here. If a band of cotton is passed between two revolving rollers, it comes out with the same velocity that it entered.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER X.

THE glass paper referred to at the end of last chapter is also admirably adapted for putting the finest points to drawing pencils, and is much more effective than the fine-cut file often used.

Drawing Instruments (*continued*). The Drawing Pen and Methods of adjusting and using it.

In an early part of our present series of papers, when considering some of the points connected with the appliances of the architectural and mechanical draughtsman, we offered a few remarks on the "pencil," and the best way of using it, and also of preparing it for use. We now do the same office in connection with its companion instrument, the "drawing pen," one of the most important of the "set" of instruments with which the draughtsman has to deal. For, however carefully a drawing be "pencilled in," should the "inking in" of the lines thus drawn be carelessly or badly done, the finished drawing will be sure to be unsatisfactory, and have no real claim to be considered as truly "finished." It is unnecessary to describe in detail the "drawing pen," as its construction is so familiar to even the tyro in drawing: its leading feature is the two steel blades placed parallel to one another, and brought near to each other by means of a small set-screw. These are so joined to the handle that they form a species of spring, so that when the set-screw is reversed the two blades separate by springing outwards. The ends or lower edge of each blade is brought to a fine sharp cutting edge; and it is the two edges which, when brought close together, constitute the drawing or inking-in part of the instrument. The ink is supplied to the open space between the blades immediately above the drawing edges. It is upon the condition of the edges or ends of the blades that the utility of the pen in giving clearly defined and sharp lines of varying breadth depends. This condition exists in two points: first, the degree of sharpness of the two edges or ends of the blades; and, second, in the length of the blades. If the drawing edges be not of the proper degree of sharpness, the line drawn will be rough or jagged throughout its length. And if the length of each blade be not precisely and accurately the same, so that the two edges be exactly coincident—that is, meet at the same point—the pen will not draw a line at all; or one still more irregular in character than that produced by rough or improperly sharpened edges. Those two points or conditions, therefore, are essential to the perfect working of the drawing pen. And of the two, the second, or accurate adjustment of the length of the blades, is the more important. What is required, then, is that both blades of the pen be of precisely the same length, and the points as nearly as possible precisely of the same thickness on the face or of equal fineness on the edge. To attain this is a matter of much difficulty with some draughtsmen; with others the "sharpening" or "setting" of a pen is a matter of ease. It certainly requires the best of eyesight to be able to say with certainty that both blades are precisely coincident at the points, or, if not, which of the two it is that is wrong. Sometimes the merest touch or "skiff" of the points on the set stone will be all that is required to make a pen work well. The best stone for bringing drawing pens to good working order is that known as "Arkansas," as it is clear and smooth in surface—colour white or greyish white. It sharpens steel very quickly. Its surface should be washed and wiped clean till the white colour of the stone appears; the black matter which collects on the surface in course of use materially injures the sharp bite of the stone. If Arkansas stone cannot be got, a "Turkey" stone may be used. The prevailing colour of a good stone of this class is a cream or yellow; the surface is much smoother than that of Arkansas stone. After sharpening each blade upon a stone, so as to have perfect evenness of edge in both, a touch or two on the surface of a razor strop will give a finish to the edges and make them work more smoothly. We have been thus particular about the sharpening of the drawing pen, as much not only of the look of the drawing, but of the comfort of the draughtsman in finishing it in ink, depends upon the condition of this important instrument. When a drawing pen becomes foul through the accumulation of the thickened portions of the ink, which in time hardens or sets between the blades, there is no better mode of cleaning it than by passing a piece of thickened paper between the blades, and while pressing them together by the fingers withdrawing it, finishing the process by the not very cleanly, but certainly the most efficient way, of sucking the pen points in the mouth. For drawing curved lines not struck or described by the compasses, a "crow quill" is used: this if properly pointed draws a very fine line. What are known as lithographic or mapping pens of steel have now, however, superseded crow quills. When lithographic or mapping steel pens get out of order, a few touches of the points—while the pen is lying upon the finger—upon the Arkansas stone will often restore their efficiency. A very good substitute for these finely pointed pens will be found in an ordinary steel pen, the points of which are reduced to the necessary fineness and elasticity by rubbing them on the stone.

Points connected with the Employment of Ink, in Inking-in or Making Permanent Pencilled Drawings.

Much of the efficient working of drawing pens is dependent upon the condition in which the ink is. This, as most of our readers will know, is not ordinary writing ink, which is totally unfitted for use with the drawing pen, although we have known some rough-and-ready draughtsmen use it—with a result, however, as rough in its effects. The ink used by architectural and engineering draughtsmen is that known as "Indian," although it is, and was in times gone by almost universally, designated as "China" ink, and this from the fact that the Chinese use it in all their writing—which is, however, done with a brush in place of a pen as used by us in writing. There have been many imitations of these two solid or cake inks, but they still maintain the supremacy, although the largest number of cakes are not brought from either India or China. The Indian ink is in the form of a cake or stick, and this, like an ordinary cake of colour, has to be "rubbed down" with water in a small dish or colour plate. Some draughtsmen are in the habit of rubbing down or making a pretty large volume or bulk of the ink at a time. But this is as wasteful a method as it is productive of inefficiency in practice. For the ink if kept long in use gets filled with dust and those minute hair-like substances ever floating in the air, and which, however carefully the liquid ink is kept covered up when not in actual use, are sure to get in. And when once in, how far they are calculated to promote the drawing of a clean sharp line of absolutely equal breadth and fineness throughout, our readers may form some conception of. Ink, then, in quantity which will be deemed only sufficient to complete the drawing should be rubbed down or made at a time; and the dish containing it should even then be covered up when not being actually used, to prevent the dust from getting access to the liquid. It is scarcely necessary to say that while thus counselling the draughtsman to rub down or make a fresh supply of ink for each separate piece of complete work, or at intervals during the progress of an elaborate drawing, which absorbs much time in its preparation and finish, it is essential that each fresh rubbing down or make be done with a *clean* dish, well and carefully cleansed in pure soft water, and rubbed with a cloth free from all greasiness, grease or oil being obviously antagonistic to a good, easy-flowing ink. If the practice of some draughtsmen be adopted, of making or rubbing down a succession of small supplies of ink for each day or piece of work, but in the same dish day after day, the advantages of a truly fresh supply will not be obtained. For with the dried-up ink will be dried up also the dust and minute hair-like substances before referred to, which will simply be added to the new liquid, and thus deteriorate its quality for drawing purposes. Each new or fresh supply of ink, then, should be made in a clean vessel or colour dish or saucer.

A good deal, not only of the look or finish of the drawing, but also of the ease with which lines can be drawn, depends upon the thickness of the ink. If too thin the lines are apt to have a brown, faded look, although the colour will also be dependent upon the quality of the ink, the best ink giving always a black shade, however light that shade may be. But the lines of a drawing, however fine they are, should be quite black; and this with the ordinary qualities of Indian ink can only be perfectly secured by rubbing it down till a certain degree of thickness of the liquid is obtained. But if this be too thick, it will not flow easily from the pen. The happy medium between too thick and too thin can only be hit upon after the draughtsman has had some practice. Badly flowing ink, however, arises much more frequently from dust and dirt being allowed to be present in it, than from its precise degree of thickness. And let it be remembered that, however well the ink may be made, good lines will not be obtained unless the pen be in good order.

Principle of Projection, as applicable to the Production of what are called Plans, Elevations, and Sections.

In accordance with the arrangement of the subject with which we have to concern ourselves in this series of papers, as already named in a preceding paragraph, we now address ourselves to the important department of plane projection, involving the points connected with the different kinds of drawings known as "plans," "elevations" and "sections"—and, what may be here included—detailed drawings, more generally and simply described as "details."

The mere delineation or the drawing-in of the lines of an object having surface only—that is, having merely length and breadth—is a matter of comparative ease, although under this department there are problems of considerable difficulty, as we shall see as we proceed. For length and breadth being the only features of the object, no matter how varied may be the nature of the boundary lines, its dimensions can at once be ascertained from one drawing. But with an object having the three dimensions which all solid bodies possess—namely, length, breadth, and thickness—these dimensions cannot be ascertained from one drawing only, for the different sides of the solid may have different forms and dimensions. By certain methods of delineation no doubt this is attempted, as has been generally stated in the final remarks in a preceding chapter, but the objections to these will be stated further on. These objections are such that in a practical sense they are not available for working drawings. Another system is therefore adopted, that being technically known as "orthographic projection," or more simply as "plane projection." Projection has for its object the delineation upon a flat surface, as a sheet of paper, of the different views of a solid body, and in such a way that the dimensions may be easily taken or read off from them by means of the ordinary scale of equal parts in use amongst us—namely, that of feet and inches. The different views have different names; and what these are, and how obtained, we now proceed to show. The surface of the sheet of paper on which the drawing is generally to be made is known as the "plane of projection"; and the different points of the drawing are, so to say, thrown or "projected" upon this plane by the visual rays proceeding, so to express it, from them; and those points being united by lines, give one graphic illustration of the various parts required.

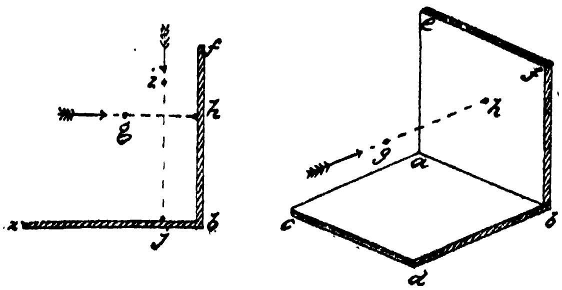


Fig. 16.

Principles of Orthographic or Plane Projection.—The Planes of Projection or Delineation.—Projection of Straight or Right Lines.

Strictly, however, according to the principles of orthographic or plane projection, there are two planes of projection. These are at right angles to each other, so that the one is horizontal and the other vertical, the line at which these intersect each other being called the "ground line." On the horizontal plane, plans are projected, and on the vertical, elevations. Thus, in fig. 16 the horizontal plane of projection is *a b c d*, the vertical is *a e f b*, *a b* being the ground line of the "projection" or drawing.

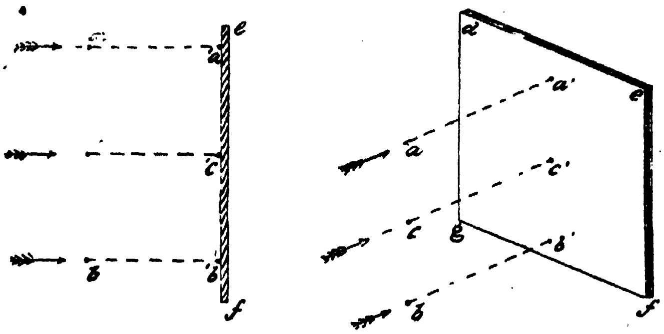


Fig. 17.

Let us suppose the spectator to be looking at the vertical plane of projection *a e f b*, in the direction of the arrow *g*, and that a point is supposed to be at *g*, as shown by the "dot"; and further, that it is sent forward or projected, so to say, by the eye or visual ray, till it strikes the plane of projection *a e f b* at the point *h*: that point is the "projection" of the point *g* in the vertical plane of projection *a e f b*. Suppose again the spectator is looking down upon the horizontal plane of projection *a b c d* in the direction of the arrow *i*, and that the point or dot is projected downwards till it strikes or cuts the face of the horizontal plane *a b c d* in the point *j*; then the point *j* is a projection of the point *i* in the horizontal plane *a b c d*. The lines *g h i j* may be called "visual rays," which proceed from the eye, looking at the points *g* and *i* in directions at right angles to the vertical and horizontal planes of projection *a e f b*, *a b c d* respectively. As a right or straight line is made up of a series of points (see the definition of mathematical terms, "a point" and "a line," in the series of papers entitled "The Geometrical Draughtsman"), by projecting the two points which terminate a line, and joining the projection of these points by a line, the projection of that line will be obtained, as in fig. 17. In this, where the points *a* and *b* are projected in the direction of the arrows, to the vertical plane of projection *d e f g* at the points *a′* and *b′*, by joining those points, the projection of the line of which *a* and *b* are the terminating points is obtained in the vertical plane *d e f g*. A third point in the line is at *c*; but the two points *a* and *b* are alone required to give the line which mathematically considered is made up of an infinite series of points placed, so to say, side by side from *a* to *b*. A line can in like manner be projected upon the horizontal plane, as shown at *a b c d* in fig. 18, the points *e′ f′* being the projection of the points *e* and *f* in the direction of the arrows as shown in the diagram. A superficies is a plane surface having length and breadth only, and is always bounded by or comprised within lines straight or curved, as the case may be.

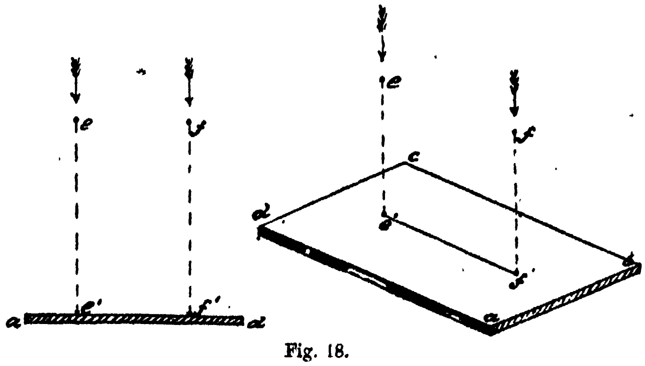


Fig. 18.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER XIV.

In Plates XXXIII., XXXIV., and Plates LI., LXXIII., LXXIV., we give various "studies" or subjects, for the student to copy. Plate LI. is the block of subject in Plate XII. Before concluding the present division of our subject we deem it necessary to state that all the subjects we have given should, without any exception, be drawn to a larger scale or size than given. For example, subjects occupying the space of one of our pages, or thereabouts, or as given in the various Plates under one heading, should be copied to a scale twice, at least, or two-and-a-half times as large.

We insist upon this practice of drawing subjects to a large scale, as essential to the correct progress of the ornamental draughtsman. It will be time enough for him to execute those "pretty little sketches," which some pupils are so fond of producing, when he is master of his art. What he has while but a pupil to concern himself with, is to gain freedom of execution and accuracy in "lining," as well as a capability to estimate distances and lengths with facility and correctness. And this dual ability, the deftness of the hand to put down what the educated precision of the eye dictates, is what constitutes a true ornamental draughtsman. And those capacities or capabilities will best—can only, we maintain—be secured, by drawing in his first or pupil practice on the large scale. When a line or curve is extended over a greater space, inaccuracies can be most readily detected, while the very space gives a freedom from manual exertion which is utterly denied by the niggling necessities of those *petite* sketches some so delight in. Had space been granted us, we should have given our examples to a larger scale; as it is, they occupy more space than is usually given to them in published papers of a character like the present. But we maintain that the space taken up by them, such as it is, is well bestowed; and it is in the interests of our readers that we have given it upon principle. In concluding this section of our papers the student will take note that each example has been selected, and every line in each drawing is done with a purpose and has been drawn with a specific object in view. The examples given embody points to be studiously and carefully followed, as well as those which are to be avoided. The student will find valuable practice in detecting the points which are wrong and correcting them in his own copies.

Before taking up the important department of our studies comprising lessons in shading of drawings, we would again impress upon the student the importance of attending to what we have more than once alluded to in preceding paragraphs—namely, the doing of his work thoroughly. If he has the conviction that in any one of the lessons we have up till now given, he has not done this, we would earnestly counsel him to be honest with himself in the matter, to bring himself to the bar of his own conscience and sternly deal out judgment upon himself. He will thank us for giving him this counsel if only he fairly carries it out. He will be not only all the better draughtsman for the doing of it, but very much the better as a man. The matter is not, indeed, lightly to be treated from any point of view. This vitally important principle of doing work of any kind lies at the root of success in it. And so far as regards the ornamental draughtsman it should not be lost sight of in the doing of his work. The principle is expressible in the well-known motto of an old and noble house—"thorough"—amplified in the text of Scripture, which, by the way, odd as the remark may here seem to some, is full of grand and noble lessons applicable to art, "Whatever thy hand designeth to do, do it with all thy might." Nature is always, as we have said, thorough. "Fool!" says a writer, somewhat warmly—and in truth it is not easy for one always to be cool in view of inept, conceited vanity—"fool! thou thinkest thou seest but a dull clod of the valley! well, down on thy knees, examine it closely, and if thy dull eyes can but see, and thy duller brain can understand what they see, thou wilt rise mayhap with clay-coloured pants which may vex thy soul, still with some, if only a faint conception of a truth other than that thou first thoughtest of. Thou wilt indeed be very dull if thou then thinkest it still a dull clod, if thou hast not seen in it a beauty, yea, a grand beauty, which may perhaps bring to thy mind some vision from memory of some Alp region thou mayest at one time have visited, wild and yet lovely place, with its gentian-coloured slopes, its glades and rich valley, green-grassed and flower-bespangled—for colour there is, and that of the richest, in the clod-of-clay region of hill and dale, of stream, mountain, and shaggy peak—for form, grand and majestic, yet in many of its aspects wonderfully minute, is there: deep, dark gorges, sun-dazzled slopes—for light and shade are there. And all, and more than all this, lies on the surface of that clay clod thou didst call dull. It may be that in thy brain-pan may come the thought that the dulness did not lie in the clod, but in thyself." All this, no doubt, is the exaggeration of warmth, but it is the expression of a great truth notwithstanding; and till the student fully grasps it, and determines to make its principles his own, he can scarcely hope to take rank with the true artists. They are ever laborious, hard-working men, ever studying the great book of nature, ever striving to learn what lessons it teaches, and to accept them in their practice.

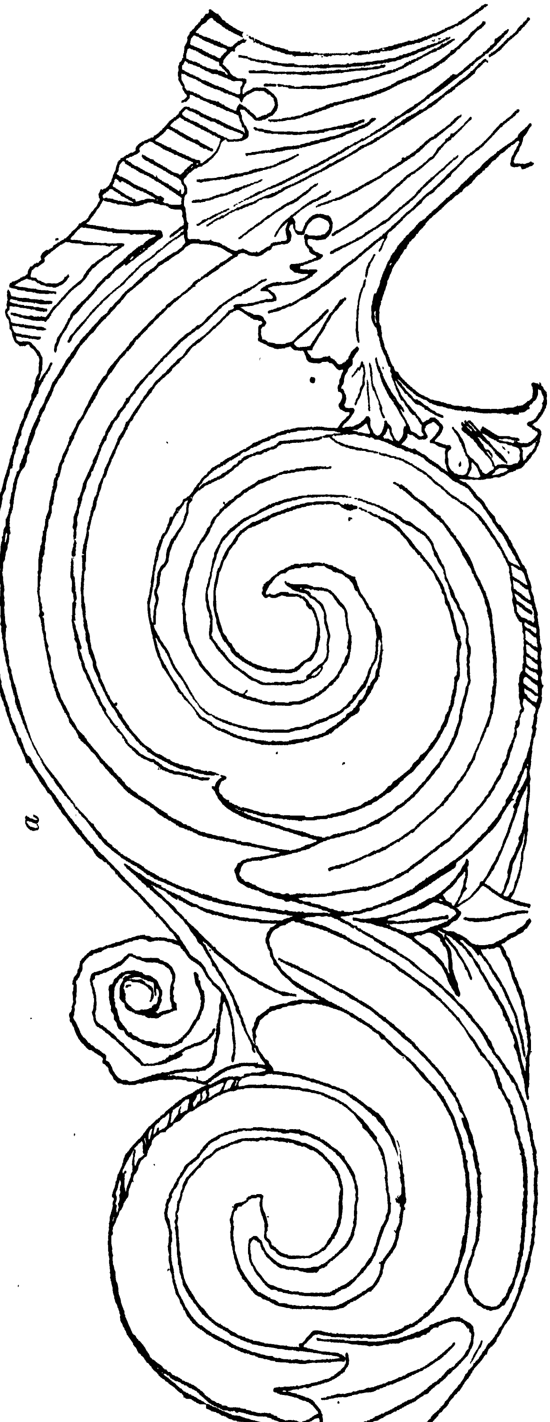


Fig. 56.

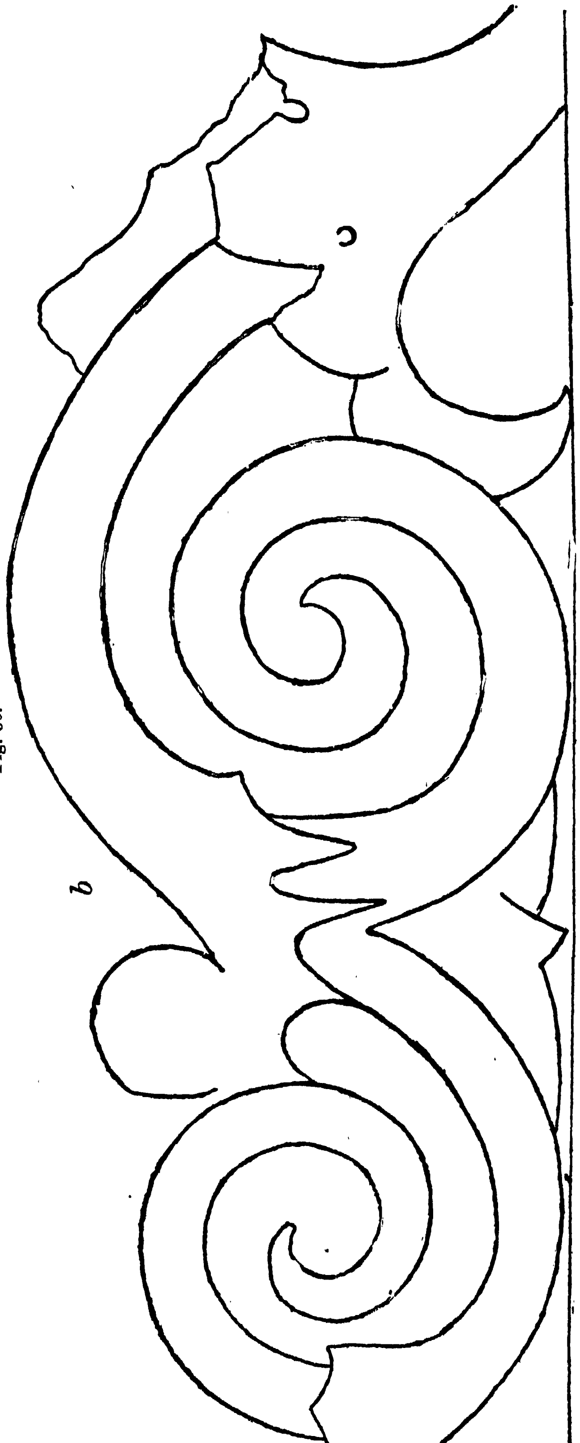


Fig. 57.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER VI.

THE Staffordshire blue brick referred to at end of preceding chapter is also shown in its absorbing power; this being in percentage as low as 0·33, or hardly perceptible: so that it may be taken as an absolutely perfect wet-resisting brick. A Dutch brick showed a greatest strength of 4000 lb., least, 3016, mean, 3580.

The Practice of Bricksetting or Bricklaying in the Formation of Walls. Different Forms of Bricks used in Construction.

We have in the preceding paragraphs more or less completely gone into the consideration of sundry points of importance connected with brick as a building material, and its characteristics as regards strength, durability, and capability to resist moisture or damp. We now proceed to take up the points connected with the setting of bricks; in other words, the practical construction of the various classes of brick-building.

We have already remarked that since the duty has been taken off bricks a great improvement has been made, not merely, as in some instances, in their manufacture, but in the introduction of new forms adapted to meet the requirements of different classes of work. Under the old system, when "duty" was paid, there was no deviation allowed from the form and the dimensions named in the Act. And although every practical man saw the advantage which would accrue from certain alterations in them, the clauses of the Act were so clearly worded, and they were so rigidly enforced by severe penalties in the case of their being infringed, that few attempts were made to introduce improved forms into practice. Now a very different state of matters exists, the result of the freedom which the trade now has to make bricks of any size or form. We have thus so wide a variety to choose from that for nearly every kind of work there is a peculiar form at hand to meet its requirements. We have hollow bricks of all kinds, segmental bricks for the building of circular work, bricks for quoins for coping, string courses, etc., etc.

The size was, or rather the dimensions of the brick under the Duty Act were, as follows: length, 9 in., breadth, 4½ in., thickness, 2¾ in. These dimensions, with slight variations, either over or under, are still those of the bricks generally used for ordinary work, the habit of making bricks of such dimensions having taken such a hold, both of brick-makers and bricklayers, through the operation of the Duty Act of Parliament, that it has been very difficult to break through it—so much so that even where larger or smaller dimensions would be more convenient for the various requirements of practice, it is found very difficult to get the workman to use them. This, however, is being overcome more and more every day. A great improvement in this ordinary-sized brick has been largely adopted, and this is the placing on the face *a b c d*, or bed of the brick, a recessed or hollow part, as *m m*, fig. 6, Plate XIII., shown in longitudinal section at *n n*, *o* being the solid part, the brick being here recessed on both faces; the cross section is at *p p*, *q* being the solid part. This admits of the mortar passing into the recessed parts, and thus forming a "key," which gives the bricks a better hold of each other, and thus adds to the strength of the wall built of them. Bricks are also made hollow—that is, having through their length, breadth, or thickness, apertures, either rectangular, circular, or elliptical, as illustrated in same figure, in which, at *x*, a circular hole passes from one end of the brick to another in the direction of its length, as shown at *z*, 1, 1—2, rectangular holes, as *e*, are made. In other cases the holes pass from side to side of the breadth of the brick, these being rectangular, as in in the end section at *z*, or at *r*. In other forms the hollows go through the thickness of the brick, and are of various shapes, as circular or rectangular, as at *p r q* in fig. 7, Plate XIII.

In fig. 6, Plate XIII., is shown the longitudinal section of the hollow brick, *x*, with one hole passing through its length; the dotted line at *v v* shows its position in face of brick. The recessed bricks, as at *m m*, may have a hollow or void place, as at *m m* 3, 4. There are other methods of giving a key to the mortar, as at *r r*, which shows two angular depressions made in the face of the brick in parallel lines, *s* being the longitudinal and *t t u* the cross section.

In some cases the holes or apertures are oval or elliptical. These hollow bricks are exceedingly useful in adding to the dryness of the walls in which they are used. They are, of course, also much lighter than a solid brick, and as strong; this more especially when the holes or apertures are circular, which gives the strongest, the weakest being the elliptical. These hollow bricks are also very often adopted, and with great advantage, for the formation of what are called "damp-proof courses,"—that is, the course laid just a little above the ground level, the object or aim of which is to prevent the damp from rising upwards to the upper courses from the damp soil. A form of brick especially adapted for this purpose is that known as "Taylor's." This is illustrated in fig. 4, Plate X., at *j j* in cross section; the recessed parts at the sides give a good bond or tie between the hollow bricks, as they stretch across the face of foundation courses. Hollow bricks have also been introduced for the formation of partitions; the diagram in *i i*, fig. 4, Plate X., illustrates the form designed by

Roberts; *k l* that by Halstead, and *n o o* by a Scottish maker. These give all good lateral and cross bond, and, being hollow, are light and dry. Other forms of hollow bricks, as at *a b c*, *d e f g* and *h*, have been designed by Roberts to fall in with a systematic method of securing hollows or cavities throughout the whole of the work. The advantages of these, and of others we have illustrated, will be seen more completely after the subject of bond has been fully gone into. Some forms of bricks have been introduced which, being solid when laid together, give cavities as in the illustration *p p*, *q q*, *r*, *s*, fig. 4, Plate X.; *t t*, *u u*, and *v v* illustrate Morris's bricks for building chimney shafts, with cavities for ventilation, etc., and *w x* Bunnett's hollow brick fire-proof system.

Bricks of these hollow forms, illustrated at *j j*, fig. 4, Plate X., or by others, are much better for the formation of damp-proof courses than the plans so long and still so frequently used where a layer of slate or tar or lead is placed round the whole wall a little above the ground level. Another advantage these forms give is that they act as ventilating bricks, allowing the air to pass under the joists, thus preventing the rise of dry rot in these. These hollow bricks, used for this purpose, are placed at certain intervals along the wall just below the line of joisting; but in the case of Taylor's system there is a whole line of hollow bricks round the building, thus securing ventilation of a thorough kind through the under part at *every* point.

Another form, or modification of the old form, of brick is what is called a "bull-nosed" brick. This is one in which the corner or both corners are rounded off, as shown at *s t*, fig. 7, Plate XIII.; if at one corner only, as at *s*, they are used for the formation of the door-openings of a house, getting rid of the sharp angles which, in the case for example of stables or cow-houses in farm buildings, are apt to inflict injury on animals coming quickly or strongly against them. If rounded at both corners, *t t*, they are useful for pillars supporting slop stones in sculleries, etc., or stone shelves, the rounded corners being placed to the outside. In this form they are useful for coping of walls, or for drips. For other purposes angular or "splayed" bricks, as at *f e*, *l i*, may be used; *f e* is a brick with one angle or corner cut off. Splayed bricks are used in foundation courses a little above the ground level, as at *m*, in which *n* is the line of outside of face of wall. Bricks for coping are made semicircular, as at *t*.

The first three diagrams in fig. 6, Plate XIII., illustrate the three views and dimensions of a standard size or ordinary brick, *a b c d*: the full length, $a\,b = 9$ in., breadth, $b\,d = 4\frac{1}{2}$ in., *e f g h*, side view, giving depth or thickness, $e\,f = 3$ in., *i j k l*, and view in cross section giving breadth, *i j*, equal to *a b*, of $4\frac{1}{2}$ in.

Technical Terms used in Bricklaying—"Brick on Bed," etc.

Bricks when set on the flat, or when lying on their broadest surface, are technically said to be "bricks on bed," as at *a b* and *e* in fig. 1, *a* being the side view, *b* the plan or upper surface view, *c* the end view, and *d a d d* elevation of several bricks, *e e* being end view of this. When the bricks are set so as to stand on their edge, they are technically called "bricks on edge," as at *g g* in fig. 1, which is end elevation of several bricks on edge, *h* plan of top of ditto, looking down on *g g* in the direction of the arrow 3; *i i* showing front view of *g g* looking out in the direction of arrow 1 or 2. In the same figure *a d*, *d* is side or front view of bricks "on bed," looking at it (*e e*) in the direction of arrow 1 or 2; *f* plan of *e e*, looking down upon *e* in direction of arrow 3.

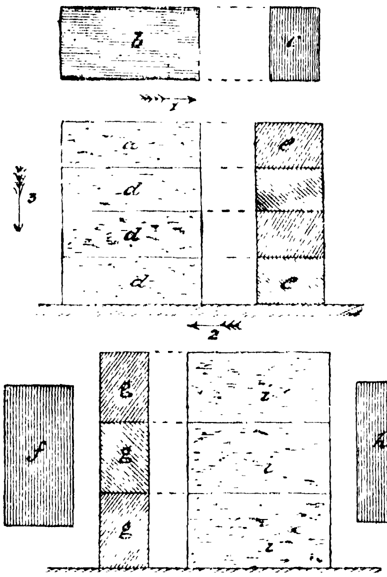


Fig. 1.

The Position or Placing of Bricks in a Wall.—Their Binding together.—"Bond" in Bricklaying.

The setting or placing of bricks in relation to one another, in using a number of them for the erection of a wall, for example, constitutes a very important branch of the constructive arts, and is known as "brick-setting" or "brick-laying." A wall built of bricks, being made up of a series of blocks of regular and unvarying size, must obviously be so constructed that they will not be merely a loose collection—the only tie, so to say, between them, and keeping them together, being the strength or cohesive power of the mortar used to connect them together into a mass; but they must also be so placed that each will in some measure, and this to the maximum extent, give to its neighbour a species of support, and also a connexion.

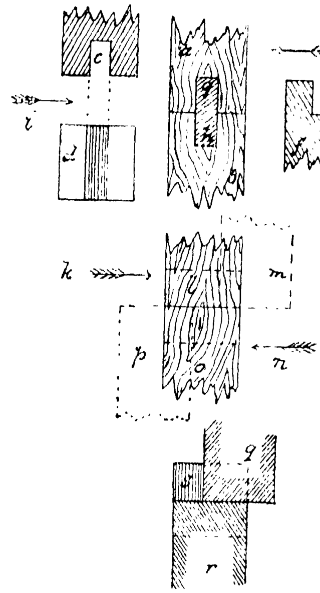
THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Progress—The Principles and Details of its Practice.

CHAPTER VIII.

Illustration of the Foregoing Principles of this Class of Vertical Joints.

In fig. 33 the simplest form of joint of the class now under consideration is illustrated. In this the end of each piece, that of *a* and *b*, are provided with grooves, as at *c*, shown in the section of the lowest of the pieces at *f f*, and at *e* at the upper; these grooves are ploughed or cut out across the face of end and from side to side, as shown at *l*; and when the two pieces are placed with their end surfaces in contact, a groove or rather slotted opening is thus formed of such depth that a flat wedge or "key" of wood or of



iron can be inserted, as at *g h*, the depth of which is twice that of the groove made at the end of each piece, as at *c* or *e*. When so placed and secured together it will be obvious that the lower piece, as *b*, may be so securely fixed at its foundation, or at its lower part, that it can resist any tendency it has, or which may be put upon it by pressure, to swerve from the plumb line. The "key" *g h* prevents any pressure acting in the direction of the arrow *i* or *j* from affecting the upper pieces and the joint remaining good. But this is because the pressure is acting against the flat or broadest surface of the "key" *g h*. But if the pressure acted upon the other side of the piece, as in the direction of the end of the key, as shown by the arrows *k* and *m*, there would be nothing to prevent the one piece, as *l*, being removed or caused to slide away from the other piece, *o*, in the direction of the dotted part *m*. Just as would be the case in the event of the pressure being applied in the direction of the arrow *n*, which would give the tendency of the piece *o* to slide away from the piece *l*, or in direction of the dotted piece *p*. Now, the pressures ought to act from both sides—from side *l* as well as from side *h*—so that the sliding away from the contact of the two, exposing *q* and *r*, the "key" *s*, as shown in fig. 33. The only thing which would prevent this action would be the friction between the end surfaces of the two pieces, and that existing between the sides and ends of the grooves *c c* and the surfaces of the key *g h*. We do not say that such pressures would come into existence as here indicated, but the careful carpenter designs his constructions in such a way that he provides for all contingencies which a due study of the requirements of his work would show were likely to arise. And in complicated framework, where so many varieties and amounts of pressure come into existence, and often in ways least expected, it is the wisest, as it is the most prudent plan, to prevent, if possible, all undue pressures or strains.

Other Forms of this Class of Joints now under Consideration.

Another, and a safer, form of joint of this class of vertical pieces or posts is illustrated in fig. 34. In this

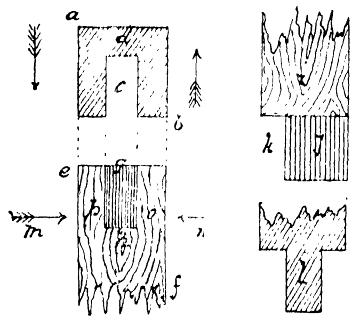


Fig. 34.

a b shows the end section of one of the pieces or posts, in which the groove is not cut across the whole face of surface—that is, from side to side, as at *d* in fig. 33—but stops short as at *c* (fig. 34), leaving a solid part, as *d*, at the side opposite to that at which the groove *c* begins. This is shown in the side elevation (*e f*) of the piece, *g h* being the back, *d*, of the groove in *c* diagram, shows the way the upper end of the lower piece or post is mortised. The diagrams *j* and *l* show the way in which the lower end of the upper part is dealt with. In place of a detached "key," as at *g h*, fig. 33, being employed, a tenon, as *j*, with a piece, as *k*, is framed at the end of the piece; *k l* shown in view is section of the other side of the piece, with the edge of the tenon at *l*. While the "key" *g h*, in fig. 33, provided for only two directions of actual pressure, as understood by the arrows *i* and *j*, it did not provide for the other two directions, four in all, there being four sides to the posts or pieces shown at arrows *k* and *n*. But in the arrangement in fig. **34** three actual pressures, tending to cause the pieces to slide away from contact with each other, out of the four are provided for: the outer ones, *m* and *n*, corresponding to *i* and *j*, fig. 33, being provided for in both cases equally; but the end corresponding to *k* or *n* in fig. 33 is met by giving a solid back (*d*) to the groove *c*, fig. 34, against which the edge *k* of the

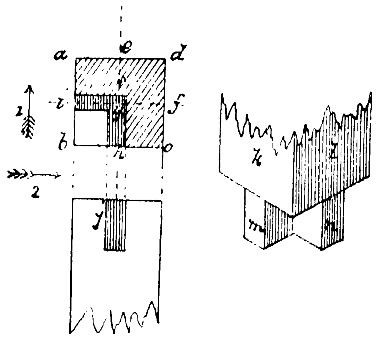


Fig. 35.

tenon *j* butts or presses, so that all sliding is prevented in the direction of the arrow *b*, or that to the right hand—the only direction of sliding pressure not provided for being that acting in the direction of the arrow to the left hand of *a*, forcing the tenon out of the mortise, which may be prevented by passing a pin or trenail through piece *a b* and tenon *j*, as from side *a* to side *e*.

In fig. 35 we illustrate another form of joint of

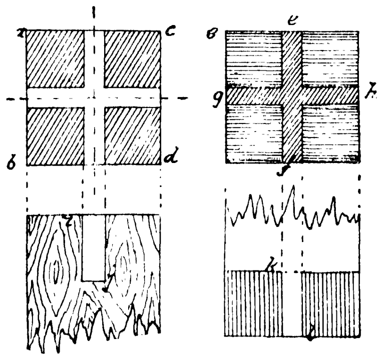
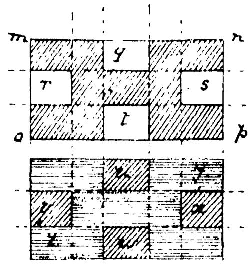
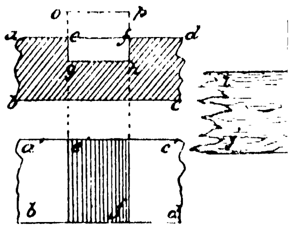


Fig. 36.

this class, in which the four actual pressures tending to cause a sliding away action of the two faces of the posts, upper and lower, are provided against. In this *a b c d* shows the end of the upper face of lower post, in which two grooves on the central lines, *e h*, *f i*, are cut, as *g h*, on line *e h*, being at right angles to the other, as *i g*, on line *i f*, a side elevation of the groove *h* being shown at *j*. On the lower face of the upper post, *k l*, two tenons, as at *m n*, are cut at right angles, as shown. These go into the grooves or open mortises *h i*, and, it will be seen, provide against the pressures arising from directions as shown by arrows 1 and 2, and from those opposite to these. A more equally distributed form of this last principle of joint is shown in fig. 36, in which grooves running from face *a b* to face *c d* of the post in opposite directions, and from face *b d* to face *a c*, forming a cross, and cut in the upper face of the lower post; while four tenons, forming also a cross, are cut, as at *e f g h*, on the lower face of the upper post, these passing into the grooves, as *a b c d*. A side view of lower post at top, with groove *i j*, is shown, as also a like view of upper post at foot at *k l*. Fig. 37 illustrates



another way of forming the joint so as to meet the pressures in all directions. In this the part *m n o p* is plan of upper side of lower piece, having parts, or what may be called open mortises, cut out, as shown at *q*, *r*, *s*, and *t*, these being of depth equal to the length of the tenons or projecting parts cut in the lower end of upper part. Plan of this is shown in the lower diagram: *u*, *v*, *w*, and *x* show the ends of the tenons, and the parts between them, as *y* and *z*, being



cut away to the same depth, thus leaving parts *u v w x* projecting from the end, and which pass into the open mortises *q*, *r*, *s*, and *t*.

Horizontal Joints used in Pieces crossing at Right Angles.

We now come to the third class of joints, used in connecting horizontal pieces crossing each other or meeting at right angles. The simplest form of this joint would obviously be by laying the one piece, as the upper, *m n*, in fig. 38, upon the other and lower piece, as *i j k l*, and securing the two by wooden trenails or pins, or by nails or screw-nails. This, for small work on which no great strain is put, would give a joint fairly secure.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER X.

WE referred at end of last chapter to the production of an article or coloured pattern upon a dyed alizarine scarlet cloth,—one of the most beautiful processes of calico printing. Bleaching powder contains chlorine, but in a state of feeble combination, and incapable of bleaching alizarine red, but when dilute acid is added to it free chlorine is given off. Therefore when an acid is printed on the red cloth, and it is dried and passed through solution of bleaching powder, the effect is that the acid forming the pattern, setting free a corresponding amount of chlorine, bleaches the colour, and so forms a white design on a red ground. When certain dyes are printed along with the acid, the effect is a coloured instead of a white design. A pattern may therefore be produced containing white and several colours, as blue, yellow, green, black, white, and red. The acid employed is tartaric, or a mixture of tartaric and oxalic. The following are practical recipes of the prepared colours for this style of printing:—

Turkey Red Discharge White.

Starch paste (hot)	5 gals.
Powdered tartaric acid	24 lb.

Add the acid to the hot paste gradually, mix until dissolved, and strain. Some colourists make an addition of pipeclay, but the author cannot say from experience that this addition is advantageous.

Turkey Red Discharge Blue.

Prussian blue pulp	3 quarts.
Oxalic acid (powdered)	1 lb.
Tartaric acid	20 lb.
Water	1½ gals.

Warm till dissolved, then add gradually to

Starch paste	3½ gals.

Turkey Red Discharge Yellow.

Tartaric acid (powdered)	25 lb.
Starch paste (hot)	4 gals.

Mix till dissolved, then add gradually solution of

White sugar of lead	15 lb.
Water	1 gal.

Cool, and add gradually, with stirring,

Nitric acid at 56° T.	5 gills.

The use of nitric acid requires great caution; only the heavier cloths should be printed with this colour, and many object to its use altogether, and substitute for it a larger amount of tartaric acid. Discharge green is obtained by mixtures of the blue and yellow.

All the above Turkey red discharge colours are printed on the red cloth in the usual manner, care being taken to print evenly, as in this style more perhaps than any other is defective printing readily detectable and noticeable.

Turkey Red Discharge Black.

This is the most troublesome colour to obtain, and requires particular care in printing, etc. The following recipe has given good results.

Mix well together

Logwood liquor at 6° T.	4 gals.
Gum dragon (12 oz. per gallon)	1 gal.
Yellow prussiate of potash	6 lb.
Starch	8 lb.

Boil well together, cool, and add gradually

Acetate of iron at 30° T.	2 gals.
Nitrate of iron at 80° T.	4½ gills.

The Chemic Bath or Discharging Beck.

The cloth is then passed through a bath composed of

Bleaching powder	150 lb.
Water	75 gals.

Mix smooth, until free from lumps. Heat to 120° F., and add to the chemic beck, containing an equal measure of warm water. Stir well, and add a little powdered chalk, and the beck, being at the temperature of about 120° F., is ready for the entrance of the pieces. These are passed from a roller on to a frame of rollers at top and bottom, which, when the chemic and pieces are both ready, is lowered into the chemic beck, and the calico drawing through, passing from roller to roller until, after an immersion in the liquid of about seventy-five seconds, it passes into another beck containing chalk and water, then into a third, containing fresh water, and being here thoroughly washed, passes into a fourth beck, containing a warm solution of bichromate of potash at 6° T. In the bichrome bath the calico runs for about seven minutes, and is then thoroughly washed in fifth and sixth becks, containing a running supply of water. The result is that we have a pattern in white, blue, yellow, etc., on a scarlet ground, which is uninjured by the passage through the liquors, or only slightly dulled. The effects capable of being produced by this style are exceedingly pretty, and are much in public favour. The carrying out of these processes, so as to insure first-class work, from the colour-mixing and printing to the final washing, etc., all require unusual care. We do not give the above recipes and methods as being indisputably the best, but simply those which have by attention been found to give good results.

8. Discharge Indigo Style.

The colours containing the discharge are printed on indigo-dyed cloth, dried and passed through a discharging bath. There are two methods in common use: (1) That by means of chrome and acid; (2) that by red prussiate and caustic alkali. The latter method is employed in practice, and therefore we describe only the former.

Indigo Discharge Colours by the Chromic Acid Method.

(1) *White.*—The neutral chromate of potash or soda is printed on with starch paste. The following recipe gives a good white on a medium shade of dip-indigo blue cloth :—

20 gallons starch paste, 1 gal. chromate of potash paste, containing 50 per cent. powdered chromate and 50 per cent. water.

(2) *Pale Blue*, or partial discharge, is obtained by using only as much chromate of potash as will partially discharge the indigo; the exact quantity used depends upon the depth of pale blue wanted, and upon the original depth of the blue cloth.

(3) *Red.* — Vermilion is mixed with the white discharge, with the addition of *albumen* for the purpose of fastening the red. The following recipe has been largely followed with excellent results :—

Egg albumen solution at 8 lb. in a gal. .	1 gal.
Oil	3 pints.
Glycerine	$4\frac{1}{2}$ "
Ammonia	$\frac{1}{4}$ "

Mix these well together; then take

Vermilion	30 lb.,

and rub in a mortar with so much of the above mixture as will form a *smooth* paste, free from lumps. Add the remainder of the albumen mixture by degrees, rubbing with the pestle until the whole is of uniform consistency. Lastly, add slowly, and with stirring, 9 gills of an aqueous paste of neutral chrome, containing about $5\frac{1}{2}$ lb. of the solid potassium chromate.

(4) *Yellow.*—Chromate of lead pigment, with albumen, mixed as described for red.

(5) *Green* is produced by using a green pigment and albumen, mixed as in the case of vermilion.

The Acid Bath or Discharging Beck.

After printing, the goods are passed through a sulphuric acid bath, which discharges the indigo, and also coagulates the albumen, and so fastens the colours. The bath consists of

Oxalic acid . . . . 40 lb.

Mix the vitriol and water, cool, add the oxalic acid, and stir till dissolved; and the bath is ready for the passage of the cloth—which should occupy about thirty-five seconds, and pass immediately into becks ... a plentiful supply of cold water and a

9. Manganese Bronze Discharge Style.

Manganese bronze is produced by padding cloth in acetate of manganese at 24° T., thickened with flour; drying, and then passing the cloth through caustic soda solution at 12° T., and aged in the air. Oxide of manganese is formed in the fibres of the cloth, imparting to it a fine brown colour. The discharge colours, given below, are printed on this brown cloth; which is then steamed, and the brown is discharged, leaving either white, or blue, or whatever colour is mixed with the discharge.

White ; 8 lb. tartaric acid.
1 gallon starch paste.
Red : 4 lb. tin crystals.
2 lb. eocine ; dissolved in water.

Any colour which, like eocine, is not injured by the discharge composition, and which is fixed by tin crystals, may be mixed with the white, and so various other discharge-colours are obtained.

FIXING THE COLOUR.

As we have before pointed out, to "dye" calico it is necessary that the colour should be present in the fibres of the cloth in an insoluble state, and that, if we cannot apply it to the cloth in this state, as in the case of pigments, we must apply it in a soluble condition, and afterwards render it insoluble. The various constituents, therefore, necessary to produce the insoluble colour are deposited in the fibres of the cloth, either separately or altogether, and we have now to cause their union together either by ageing in the air, by steaming, or by subjecting to hot air, or by passage through a liquid, or by a combination of these means.

1. Ageing or Exposing to the Air.

This was formerly much more extensively employed than at present. It is mostly resorted to of mordants printed on and afterwards dyed, ally in the case of alizarine mordants. The ... of iron, alumina, and of many other metals, when printed on cloth and exposed to air, partially decompose, and part of the insoluble oxide is deposited in the fibres of the cloth. This takes place much more rapidly and completely at an elevated temperature, and hence ageing in the air is now generally supplemented, or wholly displaced, by the action of moist and warm air, and also of steam. There are a great variety of steaming apparatuses, but the principle in each is essentially the same. The ageing machine consists of an iron chest, provided with a series of rollers at the top and bottom; the air inside the chest is kept a uniform heat, generally 190° F., and at a pressure of about 4 lb. per square inch. The cloth enters the chest through a narrow opening, and passes up and down from roller to roller until it emerges at the other end, having taken a certain specified time to travel through. The size of the chest, degree of heat and moisture, and the time of ageing, depend entirely upon the quantity and quality of goods to be aged. These machines are mostly employed for goods requiring only slight heating, such as mordants for dyeing and aniline blacks; Mather and Platt's machine being that generally used. The cloth remains in the chest from two to four minutes. In dyed alizarine style, after printing-on the mordant for red, alone or combined with aniline black, the cloth is "aged" through this machine, and is then ready for dunging and dyeing.

2. Steaming.

For steaming after printing, or after dyeing, the form of apparatus used is a little different from the above. A greater degree of humidity is required, and a greater heat; whilst the time of passage varies from half an hour to about two hours. The cloth, instead of being drawn through the apparatus, is, as soon as it enters the machine, carried through at the required speed by the progressive movement of the rollers inside. Thus the cloth is not subjected to the enormous stretch of the entire length of cloth. Dyed alizarine reds and printed alizarine reds are in some print works steamed at about 5 lb. pressure of steam for one-and-a-half hour in a large closed steam chest or boiler, with a movable door, the pieces being hung upon rails; when they have had the required amount of steaming, the steam is blown off, the door opened, and the pieces taken out. Steamers of this description are constructed to steam about 5,000 yards of cloth at a time: those of the former class are sometimes constructed to contain, when filled, 13,000 yards of calico; and for all, except some classes of dyed work, are preferable to the closed boiler steamer. The steaming of the printed goods is a most important operation, and especial care is required in keeping up the required *uniform* heat and moisture and the proper *speed* of passage of the cloth. A detailed description of the steaming apparatus in use would be both too lengthy and too uninteresting to include in this work, and therefore we content ourselves by thus merely describing their general principle.

3. Passage through a Liquid.

Many colours require passing through a liquid either before or after steaming, or without steaming. The solutions usually resorted to for the fixation of such colours are bichromate of potash or soda, and tartar emetic. It must be remembered that passage through the liquid alone does not always fix the colour, and in practice steaming almost always follows the developing bath.

Tartaric Emeticing.

All the colours mordanted with tannic acid, as the anilines, are steamed and then passed through a solution of tartar emetic, washed or slightly soaped, after which they are ready for finishing. The bath contains ¾ oz. tartar emetic per gallon of water at 120° F., and the passage through the liquid occupies about a minute. The action of this bath is that of the combination of the antimony contained in the emetic with the tannic acid, with which the aniline is mixed; forming the insoluble tannate of antimony, which, united with the dye, forms a highly stable compound. Before the introduction of this method of fixing aniline colours, the goods were steamed only; the colours produced were not fast; the tannates of the aniline bases being not so stable as the double tannates of antimony and aniline base.

Chroming.

Blacks produced by logwood and bark after printing are steamed, and are then passed through a solution of bichromate of potash; the colour is thereby developed by a double decomposition which takes place; the colouring-principle of the logwood appropriates part of the chromium of the chrome salt, and also undergoes oxidation. Other colours require passage through bichrome on account of the oxidising properties of that salt; such is the case with catechu brown, and indophenol blue (now out of use). The solution employed contains 4 oz. of bichrome per gallon of water at 160° F.; the goods occupy about a minute in passage through the liquid.

Chrome yellow and orange are obtained by printing acetate and nitrate of lead, steaming, and passing through a bath consisting of 4 oz. bichrome and 2 lb. common salt per gallon of water at boiling temperature. The action that takes place is the union of the chlorine of the salt with the oxide of lead in the cloth (formed by the steaming of the acetate of lead) to form the insoluble chloride of lead; and the chromic acid of the bichrome displacing this chlorine, or part thereof, to form the colour, chromate of lead. Sulphate of soda may be used in place of the chloride, in which case of course sulphate of lead is formed instead of chloride; which is then converted into chromate of lead by the action of the bichrome.

Dyeing upon Printed Mordants.

In some styles, as already pointed out, the mordant is first printed on the white cloth, and this is then aged, dunged, and dyed. The colouring-matter attaches itself, or fixes upon, only those portions of cloth the fibres of which hold the mordant. The cloth, with the pattern thus printed on, is, after ageing, etc., run through the dye-beck or vat containing the colouring-matter or dye. Gradually the dye becomes firmly attached to, or combined with, the mordant; and when the mordant becomes fully saturated, or unable to unite with a further quantity of colouring-matter, the cloth is said to be "fully dyed-up," or "dyed to the shade required."

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

130. Chemical Facts and Figures (*continued*).

Potassium Compounds.

1. *Caustic Potash,* potassium hydrate or hydroxide (NaOH). Produced in exactly the same way as the corresponding sodium alkali—namely, by treating the carbonate with lime. In making caustic potash, however, the solution of carbonate must be *dilute*, and milk of lime added until it ceases to effervesce with an acid, as a concentrated solution of potassium carbonate decomposes calcium carbonate, and therefore the alkali ceases to become caustic.

$$K_2CO_3 + CaO + H_2O = 2KOH + CaCO_3$$
$$\text{Potassium carbonate} + \text{Calcium oxide} + \text{Water} = \text{Potassium hydrate} + \text{Calcium carbonate.}$$

Used chiefly in making soft soap—owing mainly to the deliquescent properties of the potash alkali as compared with soda; in surgery this alkali is used as a caustic, also in the laboratory for drying gases.

2. *Pearlash,* potassium carbonate (K_2CO_3). Manufactured from the sulphate in a similar manner to that adopted in the Leblanc process for the production of soda ash; also obtained from sheep-wool, which contains a large amount of the salt,—the liquors in which sheep have been washed are evaporated down, and the saline residue calcined; also from wood-ashes, which are extracted with water; and as a by-product in the beetroot sugar industry,—the molasses or uncrystallisable sugar is allowed to ferment, and so change the sugar present into alcohol, and the remaining liquor is evaporated,—the residue is lixiviated and calcined, and the product is raw potashes or "salin."

The uses of pearlash comprise the making of soft soap, crystal glass, chromate and prussiate of potash, and other salts.

3. *Potassium Chloride* (KCl). Manufactured chiefly from carnallite ($KCl + MgCl_2 + 6H_2O$) and other minerals; also obtained from sea-water.

Used for the preparation of other potassium salts, and also as a soil fertiliser.

4. *Potassium Bromide* (KBr). Obtained by dissolving iodine in caustic potash, evaporating and gently igniting in order to convert the bromate, which is formed along with bromide, into the latter salt. Used in photography, and also largely in medicine, chiefly in the treatment of nervous diseases.

5. *Potassium Iodide* (KI). Obtained in a similar manner to the bromide. Employed largely in medicine, chiefly in skin diseases.

6. *Potassium Sulphate* (K_2SO_4). Obtained as a by-product in the manufacture of bichromate of potash, and in the lixiviation of crude potash and kelp; also from the lavas of Vesuvius; also as *kianite* ($K_2SO_4 + MgSo_4 + 4H_2O$), which occurs in Stassfurt and Kalusz.

Employed in the manufacture of potash-alum—$Al_2K_2(SO_4)_3, 24H_2O$—and pearlash; also in medicine purgative.

7. *Nitre, Saltpetre,* potassium nitrate (KNO_3). Manufactured from Chili saltpetre and natural potassium chloride. These two salts undergo under certain conditions double decomposition—potassium nitrate and sodium chloride or common salt being formed, thus—

$$NaNO_3 + KCl = KNO_3 + NaCl$$
$$\text{Sodium nitrate} + \text{Potassium chloride} = \text{Potassium nitrate} + \text{Sodium chloride.}$$

Obtained also by the lixiviation, or treatment with warm water, of certain soil of hot climates—the potassium nitrate being a product of the decomposition of vegetable matter containing nitrogen, in contact with an alkali.

Employed in the manufacture of gunpowder, which is a mixture of nitre, sulphur and carbon in such proportions as to lead us to conjecture the chemical composition of gunpowder, and the action that occurs on explosion to be such as represented in the equation—

$$2KNO_3 + S + 3C = K_2S + N_2 + 3CO_2$$
$$\text{Potassium nitrate} + \text{Sulphur} + \text{Carbon} = \text{Potassium sulphide} + \text{Nitrogen} + \text{Carbon dioxide.}$$

Potassium nitrate is employed in medicine.

8. *Potash Water-glass,* potassium tetrasilicate ($K_2Si_4O_9$). Obtained by strongly igniting for several hours a mixture of 15 parts of quartz, 10 parts of crude potash and 1 part of ground charcoal. The product is dissolved in hot water, the insoluble matters allowed to settle, and the liquid concentrated by evaporation.

Used for the same purposes as soda water-glass, which has now supplanted it.

9. *Potassium Cyanide* (KCN). Prepared on the large scale by fusing eight parts of ferrocyanide of potassium or yellow prussiate with three parts of pearlash in an iron crucible. When the carbon dioxide, which is given off copiously, ceases to be evolved, the crucible is withdrawn from the fire, and the molten mass poured off from the iron-powder which remains behind. The commercial product pre-

pared in this way contains, as will be seen by the equation below, a small quantity of this cyanate, but for ordinary use this impurity is of no consequence.

$$\underset{\text{Potassium ferrocyanide}}{K_4Fe(CN)_6} + \underset{\text{Potassium carbonate}}{K_2CO_3} = \underset{\text{Potassium cyanide}}{5KCN} + \underset{\text{Potassium cyanate}}{KCNO} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Iron.}}{Fe.}$$

Chemically pure potassium cyanide may be obtained by passing hydrocyanic acid gas into an alcoholic solution of potash,—a copious white powder precipitates, consisting of the pure salt.

Largely used in photography and in the laboratory as a reducing agent. It has also been employed recently in the manufacture of sulphocyanide of potash, which is formed when it is warmed with sulphur.

10. *Potassium Sulphocyanide or Thiocyanate* (KCNS). Manufactured from the yellow prussiate of potash by fusion of potash and sulphur: forty-six parts of the former salt, seventeen parts of carbonate of potash and thirty-two of sulphur are heated in crucibles, cooled and extracted with alcohol, filtered hot, and from the filtrate separate out crystals of sulphocyanide.

Employed largely as a refrigerant, as when 500 grammes of the salt are mixed with 400 grammes of cold water, the temperature of the mass sinks to —20°. Also recently applied to aid the fixation of certain colours of alizarine in calico printing.

11. *Potassium Chlorate* ($KClO_3$). Manufactured extensively by saturating with chlorine a solution of milk of lime of specific gravity 1·04; the liquid is evaporated until of specific gravity 1·18, and potassium chloride is then added—so as to convert the chlorate of lime formed into the potassium salt —and the liquid then boiled down until of specific gravity 1·28, when crystals of the salt, $KClO_3$, crystallise out. Many modifications of this process are adopted, but they do not differ in principle: thus, solutions of bleaching powder and potassium chloride, on evaporating together, give rise to the same reaction, which takes place in two stages. First, on boiling a solution of bleaching powder, the hypochlorite of lime contained therein decomposes into the chlorate and chloride thus:—

$$3Ca(ClO)_2 = Ca(ClO_3)_2 + 2CaCl_2.$$

On now adding potassium chloride, the readily-soluble calcium chloride and the difficultly-soluble potassium chloride are produced—the former salt remaining in solution, and the latter separating out in crystals when the mixture is sufficiently concentrated by evaporation.

$$\underset{\text{Calcium}}{Ca(ClO_3)_2} + \underset{\text{Potassium chloride}}{2KCl} = \underset{\text{Calcium chloride}}{CaCl_2} + \underset{\text{Potassium chlorate.}}{2KClO_3}$$

The uses of potassium chlorate mostly depend upon its great oxidising properties. It is largely used in calico printing; but is fast becoming displaced by the sodium chlorate for aniline blacks, in fireworks manufacture, in the chemical laboratory, in medicine, and in several manufactures.

12. *Bichrome, Red Chromate of Potash*, potassium bichromate or acid-chromate ($K_2Cr_4O_7$). Obtained by treatment of neutral or yellow potassium chromate with a strong acid, whereby a portion of the base of the latter salt is eliminated, and so the acid salt formed. The neutral salt is obtained by igniting chrome-iron ore with excess of alkali, in the presence of an oxidising agent such as nitre.

Used extensively in the arts of dyeing and calico printing; its use in some cases being based upon its high oxidising properties, and in others upon the amount of chromic acid it contains. Used in the preparation of yellow pigments, and in the making of certain cements which harden by the action of light and air; used also in the laboratory, and in photography, and in the manufacture of alizarine and a variety of other colouring matters. Used in several manufactures for bleaching—especially palm and other oils for manufacture into soap—the bleaching properties being generated by means of a strong acid such as vitriol or hydrochloric. This salt is being to a large extent displaced by the cheaper sodium salt.

13. *Chrome, Yellow Chrome*, potassium monochromate or neutral chromate ($K_2Cr_2O_4$). Obtained from chrome-iron ore as above described.

Used occasionally in place of the acid salt in pigment making, and in some cases of dyeing and calico printing.

Ammonium Compounds.

1. *Ammonia Solution, Volatile Alkali, Spirits of Hartshorn*, ammonium hydrate or hydroxide (NH_4HO). Manufactured from "ammoniacal gas liquor"—or the solution obtained as a by-product in the manufacture of coal gas by passing the impure gas through cold water. It contains chiefly free ammonia, sulphate and chloride of ammonia. The liquor is heated with lime, ammonia gas is given off, and this is led into cold water until a strong solution is obtained, of specific gravity ·880.

$$\underset{\text{Ammonium chloride}}{2NH_4Cl} + \underset{\text{Calcium oxide (lime)}}{CaO} = \underset{\text{Ammonia gas}}{NH_3} + \underset{\text{Calcium}}{CaCl_2} + \underset{\text{Water.}}{H_2O}$$

When the ammonia gas dissolves in water a hydrate or hydroxide is formed, which is ammonia liquor:—

$$NH_3 + H_2O = NH_4OH.$$

Formerly obtained by the distillation of horn (hence the name) and other organic substances rich in nitrogen with caustic soda, the nitrogen being thereby converted into ammonia.

Used in preparing ammonium salts; largely used in manure; in the laboratory in constant use; in calico printing, in soap making and many chemical manufactures.

2. *Sal-ammoniac,* ammonium chloride (NH_4Cl). Obtained from gas liquor by neutralising with hydrochloric acid, evaporating to dryness, and subliming: a white sublimate of almost pure ammonium chloride is obtained.

Used in manure making, in calico printing, and recently in soap making (to neutralise free caustic soda), in several manufactures, and in medicine. It is largely used by metal workers in soldering, to produce a clean metallic surface—which it does by reason of its *reducing* action at a high temperature, converting many metallic oxides into the metals.

3. *Ammonium Sulphate* $(NH_4)_2\ SO_4$. Obtained by distilling gas liquor with lime, leading the ammonia into dilute vitriol, and evaporating down to crystallisation.

Used in artificial manures, and in the manufacture of other ammonium salts.

4. *Ammonium Sesquicarbonate,* common commercial carbonate of ammonia ($N_8H_{11}C_2O_5$), is a mixture or compound of hydrogen ammonium carbonate with ammonium carbamate, thus: $H(NH_4)\ CO_3 + NH_4CO_2NH_2$. On exposure to the air the carbamate slowly volatilises.

Obtained by subliming a mixture of two parts of chalk and one part of sal-ammoniac or sulphate of ammonia. The produce is re-sublimed.

Used chiefly in medicine.

5. *Microcosmic Salt,* hydrogen ammonium sodium phosphate ($HNaNH_4PO_4 + 4H_2O$). Prepared by mixing 5 parts common rhombic phosphate of soda, dissolved in a little hot water, with 2 parts crystallised phosphate of ammonia, and allowing to cool, when crystals of microcosmic salt crystallise out.

Used largely in blowpipe analysis.

6. *Ammonium Sulphocyanide or Thiocyanate* (NH_4CNS). Prepared by mixing 15 parts aqueous ammonia, 2 parts carbon disulphide, 15 parts of 88 per cent. spirits of wine. The mixture is allowed to stand about twenty-four hours; about one-third is then distilled off, and the remainder is allowed to crystallise. It occurs in gas-liquor.

Used chiefly in calico printing.

7. *Colourless Ammonium Sulphide,* solution of ammonium monosulphide $(NH_4)_2S$. Obtained by saturating aqueous ammonia with sulphuretted hydrogen, and then adding an equal volume of ammonia.

Used largely as a re-agent in the laboratory.

Calcium Compounds.

1. *Common Lime, or Quicklime,* calcium monoxide (CaO). Manufactured in kilns by mixing limestone with coal and completely burning. It is necessary that there be a good current of air to carry away the carbonic acid as soon as formed, as otherwise further elimination of carbonic acid is stopped.

$$\underset{\text{Calcium carbonate (limestone or chalk)}}{CaCO_3}, \text{ on heating} = \underset{\text{Calcium oxide (lime)}}{CaO} + \underset{\text{Carbonic acid gas.}}{CO_2}$$

For each ton of lime produced about $3\frac{1}{2}$ cwt. of coal is required. Limestone containing magnesia requires, however, less fuel.

Used universally as the basis for nearly all cements and mortars for building purposes.

2. *Slaked Lime, Hydrate of Lime, Calcium Hydroxide,* $Ca(OH)_2$. Prepared by mixing gradually one part of water with about three parts of quicklime; these two combine, with the evolution of great heat:—

$$\underset{\text{Calcium oxide}}{CaO} + \underset{\text{Water}}{H_2O} = \underset{\text{Calcium hydroxide.}}{Ca(OH)_2}$$

Employed universally as a cement or mortar for building purposes.

Milk of lime is simply slaked lime suspended in water, and is frequently the form in which lime is used for many purposes.

3. *Calcium Chloride* ($CaCl_2$). Occurs in enormous quantities as a by-product in several important manufactures.

Used as a desiccating or drying agent, owing to the extraordinary avidity with which it absorbs moisture. In the laboratory gases are dried by passing through a tube containing lumps of the salt.

4 *Fluor Spar, Calcium Fluoride* (CaF_2). Found in large quantities in Derbyshire, especially in the Castleton valley, where it is called "Blue John" owing to its prevailing tint.

It is manufactured into very pretty vases and other ornaments.

5. *Bleaching Powder, Chloride of Lime,* mixture of calcium hypochlorite and chloride, $Ca(OCl)_2 + CaCl_2$. Manufactured by the late Mr. Weldon's process as follows:—Chlorine gas is generated in huge stills, constructed of stone, coated with tar and jointed with indiarubber, by the action of manganese dioxide on hydrochloric acid. (The latter is a by-product in the manufacture of soda ash by the Le Blanc process, and hence makers of soda ash and spirits of salts frequently manufacture bleaching powder.)

$$\underset{\text{Manganese dioxide}}{MnO_2} + \underset{\text{Hydrochloric acid}}{6HCl} = \underset{\text{Chlorine}}{2Cl_2} + \underset{\text{Manganese chloride}}{MnCl_2} + \underset{\text{Water}}{2H_2O}$$

The chlorine so evolved is led into enormous chamber containing slaked lime, bleaching powder being thereby produced:—

$$\underset{\text{Calcium hydroxide}}{2Ca(OH)_2} + \underset{\text{Chlorine}}{2Cl_2} = \underset{\text{Calcium hypochlorite}}{Ca(OCl)_2} + \underset{\text{Calcium chloride}}{CaCl_2} + \underset{\text{Water.}}{2H_2O.}$$

The manganese is recovered in the same form (namely, as the dioxide) by treating the waste manganese chloride with lime and passing a current of air through the mixture. The recovered oxide, or manganese mud, is employed over and over again, there being theoretically no loss of manganese, and practically only a trifling amount.

Uses of Bleaching Powder.—In bleaching cotton and paper it is always the agent used. The action in *bleaching* is seen in the two following equations, hydrochloric acid being the agent employed to liberate the chlorine.

$$\underbrace{Ca(OCl)_2 + CaCl}_{\text{Bleaching powder}} + \underset{\text{Hydrochloric acid}}{4HCl} = \underset{\text{Calcium chloride}}{2CaCl_2} + \underset{\text{Water}}{2H_2O} + \underset{\text{Chlorine (nascent)}}{Cl_2}.$$

The action of the free chlorine thus liberated is expressed thus:—

$$Cl_2 + H_2O + \text{Colouring matter} = 2HCl + \text{Oxidised colouring matter.}$$

It is used very largely as a powerful disinfectant, its action being the same as in bleaching.

6. *Bone Phosphate*, normal calcium orthophosphate, $Ca(PO_4)_2$. Manufactured from bones by gently burning them in kilns; the product obtained containing four-fifths of its weight of this compound—the remainder, one-fifth part, consisting mainly of calcium carbonate, calcium fluoride, and magnesium phosphate. It occurs native in several minerals, as in apatite—$3Ca_3(PO_4)_2 + CaF_2$, and in ornithite—$Ca_3(PO_4)_2 + 2H_2O$. Phosphorite and estremadurite are varieties of the former mineral which occur in Spain.

Obtained in a pure state as a white precipitate, by adding an excess of common phosphate of soda to an ammoniacal solution of chloride of calcium.

Used very extensively as a fertiliser of the soil, and as the source from which phosphorus is manufactured.

7. *Superphosphate of Lime*, tetra-hydrogen calcium phosphate, $H_4Ca(PO_4)_2$, and calcium sulphate ($CaSo_4$). Manufactured by acting on bone-phosphate by two-thirds of its weight of vitriol.

Used extensively as a manure, especially for root crops, and for the manufacture of phosphorus.

131. Poultry as a Source of Profit in Farming and Cottage Work.

The reader who has glanced over the opening chapters of the series of papers in the text entitled "The Farmer as a Technical Workman," will, if he had not given much thought to the matter, have gleaned some facts which will have impressed him somewhat as to the importance of farming not merely as a technical pursuit, but as forming one which possesses an interest of the highest possible value to the community at large. This vital importance which the calling possesses as an industrial occupation would seem to be apparent at the first glance, if from no other consideration than the very commonplace one that the produce of our farms is simply a necessity of existence, and that farmers must work if we are all to live. But, self-evident as this is, it is by no means an uncommon thing to meet again and again with numbers who have given so little thought to the subject that they talk as if it mattered not a whit to them or to any one else whether farming prospered or not, or whether its produce was plentiful or the reverse. And this, moreover, while they are surrounded by all the evidences of those who, taking wider views and looking at things from a higher standpoint, watch with the most anxious care whether we are to have plentiful harvests, with all the wealth they bring to the nation, or deficient ones, with all their disastrous losses. At the same time there is very much to be said in excuse for those we are now alluding to, who certainly maintain a wonderful degree of indifference about, and are content to remain in woful ignorance on, a point of such vital interest to them. To say nothing of the circumstances in which we are nationally placed in relation to other people from whom we draw enormous supplies of our daily food, it is amazing what little note we are all inclined to take of matters which, going on around us from day to day, are, so to say, being perpetually repeated. But it is only right to say that a wiser and a better view of the true relation of the people to British farming as a calling is being taken, and this over a much wider area, than at one time to some seemed at all probable. One evidence of this is to be met with in what may be called the flood of suggestions offered to farmers, or contributed, as is thought by those who make them, to raise farming as a calling from the depths of pecuniary disaster into which for the last few years it has descended to the more pleasant platform of a paying prosperity. While it would really be very interesting, assuredly most suggestive, to glance at these suggestions or some of them, inasmuch as some very striking lessons would be offered by them in more than one direction of true scientific interest, our aim at present is of a much more humble and unaspiring character. We propose looking at one only of the directions of farming work. But it is only right to note, at the outset, that that work as named in our title is by nearly all farmers considered in no way to belong to them. It is, perhaps, difficult to see why this is so, and how it is that it would seem to be a matter of indifference to farmers what kind of stock they reared—if such tiny, insignificant things as the denizens of the poultry-yard are entitled to be designated by such an imposing name—if only they made a profit out of it. But whatever be the cause, our farmers as a body have a profound indifference to, we might almost call it a contempt for, poultry breeding and rearing as a part of their industrial work. When we state that millions upon millions of eggs are demanded for consumption every year by our increased and ever increasing population, and hundreds upon hundreds of thousands of the birds themselves are required in our markets, and thousands upon thousands of "hard sovereigns" are paid yearly by us for eggs and for poultry, certainly it seems pretty well proved that some classes somewhere do not share with our British farmers that profound indifference to the subject which we have noticed above. We groan over the foreign competition with which on all sides and in all directions we have to contend, without ever giving a thought to the consideration of the fact that in some directions at least we might, if not put a complete stop to this competition, at least so reduce its pecuniary effects, that we should have less reason to groan over its amount as we groan now. When we state the fact that every year we send money to the Continent estimated to amount to at the very least £2,000,000 for poultry and eggs, the question is apt to arise, Could we not contrive somehow to rear as much poultry, and have for sale as many eggs, as would keep some considerable portion of this large sum amongst ourselves? We are of those who believe that this could be done. We may, before we conclude our notes on this subject, perhaps be able to show that such work would not be beneath the dignity of the British farmer, while it would help to recoup him some part of his losses in other departments, of which, and justly, we hear so much. If this be disputed, it will at all events be conceded that much more, very much more, could be done by cottagers and others in the way of poultry breeding and rearing than is done now. And we may be able to point out how this may be most profitably done. Leaving to an after note all considerations connected with these points here only faintly shadowed forth, we shall at once proceed to go in the first place a little into detail on the subject of the breeds or classes of fowls which are open for the choice of the small farmer who may make the department of poultry one of his chief sources of income—devoting more time and care than the majority of amateur farmers are likely to give to it.

We commence our list of "breeds of poultry" with a class to which poultry farmers will not concede the name of "breed" at all, being destitute, as they say, of all the evidences of breed of any kind. We do not care to dispute this; but simply looking upon them as a "class" of fowls—a term to which no poultry farmer can possibly object—we begin our list with the "ordinary" or "barn-door" fowl. About this we may yet have something more to say, and give also the opinions of able authorities, which we are inclined heartily to endorse. And the value of this breed —if breed we dare to call it—for household purposes, and of course also for those of marketing, is increased in a proportion far exceeding the extra cost, by giving them a little extra food and bestowing upon them a little more of that care which, unfortunately for themselves, as a rule farmers will not give. In the matter of the care of keeping and attending to these barn-door birds, there can in truth be no comparison; it is only those who breed and rear the "pure breeds," who know the continual and almost harassing attention which they demand and must have, who can contrast with telling effect the ease with which dozens of barn-door fowls are bred and brought up. In truth, as a rule they keep themselves, although, as we have said, it would pay, notwithstanding this, to bestow some little more care upon them—care which they will gratefully receive in their prating, chuckling way, and abundantly repay in the eggs they give and the meat they will yield.

Glancing now at the pure or distinct breeds, the first we note is the "Dorking." This we may call an essentially national bird, as it is indisputable that in this country by care and attention it has been brought to a high degree of perfection. Good strains or breeds of the Dorking are marked for their fine, plump, well- and evenly-shaped form; the same characteristic is shown in the distribution of the fat of the body—hence its high reputation as a fowl for the table. The objection to it is the delicacy of the chickens and young birds—a delicacy, however, which some breeders maintain is got over when once they get full feathered. The breed is said also to be peculiarly liable to disease. But many of these bad peculiarities can be got over, if not prevented, by proper housing, feeding, and care: thus an eminent authority says the chickens ought always to be kept on a hard clay or gravel soil alone; and it is scarcely necessary for us to say as regards them, for it applies to all breeds alike, that care must be taken to prevent too many birds being crowded together, and to provide, as we have already said, good food. All this, however, shows that the "Dorking" is more a breed for those who have time and inclination to go fully into it; and hence it is not one well if at all adapted for cottage occupants. The "Dorkings," however, make excellent mothers,—so good that as a rule they have their chickens longer than almost any other breed; hence they are used for sitting on the eggs of breeds not so distinguished. There are two kinds of Dorkings, distinguished by their colour: the white, and the silver-grey.

132. To find the Weight in Pounds of Cast-Iron Pipes, of which the Diameter (D), Thickness of Metal (T), and the Length in Inches (L) are known, (C) being the Constant = 3·8.

Add T to D, and multiply 3·1416 by the result, and by L and by T. Divide the product of this continued multiplication by C, and the quotient is the weight in pounds required. (*Note.* When flanges or faucets are given in the pipes, add a foot to the 9-foot length of the pipe, or say $1\frac{5}{8}$ lb. to each foot of length.)

133. Weight of Cast-Iron Pipes in Pounds per Foot Length, $\frac{1}{4}$ inch Thickness, and of Diameters from 12 inches to 1 inch.

12 inches diameter = 30·38 lb. per foot; $11\frac{3}{4}$ = 29·76 lb.; $11\frac{1}{2}$ = 29·14 lb.; $11\frac{1}{4}$ = 28·52 lb.; 11 in. diam. = 27·90 lb.; $10\frac{3}{4}$ = 27·28 lb.; $10\frac{1}{2}$ = 26·66 lb.; $10\frac{1}{4}$ = 26·04 lb.; 10 in. diam. = 25·42 lb.; $9\frac{3}{4}$ = 24·80 lb.; $9\frac{1}{2}$ = 24·18 lb.; $9\frac{1}{4}$ = 23·56 lb.; 9 in. diam. = 22·94 lb.; $8\frac{3}{4}$ = 22·32 lb.; $8\frac{1}{2}$ = 21·7 lb.; $8\frac{1}{4}$ = 21·08 lb.; 8 in. diam. = 20·46 lb.; $7\frac{3}{4}$ = 19·84 lb.; $7\frac{1}{2}$ = 19·22 lb.; $7\frac{1}{4}$ = 18·6 lb.; 7 in. diam. = 17·98 lb.; $6\frac{3}{4}$ = 17·36 lb.; $6\frac{1}{2}$ = 16·74 lb.; $6\frac{1}{4}$ = 16·12 lb.; 6 in. diam. = 15·5 lb.; $5\frac{3}{4}$ = 14·88 lb.; $5\frac{1}{2}$ = 14·26 lb.; $5\frac{1}{4}$ = 13·64 lb.; 5 in. diam. = 13·02 lb.; $4\frac{3}{4}$ = 12·4 lb.; $4\frac{1}{2}$ = 11·78 lb.; $4\frac{1}{4}$ = 11·16 lb.; 4 in. diam. = 10·54 lb.; $3\frac{3}{4}$ = 9·52 lb.; $3\frac{1}{2}$ = 9·3 lb.; $3\frac{1}{4}$ = 8·68 lb.; 3 in. diam. = 8·06 lb.; $2\frac{3}{4}$ = 7·44 lb.; $2\frac{1}{2}$ = 6·82 lb.; $2\frac{1}{4}$ = 6·2 lb.; 2 in. diam. = 5·58 lb.; $1\frac{3}{4}$ = 4·96 lb.; $1\frac{1}{2}$ = 0·34 lb.; $1\frac{1}{4}$ = 3·72 lb.; 1 in. diam. = 3·1 lb.

134. To find the Weight of Plates of Cast Iron in Pounds, the Dimensions of which Length (L), Breadth or Width (B), and Thickness (T), and the Constant (C) = 3·84, are given.

Multiply B by T, and the product by L, and divide the result by the constant 3·84: the quotient is the weight of the plate in pounds. (*a*) "To find the breadth (B) when the thickness (T), weight (W), and the length (L) are known, and (C) the constant = 3·84." Multiply the constant 3·84 by W, and divide the product by L multitiplied by T: the quotient is the breadth of plate required. (*b*) "To find the thickness (T) when the breadth (B), weight (W), and length (L), and constant (C), 3·84, are given." Multiply C by W, divide product by L multiplied by B: the quotient is the thickness required. (*c*) "To find the length (L) when the breadth (B), thickness (T), and weight (W) are given, C (3·84) being the constant." Multiply C by W, divide the result by B multiplied by T: the quotient is the length of flat plate required.

135. Weight in Pounds of Square Bars of Cast Iron per Foot, from 12 inches on the Side to 5 inches.

12 inches square = 450 lb. per foot; $11\frac{3}{4}$ = 431·44 lb.; $11\frac{1}{2}$ = 413·28 lb.; $11\frac{1}{4}$ = 395·5 lb.; 11 in. sq. = 378·12 lb.; $10\frac{3}{4}$ = 361·18 lb.; $10\frac{1}{2}$ = 344·53 lb.; $10\frac{1}{4}$ = 328·32 lb.; 10 in. sq. = 302·5 lb.; $9\frac{3}{4}$ = 297·07 lb.; $9\frac{1}{2}$ = 282·03 lb.; 9 in. sq. = 253·12 lb.; $8\frac{3}{4}$ = 239·25 lb.; $8\frac{1}{2}$ = 225·78 lb.; $8\frac{1}{4}$ = 212·69 lb.; 8 in. sq. = 200 lb.; $7\frac{3}{4}$ = 187·69 lb.; $7\frac{1}{2}$ = 175·78 lb.; $7\frac{1}{4}$ = 164·25; 7 in. sq. = 153·12 lb.; $6\frac{7}{8}$ = 147·7 lb.; $6\frac{3}{4}$ = 142·38 lb.; $6\frac{5}{8}$ = 137·15; $6\frac{1}{2}$ = 132·03 lb.; $6\frac{3}{8}$ = 127·00 lb.; $6\frac{1}{4}$ = 122·07 lb.; $6\frac{1}{8}$ = 117·23; 6 in. sq. = 112·50 lb.; $5\frac{7}{8}$ = 107·86 lb.; $5\frac{3}{4}$ = 103·32 lb.; $5\frac{5}{8}$ = 98·87 lb.; $5\frac{1}{2}$ = 94·53 lb.; $5\frac{3}{8}$ = 98·87 lb.; $5\frac{1}{4}$ = 86·13 lb.; $5\frac{1}{8}$ = 82·08 lb.; 5 in. sq. = 72·02 lb. per foot.

136. To find the Length of a Round or Circular Bar of Cast Iron when the Diameter in Inches and the Weight in Pounds are known. (*See* Note No. 103, p. 110, vol. ii.)

Take the weight in pounds and multiply it by 3·84, divide the product by a divisor found by multiplying ·7854 by the square of the diameter: the quotient is the length required.

137. To find the Diameter of a Round or Circular Bar or Rod of Cast Iron when the Length in inches and the Weight in pounds are known.

Take the weight and multiply it by 3·84, divide the product by the length in inches, and the quotient again by ·7854: the square root of the final quotient is the diameter required.

138. To find the Length of a Square Bar of Cast Iron when the Weight in Pounds and the Side of the Square are given. (*See* Note No. 102, p. 110, vol. ii.)

Take the weight in pounds and multiply it by 3·84, then divide the product by the square of the length of a side of the square bar: the quotient is the length of the bar.

139. To find the Side in Inches of a Square Bar of Cast Iron when the Length in Inches and the Weight in Pounds are known.

Take the weight and multiply it by 3·84, divide the result by the length in inches, and the square root of the quotient is the length of the side of the square.

140. Weight in Pounds of Flat Bar Iron per Foot of $\frac{1}{4}$ inch Thickness, in Breadth from 1 inch to 6 inches.

1 inch in breadth = ·83 lb.; $1\frac{1}{8}$ = ·93 lb.; $1\frac{1}{4}$ = 1·04 lb.; $1\frac{3}{8}$ = 1·14 lb.; $1\frac{1}{2}$ = 1·25 lb.; $1\frac{5}{8}$ = 1·35 lb.; $1\frac{3}{4}$ = 1·45; $1\frac{7}{8}$ = 1·56; 2 in. = 1·66 lb.; $2\frac{1}{4}$ = 1·87 lb.; $2\frac{1}{2}$ = 2·07 lb.; $2\frac{3}{4}$ = 2·29 lb.; 3 in. = 2·5 lb.; $3\frac{1}{4}$ = 2·7; $3\frac{1}{2}$ = 2·91 lb.; $3\frac{3}{4}$ = 3·12 lb.; 4 in. = 3·33 lb.; $4\frac{1}{4}$ = 3·54 lb.; $4\frac{1}{2}$ = 3·75; $4\frac{3}{4}$ = 3·95 lb.; 5 in. = 4.16 lb.; $5\frac{1}{4}$ = 4·37 lb.; $5\frac{1}{2}$ = 4·58 lb.; $5\frac{3}{4}$ = 4·79; 6 in. = 5·00 lb.

141. To find the Weight in Pounds per Square Foot of Brass, Copper, and Lead, of which the Thickness is known.

Multiply 144 by the thickness of the plate, and divide the result by the constant 3·33 for brass, 3·12 for copper, and 2·43 for lead.

142. Weight in Pounds per Lineal Foot of Round Rods or Bars of Steel, from 3 inches to $\frac{1}{8}$ of an inch in diameter.

3 inches = 24·09 lb.; $2\frac{3}{4}$ = 20·24 lb.; $2\frac{1}{2}$ = 16·73 lb.; $2\frac{1}{4}$ = 13·55 lb.; 2 in. = 10·71 lb.; $1\frac{7}{8}$ = 9·41 lb.; $1\frac{3}{4}$ = 8·2 lb.; $1\frac{5}{8}$ = 7·07 lb.; $1\frac{1}{2}$ = 6·02; $1\frac{3}{8}$ = 5·06 lb.; $1\frac{1}{4}$ = 4·18 lb.; $1\frac{1}{8}$ = 3·38 lb.; 1 in. = 2·67 lb.; $\frac{7}{8}$ = 2·05 lb.; $\frac{3}{4}$ = 1·5 lb.; $\frac{5}{8}$ = 1·04; $\frac{1}{2}$ in. = ·669 lb.; $\frac{3}{8}$ = ·376 lb.; $\frac{1}{4}$ = ·167 lb.; $\frac{1}{8}$ in. diam. = ·0418 lb.

THE SETTING-OUT OF ARCHES.

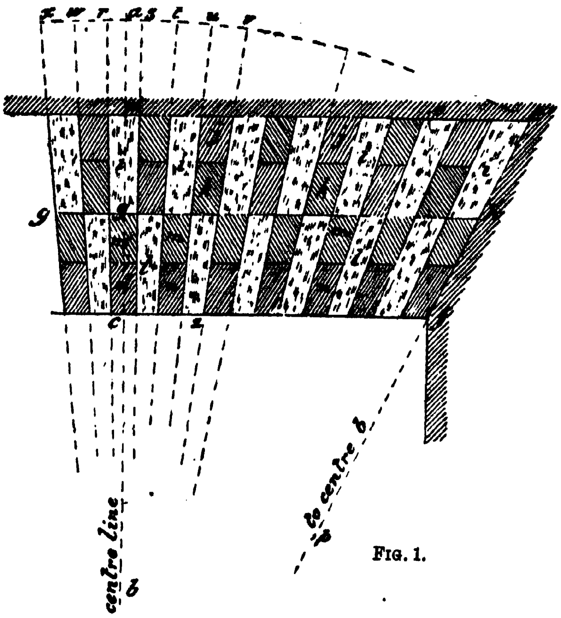


FIG. 1.

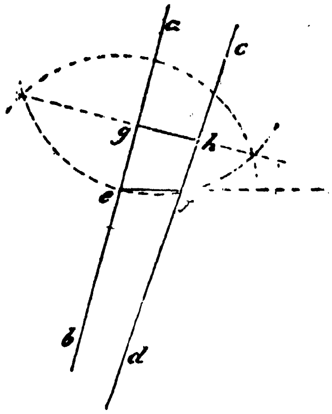


FIG. 2.

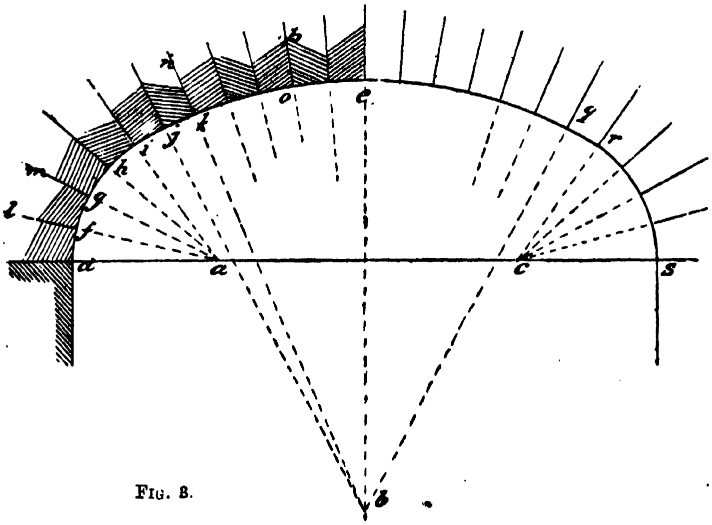


FIG. 3.

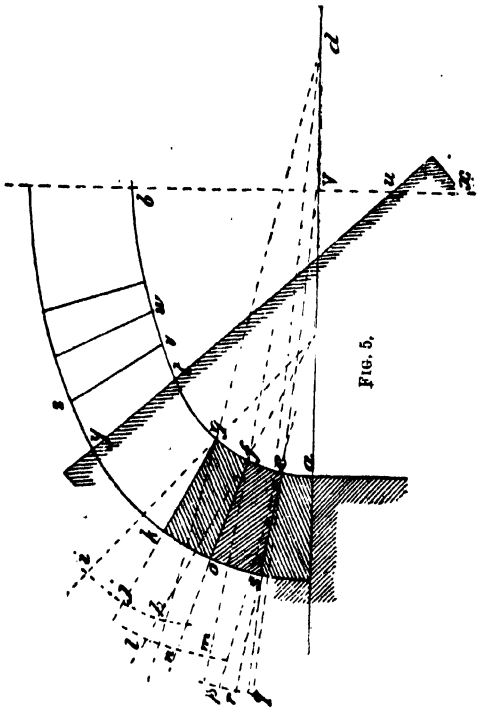


FIG. 5.

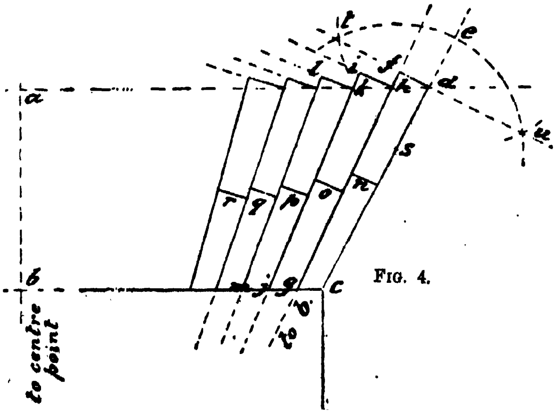


FIG. 4.

133. Weight of Cast-Iron Pipes in Pounds per Foot Length, ¼ inch Thickness, and of Diameters from 12 inches to 1 inch.

12 inches diameter = 30·38 lb. per foot; 11¾ = 29·76 lb.; 11½ = 29·14 lb.; 11¼ = 28·52 lb.; 11 in. diam. = 27·90 lb.; 10¾ = 27·28 lb.; 10½ = 26·66 lb.; 10¼ = 26·04 lb.; 10 in. diam. = 25·42 lb.; 9¾ = 24·80 lb.; 9½ = 24·18 lb.; 9¼ = 23·56 lb.; 9 in. diam. = 22·94 lb.; 8¾ = 22·32 lb.; 8½ = 21·7 lb.; 8¼ = 21·08 lb.; 8 in. diam. = 20·46 lb.; 7¾ = 19·84 lb.; 7½ = 19·22 lb.; 7¼ = 18·6 lb.; 7 in. diam. = 17·98 lb.; 6¾ = 17·36 lb.; 6½ = 16·74 lb.; 6¼ = 16·12 lb.; 6 in. diam. = 15·5 lb.; 5¾ = 14·88 lb.; 5½ = 14·26 lb.; 5¼ = 13·64 lb.; 5 in. diam. = 13·02 lb.; 4¾ = 12·4 lb.; 4½ = 11·78 lb.; 4¼ = 11·16 lb.; 4 in. diam. = 10·54 lb.; 3¾ = 9·52 lb.; 3½ = 9·3 lb.; 3¼ = 8·68 lb.; 3 in. diam. = 8·06 lb.; 2¾ = 7·44 lb.; 2½ = 6·82 lb.; 2¼ = 6·2 lb.; 2 in. diam. = 5·58 lb.; 1¾ = 4·96 lb.; 1½ = 0·34 lb.; 1¼ = 3·72 lb.; 1 in. diam. = 3·1 lb.

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138. To find the Length of a Square Bar of Cast Iron when the Weight in Pounds and the Side of the Square are given. (*See* Note No. 102, p. 110, vol. ii.)

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Take the weight and multiply it by 3·84, divide the result by the length in inches, and the square root of the quotient is the length of the side of the square.

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THE BRICKLAYER (see Text).

The Setting-Out of Arches

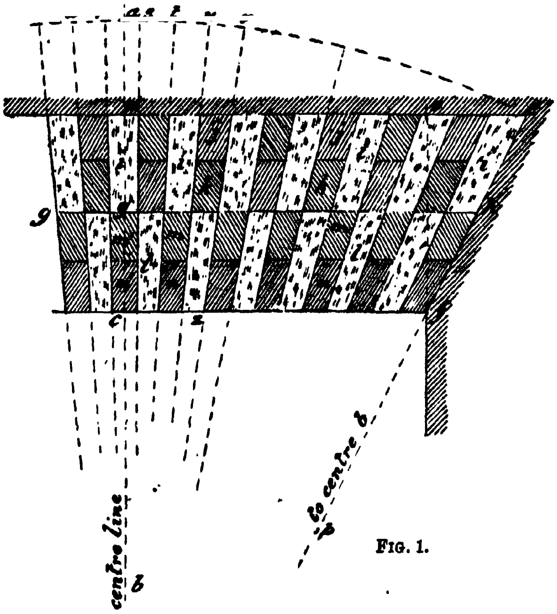


Fig. 1.

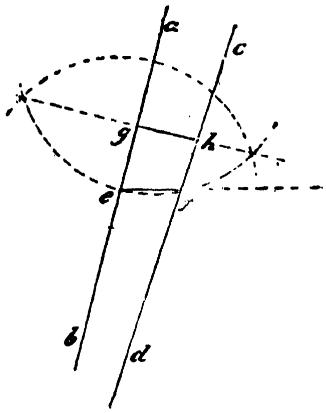


Fig. 2.

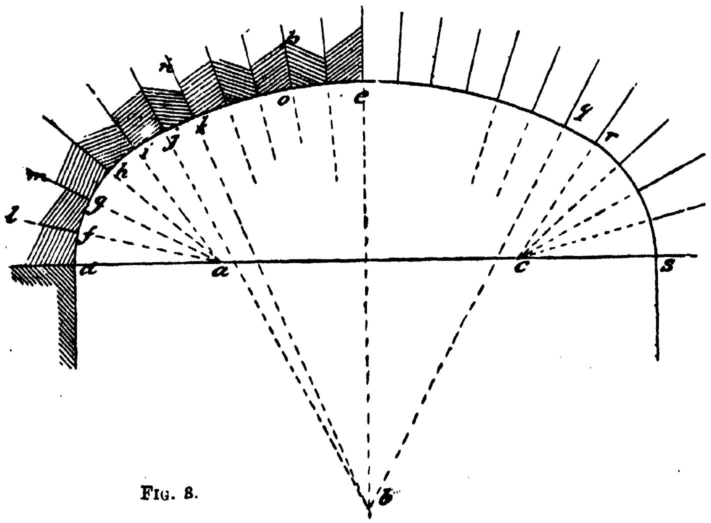


Fig. 3.

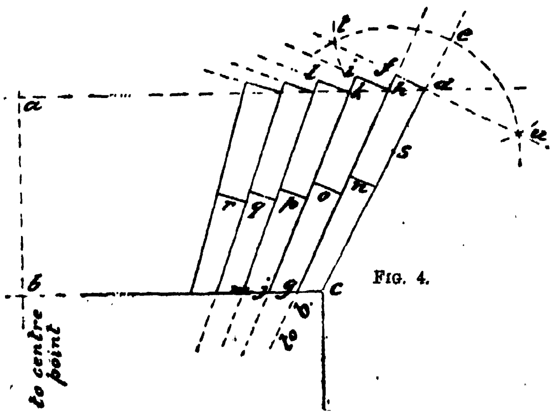


Fig. 4.

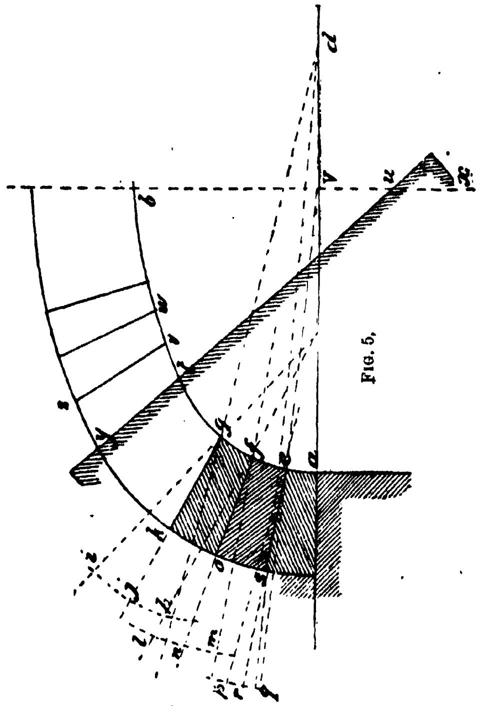


Fig. 5.

End Elevations of Cottage Villa in Plate CXXVII.

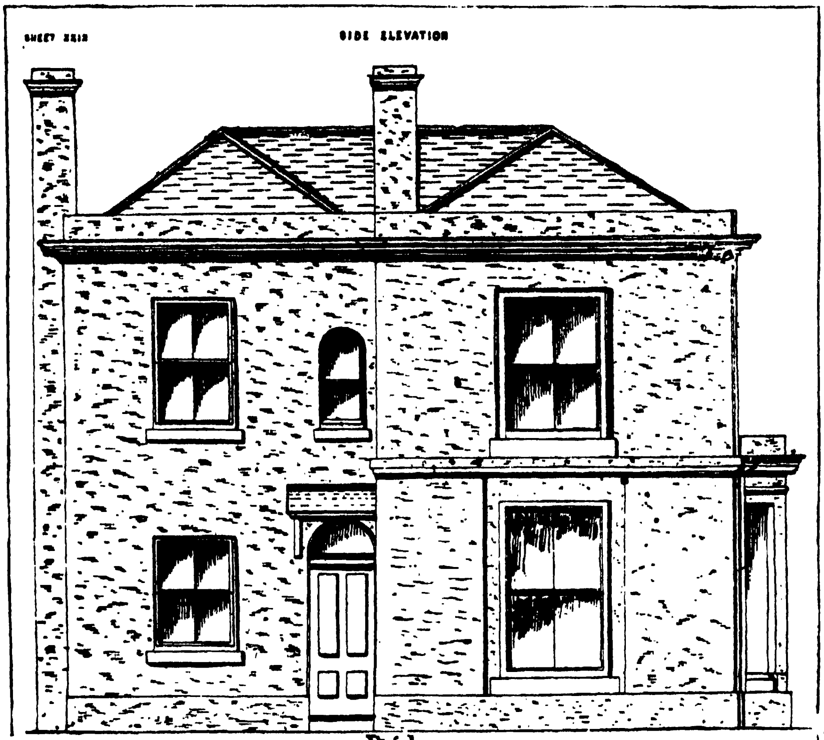


Fig 1.

East End Elevation.

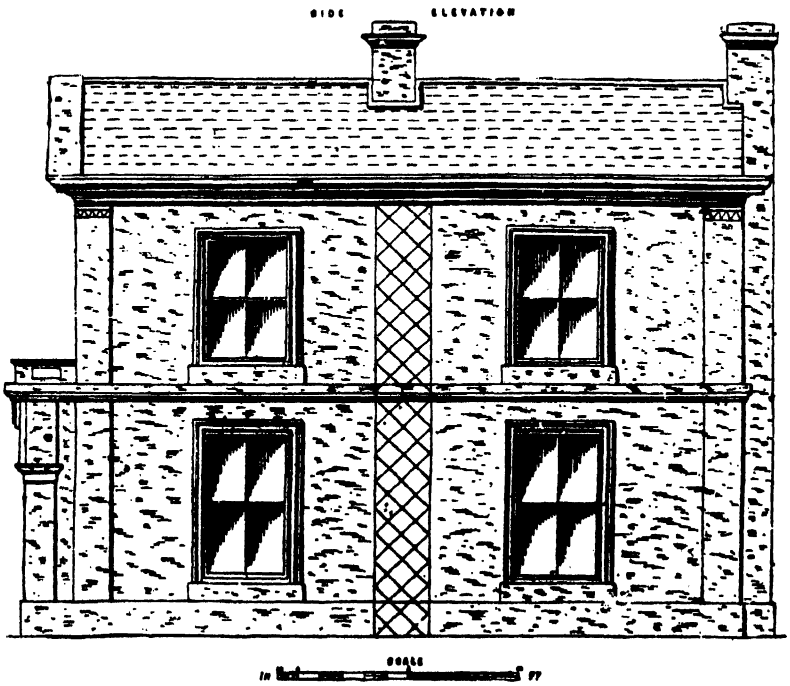
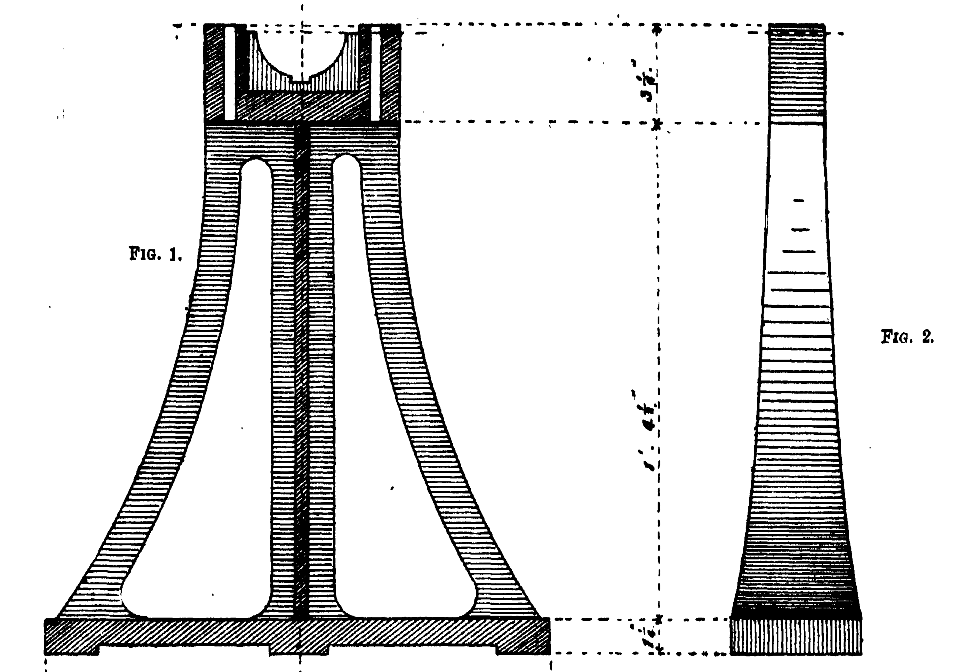


Fig 2.

West End Elevation.

DETAILS OF HORIZONTAL STEAM ENGINE. (See Plate CXIV.)



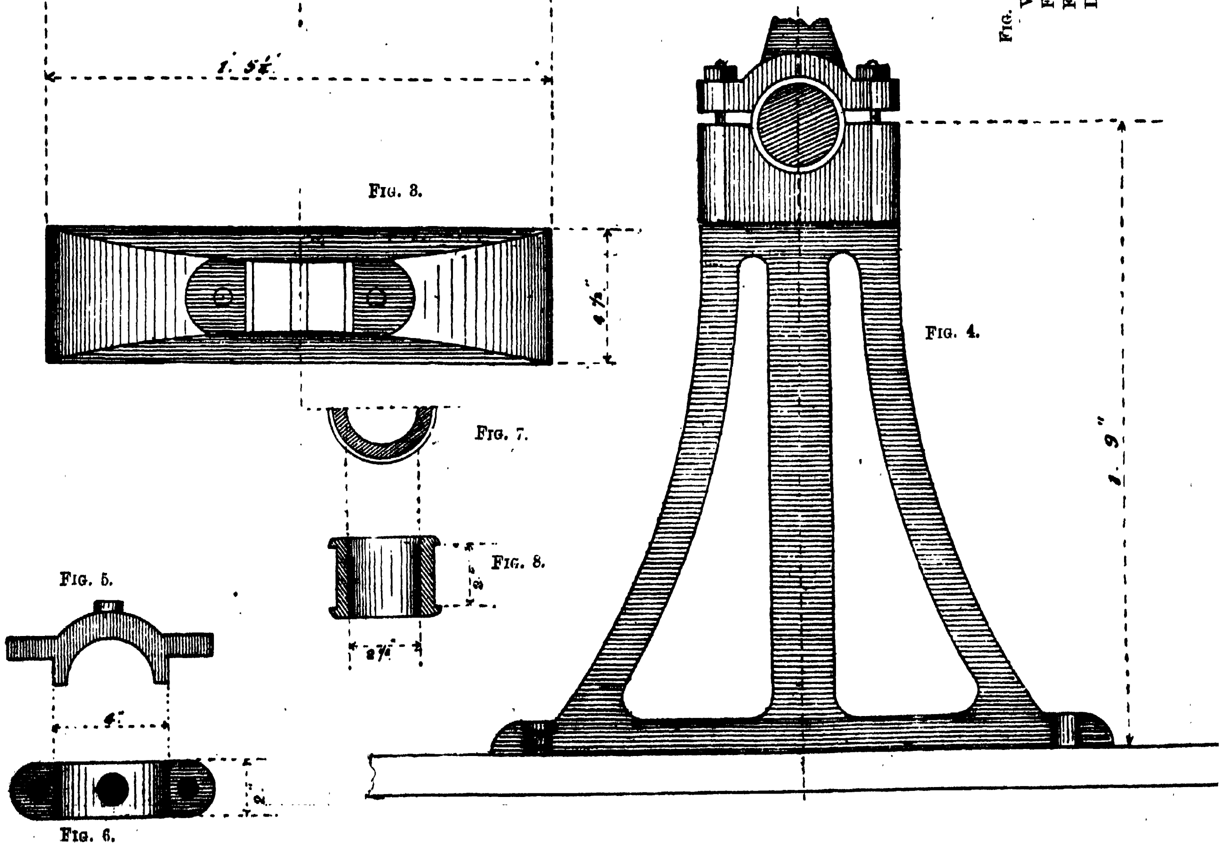


FIG. 1. VERTICAL SECTION OF PEDESTAL FOR WEIGH-BAR OR ROCKING SHAFT OF VALVE GEAR. — FIG. 2. END ELEVATION OF DITTO. — FIG. 3. PLAN OF DITTO. — FIG. 4. ELEVATION OF DITTO.—FIG. 5. SIDE ELEVATION OF "CAP" OF DITTO.—FIG. 6. PLAN OF TOP OF DITTO.—FIG. 7. CROSS SECTION OF BUSH OR BRASS OF DITTO.—FIG. 8. PLAN OF DITTO.

(Scale 2 inches = 1 foot.)

"THE JOINER" AND "THE CABINET MAKER."

Architraves, Figs. 1, 2, 3, 4 (Fig. 1 Double-Faced Architrave); Figs 5 and 6, Sash Bars.

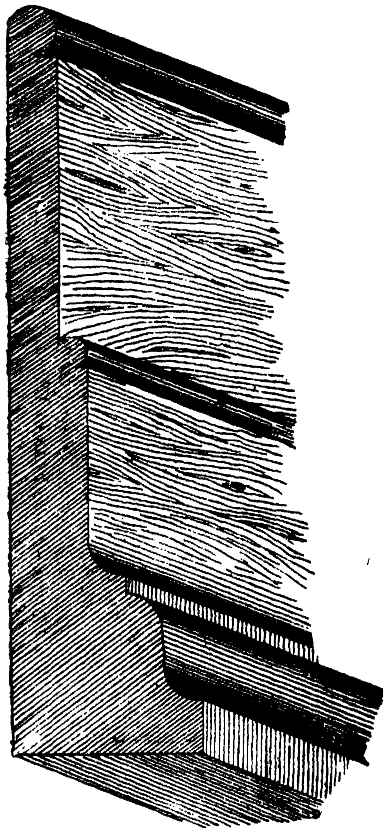
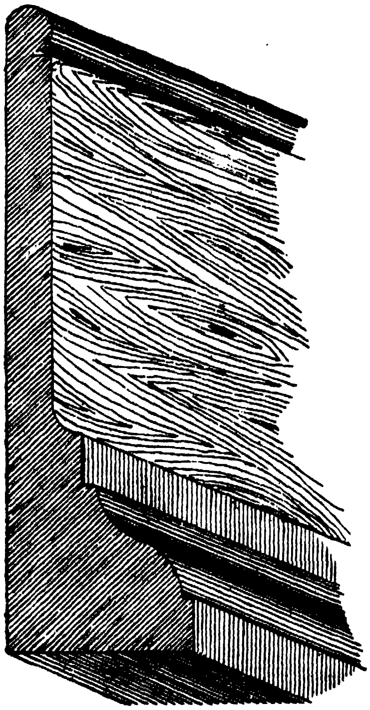


Fig 1



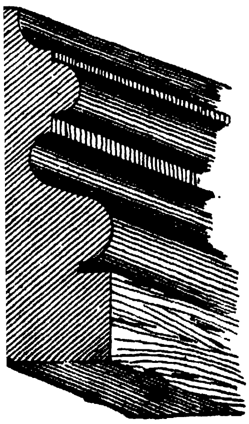


Fig. 3

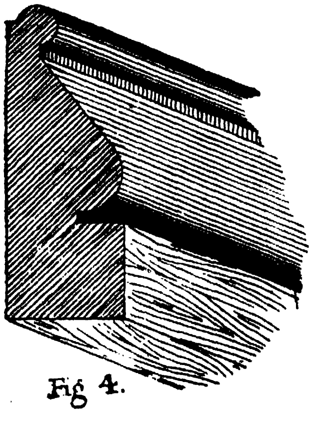


Fig 4.

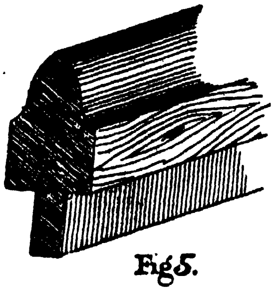


Fig 5.

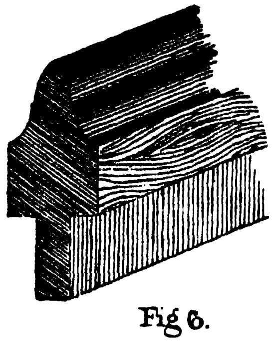


Fig 6.

FLOOR CONSTRUCTION.

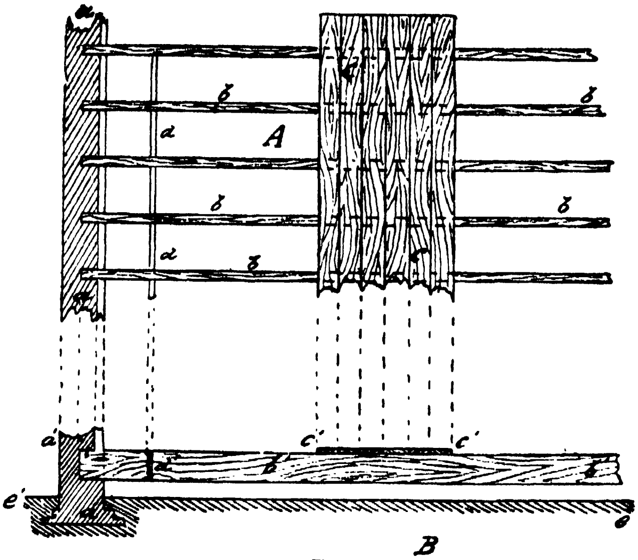


FIG. 1.

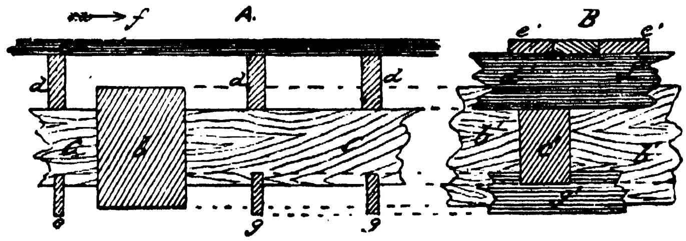


FIG. 2.

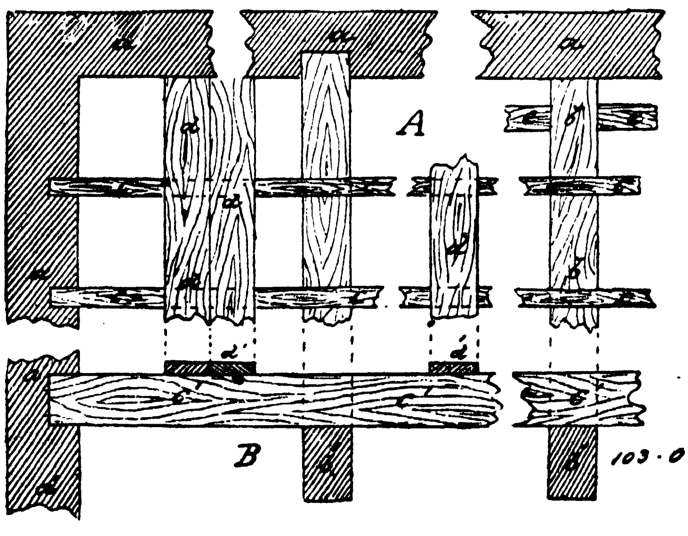


FIG. 3.

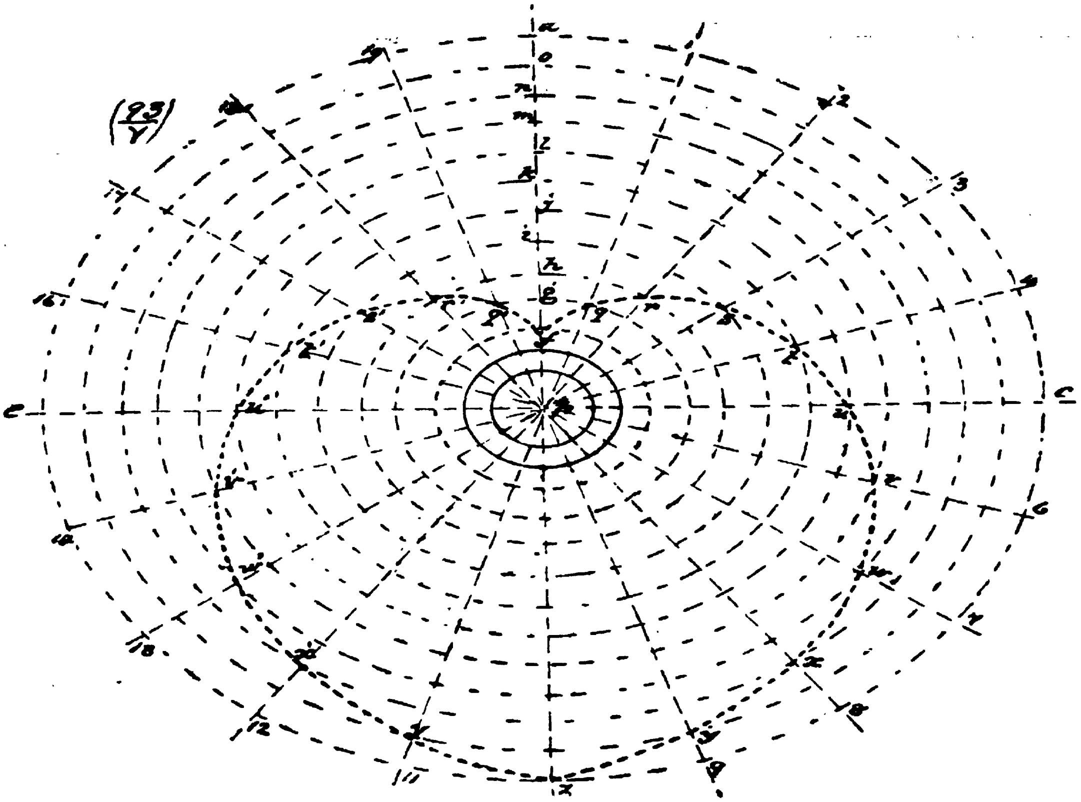


Fig. 1.

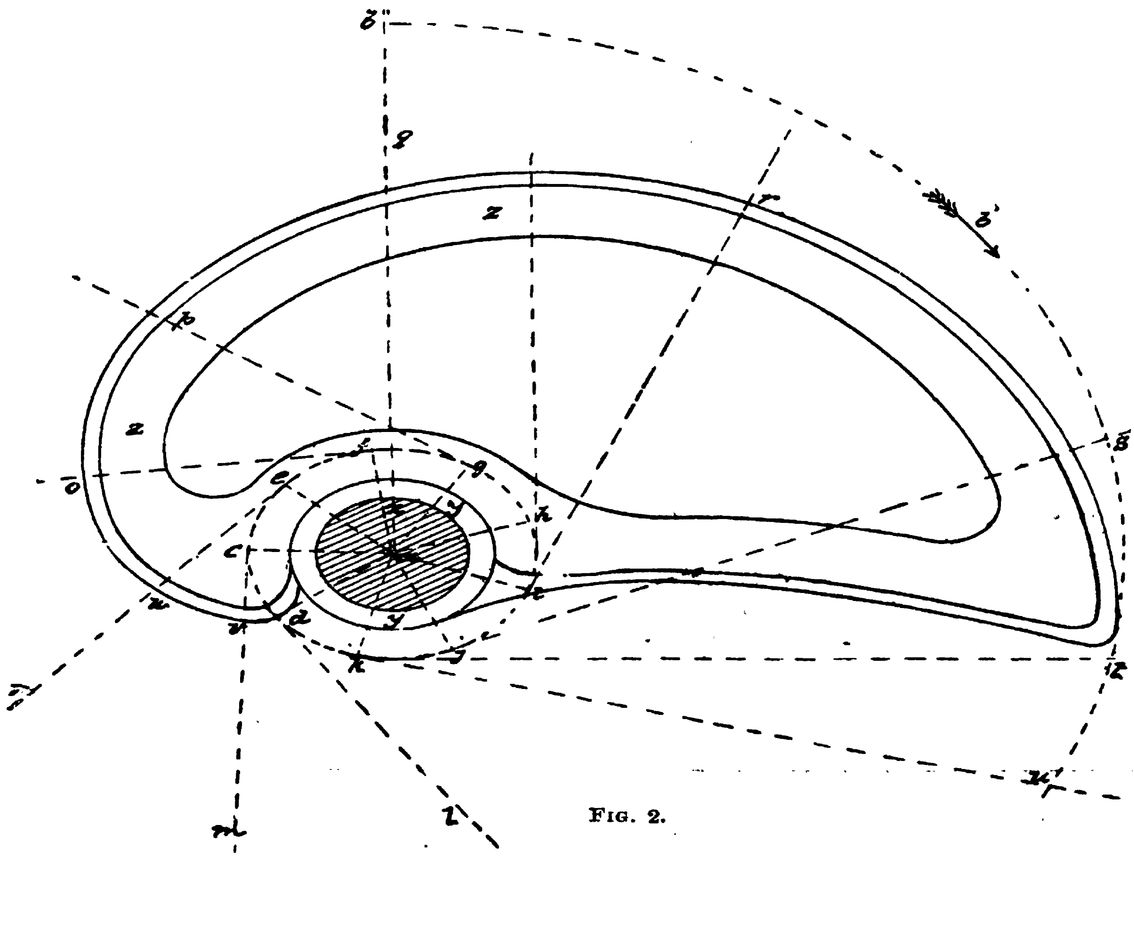
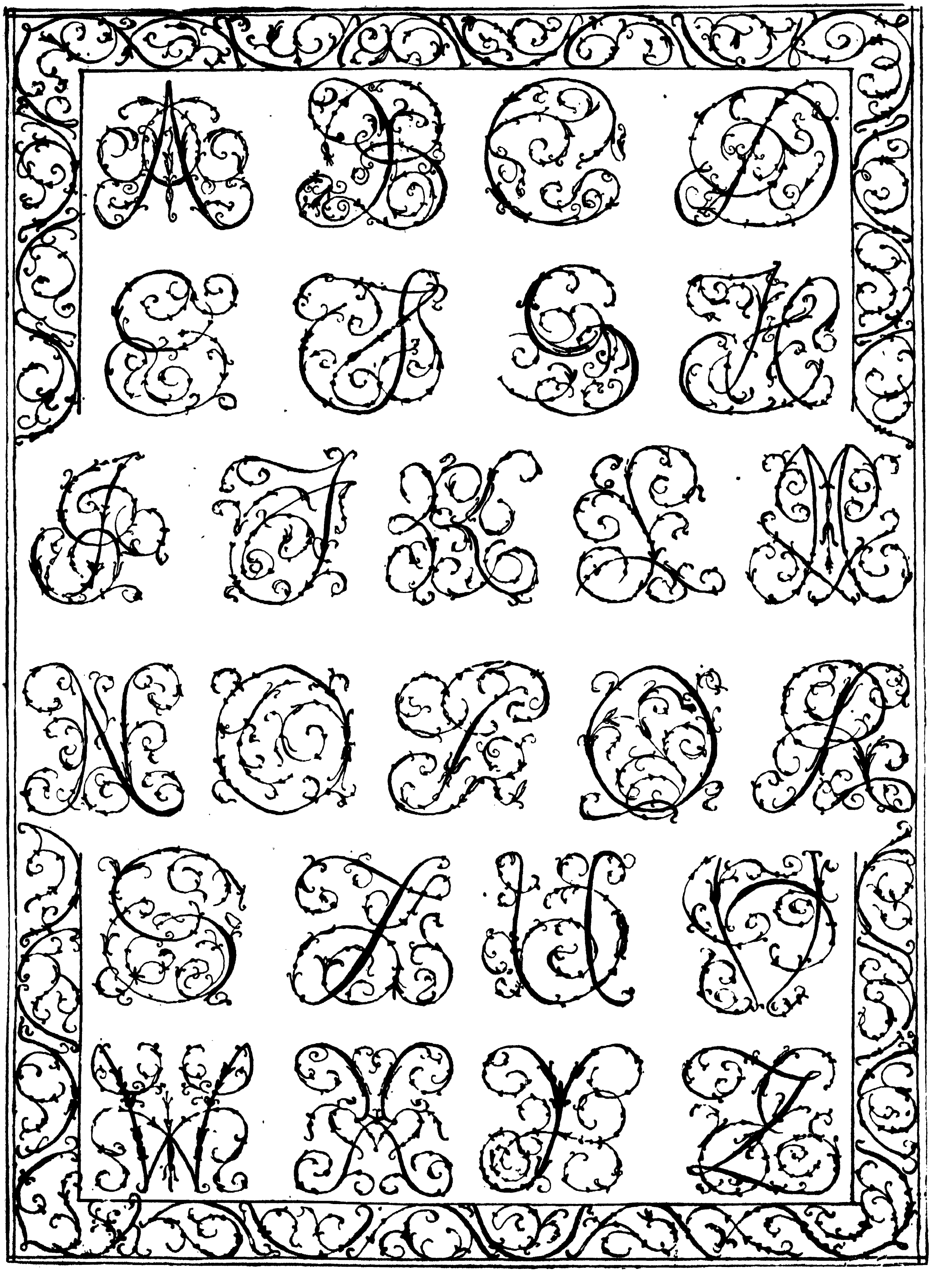


Fig. 2.

SUGGESTIONS FOR CAPITAL LETTERS.



THE BUILDING AND MACHINE DRAUGHTSMAN (*see Text*).

Coverings of Solids, Development of Surfaces, Domes, etc.

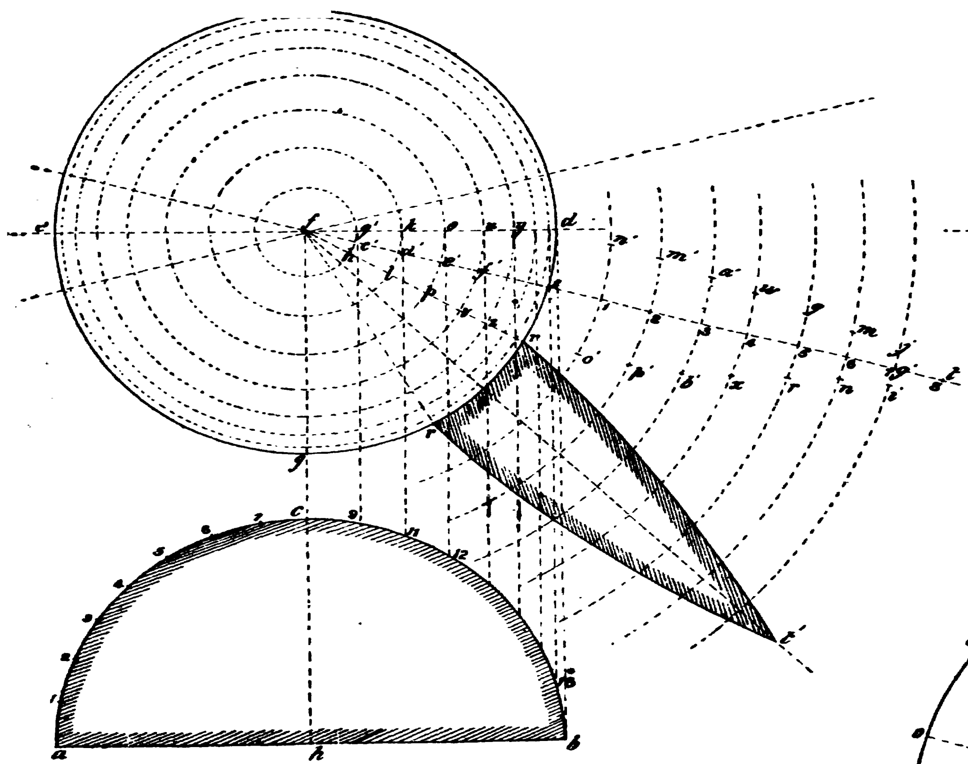


Fig. 1.

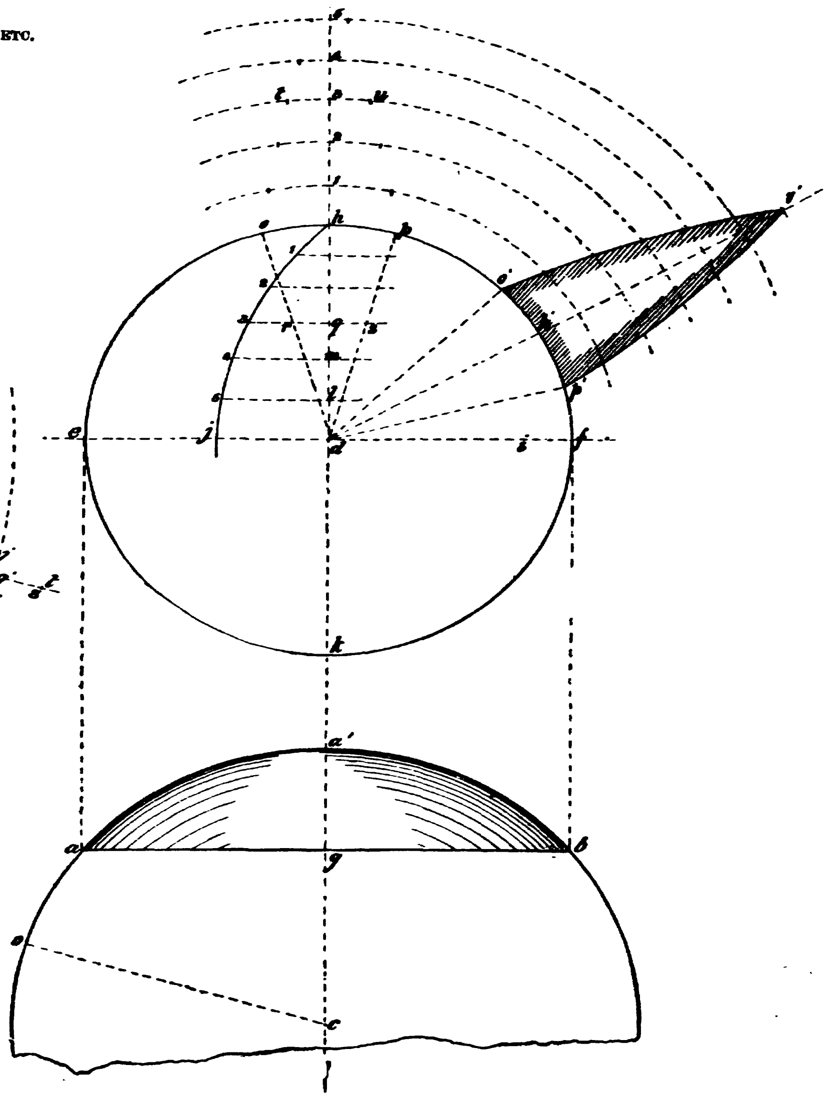


Fig. 2.

THE ALKALI MAKER AND HIS TECHNICAL WORK.

INDUSTRIAL IMPORTANCE OF HIS PRODUCTS—THE MAKING OF SULPHURIC ACID, SODA ASH, CAUSTIC SODA, SODA CRYSTALS, USED IN A WIDE VARIETY OF PROCESSES.

CHAPTER V.

Manufacture of Chlorine (*continued*).

WE concluded the last chapter by pointing out the objections offered to the process of making chlorine there described. To overcome these, very many processes have been patented, and the most signal success has attended the one patented by Mr. Walter Weldon, and commonly known as

(*c*) "The Weldon process."—In 1867, Mr. Walter Weldon introduced on the large scale the process now known by his name (and on which he had been working for some years), and in the following year it was in full operation at the works of Messrs. Gamble, in St. Helen's, and about twenty tons a week were made by means of it. The actual preparation of the chlorine depends on the same reaction as that of the previous process—namely, the action of hydrochloric acid on manganese dioxide; and the improvement consists in utilising the manganese chloride over and over again, instead of discharging it into the rivers as a waste product. The theory of the process is extremely simple. It was well known that manganese chloride solution when treated with an alkali (such as soda, potash, or lime) was precipitated as hydrated protoxide; and further, that this oxide on exposure to air took up oxygen and was converted into higher oxides of manganese. Now, the protoxide, when treated with hydrochloric acid, dissolves with formation of manganese chloride but *without* evolution of chlorine, whereas the higher oxides likewise dissolve with formation of manganese chloride and *with* evolution of chlorine. Mr. Weldon saw that if this oxidation of the protoxide could be carried on rapidly, the manganese liquor could be made to furnish over and over again a supply of manganese dioxide for the preparation of chlorine; and he attained this result by precipitating the manganese liquors with excess of lime and then blowing a current of air through the precipitated liquid. The precipitate so obtained is dissolved in hydrochloric acid, and furnishes a supply of chlorine and a fresh quantity of manganese chloride, which is again treated with lime and oxidised by a current of air. Theoretically the process should be quite continuous, but it need hardly be said that there is unavoidable loss (by leakage, etc.), and from time to time fresh quantities of manganese chloride have to be added to the original amount. The details of the process are as follows:—A stock of manganese liquor having been obtained by the previous process, is placed in a tank provided with an agitator, and treated with powdered chalk, which serves to neutralise the acid always present in the liquor and to precipitate the iron contained in the solution. After being allowed to settle, the clear liquid is pumped into a large upright cylinder, which is about half filled; lime is next added in sufficient quantity to decompose all the chloride of manganese, and steam is then passed through the mixture till it reaches a temperature of about 55° Centigrade. Air is then blown through the mixture, more lime is added, and the blast is continued until the precipitate has become almost black in colour, when the whole is transferred to a tank and allowed to settle. In the course of twenty-four hours the mixture is found to have separated into two layers of about equal bulk: the upper one is simply a solution of calcium chloride; the lower one consists of the recovered manganese or "manganese mud," and which when separated from the liquid portion is ready for the stills. These are much larger than those used in the preceding process, but are otherwise of similar construction. The necessary quantity of hydrochloric acid is first placed in these stills, and then the manganese mud is allowed to flow into them at a regular rate, and steam is at the same time passed through. The mud dissolves with great rapidity, and chlorine is continuously evolved, until all the acid has been decomposed, when the stream of manganese is stopped, and the warm contents are run off into the neutralising tanks placed below, and are ready to be again treated in the manner just described. The loss occurring in the process varies, of course, according to the care with which the operations are carried out, but may be taken as about 5 per cent. of the total quantity of manganese operated on, and must, of course, be made good from time to time by the addition of manganese liquor made in an ordinary still. The construction of the Weldon plant will be understood by a glance at the sketches in diagrams B and D, in fig. 13, which show one still, tank, etc.; but it will easily be understood that in practice several stills, etc., are worked by side by side.

Some idea of the revolution which the introduction of the Weldon process has brought about in the chlorine manufacture may be obtained from the following statistics:—In 1868 the annual production in Great Britain of chloride of lime and chlorate of potash was equivalent to about 40,000 tons of chlorine gas, while in 1877 the amount had risen to 120,000 tons, of which no less than 105,000 are made by the Weldon process. (See fig. 14.)

a a, tank for manganese liquor; *b*, cylinder in which the oxidation takes place; *c c c*, tank for the recovered manganese dioxide; *d*, Weldon still where the acid and recovered manganese meet and react on each other; *e*, well to receive the saturated liquor from *d*; *f*, pipe connected with a pump to raise the liquor to *a a*;

g, tank in which the lime and water are mixed with the aid of an agitator; *h*, pipe connected with a pump to raise the milk of lime to the cylinder *b*; *i*, pipe leading the air blast to bottom of the cylinder; *j*, openings through which the air escapes to the contents of the cylinder; *k*, pipes for discharging the contents of tank *a*; *l*, pipe for discharging the contents of the cylinder into tank *c*.

(*d*) The Deacon process.—The previous processes all involve the use of manganese dioxide, an expensive substance, which we have just seen can only be recovered by the use of elaborate plant. It was reserved for Mr. Henry Deacon, of Widnes, to introduce a process which requires none of this material, and in which the hydrochloric acid made by the decomposition of the salt is at once treated so as to yield chlorine. The reaction on which this process depends was discovered by Oxland in 1847. He showed that when a mixture of hydrochloric acid with air is passed over heated bricks, chlorine is evolved and water formed by the union of the hydrogen of the acid with the oxygen of the air. The reaction may be thus represented:—

Hydrochloric acid + Oxygen (from air) = Water + Chlorine.

$$4HCl + O_2 = 2H_2O + 4Cl.$$

It need scarcely be added that the chlorine evolved is not pure, but is mixed with nitrogen derived from the air. This reaction forms the basis of Mr. Deacon's process. He ascertained that when the bricks are coated with sulphate of copper the reaction is much more rapid and complete, while the copper salt is not materially affected even after long use. Theoretically the process is perfect, and involves no loss of material; the hydrochloric acid gas passes from the pans (fig. 8, page 177) to a tower packed with small fragments of bricks coated with copper sulphate and heated to a certain temperature; the escaping gas is a mixture of chlorine and nitrogen, and is at once led to the chambers to be absorbed by the lime. Unfortunately this beautiful process is difficult to carry out in practice, chiefly owing to the admixture of nitrogen, which so dilutes the chlorine as to render its absorption by the lime slow and incomplete. These difficulties were overcome by Mr. Deacon by the introduction of chambers specially adapted for his process, and which by an ingenious arrangement of shelves secured the action of the strongest gas on nearly saturated bleaching powder, while the diluted gas was brought in contact with fresh or nearly fresh lime.

The details of the process need not be described; they are somewhat elaborate, and, as we have already pointed out, the bulk of the bleaching powder produced is made by other processes. Suffice it to say that, but for the practical difficulties in carrying it out, no chlorine process yet introduced could compare with it as regards economy of materials.

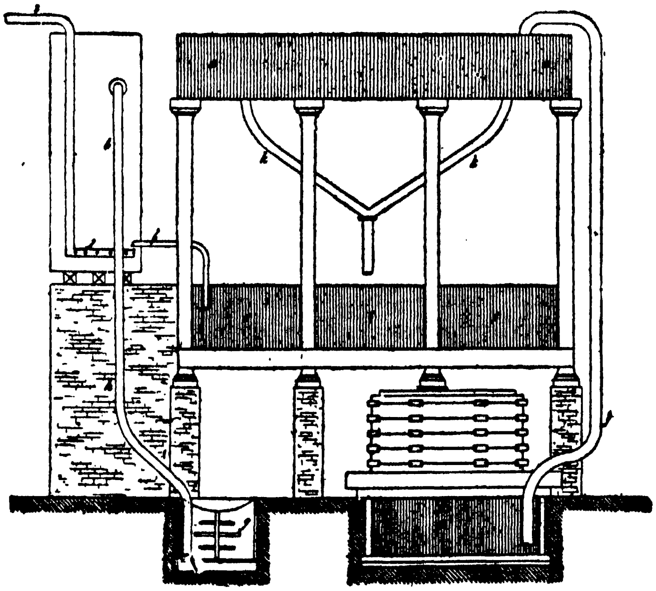


Fig. 14.

(*e*) Dunlop's process.—Only one other process dispensing with the use of oxide of manganese need be mentioned. It is due to the late Mr. Dunlop, of Glasgow, and is based on the fact that when nitric and hydrochloric acid are liberated together they decompose each other with formation of chlorine, oxides of nitrogen and water. The two latter are easily separated by means of strong sulphuric acid, and the purified chlorine is passed on to the bleaching powder chambers.

On the large scale the decomposition is carried out in the way which will be described in the next chapter.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER X.

Some Points connected with the Forms and the Reading off of Indicator Diagrams (*continued*).

TAKING the diagram in fig. 11 (*ante*, p. 227) as a representative or typical one, we may trace the various points of what may be called the progress of the steam from the beginning to the end of the forward stroke of the piston—the whole area bounded by the inner curved figure representing the energy, power, or effective work done by it. The point of admission is at *g* or *e* in the theoretical diagram; the point of cut-off is at *d* or *l*, and the period during which expansion goes on is represented by the distance *d e* or *l m*. On the line *m q p g*, which represents, as we have seen, the work or energy lost by the steam being expelled by the exhaust port, the point *p* represents what may be called the point of compression of the steam as it is forced up, so to say, against the end of the cylinder by the piston, and *q* that of back pressure. The mean effective pressure of the steam in the piston is an important element in the calculation of the indicated power as shown by the diagram. This mean pressure is obviously obtained by taking all the figures indicating the pressures on all the ordinates as that —25 lb.—on the ordinate *j n*, fig. 12 (*ante*, p. 229), or, what is the same thing, measuring the heights, as *j n*, from the scale of pressure, as *a b*, till those figures are added together and divided by the number of the ordinates, which thus gives the mean of the whole; which is the mean effective pressure as per square inch, which we shall call *p*. The next of the data required in estimating the indicated horse-power off the engine is the area of the piston in square inches, which we shall call *a*; next the length of the stroke, which we call *s*; and last, the number of revolutions per minute. These data being known, multiply *a* by *p*, and by twice the length of the stroke, and by *r*, and divide the product of these amounts multiplied into each other by 33,000, which gives the indicated horse-power. Further calculations will be found in future paragraphs; but we must here remind the reader that the indicated horse-power thus found by the aid of the diagram or indicator figure does not give the effective power of the engine capable of being used for driving machinery, etc., etc. The horse-power thus found by the calculation above given represents only the effective power given out by the piston, or that at which the piston moves: large deductions have to be made for the power absorbed by friction of the moving parts of the engine itself, the working of the pump, etc. For all these an allowance of from one-fourth to one-fifth of the indicated power must be made, which deducted will give the available effective power of the engine for actual work. Some authorities deduct as much as one-third of the indicated horse-power, leaving only two-thirds for effective, practically working power. It may be said in favour of adopting this high percentage of the indicated power for deduction, that it will be thoroughly safe, and will give a considerable margin of power to fall back upon; and it is always wise to have a pretty good margin,—over-driving of machinery is never a good thing. We have alluded in a preceding paragraph to the defects, or at least the irregularities, in the diagram given by an indicator due to the bad working or arrangement of the indicator itself, its friction, and the oscillations produced by one cause or another. But the cause of the real or true defects is the behaviour or action of the steam brought about by different causes. In connection with fig. 11, p. 227, we stated that the change from the theoretical form *g e k* to the rounded curve *g k* was caused by the valve admitting the steam to the port and cylinder moving gradually and not opening quickly. But from the very nature of the valve movement, when it is a slide valve, its motion is gradual, not instantaneous, like some forms of "dead beat" lifting valves. Again, in closing, as when the cut-off at point *d* is effected, the same gradual motion is met with. The loss of pressure sustained in and by the steam passing from the steam chest to the cylinder through the port is gradually increased, so that the pressure gradually diminishes up to and beyond the closing of the valve at the cut-off point. This gives the falling curve *k l*, *m* being the curve of expansion. These two curves give the double curve, or a curve of contrary flexure, *l k g*, to which we have in a preceding paragraph referred, the point *l* of which represents the point at which the cut-off is actually effected—that is, when the valve is completely closed—and of this double curve the convex line *l k* represents the curve produced by the action of the valve at the port—which produces the effect of wire-drawing or throttling the steam—and the concave curve gives the line *m l*, which, as we have said, is the expansion curve. What is called the effective cut-off point is found by prolonging the line of expansion curve *m l*, as shown by the dotted line *l r*, cutting upper line or line of length of stroke, *c f*, in the point *r*, which point is that of effective cut-off. In a preceding sentence in present paragraph, we pointed out in connection with fig. 11 the point *p* in the path of the steam behaviour, or action in the cylinder, as shown by the curve of the diagram, as that known as the "point of compression"; this being sometimes termed the "cushioning." It is brought into existence by closing the exhaust port before the completion of the backward or return stroke. As this arrests the flowing out of or passing away of the steam from the cylinder, it is equivalent to keeping back or retaining a certain volume of steam; and as the piston proceeds in its return or backward stroke it of necessity compresses this confined steam against the end of the cylinder; and the consequent rise of its pressure is represented by a curve something like that shown in fig. 11 at *p g*. In the theoretical diagram this cushioning or compressing curve terminates at *c*, and this represents the most economical amount of it, which prevents any loss from "clearance." By this last term is meant, in the ordinary acceptation of the term, a space left at the ends of the cylinder at which the piston actually stops—that is, does not move forward into. This, it will be perceived, gives a certain amount of "clear" or void space in the cylinder, in which steam is retained, and which acts as an elastic "cushion" tending to ease the motion of the piston at the time it reaches the end of the stroke, and before it changes the direction of its motion to take the return stroke. And the void spaces thus left, or "clearances" at the ends of the cylinder, prevent the piston from knocking up against the ends of the cylinder. Clearance, however, in the extended and more accurate sense, includes not only this void or clear space here named, but also the cubical space of the ports or channels at the valve, leading the steam from the valve face and steam chest to the interior of the cylinder; these spaces have obviously to be filled with steam, as well as the clearance spaces proper,—so that they all have an influence in the cushioning or compressing points, as above described. As this compressive action is produced, as we have just seen, by closing the exhaust port before completion of the backward or return stroke, thus confining a certain portion of the steam within, and preventing it from passing from the cylinder—so conversely, by arranging to open the exhaust port before the forward stroke is completed, what is called the "release point" of the diagram is produced. As the point of compression or cushioning, *p* in fig. 11, is of course on the lower line (*m q p*) of curve, which represents the path of return or backward stroke, so the "point of release" must be on the upper line of curve, as *m l o k*, representing the path of the forward stroke—this point of release being, say, at *s*; and such that about one-half of the amount due to force of the pressure shall occur at the completion of the forward stroke, the other half of this amount at the beginning of the backward or return stroke; this will give the curve, as *s m t*.

Practical Illustrations of and Remarks upon different Forms of Indicator Diagrams or Figures.—Condensing Engines.

We now present to the reader diagrams of different forms which have come within the range of our own experience. As we have just seen in preceding paragraphs, the principal changes in the forms or varieties of the forms of diagrams owe their existence chiefly to the action or behaviour of the steam; and this is controlled by the valves.

Some of these effects of the valves may be here stated: as when the steam comes on too soon or too late; if the exhaust is too soon or too late; if the steam is on the piston to the end of the stroke—*i.e.*, from the top of the cylinder to the bottom of it in a vertical engine, or *vice versâ*; or if it can be ascertained at what part of the stroke the steam is cut off—*i.e.*, where the valve closes the port through which the steam passes to the cylinder before the piston gets to the bottom of the cylinder.

We first take up the diagrams taken from a condensing steam engine, such form of engine being in

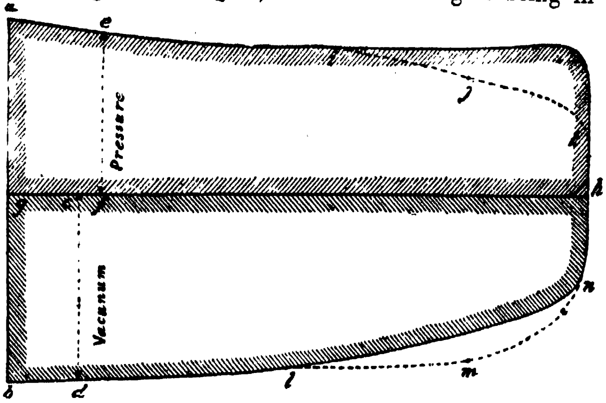


Fig. 13.

general use in the manufacturing districts. The condenser consists of a cylinder which is in connection with the side pipes or other arrangements for conveying the spent steam from the steam cylinder, and there the steam is condensed, and thus a vacuum is formed.

Fig. 13 is the diagram of a steam engine fully loaded. In this *a b* is the end at which the steam goes in, *c d* the "vacuum" space, *e f* the steam space above atmospheric pressure, *g h* the atmospheric line. The diagram also directs our attention to the manner in which the steam is continued during the whole stroke of the engine—*i.e.*, there being no expansion of steam, the full pressure of it is carried on to the end of the stroke. Now, it will be seen that a considerable quantity of steam is at the end of the diagram above the atmospheric line, and that has to be condensed. It is not getting the full value out of the steam, as will be observed; but it is overloading the condenser, and thus the vacuum is deficient, which is a loss by involving the necessity to consume more fuel. If the steam valve were so arranged as to be closed when the engine had gone two-thirds of its stroke, the dotted line *i j k* on the steam side would be as is shown on fig. 13, and what was lost in power by closing the valve sooner would be gained in the vacuum or dotted line *l m n*, as marked. Whatever is gained in the vacuum is a saving in fuel, because less steam is needed to perform the work required. This is working expansively as far as can be done

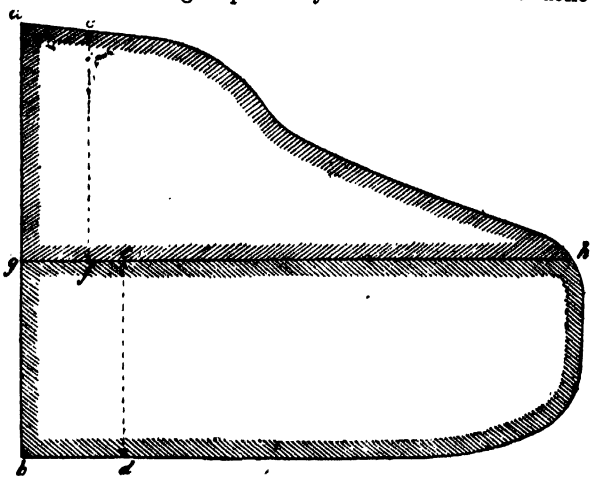


Fig. 14.

under the circumstances. If a higher pressure of steam could be procured, a very different diagram would be produced (fig. 14), with a higher pressure of steam on the piston and the steam cut off at one-third the stroke. The remainder of the stroke is worked by expansion, and therefore a less quantity

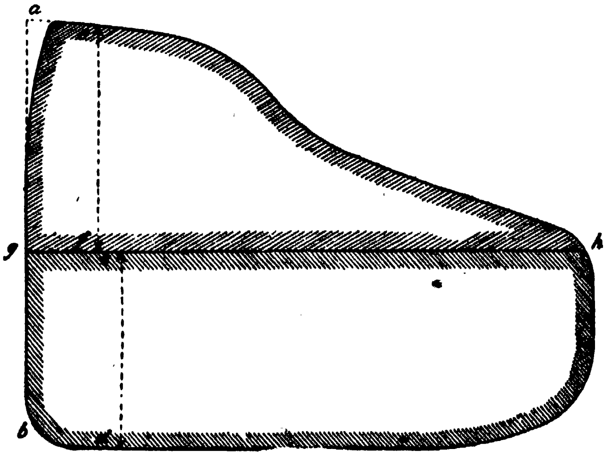


Fig. 15.

of steam has to be conveyed to the condenser, and the vacuum is more perfect throughout the length of the stroke. In this case much saving in fuel would be effected. It will be observed how straight the line is at the commencement of the stroke: this denotes the steam going on soon. When an engine is heavily loaded the steam is mostly arranged to go on to the piston soon—*i.e.*, on or before the piston is ready to return. It often causes a little knock on the engine.

Fig. 15 is a diagram representing the steam as being admitted a little later, and the line is a little rounded or curved on the steam side. The later the steam is admitted, the more the line is curved. It is also as well for the corner or end of the vacuum line to be rounded.

When steam is admitted early on to the piston it is termed "bad"—*i.e.*, the steam valve is open before the piston arrives at the point to return.

We wish our readers to fully understand how certain changes arise with the different arrangements of the valves. If the steam valve opens before the piston arrives at its turning point it gives a straight line to the diagram on the steam side of the atmospheric line. If the steam is admitted on to the piston after it has returned, then the line above the atmospheric line will be curved. In the vacuum it is

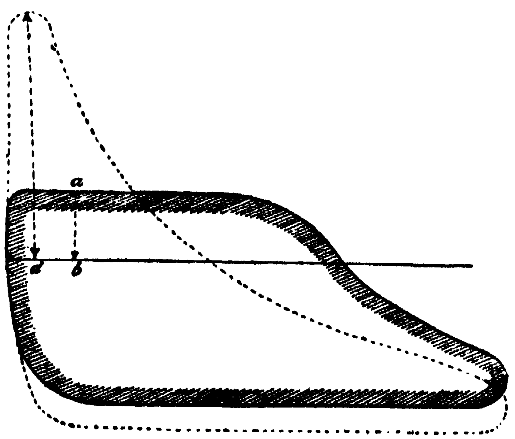


Fig. 16.

just the reverse, looking at it at the same end of the diagram. If the exhaust valve is kept open late the line will be straight, but if the valve is closed before the piston arrives at its turning point the bottom part is curved or cut off. The exhaust valve being opened sooner helps to take off the spent steam more quickly, and therefore produces a better vacuum at the commencement of the exhaust.

The following diagram in plain line in fig. 16 is on the principle of very little expansion; the dotted line represents great expansion. The line diagram only has about 5 lb., from *a* to *b*, of steam pressure above the atmospheric line, and therefore it cannot work very expansively with the load it has to carry. The dotted line *c d* has a pressure above the atmospheric line of about 18 lb. In one case there is but a low pressure in the boiler, in the other a much higher pressure—probably a new boiler. It is immaterial how the extra pressure is obtained, so long as the result is gained. An additional vacuum is certain to be the issue. Any increase in the vacuum of a steam engine means economy. Expansion of steam also insures the full value being taken out of it. (See fig. 16.) If a boiler be capable of furnishing a high-pressure steam, all steam engines are not constructed to withstand the strain which would be the result of so working it. If the working parts of the engine are not sufficiently calculated for so sudden a force, the result would be disastrous. Old engines are seldom adapted for such changes. New engines are generally made sufficiently strong in those parts most affected by extra pressure of steam.

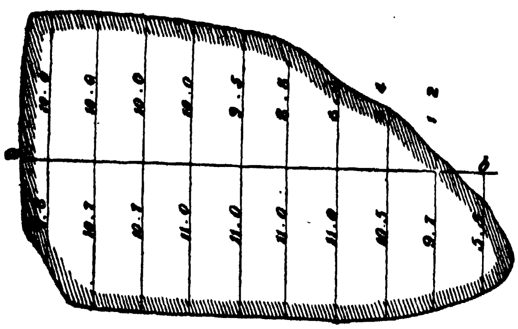


Fig 17.

The two diagrams we now present will appear somewhat contradictory. Fig. 17 was taken when all the machinery was in full motion, which accounts for the largeness of it in comparison to fig. 18—the latter diagram having only the friction of the engine and shafting in the works to provide for.

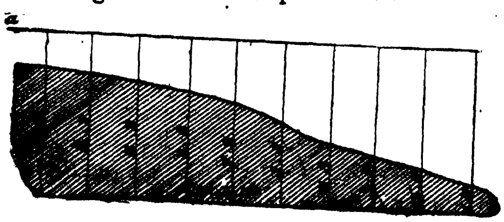


Fig. 18.

For example, take the diameter of the cylinder as 30 in., length of crank 2 ft. 6 in., which makes a 5 ft. stroke and 35 strokes per minute.

```
        30 inches.
        30    "
       ----
       900
      ·7854
    ---------
    706·8600
        350 (no. of ft. per minute.)
    ------------
    3534·30000
   21205·800

  33,000)2474·010000(7·5
         231
        ----
        ·164
```

The average pressure of steam and vacuum on fig. 17 is 16·88 multiplied by the above:—

```
    16·88
     7·5
    -----
    8440
   11816
   ------
   126·600 horse-power.
```

The average pressure of the engine shafting being 5·93, and multiplied by the above 7·5, gives the result in horse-power:—

```
    5·93
     ·75
    ----
    2965
   4151
   ------
   44·475 horse-power.
```

The two foregoing examples will serve in casting up diagrams, and also show the form of calculating to ascertain the needful figures to multiply into the average pressure which is upon the diagrams, and thus to arrive at the horse-power which is exerted by the steam engine.

The total power on fig. 17 being 126·6 indicated horse-power,—

Engine and shafting on fig. 18 being 44·47 indicated horse-power,—

Take 44·47 from 126·6, leaves 82·13 indicated horse-power for machinery.

It is a common custom to accept $\frac{1}{3}$ or $\frac{3}{10}$ for engine and shafting. The different arrangement of shafting causes the variation.

We need scarcely allude to the "ten" we divide by. Whatever number of divisions we divide the diagram into, we must also divide the sum total by the number of divisions (or "ordinates"—see a preceding paragraph, and figs. 11 and 12) to obtain the average pressure.

It has often been said that to have the form of a Wellington boot in a diagram is the surest way to show that in the working of the engine we are having economy. We have before said that such cannot be done except in situations which are favourable. Want of boiler pressure; heavily loaded engines, and engines not calculated to bear the extra strain, introduce great variations in the diagram.

High-Pressure Engines.

A high-pressure or non-condensing engine is of much simpler construction than that of the condensing engine. It has its advantages, and it also has its disadvantages. Condensing engines must be provided with a very liberal supply of cold water. Less water is required for a boiler in the working of condensing engines, but a considerable supply is needed for condensing the steam.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER VII.

UNDER the head of "Testing Iron Ochres," at end of last chapter, we stated that a certain process would yield a copious deep-blue precipitate; under this head we may remark that a *slight* blue precipitate would not indicate any appreciable percentage of iron, as the test is delicate, and this would probably not be an essential ingredient of the pigment. Iron is estimated by dissolving in acid, precipitating with excess of caustic soda, then collecting the precipitate, drying, igniting, and weighing, as Fe_2O_3.

Chromate of Lead Yellows.

The chromates of lead are largely-used pigments, varying in shade from pure canary yellow to deep red-orange and even scarlet, according to their composition and the methods used in their preparation. Neutral chromate of lead is of yellow shade, but varying very greatly in shade without differing in composition; the basic chromate of lead is more or less orange, and may even be of scarlet colour. A lead yellow of lemon colour is one of the most difficult of all pigments formed by precipitation to obtain. When a soluble salt of lead and chromate or bichromate of potash are mixed, a beautiful yellow heavy precipitate forms. If the solution be very *dilute* and the lead salt be in excess, and the two mixed slowly in the cold, the product obtained is of lemon colour. Hot concentrated solutions form orange chromates.

The formation of the yellow chromate is represented in the following equation:—

$$K_2O(Cr_2O_3)_2 + 4Pb(C_2H_3O_2\cdot)2H_2O = 4PbO\cdot CrO_3 + 2K(C_2O_2H_3)_2$$

399	+	1204	=	1292·8	+	310·2
Bichromate of potash.	+	Acetate of lead (crystals).	=	Chromate of lead.	+	Acetate of soda.

We have always found it better to neutralise the bichromate of potash with alkali previous to precipitation. The action of carbonate of potash on bichrome is seen in the equation:—

$$K_2O\cdot(Cr_2O_3)_2 + 3K_2O\cdot CO_2 = 4K_2CrO_4\cdot$$

Bichromate of potash.	+	Carbonate of potash.	=	Monochromate of potash.

If the above proportions of chrome and lead be used, and both be highly diluted, on mixing a beautiful bright pigment of pure lemon-yellow colour is precipitated. This is washed in water and put in the filter press, and converted into a thick pulp. We have frequently known this pulp, prepared apparently with the utmost care, to turn orange on mere exposure to the air.

Orange and Red Chromate of Lead.

This pigment has the formula $PbO\cdot PbCrO_4$, and may be obtained by the action of alkalies or lime on the neutral or yellow chromate. A portion of the chromic acid unites with the alkali or the lime, and on washing the remaining precipitate it is found to be of the above composition and of orange colour, which becomes deeper and of redder hue by cautious heating. It is also formed by precipitating strongly alkaline solution of chromate of potash with a lead salt—preferably the nitrate—the greater the amount of free alkali, the more orange in shade is the precipitate, until it is of scarlet colour and crystalline. Another method of obtaining orange chrome is to fuse the neutral chromate with excess of nitrate of potash in a crucible over the open fire, a product of deep orange-scarlet being obtained. Another method of obtaining orange is by prolonged boiling of sulphate, chloride or carbonate of lead with a strongly alkaline solution of chromate of potash. A method which we have found to yield a good moderate shade of orange from sulphate of lead pulp is as follows:—Heat 47 lb. lead sulphate pulp, and add gradually, with constant stirring with an iron rake, 10 lb. of 48 per cent. soda ash; add gradually about 5 gallons water; boil until effervescence nearly ceases, and boil with 10 lb. bichrome. Continue to boil for several hours, replacing the water of evaporation. After repeated washing place in the filter press. Chromate of lead obtained in this manner, it need hardly be mentioned, contains unconverted sulphate of lead, and is not nearly so finely divided as the products obtained by precipitation. It is nevertheless a useful pigment, and applicable for all except fine work.

Testing Lead Yellows.

Chromate of lead is tested-for, qualitatively, in the following simple manner:—Heat with moderately strong caustic soda solution—a *white* precipitate and yellow liquid are formed, and dilute; add now sulphide of soda or ammonia to the mixture, and it goes black; heat another portion of the pigment with strong hydrochloric acid—the colour is destroyed; a white precipitate (best seen on diluting with water) is formed of chloride of lead, and a *green* liquid, due to the chloride of chromium, formed. Chromate of lead may be estimated, accurately enough for most practical purposes, by dissolving in very strong caustic soda (which completely dissolves), filtering, and diluting the filtrate, and adding acetic acid in excess, when the whole of the chromate of lead is precipitated, and may be collected on a filter and weighed.

Zinc Yellow.

The disadvantage of turning black on exposure to a sulphurous atmosphere possessed by lead yellow is entirely absent in this pigment, and hence it is largely used as an artists' colour. Zinc yellow (chromate of zinc, $ZnCrO_4$) is a stable pigment of a pure, bright lemon-yellow shade, almost insoluble in water, and although not absolutely fast, is not acted on by moderately prolonged exposure to light and impure air. It is much inferior in density to chromate of lead; otherwise it would supersede the latter pigment to a much larger extent than it does. It is obtained by the gradual addition to a perfectly neutral hot solution of sulphate of zinc of neutral chromate of potash,—a brilliant yellow precipitate of a canary-yellow colour is precipitated as a fine powder. This is washed well by decantation, and filtered. It generally retains a small proportion of potassium, unless the washing be conducted as speedily as possible—forming, in fact, a double chromate of zinc and poatssium, which is slightly soluble in the water, and which imparts an orange tinge to the product. To obviate the formation of this double salt, which is antagonistic to obtaining a "pure" yellow, both liquids should be moderately dilute, and the first water run off as soon as settled sufficiently to allow of half being drawn off.

It is, as already stated, largely used by artists—under a variety of fancy names—and has been proposed, but without encouraging results, to be used in calico printing and paper staining.

The presence of lead yellow in this pigment is readily detected by dissolving in caustic soda and adding sulphuretted hydrogen, when the precipitate obtained will be dark-coloured in the presence of the former pigment.

Baryta Yellow.

The neutral chromate of barium, $BaCrO_4$, generally known as "lemon yellow," is a pigment of great value to the artist, and extensively used, being, like the last-treated compound, not acted on by sulphurous fumes; like it, too, it is inferior to lead yellow as regards density, though heavier than zinc yellow. Chromate of baryta is readily destroyed by the action of dilute alkalies, and hence is inapplicable as a pigment in calico printing, as it is not "fast" to soap. It is very fast to air and light. In the trade it is sometimes known as an artists' colour under the absurd name of "yellow ultramarine"; also as "lemon yellow," but this latter name is also applied to lead yellow.

To prepare baryta yellow, chloride of barium ($BaCl_2$) is carefully precipitated with chromate of soda or potash, care being taken not to add an excess of the latter.

Neutral chromate of strontium, $SrCrO_4$, possesses similar properties to the barium pigment, and can claim no advantages over it.

Lime Yellow.

Neutral chromate of lime ($CaCr_2O_4$) may also be used as a pigment. It possesses somewhat the same shade as the corresponding barium salt, but has no advantage over it—or rather is inferior to it, being even when carefully prepared, slightly soluble in water—and hence is rarely used. As an artists' colour it is not to be recommended; it is known as "Gelbin's yellow." It is obtained by mixing calcium chloride and chromate of soda and adding ammonia until the mixture ceases to throw down a yellow powdery precipitate. The latter is then washed, collected, and heated to 200° C., by which treatment it is rendered more uniform and stable. It is then ground, washed, and filtered.

Orpiment.

Trisulphide of arsenic, As_2S_3, is a well-known yellow pigment, now seldom used. The fact of its containing arsenic is sufficient, apart from indifferent claim to beauty of shade and durability, to debar it from extensive use. It is of a pale, orangey-yellow colour. It is sometimes called "King's yellow." It nearly always contains free arsenious acid, which renders it highly poisonous. It is best prepared by passing sulphuretted hydrogen through a hot and somewhat concentrated solution of arsenate of soda until in excess, when dilute hydrochloric acid is added and the whole boiled. The yellow copious flocculent precipitate is washed by decantation and filtered. It may be prepared by heating flowers of sulphur and arsenious acid, and this is the usual but less preferable mode of preparation.

"Mineral" Yellow.

When arsenious oxide or white arsenic, As_2O_3, is fused with litharge, and the resulting mass powdered, it forms what is called "mineral" or arsenic yellow, $PbO + As_2O_3$. It is similar in shade to orpiment, and rather more stable; but otherwise possesses the same disadvantages as the latter pigment, with the additional ones of being blackened by copious sulphur fumes, and of more irregular composition. It has fortunately fallen out of use.

Antimony Yellow.

The sulphide of antimony, Sb_2S_3, corresponding to that of arsenic (orpiment) treated above, has been used as a pigment, being of a shade somewhat similar to the latter. It has fallen out of use, however, superseded by better pigments.

A soluble antimony salt (tartar emetic) has found a somewhat extensive use in pigment making, to add to lead yellows to prevent them from turning black on exposure to sulphurous fumes. The action is simply that the yellow sulphide of antimony is formed instead of the black sulphide of lead, when the pigment comes in contact with sulphur. If more sulphur be applied than suffices to unite with all the antimony present, then blackening ensues, owing to formation of lead sulphide.

THE YOUNG ARCHITECT OR ENGINEER.

His Studies—Office Duties—and Practical Work in the Preparation of Working Drawings, of Specifications, and Contracts for Work.

CHAPTER VIII.

The Sections of the House.

Fig. 9 is the "cross or transverse section" on line C D in figs. 2 and 3; Plate CLI. the "longitudinal section" on line A B in figs. 2 and 3. The scale to which all the drawings are made is given in fig. 5. It is not a regular scale, but one adopted to suit the size of the space in our pages. In practice the drawings should be made to a regular scale; a very useful one, and one very largely employed, being eight feet to an inch, or, as it is perhaps more generally named, one-eighth of an inch to the foot, often also designated as a one-eighth scale. Another scale pretty often adopted is ten feet to the inch, in which the inch is divided into ten equal parts, each of which denotes a foot (see the "Building and Machine Draughtsman" papers in this work for remarks on scales).

Extra Drawings to be prepared by the Young Architect.

In addition to the various drawings required for the erection of a building in towns and districts, having building Acts or legislative enactments corresponding to these, a number of drawings are required for the purposes of these Acts; and where the structure is at all costly and complicated in design, the number of such drawings is extra to those which in ordinary and other circumstances would suffice for the actual work of erection. These extra drawings will be described under the following heads:—

(1) *Drawings to be deposited with the local authority* (Corporation, Local Board, Vestry). (2) *Large-scale and full-size details.* (3) *Duplicates* or *tracings* for the clerk of the works or contractor.

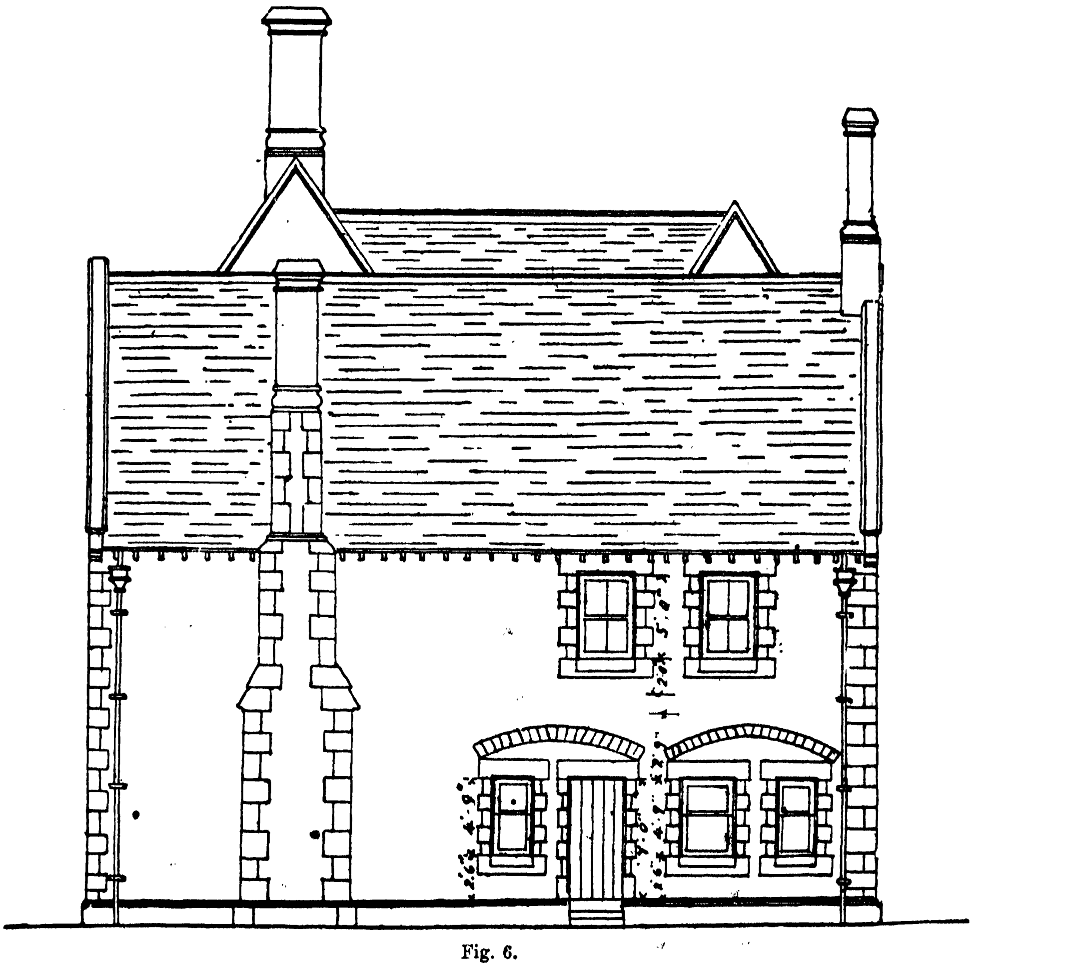


Fig. 6.

Corporation or Local Board Drawings.

(1) The drawings for every new building proposed to be erected within the jurisdiction of any corporation, local board, or other authority, as well as the drawings of all alterations of or additions to existing buildings, must be prepared in accordance with certain bye-laws and building regulations, which vary con-

siderably in even adjacent localities. The general object of these regulations is to prevent the erection of badly constructed and drained property, to preserve a uniform line of street frontage, to prevent encroachment on the line of the public footpath, and to facilitate the removal of ashes and refuse.

In addition to the special bye-laws and regulations of local authorities, there are several important Acts of Parliament with which every young architect should make himself familiar. The Public Health Acts, 1875, 1878 and 1879, have been published, with an ample index in a compact form, by Messrs. Knight and Co., Fleet Street, London; price 3*s.* 6*d.* Other Acts contain important regulations with reference to the planning of buildings, as for instance lunatic asylums, handbooks of which have been issued by the same publishers. (*a*) The Metropolitan Building Acts, (*b*) The bye-laws as to buildings, etc., of the City of Manchester, (*c*) The building regulations of the Borough of Bradford, and (*d*) the bye-laws of the Moss Side Local Board of Health, are typical examples of the various regulations to which the architect must conform in different districts. If the site of a proposed new building or an addition to or alteration of an old one is within the jurisdiction of any local authority, the architect must before commencing his contract drawings obtain a copy of the bye-laws, and must whilst preparing them conform in every way with their requirements. In probably all cases the first is as follows: A certain number of the contract drawings, or duplicates in some cases on tracing cloth, must be deposited with the authority, and certain written notices given of the intention to build. These drawings and notices are generally examined by a permanent official; if they conform with the bye-laws they are submitted to a building committee, and after being signed by the chairman, permission is given to the architect to proceed with his work. The drawings which have to be submitted vary in different localities.

Fig. 7.

THE ORNAMENTAL DRAUGHTSMAN.

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER XV.

THE true workman need not to be ashamed, but for him it is still necessary to learn patient labour by going to the ant, painstaking completeness from the flower of the field or the clods of the valley.

This, then, is the shape which we hold this question of truthful detail to assume—"That which is worth doing at all is worth doing well;" and he who pretends to draw a rose should in everywise represent it so that we can distinguish it from a poppy or a dahlia. If he be not willing so to represent it, let him in no case put what is not truthful on his canvas or his paper, but let him consider whether it will not be better to leave such untruth out altogether. This does not, of course, as we have already said, preclude or forbid the artist to conventionalise any natural form, any more than it denies him the right to give us some representation of the workings of his imagination, however strange his fancies may appear, unlike aught that is in earth or air or sea. Only let the conventionalising he does be so done that it tells its own story, and plainly doing so is not likely to convey an untruth; at all events so represented that it will be at once known that he does not mean to deceive. As for the pencillings of his fancy, there is little chance of their being taken for truth.

We commenced by saying that the art of Drawing is concerned with the representing of any object. But in order that we may represent, it is of the highest importance that we shall first *know* what it is we really wish to represent. In other words, the first thing the artist, or draughtsman—we take the terms to be synonymous, as no one deserves the title of draughtsman who is *not* an artist—ought to do, is to acquire a knowledge of the object to be represented. And there are two or three points in relation to the character of this knowledge which we shall examine, now that we have practically drawn the student's attention to the objects of it. It is essential to the reader as an art student that these said points should have his best attention, that kind of attention which he would bestow on some object he was determined to win for himself.

We remark, then, in relation to this knowledge, that it should be an acquaintance with the highest or representative specific forms of the things the artist or ornamental draughtsman wishes to draw. Let the student mark the words. We do not write anything in this sentence but what we mean. "Highest or representative specific forms" are what is necessary; the student should know minutely, —in a word, perfectly. Not "individual" forms, not a knowledge of the shape of every cloud in the sky you gaze in wonder or in awe at, or of the smallest curves in your tarn, or of each leaf on your tree, each grass-blade in your field. Not that you should "count the hairs on a donkey's hide, or the spicula in a haystack," and with Flemish patience seek to draw them, until you throw up the pencil in disgust, and cry "Vanity of vanities—this *is* a vexation of spirit!"

Let us understand, then, minutely, the character of this specific knowledge. We would define it, in reference to art, as "an exact acquaintance with the most perfect forms of those species of objects which enter into pictorial composition, or into any specific work which popularly, if not accurately, is called a design." Thus, in a noble landscape the trees will be noble, quite different in every essential point, as much from the small niggling of certain schools of art, as the outrageous blurring or blotting work of others. The artist draughtsman will draw his rocks so that we may not only be able to say whether they belong to the older or newer formations, but that we may feel their sublimity or their ruggedness—characteristics of which some artists of the old school seem to have been altogether ignorant. In a word, the artist will represent those objects in his landscape which will most conduce to nobleness in general plan, nobleness in truth of highest detail.

We remark, also, in relation to this knowledge, that, whilst entirely distinct from that acquaintance with mean and vulgar individuality which characterises generally the work of some artists, it should still be minute, and extend to the specific character of every object represented. It is necessary, we repeat, that this knowledge should be minute, and extend to the specific character of everything represented. In other words, in drawing any object, the artist should know what he *is* drawing. He should not be influenced by vague conjecture, or an indefinite hope that the drawing will "come out right in the end." The specific idea should be distinct from every other idea, and should stand out clearly before the artist's mind with all the definiteness and precision which results from this treatment—as something known, something understood. The "motive and guide" should not be the "intellectual initiative" which is required in inductive experiments, but the settled conclusion of a syllogism, whose major and minor premises the artist is thoroughly acquainted with, and of the correctness of which he is as assured as of the correctness of a mathematical axiom. He should know and represent with equal certainty. Every object he draws will be thus understood by him; and he will by no means draw it unless he thus understand it. Indeed, it will be infinitely more correct to say that

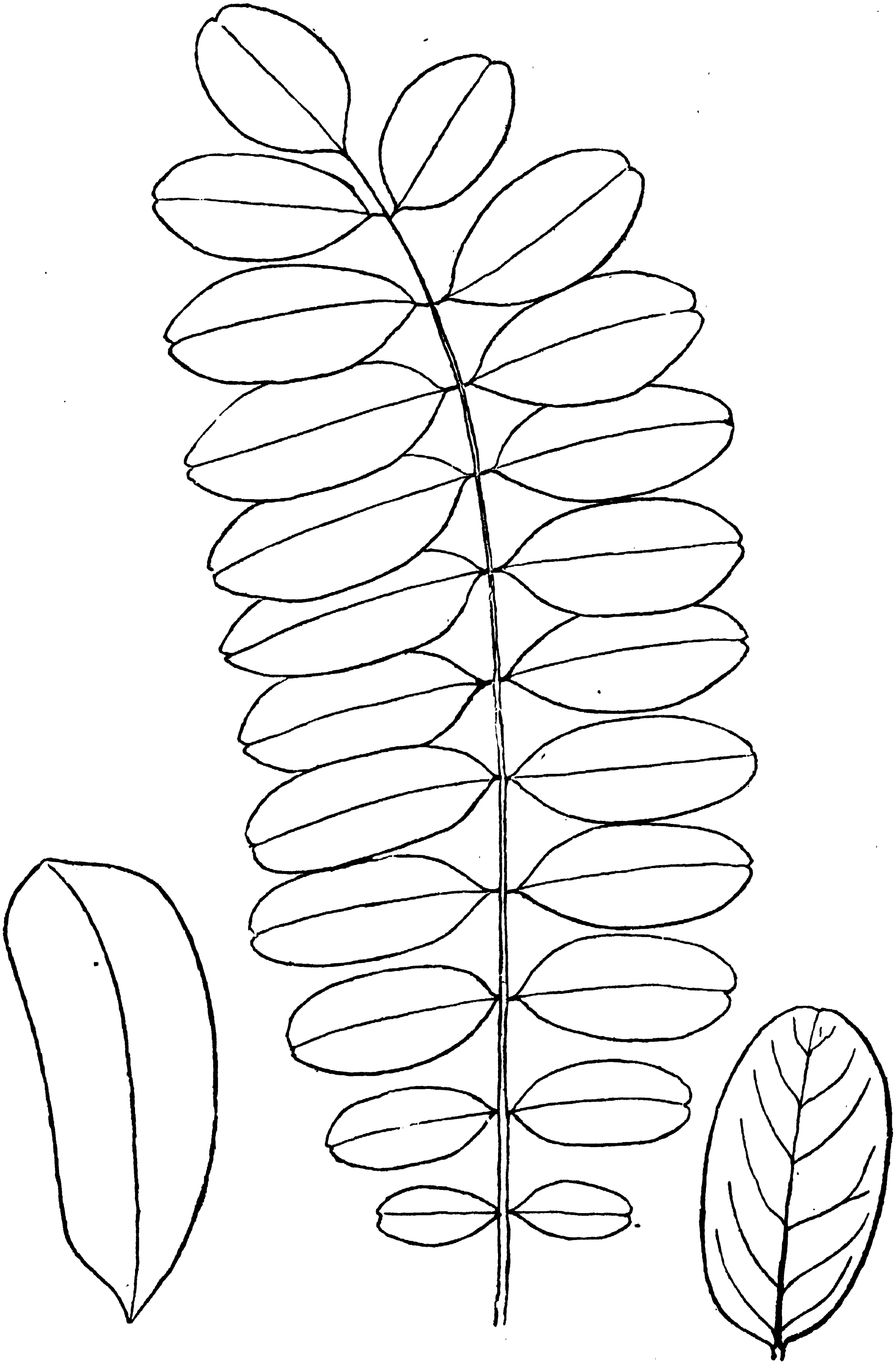


Fig. 58.

without understanding he cannot really draw it. He may attempt; but this will be a failure.

We have also affirmed that this symbolism and its consequent sympathy will be the cause of an augmentation of the insight of the artist into form and colour. In so far as it desiderates examination, and thus does away with ignorance, it tends towards this insight, but in a higher sense this may be asserted of it. This symbolism forces him to love, so that the objects of his symbolism become the objects of his closest study; for what one loves one likes to know, and the artist gets in time acquainted with them in their detailed specific character, because it is a delight to him to make the acquaintance.

It is not our intention to treat of this specific and symbolic knowledge as they influence artistic details. In the course of these chapters on Design it will be our task, or, honestly to say, our privilege and pleasure, to sketch the character and meanings of certain objects, which are of a widely representative character. Such minutiæ as it may be necessary to examine, in carrying out our idea of giving initiative facts, will be described with so much of specificness as their representative quality will allow; but our main purpose will be best fulfilled by confining ourselves to general considerations, which, whilst imperatively demanding attention and obedience from all, will still admit of the widest development of all true artistic idiosyncracies or likings, and applicable to all branches of design. We do not, however, and for obvious reasons, say much on the subject of colour in the present series. This is gone into in the separate paper "On Form and Colour in Industrial Decoration," to which the reader is referred. It will, of course, be seen that the principles which have been laid down in relation to specific knowledge and the symbolism of nature apply as well to colour as to form. The infinite is in both, but certainly the subtler and the more noble and suggestive is colour.

We have stated that an embryo artist, setting himself down to think over the vocation to which he was called, would consider first what he had to know, and afterwards how to express his knowledge. But an acquaintance with the right modes of expression should be contemporaneous with the learning of theory. For there is so much to learn, that *how* to represent is scarcely less important than *what* to represent. And although this knowledge is glorious in itself, even if it were incommunicable, it becomes vastly more so when we not only possess, but can likewise give it,—when, in a word, our riches become usable. Indeed, is it not its being capable to be used somehow, and for the good of some one in this world, that a man should carefully consider in his attempt to get learning of any kind?

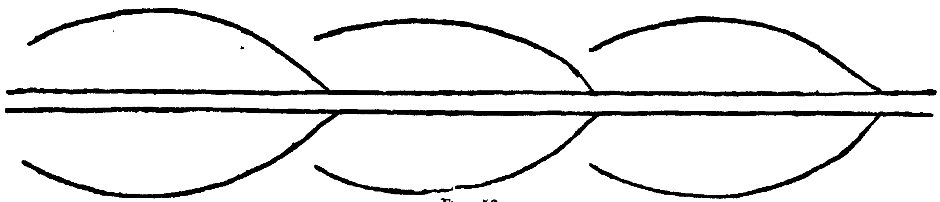


Fig. 59.

It will be well for us, then, to begin by learning what Nature teaches us, and afterwards to learn how she teaches. And it is to this point of the manner of her teaching that we would now direct attention. We wish, therefore, the reader, or rather, as we should say, the student—for it is study, not merely a mechanical reading of what we say, that is demanded here and throughout of him—to notice under this head the various characteristics of Nature's expressional power, and would advise him to seek to secure a mode of representation which shall possess as nearly as possible the same characteristics,—this being the best possible guarantee of success in what may be called the mechanical part of the art of drawing. We use this term to indicate what is to be *done* by the deftness of the hand and the quickness of the eye as distinct from that which has to be grasped by the mind or dictated by the imagination or the fancy.

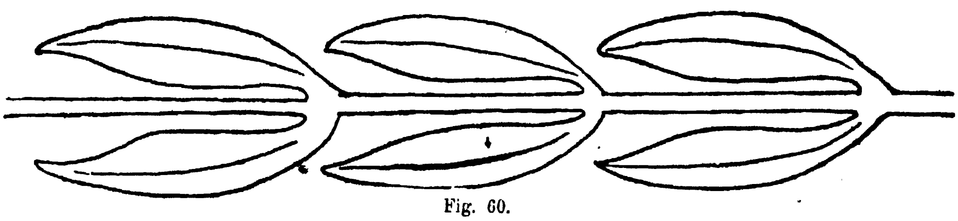


Fig. 60.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XV.

AT the conclusion of last chapter we pointed out the analogy between the action of the moon and the earth, and the stone in a sling and the sling itself. Now, it was a matter of mathematical proof, or an axiom—that is, something which could not be disputed—that the amount of force of the body which acts upon the stone through the agency of the cord or string depends upon and can be calculated by a knowledge of the length of the string itself, and by the velocity or rate of motion through the air of the stone at the end of it. Newton sought to apply this to the case of the moon in relation to the earth. The distance of the moon from the earth (corresponding to the length of the cord between the hand and the stone) was known: one factor in the problem was thus secured. The rate or velocity of the moon's progress in its orbit or path in space was also known: another factor in the problem was thus obtained. Newton could then proceed to calculate, as in the case of the stone, the amount of the force which the earth (corresponding to the body or arm of the stone whirler) exerted upon the moon. Newton did not trouble himself with any speculations as to what that force or cause was, or how it came into existence; he no doubt decided that *that* was a matter beyond the knowledge of man, just as light or heat, or rather those "somethings" which we call by those names, are in reality. All that as a practical, that is a true man of science, Newton was concerned with was to *prove* that his conjecture was right as to the actual identity of the two "somethings"—call them influences or forces or what you will—which in the one case held the stone and in the other the moon in their whirling orbits or paths. And this proof was a matter of mathematical calculation, and one therefore of certainty. But the student of the principles of mechanics will perceive that while this was so, Newton felt that his position was not secure till he could (to use this somewhat tautological expression) prove his proof,—just as, to apply an illustration of a small to a great thing, a schoolboy proves a sum in subtraction. If Newton by two methods of calculation, both based upon certain hypotheses, could arrive at precisely the same result, then, beyond all doubt, cavil and dispute, his theory would be proved, the amount of the two forces or influences being identical. Newton made the two independent calculations, and with identical results.

Hypothesis, Conjecture, or Imaginary Conception one of the Factors in all Great Scientific Discoveries.—Their Legitimate, their Scientific, or Philosophical Application, or Use, as exemplified in Newton's great Discovery of the Law of Attraction of Gravitation.

The method of the second calculation, or the principle upon which it was based, in itself affords a remarkably suggestive point for the consideration of the reader. Practical men may now and then be met with who laugh to scorn the idea that a scientific man has anything to do with imagination. Leave that, they say, to the poets; practical men will have none of it. Now, a very valuable factor in the labour of men of science, we would wish the student to note, is this power of imagination. In nearly every discovery —certainly in all great discoveries, such as that of Newton, now under consideration—carried out by inductive and deductive reasoning, the very first step taken or thing done is to make a conjecture or raise an hypothesis. Then facts are looked for and examined; and if the facts will not square with or fit into the hypothetical suppositions, or imaginative guesses, or conjectures, then those are set aside as incorrect and worthless, and another imaginative conjecture created. Newton gives in the history of his great discovery a remarkable proof of this. We have elsewhere explained the phenomenon of falling bodies, and the rates or velocities, etc. We now know that such are true; and they can be physically proved—that is, displayed before the sight—by the gravitation machine invented by Attwood. But although we now know the "law" regulating the force of bodies, and which is the law of attraction, by which the earth or globe draws or attracts bodies to its surface, that law was, we need scarcely say, unknown to Newton when he began his investigation, for the best of all reasons—that it was he who was the discoverer of it. But—and this is the point the reader should take note of—in order to prove his proof in the way we have alluded to, Newton conceived a hypothesis which was purely imaginary; and it was this,—that in the falling of a body, as a stone or the traditional "apple," the greater the height which the body was above the surface of the earth, "the less was the force which the earth exerted upon the body," or, to use the term now familiar to every one, by which it was "attracted to the earth," and that this decrease of force might be stated in this mathematical form—"that the force of attraction decreased as the square of the distance from the centre of the earth increased." We now know beyond all dispute that this is the law of attraction; but with Newton, his conception of it was at first purely hypothetical or imaginary. He had now to prove that this hypothesis or imagination was correct; and we would here note (what is well worth the reader's careful consideration in all its practical outcomes, as showing the way in which one process depends upon another) that the proof of this hypothesis of the law of attraction —which, be it remembered, was made with the direct object of "proving his first proof," namely, the amount of force acting upon the moon due to its velocity along its path and its distance from the earth—was itself connected with the preceding investigation of Newton. If the hypothetical law of the force of attraction being as the square of the distance, as above stated and as fully explained elsewhere in this series of papers, was absolutely true, its truth could be proved thus. Newton knew the distance in miles of the earth's surface from its centre; he therefore, with his hypothetical law, could calculate what would be, in virtue of it, the amount or force of attraction at the surface. And knowing also the distance of the moon from the earth, he could calculate the amount of force acting upon the moon, or rather what he knew it should or must or ought to be, if his hypothetical law were the actual or true one. Assuming it to be the actual law, he made the calculation, and found a certain force or amount of force as the result. We have already seen that by the other method of calculation he knew the force due to the velocity of the moon in her orbit or path in space, and its distance from the earth. What if the two results were identical? They were so! One can easily understand how it was, as history tells us, that as Newton approached the end of his most intricate calculations, and with *his* mind, in the highest degree imaginative —foreseeing some at least of the wonderful results, as ministering to the progress of civilisation and the welfare of his fellow-men, which would flow from his great discovery—he became so agitated that he could not proceed with his calculations, seeing how they neared the hoped-for result, and was compelled to beg a friend to carry them out to their completion,— which, when done, proved the great law.

There is something profoundly pathetic in this circumstance of Newton's life—all the more that it stands out in such bold and morally healthy relief,— and it most happily affords a delightful contrast to that petty pertness which we have of late years found displayed in the case of some of our so-called men of science, who propound theories, and dogmatically assert that they must be and shall be taken and accepted by all as correct, simply because they assert it to be so, without deigning to give, or rather attempting to give, a proof of it. And this not because they have any facts to prove their accuracy —knowing, indeed, that they theorise in a region in which no facts exist—but simply in the swelling fulness of their intellectual pride, they say things must be as they propound them, because it is *they* who say it, and with them this covers all. True science. the science which has "built up the grand fabric" of our modern mechanical work, which has been *done*, knows not of intellectual pride,—it is essentially humble-minded,—and the modern followers of this true science do not disdain in this way to follow in the steps of their great master Newton, who, when congratulated by some one in flattering terms on the greatness of his discoveries, in effect, if not in the actual words here given, made this grandly noble reply, well worthy of the student's study:—"I have been but as a child picking up here and there, on the shore, a pebble of more than ordinary size; while the great ocean of truth lay unexplored before me." It is ever thus, ever will be thus, with true thinking men: the very fact of the vast extent of the unknown makes them profoundly humble as to the little they know. So true is the sentence which, in the alliterative arrangement of its words, conveys a great lesson to the young reader: "the more we come to know, the more fully do we know that, in view of what remains to be known, we know nothing." And if Newton's example had been followed, the student who has been careful to peruse every treatise and paper purporting to lay down the laws of mechanics, would not have been perplexed and painfully puzzled by the clearly manifest contradictions which appear in some of them. These are altogether incapable of being reconciled, being brought into existence by dogmatic theories wholly unsupported by facts,—and this for the best of all reasons, that no facts exist, the theories being based upon the purest assumptions, which in the present state of knowledge (and to all appearance this will for ever be its state) cannot possibly be backed up by any facts derived, as all facts are derived, from things which we *know*—which, by the way, form what is entitled the "region of facts."

Further Lessons to be Learned from a Glance at the Great Discovery of Newton—The Law of Attraction.

The accuracy of the calculations made by Newton depended upon the accuracy of the measurements made of the distance of the centre of the earth from its surface. And the fact affords a very striking illustration of another attribute, well worthy of the earnest consideration of the reader, of the true man of science possessed by Newton—that is, patience. It so happened that the calculations first made by Newton did *not* show the result he anticipated. Like a follower of true science—which term, properly defined, means neither more nor less than that which we *know*—Newton in this put aside his hypothesis or theory as not correct; and this simply because it had not facts, or the fact, to coincide with it. as it did not square with the fact which he *knew*, Some of our modern so-called scientists would not have so acted: it would have quite satisfied them to have framed an hypothesis which they wished to be believed as proved to be correct, simply by their assuming certain things which might or might not exist, and putting them forward as proofs. It was many years afterwards that the result of a new measurement of a degree of the meridian by an able and accurate French *savant*, gave Newton the data which enabled him to get the accurate measurement of the distance of the earth's surface from its centre, and which led to the final result we have shown.

The whole history of what Newton did, and what was done by those who succeeded him, in following up the results of this wonderful discovery, is full of interest to the scientific man, and no less to the student in the principles of mechanics, who will derive no small benefit from his study of it. If he rise from this study with no other determination than this, he will have good reason for congratulation at such a result of it—namely, that he will not be led away, and for aught he knows widely astray, by theories however apparently sound, by speculations however attractive, unless they appeal to facts, and have facts to support them. But if they go no further than mere conjecture—for the best of all reasons, that in its region there are no facts, nothing which is known—this alone should determine their practical uselessness, for in a region of pure conjecture it is obvious that one theory or conjecture is just as good as another: "my statements are just as good as yours," seeing that to all alike is denied a common standard to which appeal can be made, a common platform on which all can meet. These considerations are possessed of much greater value to the student, as influencing his practical career, than some may be disposed in the first instance to allow to them.

The Law of Attraction as Exemplified in the Work of the Mechanic.—Examples from Practice.

The law to which the generic name "attraction of gravitation" is given, with its other classes, such as the attraction of cohesion, and capillary attraction, which will be explained in future paragraphs, is not important, therefore, solely on account of the wonderful ways in which it manifests itself in the general phenomena of nature; but possesses, if a less striking, still a more special or individual value to the practical mechanic, inasmuch as it is manifested in a great variety of ways in the ordinary practice of his varied work. In one or other of its classes this wonderful influence or power is brought into daily requisition in industrial work, and in the multifarious operations of the workshop. While to it are due some of the greatest phenomena of nature, its influence is no less seen in some of her gentlest manifestations, such as the fall of the leaf, and in the sparkling dewdrop in hedgerow or meadow. The very form of the dewdrop, which looks like a little globe of clearest crystal, and sometimes "sparkles like a diamond" in the hedgerow or the grass, owes its production to this law. So also do the little globules of quicksilver; and to the same law is due the going together or the meeting of the dewdrops, forming little pools of liquid, of the globules, forming larger masses of quicksilver.

The tendency of small volumes of liquids free to move to form globular masses or spheres, above alluded to, is taken advantage of in the well-known method of forming the small shot of sportsmen. Melted lead is poured through a sieve placed at a great height from the ground, and in falling, the shower of lead forms itself into little spheres, solidifying in this shape through the cooling action of the air. The imperfection of form of some of those globules is dependent upon certain circumstances: some, through the lead possessing too little fluidity, solidifying into pear-shaped bodies; others, through possessing too much, becoming flattened spheres or oblate spheroids. This tendency of matter, in conditions varying as regards fluidity, to gravitate—so to say—or to be attracted to a common centre, is taken advantage of in, and in many ways influences, the work of the mechanic. But the same law which thus gives the spherical form to liquid bodies subjected to modification from varying circumstances of condition is that also—although we give it another name, as indicating another department of it, namely, the law of gravitation—which compels, so to say, the lead pellets to drop from a height and fall to the surface of the earth, and regulates all the phenomena of falling and of moving bodies, whether those bodies are projected or propelled through the air, or move along surfaces, solid or otherwise.

And those phenomena, having been closely observed by man, have been in the course of time applied to various departments of his work in ways as useful on the one hand as on the other; they are interesting as examples of what observation, aided by close thinking or reasoning, can do in making natural laws subservient alike to the lower and to the very highest necessities of man in his daily life and work.

Some Practical Considerations in regard to the Invention of Machines taking Advantage of the Operation of Certain Natural Laws.

And this adaptation of the great law of gravitation, even to such a simple matter as the separating grain from the chaff, by what we call a riddle or sieve, took, we have every reason to believe, no short period in the history of man before its principle was perceived and acted upon. And the reader interested in the principles of mechanism may rest assured of this: that before the very simplest form of what is known in farming operations as the "corn-dressing machine," the "fanners" of even the smallest of barns, was perfected, many years, possibly generations, in the history of man passed away. The principle is comparatively simple upon which the various members of that wide class of machines used in separating and sifting materials depend for their operation. But if such a thing as a record of progress of invention in this department existed, which, unfortunately for the machinist, it does not,—and this remark applies to but too many, almost all, indeed, of the departments of mechanical invention,—he would be very much surprised to find for how long a period the work was purely tentative or experimental, and what an amount of patient trial and thinking had to be gone through before the appliances and machines he now sees, and that so frequently that he never gives a thought to the way in which they originated, were perfected, and assumed the form he now sees them in. And all of them afford in their action very striking and beautiful exemplifications of the phenomena of falling and of moving bodies. They are all interesting when in this way looked upon as philosophical operations, illustrating natural laws—which office all of them may be said to fulfil. But it is when we consider them conversely, in the way above alluded to, and try to trace out how our predecessors in mechanical work, having first during a long course of years observed certain phenomena in nature taking place around them, were led to take the steps by which those phenomena were applied, or rather what they taught were adapted to the work required, through the agency of certain mechanical contrivances, that we can arrive at anything like a fair estimate of what our predecessors have done, and the difficulties they had to encounter and overcome before the work was at all satisfactory. They had everything to learn, and we, who have entered into the inheritance of the knowledge they bequeathed to us, have had comparatively little to do. This is true of all departments of mechanical invention.

Examples of Mechanical Arrangements taking advantage of the Law of Gravitation (*continued*).

And yet, even in the department of "separating," "sifting" or "cleaning" machinery, alluded to in last paragraph, simple as the reader may conceive it to be, much has been left us by our predecessors to do in perfecting their original conceptions of mechanical adaptations which utilise the operation of our natural laws; and under this head the student would possibly be much surprised to learn the great number of patents which have been taken out for machines in this class, and that are being taken out almost every day. And some of those which have gone beyond the region of mere patents, and have taken place as working machines in daily use, could be referred to here, if space permitted, as beautiful examples of how natural laws are made subservient to the doing of such work.

In another paragraph we have explained the phenomenon of falling bodies and the law which regulates their velocity or speed of falling freely through the air; we have noted the importance of this law in mechanical work of a very wide range. In yet another paragraph we have also explained some of the points connected with the motion of bodies rolling or falling (for it is virtually this) down inclined surfaces or planes. If we take a shallow vessel or receptacle formed out of a flat plate with narrow upturned edges at the side only, open at the ends, and in place of the plate being solid, have it throughout perforated with holes of uniform diameter,—and if on this surface we place a heap of material composed of particles, so to say, differing in weight and size, and shake the plate to and fro, it seems a very simple thing indeed that the lighter particles should come to the top or form the upper surface, and that the heavier particles, being left to or settling themselves below, should pass through the holes and fall to the ground—that is, if the holes are large enough. Not less simple would seem the result if, in place of the holes being of uniform size, they were of different or varying size or diameter; when the different-sized particles would fall through different holes, each size selecting, so to say, its own hole. And if in place of having the receptacle held horizontally while it and the material lying on its surface were being shaken—to use the technical term, vibrating or oscillating—it were inclined or placed on the level or slope, it would seem a very simple thing that the velocities or speeds of the different particles should be different, and also that while some would be shot beyond the plate to a certain distance, others would be projected to a greater, others to a less distance than this, while some would have such a low velocity that they would be a long time in passing from the plate. Again, in watching the method—the primitive one, where no mechanical help, even of the simplest, is applied to the work—of freeing a lot of wheat from its chaff and light straws by dropping it from the extended hands while a brisk breeze was blowing, it would seem a simple or as we should say a natural thing that the chaff and straw would be blown away to varying distances—some far from the hands, some near—and that the wheat should drop right down to the ground. But if the young reader will place himself in the position of one noticing for the first time those phenomena happening in some natural way, no matter how, long before they were exemplified in mechanical contrivances, however simple, he will be able to see what a long train of thought had to be given, and a great number of circumstances happening to be observed, and what a wide range of trials had to be made before those phenomena exemplified to those who looked for or observed them every day in nature could be applied to the numerous machines we have in use.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XI.

RESUMING our description of right-line projection given in last chapter, and of some points connected with it, we can suppose the case of a rectangle, as *a b c d* (fig. 19), being bounded by lines the terminations of which are the points *a b c d*. By supposing these to be projected, in the direction of the arrows at *a′ b′ c′ d′*, to a horizontal plane of projection at *e f g h*, we obtain the points a^2 b^2 c^2 d^2; and if we join these by straight or right lines, we obtain the projection on the horizontal plane a^2 b^2 c^2 d^2, equal to the rectangle *a b c d*.

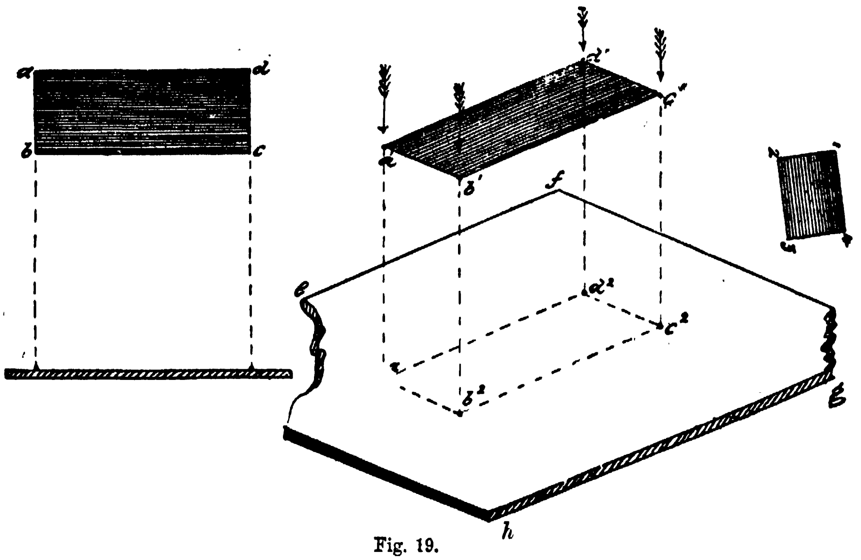


Fig. 19.

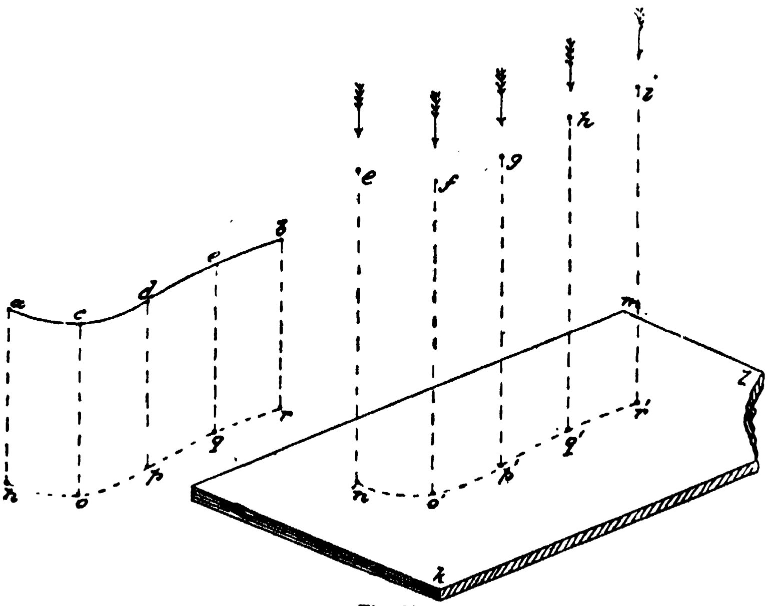


Fig 20.

Principles of Orthographic or Plane Projection (*continued*).—**Projection of Curved Lines.**

It is obvious that whatever be the form of the superficies or surface technically or geometrically termed a "figure"—and which, be it remembered, has only two dimensions, that of length and that of breadth—we can project it on its plane if we have the terminating points which indicate or mark out the boundary, giving the form or outline of the figure. Where the bounding lines are curved a little more complication is introduced into the projection. But curved lines as well as straight are made up of a series of points, so that if we take a series of points within or on the curved lines, we can project those points precisely in the same way as the points of right or straight lines are projected. Thus, suppose we have the curved line shown at *a b*, fig. 20, to be projected on a plane surface. We take in the length of this any given or desired number of lines, as *c, d* and *e*. Let us now suppose that we have those points represented by *e f g h i* respectively, and those are to be projected on the horizontal plane of projection *j k l m*. Proceeding as in figs. 18 and 19, those are projected in the direction of the curves and dotted lines till they reach, or intercept, or "cut," to use the technical phrase, the plane of projection in the points *n' o' p' q' r'*. By joining a line—or a series of lines, to put it more correctly—we obviously have a line which is precisely the same as the curved line *a c d e b*.

To one point in connection with this projection of a curved line we would draw the particular attention of the beginner in the art of projection, which is the basis of all architectural or engineering drawing. This is, that in the projection of all curved lines the direction of which is indicated or given by a series of points, the more numerous the points are the more accurate will be the line we obtain—that is, the more closely will the true projection of the curve be followed, or, as the technical phrase puts it, "copied." Thus, let *a b*, fig. 21, be the terminating points of a given curved line, of which the projection is required to be made in a horizontal plane of projection—as, for example, the plane *j k l m* in fig. 20. To obtain this projection, we assume or take any given number of points, as explained in connection with fig. 20. Suppose we take in the present instance—fig. 21—only two, namely, *c* and *d*. Projecting these as explained in fig. 20, we obtain the points *e f g h*, corresponding to *a c d b*. Now let the beginner think over the way in which those points must be joined by a series of lines, as from *a* to *c*, from *c* to *d*, and from *d* to *b*, and he will soon perceive that there are difficulties in the way of his obtaining a true or positively accurate "copy" of the line *a c d b* to be projected, by having taken only two points, as *c* and *d*, between the terminating points *a b*, or ends of the line *a c d b*. As in proceeding with the chapters yet to follow in our present series of papers on architectural and engineering drawing, he will see that a great number of the most important projections required in the practice of those two branches of the art depend upon this principle of "finding a series of points," through which the lines of the projection or working drawing have to pass, it will be worth the little time expended upon it, if he examine somewhat closely the work to be done before he can obtain a true curved line—that is, precisely the same as in *a c d b*, when so few points, as for example the two only, as *c* and *d*, are taken on the given line to be projected. Thus, let the pupil take the two points *a* and *c*, as at *i* and *j*. In looking at the original line, or what in the technical language of the art of projection or drawing, is termed the "copy," he will perceive that the line which joins the two points *a* and *c* is a curve very sharply defined—that is, it is far removed from the character of a straight line. Now, we have already defined the projection of a curved line to be the finding of a series of points in the line, and projecting these, and the joining these points so projected by a series of lines.

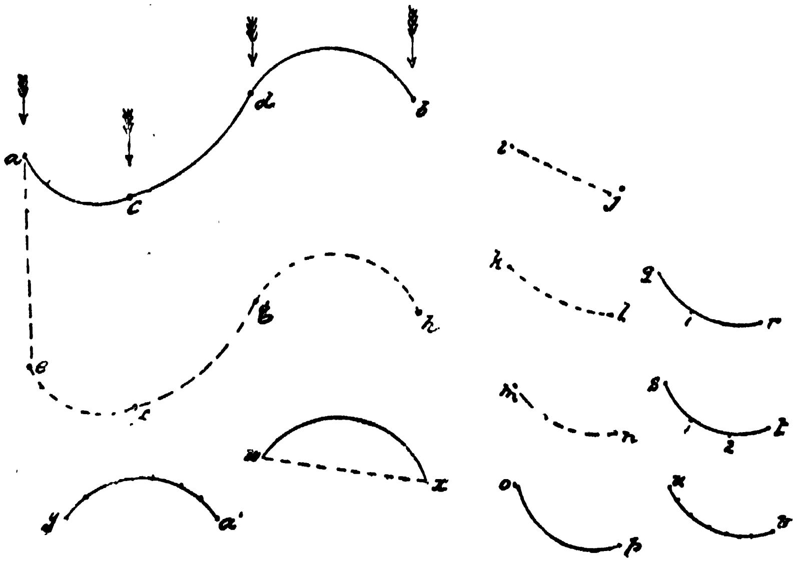


Fig. 21.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XI.

IN preceding chapter we referred to the individual or separate influence exercised by the sire and dam on the organisation of the calf. This separate influence is so well defined that, in the words of an eminently practical breeder, "the male parent chiefly determines the external characters, the general appearance in fact, the outward structure and locomotive powers of the animal—for example, the brain nerves, organs of sense, and the skin, and likewise the bones, and muscles more particularly of the limbs. On the other hand, the female parent chiefly determines the internal structure, and the general size and quality, mainly furnishing the vital organs—as for example the heart, lungs, and digestive organs—and giving a tone and character to the vital functions of growth, nutrition, and secretion. Not that the male is wholly without influence on the internal organs and vital functions, or the female wholly without influence on the external organs and locomotive powers of the offspring.

Third, Fourth, and Fifth Laws, Explaining the "In-and-In" System of Breeding.—The Law of "Limitation," that of "Modification," and that of "Importation."

The last holds good only "within certain restrictions." Those constitute what another authority on breeding calls the "law of limitations," which law regulates the length, so to say, to which the influences above named go. And to this we might add another, the "law of modification,"—or rather, as we are inclined to put it, the "law of limitations" includes as a subordinate principle that of modification. But though subordinate in this sense, this principle is of such vital importance that, if lost sight or not taken account of in our consideration of the general laws or principles of breeding, we shall make grievous mistakes, as mistakes have already, and not seldom, been made in practice. This principle of modification acts only, it is scarcely necessary to say, in a dual or twofold relation—that is, only in the conjunction of the two parents: thus, while the leading and characteristic influences which the male imparts to the offspring—namely, the external features, as we have already named—are as a rule the general result in breeding, those influences do not remain, to use a familiar expression, pure and unadulterated, but, on the contrary, are so acted upon by the characteristic nfluences of the female that they become modified or changed; and this modification has again its boundaries, so to say, beyond which it does not go, being under the "law of limitations" already named. But the principle of modification acts also in the other direction, the male modifying the characteristic influences which the female imparts to the progeny. Those female characteristics are, as we have seen, connected chiefly with the internal organs of the animal, which, being vital, constitute what are in reality the higher characteristics. But there is in connection with these another important principle, so important that it might well be termed a law, to which the name of the "law of impartation or conferring" is applied. It is the female which alone gives or confers the influences which create the higher or vital characteristics of the progeny, or those in connection with the internal organs; those are not therefore due to the male, who only modifies or may modify them. And, on the other hand, he it is who confers upon or imparts to the progeny the characteristic influences which create, so to say, the external features of the progeny, the female not giving these, but only modifying them. It is of course scarcely necessary to say that these views now explained, all too briefly for their importance, are not held by all; for the scientific, and indeed we may say the practical points of farming, or rather that department of it with which we are now concerned—namely, grazing — like those or many of those of other sciences, form the battle-ground, as it were, on which somewhat fierce combats are maintained. But diverse as are or may be the opinions on points of practice, it is only right to state that the same diversity does not exist in connection with what are the scientific points. And although the views on breeding just explained are not agreed to or held by all, and although they are not precisely and definitely accepted as true, and as explaining all the phenomena of cattle or animal life, we believe that they approach very closely indeed to the point of absolute accuracy. One lesson can at all events be learned from them, and that is that the influence of both parents *must* be taken into account and dealt with in the practice of breeding, if that practice is to afford the most economical because the highest developments. We have seen that with some it is a matter of the purest indifference whether the one parent or the other be good, or the reverse,—they are simply taken as they happen to present themselves. Thus we find that equal indifference exists as to what the male parent is, or what the female. This indifference simply ignores the fact that there is any scientific principle which regulates the production of stock, and tacitly admits, or rather gives no thought to the subject at all, that one way is just as good as another. It is scarcely necessary to say that those who hold these views, or act in this way, are the class of farmers or graziers who have done nothing to improve these arts, and who from their mere numbers constitute what may be called a stopgap to the wide or complete extension of agricultural progress. On the other hand, we meet with those who are much—very much further advanced in a knowledge of what is right to do in order to insure a higher degree of success in their dealing with the live stock of the farm. They have given thought to the matter, have at all events admitted that improvement being necessary, something must be done in order to secure it. But the direction in which their thoughts tend, at least in which their efforts are made, are, we conceive, wrong, inasmuch as they look to one side only of the subject, ignoring altogether the other side. Those of this class are found to act as if they believed that the male parent—the bull—was everything and the only thing to be considered; the female—the heifer or the cow—nothing. This position can, however, from one point of view scarcely be matter of surprise. We have seen that the external characteristics of the progeny are conferred or given to it by the male parent; and as those are visible, and so to say touchable, it is not to be surprised at that they are taken hold of and considered as the most valuable indices of a valuable beast. And the value of such "points," thus visible and touchable, being confirmed by an almost universal consensus of opinion, breeders aim at producing them in their stock. But though beyond all doubt those points are of the greatest value, it is nevertheless the truth that those of the class we are now specially referring to ignore almost completely the influence of the female parent in producing those valuable points; and, what is even worse in some of its aspects, they forget, or are not careful to inquire into, the fact that the influence of the female alone gives those characteristics to the animal without which it cannot take advantage, so to say, of those points which it derives from the male parent. The animal can alone give all the points necessary for its full development when the influences of both parents are allowed to operate—those influences being of course those met with in good animals of both sexes. It is impossible to overestimate the value of the influences of the female, for these affect the vital organs of the animal. And however valuable its external characteristics—which, as we have seen, are chiefly imparted by the male—may be, it is obvious that if the animal be weak in its vital organs, the highest results cannot possibly be secured and maintained; as good breathing and good digestive organs are absolutely necessary to a perfect or choice animal. On the other hand, it is equally obvious that if the frame of the animal be bad, and ample room be not given in which the vital functions of breathing and digestion can be carried on with all the ease of operation necessary to healthy existence, the animal will not be of the class which yields the highest and most economical results. Hence is deduced the great truth in breeding, that the best males and the best females are essentially necessary to procure the best stock. One would conclude that this common-sense deduction from the principles we have stated would be admitted as correct, and practice be based upon it. But that this is not so can only be too widely and unfortunately exemplified by the stock bred and raised in but too many districts of the kingdom—animals which, even on the most cursory examination, show how grievously neglected have been the lessons which successful experience, based upon sound science, is so well calculated to give.

General Remarks on Breeding continued.—Objections to the "In-and-In" or "Line" System.

"In-and-in" breeding, and the principles upon which it is based, are so widely adopted and accepted that it may be safely said that it is the rule amongst breeders, the opposite or the "crossing system" being the exception—an exception, doubtless, however, very frequent. But remembering the adage "Many men, many minds," we need not express surprise at the fact that objections to the "in-and-in" system are freely and somewhat widely held. The great, if it be not the only objection—as it is this with many—to the "in-and-in" system of breeding is that it brings about diminution of size or bulk, weakness of constitution or debility, a tendency to barrenness, and in brief, a general deterioration of the whole system. This objection is based upon an analogy with the human being. But it is often specially unsafe, always dangerous, to found theories or hold opinions based upon analogies or comparisons between two things. Those can only be safely made when the two things compared are alike, or somewhat alike, in general characteristics. And it is one thing to base an opinion or found a theory on facts taken from experience in human, and quite another thing to do so upon facts taken from experience with animal existence. The chief objection to, and the most lamentable result of, close affinity or intermarrying between members of the same family is the weakening of the mental powers, and the tendency to consumption, as also to strumous or scrofulous diseases—the chief being, however, the deterioration in the mental powers. The mere bodily powers are not deteriorated, certainly not in the same proportion: many fatuous, silly or idiotic people are positively conspicuous for great bodily strength, the possession of vigorous appetites, sound and good digestion, and generally speaking what is called "rude" bodily health.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER VIII.

Shop Fronts a Feature in the Architecture of Towns.

LASTLY, so far as street architecture is concerned, it is difficult to ignore the position which "shop fronts" occupy with relation to it. These now form such an important and striking feature of this department of what may in one sense be called domestic architecture, although perhaps in another not strictly so, that examples of some of the styles of its treatment cannot well be left out from the pages of a paper such as this aims at being. To attempt to give anything like an exhaustive treatment of it would clearly be out of the question. For a very brief consideration of the department and its varied requirements would suffice to show that to give even but what would be called a fair exposition of its features as now exemplified throughout our towns, a special work would be demanded. And that of no small dimensions; embodying of necessity—if justice was to be done to all its features—a large number of drawings. Indeed, it may be fairly claimed for this branch of architecture that it has now reached that point at which it ought to have a special work, doing full justice to its claims. The exhaustive treatment, or at least specially full or extended illustration of this department, precluded by our lack of space, if not by the requirements of the scheme of our papers, prohibits also a like extended illustration of the other departments. At the best, our space can only permit us to give a few specimens of designs of the period. These cannot be considered as examples of all the styles; they can only be looked upon as representative of the leading ones, and as illustrating important aspects of the general subject.

Estimates of the Cost of Houses of which the Plans are given in this Paper.

In giving our various designs of houses of different classes, it might have been expected that we should also have given, in the case of each house, an estimate as to how much it would cost. This point has not been overlooked by us; but, however desirable it may seem to some that estimates should be given, it was decided after due consideration that they should not. And this for various reasons. The prices of materials and of labour vary so much in various districts, and the circumstances under which the houses may be built—their locality or position, for example, in relation to quarries or brick-works, or their distance from a railway station—differ also so materially in different places, that the estimate which would be useful in one district or locality would be of no practical service in another. Further, the prices vary with the times, so that a house costing so much to-day will three, six months or other periods of time hence, cost either so much more, or so much less. Again, the wants and wishes of proprietors vary so much that unless they are known, it is impossible to give prices or cost. A style of finishing or the kind of fittings which would please one, would not please another. These reasons, and others which will be obvious to the reader on consideration, will prove, we trust to his satisfaction, that where it is impossible to give information which will be accurate over a wide range of the kingdom, it is the best way to omit giving it at all.

There is still another consideration affecting this point of estimates. It is within the range of possibility that some reader not professionally but generally interested in the subject—and most classes take an interest in it, as all like the idea, if they cannot reasonably look forward to its being realised in fact, of having "a home of one's own"—may have a desire to build a house or cottage according to some of the plans and designs given. He may, however, while on the whole satisfied with the design as it is given, desire (and the probability is that he will desire) to modify it so far that it will meet some peculiar notions of his own as regards the arrangement. Or he may like the plan, but not the style or design of the exterior, or *vice versâ*. All this will change the design, considered as a whole, more or less, and in proportion affect the cost or estimate.

Another point, alluded to above, remains to be noticed in connection with this department of the subject. The prices of both materials and labour are constantly varying. At one period a very marked and considerable rise may take place, so that the cost of building may reach a point which in the case of many may act simply as prohibitive of all work. That prices, however high at one time, will continue to rise, at least much above the present ruling, is not at all likely. Many in the trade will believe they have reached their maximum, and quietly await a fall before entering into contracts or speculating in building on their own account. When a fall does take place (as, say they, sooner or later it will) they then commence to build extensively. All experience in trade and commerce goes in proof of this; for when prices through any cause or a variety of causes reach what may be called a purely conventional or artificial height, and if they are maintained for some time at this, the reaction at last sets in and a rapid fall may take place, and this may continue till prices often fall below what is really their proper rate or point. That estimates, therefore, taken at one time would fail to impart to those proposing to build a fair idea of their cost is obvious enough; hence another reason to those already given for our refraining from adding to our pages by giving them. At the same time, so far as the young architect or builder who is studying for practice is concerned, the subject of estimates has not been overlooked in the general scheme of our work. In the series of papers under the head of "The Young Architect and Engineer," the reader interested in the subject will find remarks on estimates and the cognate or kindred subject of specifications. To this series, therefore, we refer him, proceeding to the various departments of our special subject still to be treated of, commencing with

Examples of the Class of Houses known as Street or Town Houses, or Middle-Class Houses.

In a preceding paragraph we described the arrangement under which we proposed to treat the various departments of our important subject, detailing the classes and sub-classes under which houses may be arranged. Of these the first class or division is that of "street," or, as they are sometimes called, "town" houses, inasmuch as the great majority of the domestic houses of a town are arranged to form streets or roads, running along either one side or on both sides of the street or road. It is difficult to name the "principle" upon which such houses are planned; it would be nearer the truth to say that there is no principle at all common to the class, so completely is it the case that each designer is a law unto himself. And yet somewhat contradictory to this statement appears the fact that so slavishly has one generation of builders copied the work of the generation which preceded them, and so persistently is this being done even in our own day, that there seems after all to be a principle connected with this class of houses which seems thoroughly established in the minds of those to whose speculative energy we owe the miles of street houses "run up," as the suggestive phrase has it, in all our large towns and cities. Of these the Metropolis is the type, differing only from some other large towns in the enormous capability it has for the extension of its inhabited districts. It would, however, be more correct to say that this principle, if it is entitled to the dignity of such an appellation, is one which refers much more to the style of the construction than to the method of arranging in detail the accommodation which that system gives. What the peculiarities of this principle of construction are we shall presently see. We should always bear in mind what we have in a preceding chapter so earnestly insisted upon, namely, that "planning," in the true sense of the term, is the providing, in the accommodation of the house being planned, everything which will minister not only to the health but to the household comfort and the economical conveniences of those who are to live in it. Keeping this vitally important principle in view, we shall find, taking the vast majority of the street houses, that there is no method of planning which can be laid hold of with such firmness as to be deserving of being called a principle. This, of course, applies with the greatest force to street houses of the middle classes, and with special force to those belonging to the class just above that of the working classes—those latter occupying a species of debatable land between the territories of those who "have money in their purse" and those who, as a rule, do not keep purses, or, if they do, do not put, or certainly do not keep, much in them.

Higher-Class Street Houses.

Although the accommodation is so much more comprehensive in kind and extent, the rooms larger, the fittings finer, and the architectural design more elaborate and costly in those street houses in the wealthier districts of our cities and towns, still even to them may in large measure be applied the statement that it is not easy to point out a definite principle which guides the designer or planner. There is no doubt largely in this case the same characteristic of stereotyped constructive arrangement as is found in classes of street houses below them in the scale of cost and accommodation; but this involves, as we have seen, more correctly a principle of construction rather than of planning, using this term in its widest or rather in its true acceptation. And however much may be said in favour of the statement that a great amount of care is exercised in the planning of this the superior class of street houses, it is nevertheless true enough that there is still a wide field open for improvement in this respect. Not a few houses costly in construction present features in planning which are quite as gravely in error as any one of the worst faults met with in houses of an inferior class. And this arises simply from the cause we have in a preceding chapter pointed out—that they are designed by young architects or those inexperienced in or careless of what constitutes sound planning, and who think much more of how the outside of the house is to look, than how the inside of it makes it thoroughly fitted to live in; house-"living," as we have seen, involving very much more than merely having so many rooms under the roof or within the walls of the house lived in.

As a rule, however, the superior class of street houses are well planned, and that they are becoming daily more and more so may be readily enough conceded, and this because the truths are becoming more and more recognised which we have endeavoured to explain in the preceding paragraph, in which we took up what may be called an exposition of the general principles of planning.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION— GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

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143. Weight in Pounds of Square Bars of Cast Iron per Lineal Foot, from $4\frac{7}{8}$ to $\frac{1}{4}$ of an Inch on the Side.

$4\frac{7}{8}$ in. = 74·26 lb.; $4\frac{3}{4}$ = 70·5 lb.; $4\frac{5}{8}$ = 66·84 lb.; $4\frac{1}{2}$ = 63·28 lb.; $4\frac{3}{8}$ = 59·81 lb.; $4\frac{1}{4}$ = 56·44 lb.; $4\frac{1}{8}$ = 53·17 lb.; 4 in. = 50 lb.; $3\frac{7}{8}$ = 46·92 lb.; $3\frac{3}{4}$ = 43·94 lb.; $3\frac{5}{8}$ = 41·06 lb.; $3\frac{1}{2}$ = 38·28 lb.; $3\frac{3}{8}$ = 35·59 lb.; $3\frac{1}{4}$ = 33 lb.; $3\frac{1}{8}$ = 30·51 lb.; 3 in. = 28·12 lb.; $2\frac{7}{8}$ = 25·83 lb.; $2\frac{3}{4}$ = 23·63 lb.; $2\frac{5}{8}$ = 21·53 lb.; $2\frac{1}{2}$ = 19·53 lb.; $2\frac{3}{8}$ = 17·62 lb.; $2\frac{1}{8}$ = 14·11 lb.; 2 in. = 12·5 lb.; $1\frac{7}{8}$ = 10·98 lb.; $1\frac{3}{4}$ = 9·57 lb.; $1\frac{5}{8}$ = 8·25 lb.; $1\frac{1}{2}$ = 7·03 lb.; $1\frac{3}{8}$ = 5·9 lb.; $1\frac{1}{4}$ = 4·88 lb.; $1\frac{1}{8}$ = 3·95 lb.; 1 in. = 3·12 lb.; $\frac{7}{8}$ = 2·39 lb.; $\frac{3}{4}$ = 1·75 lb.; $\frac{5}{8}$ = 1·22 lb.; $\frac{1}{2}$ in. = ·78 lb.; $\frac{3}{8}$ = ·439 lb.; $\frac{1}{4}$ = ·195 lb.

144. Poultry as a Source of Profit in Farming or Cottage Work.

In our first note under this heading we stated at its conclusion that the Dorking hen is often used as a sitter for the eggs of other breeds which are not such good hatchers as the Dorking. Of this class is the "Spanish," or, as it is generally known, the "Black Spanish," this variety being that principally, almost wholly, met with amongst us; and distinguished by its white face and black body, as regards appearance, and by its being an excellent layer of large-sized eggs, but a bad sitter, and perhaps a worse, at least as bad, a mother.

The "Hamburg" or "Hamburgh," like the Dorking, may be said to be a thoroughly English breed, as it has been so long and successfully established amongst us. There are two varieties—the "Silver" and the "Golden Spangled or Pencilled." Of all our breeds they are pre-eminent as splendid layers,—so much so that they have been and are often called the "Everlasting Layers." This of course precludes, or seems always to preclude, the birds from being good sitters, which they are not. Their small size makes them also poor "table" birds. They do not thrive and will not readily sit in small confined spaces, hence they are not a cottager's bird. Their qualities, however, makes them great favourites with those who have facilities for keeping poultry in the best way, and who carry out the keeping of pure breeds.

The "Game" breed is a favourite with many poultry keepers, not merely because the birds possess the attribute of great bravery—with, however, as other breeds in a mixed lot know too well to their cost, a corresponding tendency to fight it out and be "cock of the walk"—but because they are handsome and noble-looking birds with a bold defiant carriage and fine beautiful plumage. But the birds possess other attributes useful to the poultry keeper. The hen has all the three qualities, in fair abundance, of laying well, sitting well, and acting as a good careful mother; to which may be added a fourth, in which it is superior to the breeds possessing the same merit—namely, a capability to keep on breeding for a great length of time. The chickens are easy to bring up, requiring little attention, as the mother is a most assiduous caterer for her young. They are thus great favourites with cottagers, and all the more so from their naturally strong constitutions, which keep them greatly free from diseases to which other and delicate breeds are liable. There are many varieties of the breed, some being valuable for their fighting qualities—of which we need only say that we hope none of our readers will have anything to do with them.

Of late years we have added to our list by importations of foreign breeds which are distinguished by many excellences. The "Brahmapoohtra," or simply the "Brahma," perhaps stands at the head of those, as best adapted to general purposes, and especially for its aptitude for laying, this being carried on even during the winter months when other hens have ceased to lay, and of course at the period when eggs bring the high prices to which we have alluded. A good layer is in one sense incompatible with the capability to be a good sitter and an attentive mother; and this detracts somewhat from the value of this breed; nevertheless, even with this it is superior to many of our own and other breeds as a sitter and mother. The birds are remarkably docile, so that they are well calculated to be confined; hence, for cottagers who have small spaces at command, they are excellent birds, as they will thrive in places where some of our breeds, as the Dorking, would soon die off. The "Brahma" is also distinguished by the large size of the body, some birds attaining—for the male the great weight of 12 and even 14 lb., the female 10 and 12 lb.; thus making them excellent market birds, as they give eating not far short of a good goose or a small turkey.

The "Crève Cœur" is another importation. Taken as a whole, it is an ugly bird in appearance, especially about the head, which has a weird, wild look; but this weighs nothing in comparison with its good qualities, of which the most remarkable is its precocity to fatten, and to give flesh of such general average quality that it may be said to be the table bird *par excellence* of France. It has remarkably light bones, so that the purchaser gets the most for his money. The pullets show the most extraordinary tendency to fatten: they are ready to be "put up" for being fattened for table at so early an age as from two-and-a-half to three months; and so quickly is the flesh or meat taken on by them that they are ready for use in a fortnight afterwards. The bird is at its best when full five months old. A pullet of six months weighs on the average from 7 to 8½ lb. The hen is a capital layer, the eggs being large and of fine quality; but she is so bad or uncertain a sitter that her eggs for hatching must be put under other birds. In France the turkey is often used for this purpose. Taking the breed altogether, an authority states that it is for delicacy of flesh, ease of fattening and precocity, the "first in the world"; and to these valuable attributes must be added another scarcely less likely to be appreciated by some, its facility for being crossed with other breeds, especially with the Cochin China—on which a note will be given presently—the cross, when the two birds are pure breed, producing a breed peculiarly hardy in constitution, having large frames and flesh of excellent quality. The colour is jet black; the breed takes its name from a small village on the Paris and Cherbourg railway, not far from Caen. It is now so thoroughly naturalised amongst us that as good, perhaps finer, specimens are bred by us as those reared in its native *locale.* Although in some respects differing from it, yet assuredly for its superior qualities standing at the head of all the French breeds, is that known as

"The Houdan," so called from a small town in the department of Seine et Oise, in France; Mantes being the locality in which it is reared and fattened for the Paris market in enormous numbers. Considerable difference of opinion exists as to its appearance, some thinking more highly of it than others; but as in the case of the Crève Cœur, so in this, looks are quite outweighed by the qualities which make it valuable for the breeder and rearer. It is even more remarkable than the Crève Cœur for its precocity to fatten and its early maturity, the lightness of the bone and the excellence of its meat. It is also a capital prolific and prolonged layer, the eggs being large and of a fine white colour. It is easily reared, docile, does well in confined spaces as it is little given to wandering; but from what we have said as to its laying properties it may be known that it is not a good sitter. We have said that it is a good fattener: it indeed stands at the head of all the breeds we now possess in this respect, and such is this tendency that it is found to fatten upon food which will but barely serve to keep fowls of equal size in good condition. We now come to notice another breed of foreign extraction, having, as its name indicates, been brought from so great a distance as China: we refer to the

"Cochin China" breed, which some praise for their beauty, but which more, we imagine, deem to be *par excellence* the ugliest bird of the yard. No doubt its plumage, if closely examined, is very beautiful; but this is lost by distance, and if kept in towns or their immediate neighbourhood, by the smoke and dust. The breed is, however, esteemed for many valuable qualities—at the head of which stands the value of the hen as a sitter and a mother—so much so that a high authority on poultry says it seems to have been formed specially for this purpose. The breed is remarkable for the large—the enormous—bulk or weight by the poultry scale to which it attains; but although carrying much flesh, it is only when the birds are killed young that this is considered good for the table. The hen is a good regular layer, the size of the eggs moderately large, in some instances small, and of a yellowish tint. As the birds have a great tendency to fatten on the abdominal parts of the body, and thus to produce a tendency to apoplexy and other diseases, the food given should be moderate in quantity and not of too rich a quality. We finish our list with a breed which from its name might come under our category of foreign poultry, but which is notwithstanding one of our own breeds, namely—

"The Polish." This, from its elegant form, with the head terminated by the characteristic "top knot"—which, however, in the pure breeds is confined only to one class—is a favourite with many; and in its favour it can be said that, although of small size, and therefore yielding little meat for table and market purposes, they are such good layers that they also, in common with the other breed we have named elsewhere as distinguished by the same name, are sometimes called "Everlasting Layers." With this characteristic they of course are bad sitters, and certainly not good mothers. Like the game fowl, they continue to improve for a long time, and keep useful as layers long after other breeds have, so to say, died out. They are, however, a fancy breed, require great care, and are in no sense fitted for the rough work and usage of the farmyard or the cottage. We should be doing one breed a great injustice—from which, however, in one sense the farmer and cottager cannot be said to be able to make much of its birds, either in the way of meat or eggs—if we omitted to name the "Bantam." If only kept to amuse, they are worth keeping for that; for nothing can exceed the extreme amiability, we were about to say humour, of the bearing and conduct in the yard of this the dwarf pet of poultry fanciers and breeders. They have in addition to this the merit of being very beautiful in form and plumage, and are capital layers, of course of very "tiny" eggs, but which are rich in flavour, and which will be treasured as exceeding dainties, if by no one else in the house assuredly by the "little folks," should it be blessed by their presence. The Bantam cocks are all brave, and show their courage off, moreover, in a consequential "Spanish Hidalgo" style—the "game" variety, we need scarcely say, displaying this to the utmost, in such a way that to see them is enough to raise a smile on the most reserved and sullen. As life should not be all work and labour, and amusement ought to form part of it as a duty, again we say the Bantams ought to be kept, especially for the little folks, with whom they are prime pets. We make a decided and marked change so far as regards size when we conclude our remarks with the dwarf Bantam pet, and commence them in our next note, under another heading, with the largest denizen of the poultry yard, the gigantic in body but small in liver and heart of courage.

145. Ensilage, considered in relation to the Value of its Produce as a Food for Farm Live Stock.

In our last note under this heading, we glanced at the crops suitable for the new system of preserving farm produce; in the successful adoption of which lie, in the opinion of many, the hopes of the live stock breeder and dairyman, so far as securing supplies of nutritious food on a more economical system, and which is possessed of fewer risks than the old methods. Before giving a note on the probable future of ensilage, and whether the system is likely to realise the hopes which at present—and it must be confessed that these are well founded, judging from the experience as yet obtained in connection with it—are entertained respecting it, it will be better to precede this by remarks on the points connected with the value of ensilage produce as food for live stock. This is indeed the crucial point, for after all, it is obvious that the very object which the process of ensilage purposes to effect is the treatment of farm produce, which in its ordinary or primary condition is good for food for farm stock, so that its nutritive qualities shall be preserved for a time more or less considerable. For no matter how well the produce may be preserved—that is, in the limited sense of keeping it from putrefaction or decay, which may be more or less complete—if, while the physical characteristics are thus preserved, its chemical ones considered in relation to food or feeding value be so changed as to reduce the value, ensilage is a process not worth carrying out. We may keep a thing in a certain sense sound, and keep it to save expense; but if while it is so kept it is also somehow so changed as to lose some of its valuable characteristics, the object proposed in the keeping is not realised. Fortunately for the future prospects of ensilage, it is admitted that the produce treated by the system is preserved in the best sense of the term. This term does not, however, include that the preservation proceeds on such lines that the substance is the same as before: a change *does* take place in the character of the produce, but it is a chemical, not a physical one, and is such that when ensilage is well and carefully carried out, it does not deteriorate the primary value, while in some cases this is so far increased that the siloed produce is more appetising than the food in its original form was.

What the chemical change is, or changes are, is a point which up to the present time has not been definitely decided, from lack of those systematic experiments and investigations which will no doubt yet and speedily be made. The scientific part of the question is yet an open one, for as the eminent agricultural *savant*, Dr. Voelcker, the late consulting chemist to the Royal Agricultural Society (whose lamented death entails a loss upon agriculture which cannot well be estimated), says, "we have yet a great deal to learn about the process." Roundly or generally described, it may be said to be one of "fermentation." But there are several kinds of fermentation, of which two only concern the ensiloer—namely, "lactic acid" and "acetic acid" fermentation. And of these two the "lactic acid" fermentation is the one he should aim at securing. This can only be done in a way which will give the best silage when the produce preserved is of good quality, nutritive, and rich in sugar. There are certain of the albuminous or protein compounds in the food which act as ferments with the sugar constituents. The sugar "simply breaks up," to use the words of Dr. Voelcker, "and its elements arrange themselves in a different manner, so as to form lactic acid. Now, lactic acid has the same percentage composition as sugar—that is to say, you have neither more nor less carbon, hydrogen, or oxygen, in the lactic acid than in the sugar." But in thus writing of fermentation we must warn the reader against the notion that it is accompanied by the active decomposition or change, and the evolution of gases, which are popularly associated with the process, as in the case of fermentation with common or brewer's yeast, or barm. This active fermentation is not present in the silo—that is, when the produce is properly pressed down in the way we have described. And this careful—we have shown that it cannot be too careful—pressure has for its very object the prevention of this active fermentation. Let us see what will be the result if the pressure be not attended to and the air carefully excluded from the mass in the silo. If active fermentation sets in, or more correctly stated, if it be allowed to set in through careless packing of the produce in the silo, then a loss of the produce or material will take place. For this active evolution of gases arises from a form of fermentation setting in other than the lactic—that is, what is called the "acetic," or to give it its popular name, vinegary—fermentation. This is brought about by the air rapidly changing the sugar which is present in the silo produce into alcohol. But alcohol in free contact with the atmosphere cannot exist for any length of time in the porous mass of the silo, any more than it can exist in the hay of a stack or barn, where the process of fermentation, under similar conditions, is carried on just as it is in the packed silo. For the alcohol in such conditions is rapidly changed into acetic acid, it loses a part of its hydrogen, and becomes aldehyde, the presence of which is denoted by the pungent penetrating odour exhaled by the mass. If the fermentative action is allowed to proceed, that stage will be reached at which a high temperature is produced, which may ultimately end in the actual combustion of the produce, just as hay in like conditions is known to take fire. This is an actual and a visible loss of material but too well known amongst farmers; and although the fermentation may not go on or be allowed to go on to this stage, still it is evident that if the acetic fermentation is permitted in the silo some loss of produce will result, and the value of the produce as a feeding material will be proportionately lessened. Such is the theory of the ensilage process as propounded by Dr. Voelcker, the first agricultural chemist of his day. It is right, however, to remind the reader that the theory is, as Dr. Voelcker stated, largely as yet tentative only; for, as he remarked, we have yet a great deal to learn in connection with it; and like a true man of science he refrained from dogmatically stating that this is so, or that that is so absolutely. This eminent authority was still engaged in investigating the subject when he died, and therefore wisely withheld a definite opinion with regard to it; but he was so far assured of the truth of the theory that there is certainly no violent evolution of gases in a well packed silo, that he said, "I believe it will be found, when the balance is struck, that so long as you confine your process to the lactic fermentation there will be no loss in substance."

The reader will now perceive the reason why farm crops or produce which are what is called sugary in composition are the best adapted for ensilage, and this because the presence of the sugar aids the lactic acid fermentation which it is the aim of the ensiloer to produce. And it is this characteristic of sweetness which gives such a value to maize or Indian corn, to sorghum or the North China sugar cane. As to the fact that maize up to its best condition of a green succulent crop can be grown well in this climate, there is no doubt. Still, as it is our duty to give the reader the fullest information on the subject, it is necessary to remind him of a caution in relation to this crop which Dr. Voelcker gave: namely, that the percentage of sugar in the plants depends much upon circumstances of climate; and he himself held the opinion that our climate is too humid, "too risky," as he termed it, for the growth of maize or of sorghum on the extensive scale for ensilage. On this point, however, we might hazard the opinion that as the same influence of climate will affect the constituents of meadow grass or of other forage crops which are regularly grown with us, and which nevertheless are used largely, or we should say mainly for ensilage, so we think it likely that on the average sugary crops, such as the maize or the sorghum cane, may be grown so as to form excellent ensilage crops—as good at least as the grass or more ordinary crops grown—but, be it remembered here, in the same season. We would at all events be inclined to counsel the amateur farmer at least—as he may be able to stand the loss, if loss there should be—to try a variety of crops, even these deemed to be "risky." We have yet almost everything to learn in connection with ensilage, and we can only learn from experience, and this in turn can only be had by courageously, yet hopefully experimenting. And of this we feel well assured, from what we knew of Dr. Voelcker, that he would have been the last to say or do anything which would dissuade any farmer from trying new crops and new processes of all kinds.

Having thus explained what only at present is known as to the theory of the ensilage process, we can now glance at the value of its produce as a food for farm live stock. And here, just as we have seen is the case in relation to the theory, and for the matter of that the details of practice, we have yet much to learn. In point of fact, so far as knowledge of the feeding value of ensilage produce of the same definite kind as agricultural chemists and practical farmers have given us in relation to all the ordinary forms of feeding produce and of stuffs is concerned, we have everything to learn. For, as stated by Mr. Jenkins in the able paper on the subject to which we have made pointed reference as read before the "Farmers' Club," London, "Unfortunately up to the present time we are singularly deficient in records of actual experiments made with care by competent persons." Enough has, however, been ascertained by the extensive practice of ensilage in this country, the Continent, and in the United States and Canada, to prove beyond any doubt that silage, or the produce of silos, is generally a valuable food. This, in fact, must have been the result of experience as a rule; for otherwise we should not have witnessed the rapid spread of the process amongst farmers. And it must not be overlooked that the modern practice of ensilage was based on the very fact that silage was a valuable food.

What is the actual or definite value, and upon what principle or principles that value is ascertained, is quite another thing. And, as just said, on this point or these points we have as yet everything to learn. But there is one thing which we venture to say will be found as the result of wider experience and the more precise and carefully conducted experiments which will be sure to be made—and that before long, else the spirit of enterprise both scientific and practical which has hitherto distinguished modern agriculture will fail to be displayed. And this lesson, if we may so call it, which we shall learn from thus experimenting will be that while the fact that silage is most valuable as a food will be made still more clear and satisfactory than has as yet been done, this will be done only in a general way—so that it will be vain to expect that we shall have what may be called a "standard analysis" giving us a standard for the feeding value of ensilage in the same way as chemistry has given us a standard for the value of the farm crops and feeding stuffs. For although it may be said that while the circumstances connected with the cultivation of a cereal crop such as wheat or oats, or a root crop such as swedes or kohl rabi—as soil, seed, manure, climate or weather, and the method of culture—do exercise an influence upon the character of the crop produced, giving rise to differences in their constituents and therefore in their feeding value, still it must be remembered that those differences are so very slight that the analysis of a few roots or of a few samples of corn serve as a guide or reference by which we can judge with a large element of definite precision as to all samples of corn or crops of roots. Hence it is that we have tables compiled by our agricultural chemists, the facts of which are based upon a wide series of analyses, which give us the feeding values of farm crops and feeding stuffs such as linseed or oil cake and other foods known as "artificial."

But this aid we must not look for in the case of ensilage produce. It is not that the crops individually considered may vary, the one grown upon one farm and under certain circumstances being different in analytical or feeding value from the crops grown in another place and under other circumstances; for we have seen that this difference is but slight, and that for all practical purposes we have analyses for each crop which can be taken as standards. But it is in this that lies, and will in future lie so far as present circumstances indicate, the peculiarity of ensilage produce—that its value depends upon a number of details connected with the actual work of the silo—some of these having the merest shade of difference, but which shade affects materially the character of the produce. And although it may be said that the methods adopted in storing up or keeping ordinary farm produce, as grain crops in the barn or the granary, or roots such as mangold in the "pit," are affected in value by the way in which they are carried out, those methods have not the number of details, nor are they represented by those fine shades of difference, which distinguish the ensilage process. We can predicate with a clear degree of accuracy that by adopting what are called merely ordinary prudential methods we shall be able to keep our grain or preserve our roots in good condition. But even now, with our comparatively limited experience of ensilage, we know enough to make it very clear that the value of the silage—the feeding value (for that is the point)—depends upon a number of circumstances, and those with only nice shades of difference, connected with the condition in which the crop is taken to the silo, and the way in which it is put and stored up in it. Hence has arisen, as we know from actual facts, the success which one farmer has met with in his ensilage, and the failure which has disheartened another; and although in both cases the produce really preserved in the one case and only attempted to be so in the other was, so far as could really be ascertained, of precisely the same character and in the same condition.

146. To find the Weight in Pounds per Lineal Foot of Brass, Copper, and Lead, in Square and Circular Bars.

(*a*) *Square Bars*, when the length in inches and side of square are known.—Square the side of the bar and multiply the product by its length in inches. Divide the product by the constant 3·33 for brass, 3·12 for copper, and by 2·43 for lead: the quotient is the weight in pounds.

(*b*) *Round Bars or Circular Rods*, when the length and diameter in inches are known.—Square the diameter and multiply the product by ·7854, and multiply this product by the length of the bar. Divide the product by 3·33 for brass, 3·12 for copper, and by 2·43 for lead: the quotient is the weight in pounds.

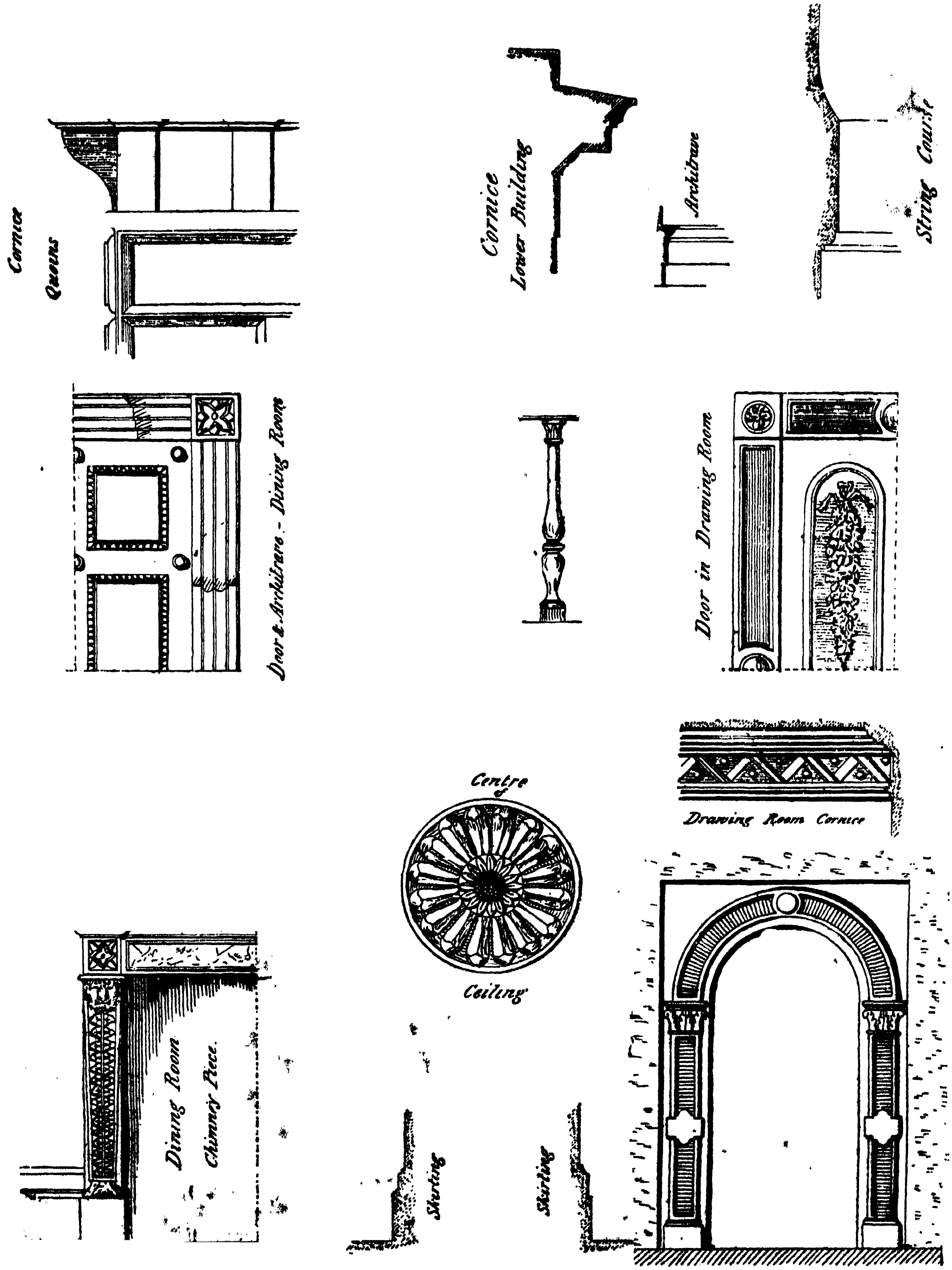
147. To find the Weight in Pounds per Lineal Foot of Cast or Crucible Steel of Various Sections.

(*a*) *Square Bars*, when the side and length in inches are known.—Take the length of side of bar and square it, or multiply it into itself, and multiply the result by the length of the bar in inches. Then divide the product by the "constant" 3·52, and the quotient is the weight in pounds.

(*b*) *Round Bars or Circular Rods*, when the length in inches and diameter are known.—Square the diameter, and multiply the result by ·7854, and multiply this result by the length of the rod in inches. Divide the product by the constant 3·52, and the quotient is the weight in pounds.

(*c*) *Flat Bars*, of which the length, the breadth, and the thickness in inches are known.—Multiply the breadth by the thickness, and the product by the length. Divide this final product by 3·52, and the quotient is the weight in pounds.

INTERIOR AND EXTERIOR WORK. STYLE—ITALIAN.



THE DOMESTIC HOUSE PLANNER (see Text).

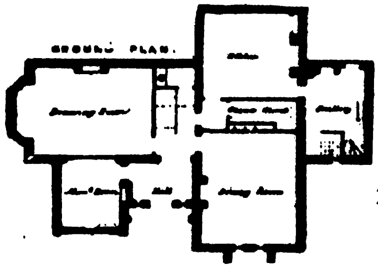


Fig. 1.

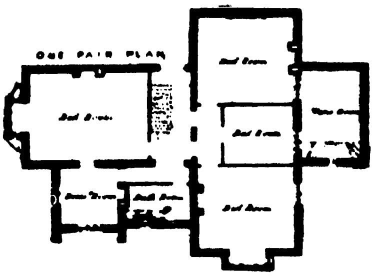


Fig. 2.

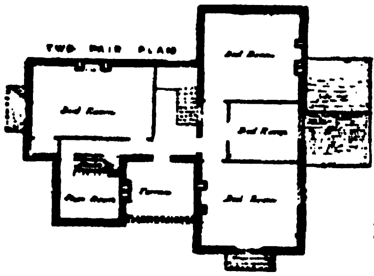


Fig. 3.

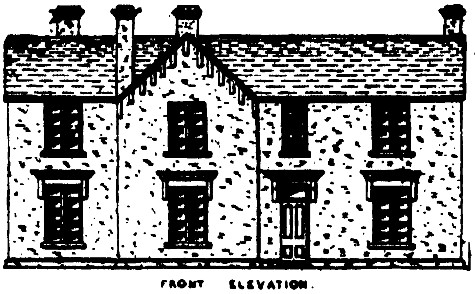


Fig. 4.

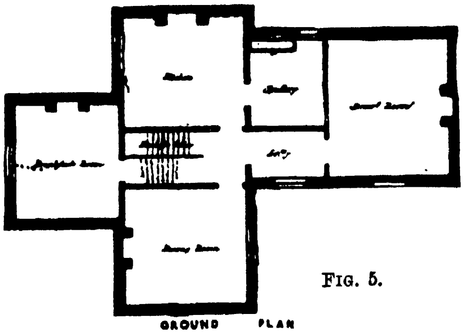


Fig. 5.

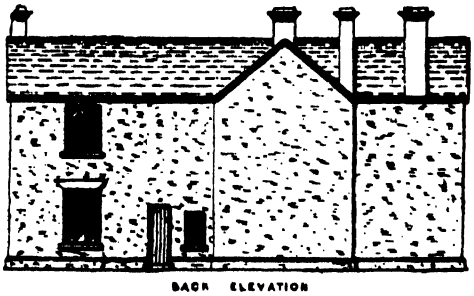


Fig. 6.

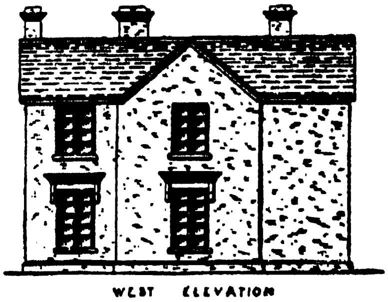


Fig. 7.

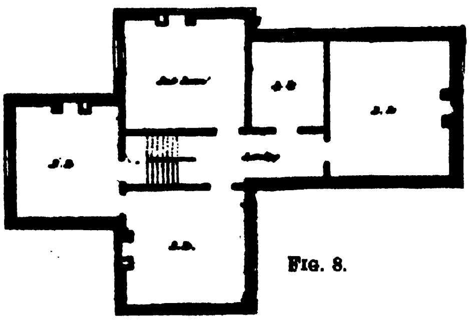


Fig. 8.

Figs. 1, 2, 3. Plans of Domestic Gothic Villa in Figs. 1 and 2, Plate CXXXIII. (Fig. 1, Ground Plan; Fig. 2, Chamber or One-Pair Plan; Fig. 3, Two-Pair Plan.)—Figs. 4, 5, 6, 7. A Cottage Villa in the Italian Style. (Fig. 4, Front Elevation; Fig. 5, Ground Plan; Fig. 6, Back Elevation; Fig. 7, West Ditto.)—Fig. 8. Chamber Plan.

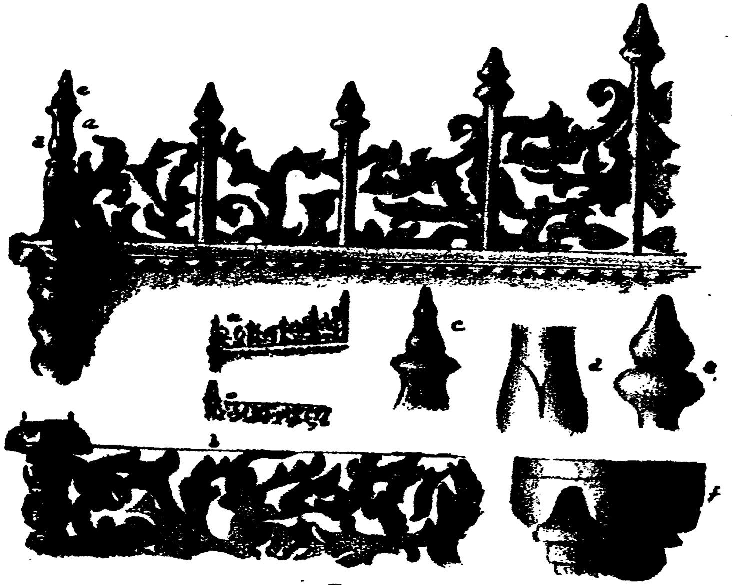
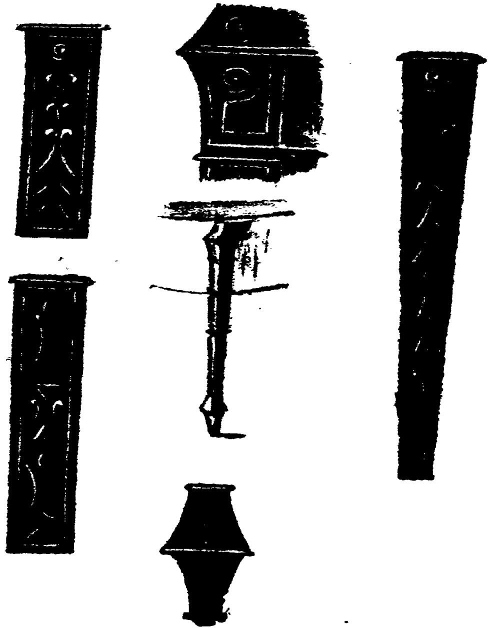


FIG. 1.



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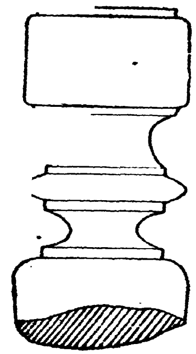

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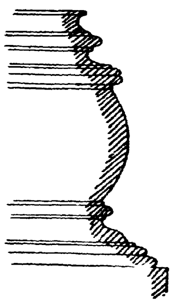

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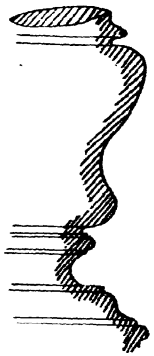

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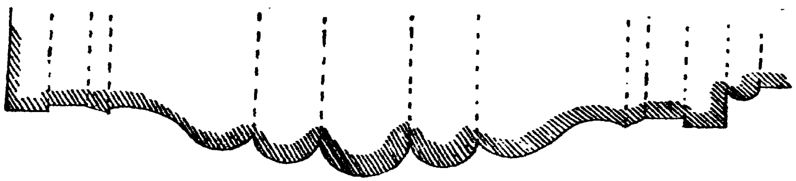
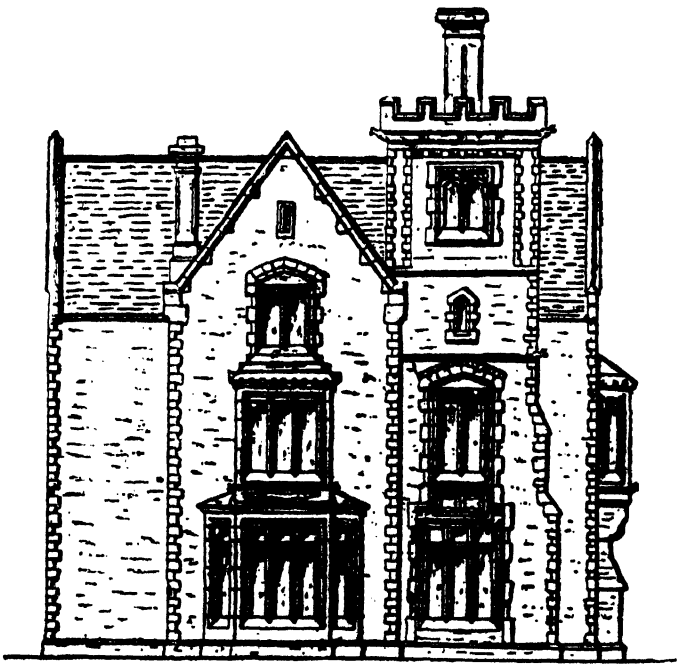


FIG. 5.

MANSION OR VILLA. STYLE—DOMESTIC GOTHIC.

FIG. 1.



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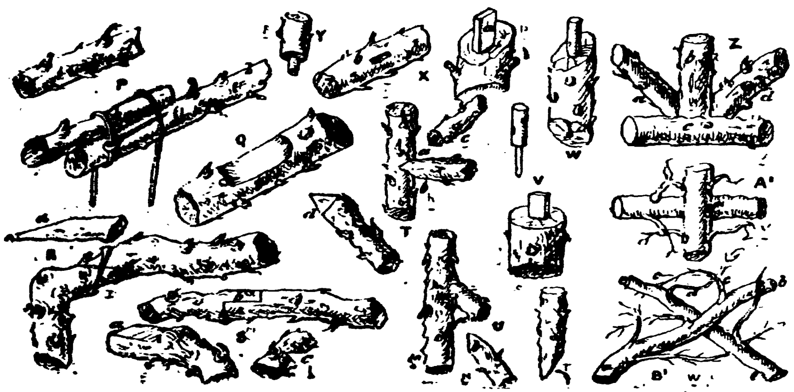
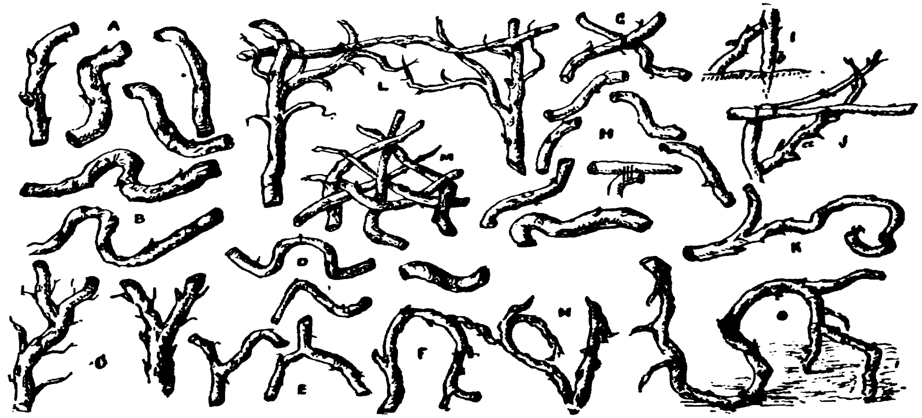


FIG. 1.



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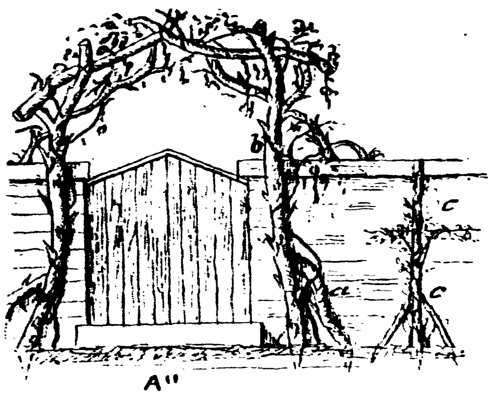
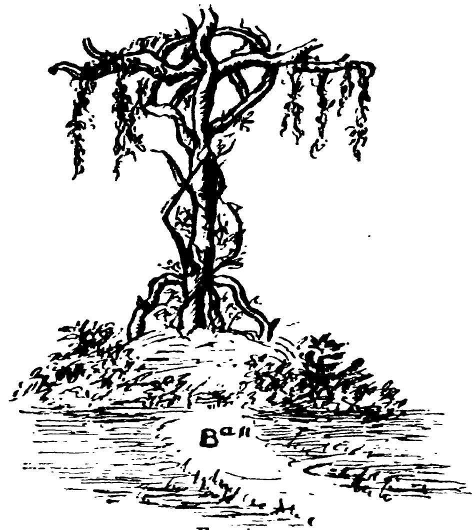


FIG. 3.



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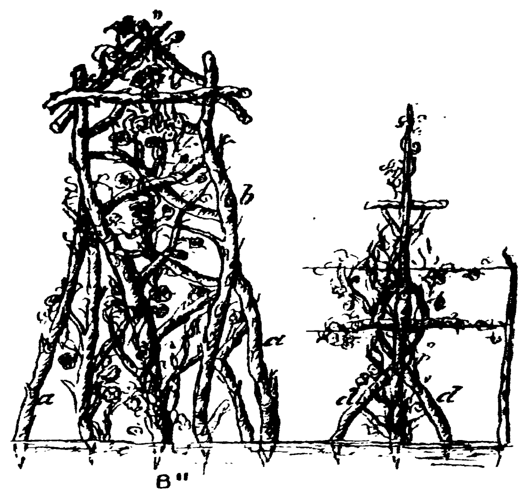


FIG. 5.

(Scale 2 inches = 1 foot.)

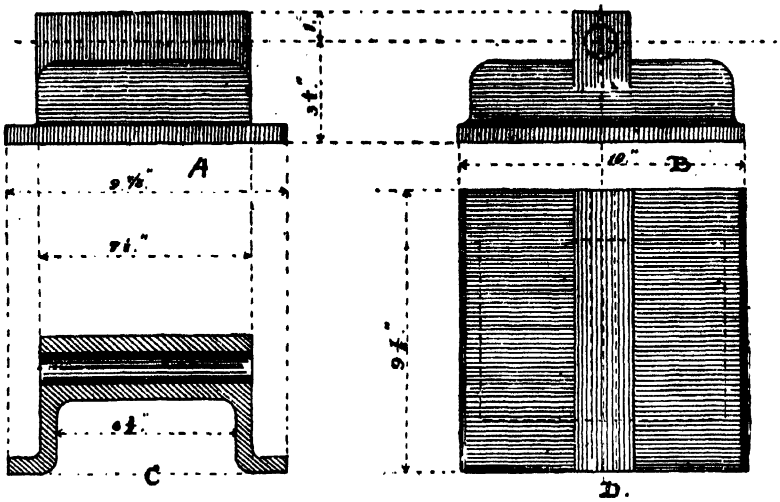


Fig. 1.

A. End Elevation of Slide Valve.—B. Side Elevation of Ditto.—C. Section of Ditto.
D. Plan of Ditto.

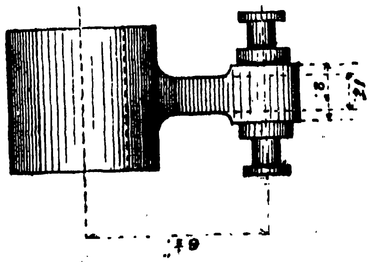


Fig. 2.

Plan of Lever of Weigh Shaft for Slide Valve.

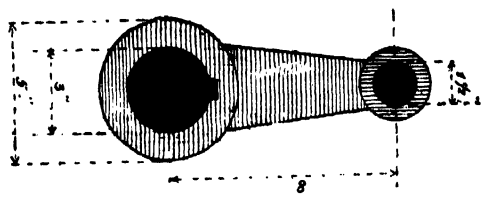


Fig. 3.

Side Elevation of Lever of Weigh Shaft for Slide Valve.

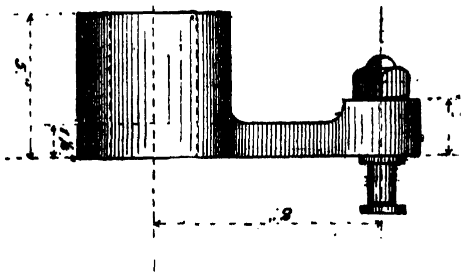


Fig. 4.

End Elevation of Lever of Weigh Shaft for Slide Valve.

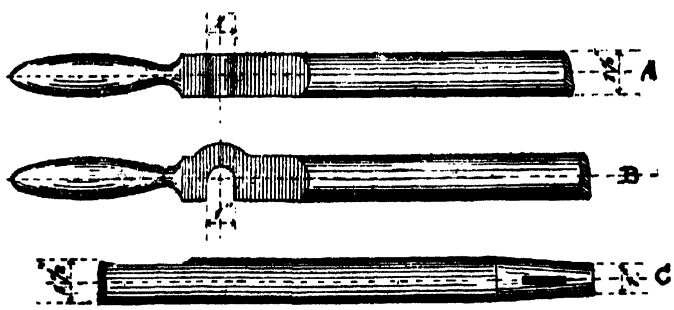


Fig. 5.

A. Part Plan of Eccentric Rod at Gut, or Lifting End.—B. Side Elevation (see Fig. 4).—C. End at Eccentric Strap.

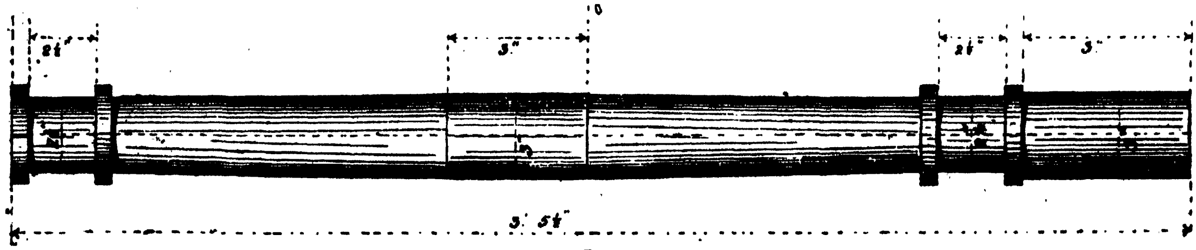


Fig. 6.

Plan of Rocking or Weigh Shaft for Slide Valve.

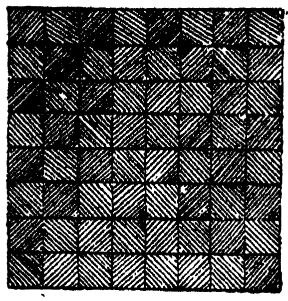
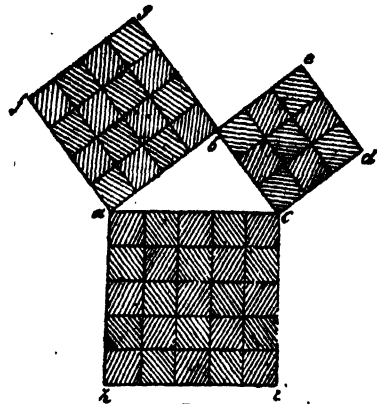


FIG. 1.



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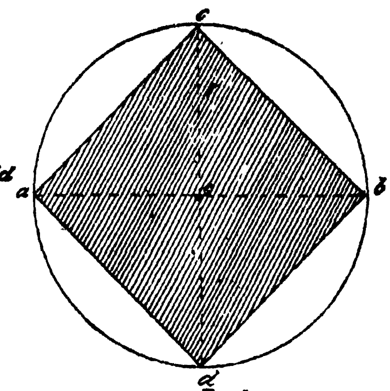

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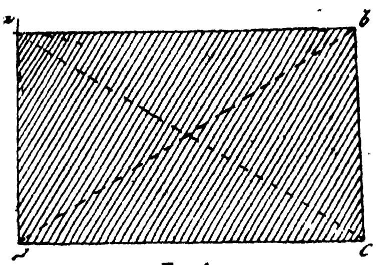

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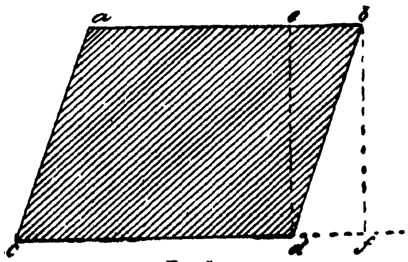

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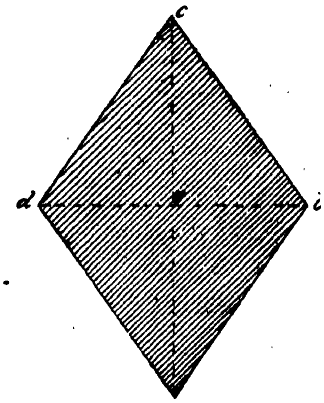

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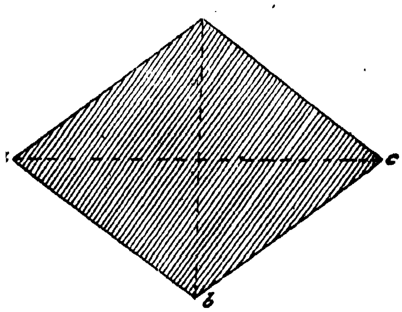

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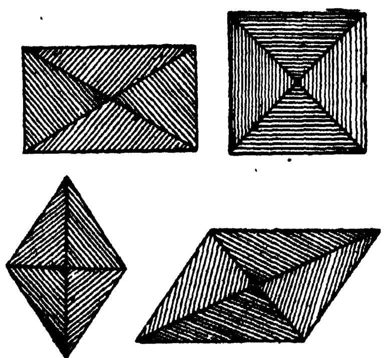

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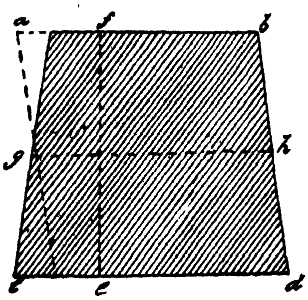


FIG. 9.

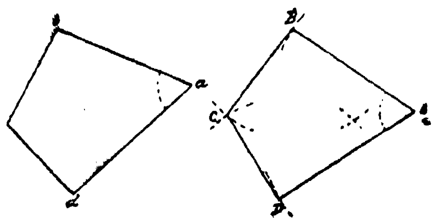


FIG. 10.

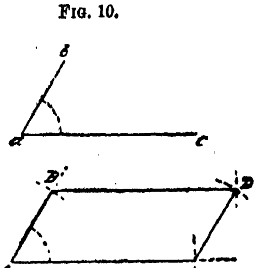


FIG. 11.

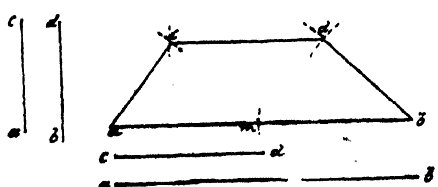


FIG. 12.

THE BRICKLAYER (*see Text*).

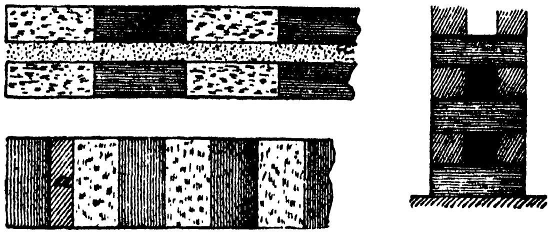
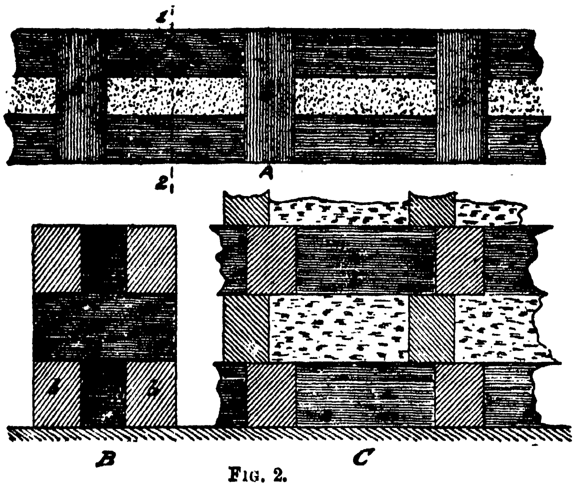


FIG. 1.



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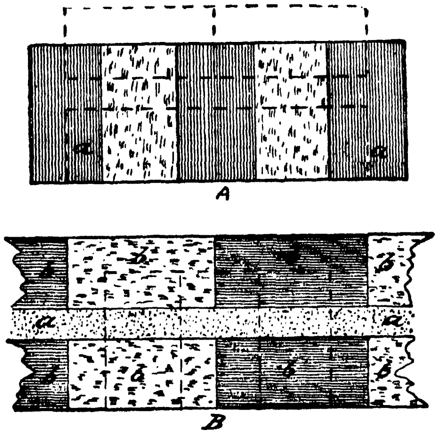


FIG. 3.

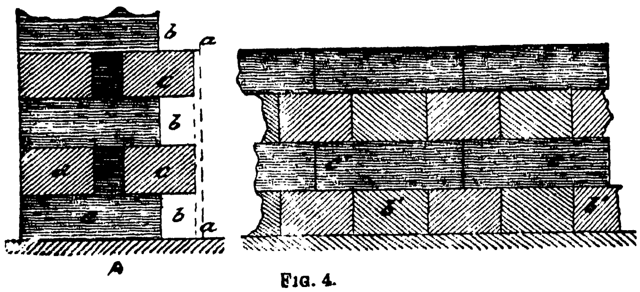


FIG. 4.

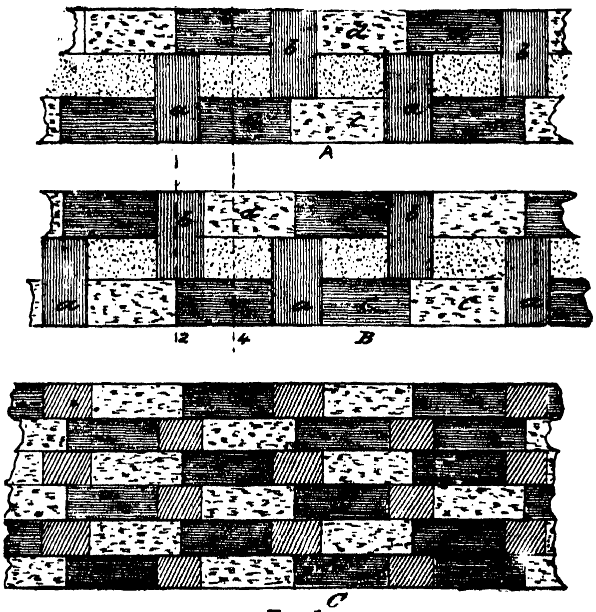


FIG. 5.

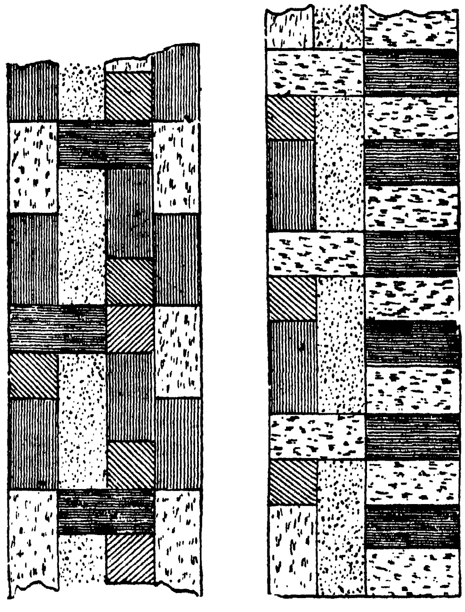


FIG. 6.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XVI.

WE concluded our last chapter by drawing the attention of the young reader to the long course of observation and experience required to be given in early days before natural phenomena and laws could be applied to the machines we have every day at work. To trace the connection, to see clearly the "nexus" in all its steps which bound up the phenomena, so to say, with the mechanism, would, on the part of the reader placed in the position we have supposed him to be, be virtually the invention of the mechanism. And here it will be seen that the word "bound" is strictly in keeping with the root of the word "connection" ("connecting rod," for example, in practical mechanism) and "nexus." Connection being derived from the Latin words *con*, with, and *nectare*, to bind, nexus is thus a binding mechanism, or, as it may be called, the chain which binds the parts together.

But in adapting natural phenomena to mechanical contrivances the machinist finds in practice that what may be called the natural or normal action of those is very much modified by the condition of the bodies or substances he has to deal with; and the converse is equally true—that the machines he may contrive may, while on the whole operating as he desires, yet bring about a condition or conditions in the materials operated upon which may be anything but desirable. Both of those the machinist has to provide for; and not seldom do we find it occur that, in the latter case more especially, the provision is so difficult that it takes long years of experience and costly experiment before the true remedy is discovered. In a succeeding part of these papers, in illustrating different classes of motion, the reader will find various points considered in relation to the modifications in the line or course of bodies moving, under the action of some force, along level, and also along inclined surfaces, which modifications are brought about by the condition or form of the bodies.

Mechanical Arrangements and Appliances based upon Motion of Falling or Rolling Bodies as Influenced by their Form.

The phenomena attendant upon conditions of the kind just named would be observed a long time before their connection with and application to mechanical work could be traced out or even conjectured. Thus, to return to our supposed case of an inclined table or perforated plate, if the bodies were of different shapes, as well as of different sizes and weights, those shapes would influence the way in which, and the velocity at which, they would move down the incline; or, to put it more accurately, the time taken in reaching the foot of the incline would be different according to the form of the bodies, for theoretically the velocity due to the gravitation of the bodies would be the same. Thus, while all the bodies of a truly spherical form would roll down in straight lines from top to foot of incline, all bodies approaching the form of a cone would not roll in straight, but curved lines, those lines having a tendency to the right hand or to the left according as the large end of the cone, or body, lay toward the left hand or the right. And as the table or plane was made to vibrate laterally, the positions of the cones might be continually changing, so that they would take a zigzag path down the incline, just as a horse takes in dragging a cart up or backing it down a very steep hill. Simple as the primary principles are upon which separating machinery is based, the young student in the principles of mechanics would be surprised if he were made acquainted with the amount of mechanical work done by its aid, even in the simplest forms of mechanical arrangements; the large amount of capital involved, and the extent of steam power used in their working. At some collieries, for example, thirty horse-power will be required for the "screening" of the coals, separating them into different sizes or lumps. And he would be still more surprised if he saw in some collieries the very complete mechanical arrangements, and their extensive range, in this department. In place of using the flat inclined "screen," or what would popularly be called a "riddle," circular cages or screens are used with perforated peripheries, by which the advantages of circular motion are obtained. But with soft coal these, while doing their work of separation very quickly, are apt to break or smash up the pieces too much. To overcome this difficulty, M. Briart, a Continental engineer of great mechanical ability, has recently gone back to the use of open or flat inclined screens; but to increase their producing power he has in a most ingenious manner taken advantage of the principle of change of form—as influencing their motion—of the parts or pieces of coal to which allusion has been made. The screening apparatus is daily working with great success in more than one of the large collieries on the Continent—markedly in the coal district near Liége, in Belgium — the extent of some of which may be judged by the fact that two collieries, those of Mariemont and Bascoup, employ no less an amount of steam power than 5,200 horse, the steam for which is raised in no fewer than 111 boilers. At these collieries the screening or separating apparatus of M. Briant is erected. The apparatus as a whole consists of one or more gratings placed one above the other, all working in the same way. In place, however, of having one row of bars, as is usual, each grating is provided with two sets of bars, and it is in the way in which those are arranged that the peculiarity of M. Briant's system lies. One set of the bars is fixed and the other movable, the latter when at rest lying in the same plane as the fixed bars. The movable bars are fixed in a frame, this being carried or supported at its lower end on two cranks, while the upper end is carried by two eccentrics fixed on a cross shaft which has a motion of revolution. By this arrangement, during one revolution of the eccentric shaft the movable bars are alternately—each half-revolution—below and above the fixed bars. While above the fixed bars, the movable bars have a longitudinal or rectilineal motion uphill—that is, in the direction from the foot to the top of the grating; but during the other half-revolution, when the movable bars are below the fixed one, the former have a downhill rectilineal motion—that is, in the direction from the top to the foot of grating. When the coal is delivered by the tipping waggon to the upper part of the screen, it is in the first instance lifted up by the movable bars, and these having the downhill motion carry the coal so far down the screen; and it rests on the fixed bars while the eccentric shaft is its other semi-revolution. The next half-turn again lifts the movable bars, and again their downhill movement carries the coal to the next resting-point on the fixed bars. At each revolution the coal is shaken up throughout its whole mass—the small coal falling or gravitating through the spaces between the bars, while the large pieces are carried on to the foot of the screen by a series of steps or drops, without any shock. In the more recent and much improved forms of this screening apparatus the distance between the bars can be adjusted without stopping the work by merely turning a handle or lever.

Mechanical Arrangements based on the Law of Gravitating or Falling Bodies.

Before discussing our illustrations of some mechanical work in which the law of gravitation is taken advantage of directly, it will be wise to allude, however briefly, to another department of work in which the principle is also exemplified—that is, in cotton factory machinery. The material here to be dealt with is in its primary condition a light substance, giving, with little weight, a very large surface. But, delivered to the factory, it is, through the requirements of transport, found in the condition of lumps, more or less closely matted together, and more or less mixed with dust, particles of seed and other extraneous substances (see "The Factory Worker"). In the opening up of those lumps or masses, so as to have the fibre presented in its native condition of a light, open mass of a fibrous material, the laws of properties of "matter" known as gravitation, weight and inertia are taken advantage of in the machinery employed. The property known as inertia will presently be explained, in next paragraph; that of weight or gravity has been already treated of. The reader will find, in the chapters of the paper "The Factory Worker" a description of the machines used for opening up cotton. What we have here to notice, however, is a point coming under the principle we have been discussing. Having a mass of cotton so far opened up as to be light and open, and capable of being supported by or of floating in the air, and it being necessary to strike it, so that any dust or light or extraneous matter in it would be, so to say, shaken out, it would appear to be but a matter of indifference whether the mass was struck downwards by the blow coming from the upper side, or upwards by the blow directed from below. If the dust could be expelled perfectly by one blow, this would certainly be true, but the conditions of the case would be very naturally altered if more than one, or a succession, of blows were necessary to free the mass of cotton from dust or other impurities. One upward blow would obviously give the mass such an impulse that it would rise; and after reaching its highest point the law of gravitation would, when the force ceased to act, come into play, and the mass would again fall, again to be struck upwards—each blow driving out, to use the common expression, so much of the dust. All this was known for a long time, but no one thought of applying the very familiar phenomenon of a mass of cotton acting in this way to the operation of cotton cleaning till quite recently. How these phenomena were applied, and how their application opened up in the opinion of practical men quite a new era in cotton cleaning, the reader must refer to the chapters of the paper entitled "The Factory Worker" in this journal to have explained to him.

Bodies in Motion.—Momentum.

In the preceding paragraph, while treating of "inertia," we have shown how the term is so far vague or indefinite, or it will perhaps be more correct to say incomplete, inasmuch as, from the very derivation of the word, to say little of the universal meaning attached to the word "rest," it (the term "inertia") takes, or seems to take, cognisance only of the law as it concerns bodies at "rest," and their tendency to remain so till influenced by causes external to themselves putting them in motion. There is, therefore, in mechanics a practical division of the subject of the law of inertia, and the phenomena of bodies in motion are considered under the term "*Momentum*," which has been itself defined to be, as indeed it actually is, the "inertia of bodies in motion." The term "momentum" is derived from the Latin word *movere*, to move. It therefore involves the conception of motion, and may be considered as synonymous with the phrase "the quantity of motion,"—so that when we say that the momentum of a body is so much, we simply state the amount of its motion. This is estimated by multiplying the speed or velocity by the weight or "mass" (see a preceding paragraph on *mass*). This will be easily understood by the student, since, just as in the case of bulk he naturally associates with it the idea of weight, so he naturally associates with a moving body the idea that there will be a greater difficulty in arresting its motion if it is large, or if its mass be great, than if it is small. And equally may it be said that he intuitively comprehends that if this body, be it large or small in mass, can be arrested in its motion with ease corresponding to this mass, so will this stopping be made more or less easy just as the speed of the moving body is great or little.

Momentum as Mass or Bulk or Weight and Velocity or Speed of Moving Bodies.

These two circumstances of "mass," "bulk," or "weight" of a moving body, and the "speed" or "velocity" with which it moves, are, we say, associated, and that as it were naturally, being taught us by an infinity of examples from earliest youth up, so that we intuitively know that the power or force of a moving body depends upon the two. This power or force we call "momentum." We see how this force of momentum increases, for if we conceive of any particle as moving at the rate, say of one foot per second, we have the momentum or the quantity or the inertia of its motion, as measured by the two, the one multiplied by the other; but if the speed be two feet per second we have the force doubled, or twice the quantity of motion. But if there be more particles than one, the greater the number of the atoms the greater the momentum or quantity of motion, and this just in proportion as the number is increased. Thus, a ball of 2 lb. weight propelled with a velocity of 224 feet per second will have the same force or momentum as a ball weighing 2 cwt. propelled at the rate of 2 ft. per second. The blow given by each will therefore be equal; for as the momentum of any body is as the mass multiplied by the velocity, we have the same result in each case—for 224 (vel.) $\times$ 2 (mass) $=$ 448, and 2 (vel.) $\times$ 224 (mass) $=$ 448. We have many examples of the force of a body of great mass or weight, even when the velocity or speed with which it moves is very small. A waggon heavily loaded which has been forcibly backed, although in nearing a wall its motion may have almost but not quite ceased, may yet have such force of momentum as to crush or bend back a piece of strong timber lying between it and the wall. Just so a steam-vessel in being brought up to the quay side may have so little "way" on her—that is, so little of the motion imparted to her by her engines—that the movement towards the quay can scarcely be taken in by the eye, yet the force of momentum is such that strong bodies would be crushed like eggshells between the quay wall and the side of the vessel. But as momentum is measured also by the velocity, when we combine great mass or weight with great velocity we obtain a force or power so great—as in the case of two railway trains colliding with each other on the same line, or two steam-vessels going in opposite directions—as to bring about catastrophes which in loss of life and property are little short of national calamities. The connection of mass with momentum is illustrated thus. We have two balls of such a material that one striking the other will adhere to it, forming one ball or mass, still capable of rolling or moving on. The one ball which we suppose to be at rest has a mass represented by 90 lb.; the moving ball has a mass of 10 lb., and is by some force applied to it moved along at the rate of 100 ft. per second. On coming in contact with the 90-lb. ball at rest, it communicates its motion, and adhering to it, the two balls continue to roll or move on. But the velocity is no longer 100 ft. per second, but only 10 ft. per second, for the mass is not now 10 lb., but 100 lb., since the primary quantity of motion is spread amongst the greater number of particles, these being now expressed by 100 lb., so that the velocity is only one-tenth of the primary velocity.

Increase of Momentum in Moving Bodies.

When a force is applied and continued to a body, causing its motion, the velocity or speed being small at first, it moves therefore very slowly; but such momentum as it has—say at the end of a given time—acquired, added to the force which moves it, increases the velocity. This increase in velocity gives now at the end, say of another period of time, increased momentum or quantity of motion, and this added to the still continued force, gives a still quicker speed or greater velocity. It is this principle or law on which we rely—this momentum or quantity of motion in the inertia of moving bodies—in getting up the speed of machines and parts of machines or of bodies moved by extraneous forces. Examples of the law abound everywhere in daily life: a railway locomotive dragging a train moves slowly at first, the motion almost imperceptible, but it becomes quicker and quicker till the desired "speed" is obtained, the mass and the force still remaining the same. Of two bodies of equal size, but moved by some force at different velocities, the one which we suppose to move at twice the velocity of the other has twice the momentum. Hence we deduce the truth or law that, knowing the quantity of motion in, or the momentum, of a body, we have the measure of the force which produced the motion.

THE ROAD MAKER.

His Work in the Laying out of Roads in Rural, Suburban and Town Districts, their Construction, Repair, and in the Choice and Use of the Various Materials Employed.

CHAPTER VI.

Footpaths.

The construction of footpaths, like that of carriage-roads, should not be dependent on their covering for being at all times in a state of efficiency and dryness. The covering, whatever it may be, should be wholly to protect the soil in which the path is made from abrasion. The breadth of the path should be bounded by a kerb, to the top of which the surface of the path should be flush. Whenever it can be conveniently obtained, the kerb will be best of hammer-dressed stone, not less than nine inches deep and six inches thick, set on edge, and rising six inches above the level of the haunch or channel of the road. When stone cannot be conveniently obtained for a kerb to the path, two courses of good sound turfs may be substituted. When a footpath has been rendered perfectly dry by being drained, the covering need not exceed four inches in thickness; and, when finished, it should be nearly level in its lateral contour. A fall from the fence to the carriage-road of 1 in 60 is all that is necessary for shedding wet from the surface of a footpath; and any greater declivity will make the path unpleasant to walk upon. The best material for the footpaths of public roads is pit gravel; and a small quantity of ground chalk-lime, or even Portland cement, say about one-sixth or one-eighth of the volume of the gravel, will assist in making the gravel bind. The cinders from steam engine or brewery furnaces make an excellent covering for footpaths. The breadth required for a footpath will be six, nine, or twelve feet, according to the number of foot-passengers using the path. It is only in the finely constructed and broad roads which are made leading to towns, in their immediate neighbourhood, and intersecting its most important districts, that a footpath is given to each side. And within the boundaries of these they partake more of the character of—if indeed they be not formed as a rule in the same way as—ordinary street pavements. But in what are truly rural roads—and the remark applies to many suburban ones—the road has only a path on one side. Where, however, the width of the road will permit, in place of giving a footpath at each side, which may well enough be dispensed with, a "horsepath" may be given. This, for saddle-horses, will be found to be a useful accessory to a public highway. The form of the horsepath should be as flat as the footpath, and its outward margin should be kerbed with turf, with the adjoining haunch of the carriage-road forming a channel. There need not be, or rather there should not be, any covering of stone or gravel on the horsepath; it should depend for its good condition upon its being thoroughly drained; but the growth of a sward of grass as a cover will be found to be an advantage in keeping the road cool and elastic for horses' feet. This path should be from nine to twelve feet in breadth.

Fences of Roads.—Hedges.

The most suitable fence for a road is a hedge, for which several kinds of shrubby plants are well adapted. In the list of plants suitable for hedges for roads may be included the hawthorn (*Cratægus oxyacantha*); the common holly (*Ilex aquifolia*); the beech (*Fagus sylvatica*); and the hornbeam (*Carpinus betulus*). Of these the common hawthorn—from its free habit of growth, its being more tractable than any other plant adapted to the purpose, and by its spines offering, when sufficiently grown and properly managed, an almost impenetrable barrier to all kinds of stock—far surpasses any other plant for the purpose; therefore the following remarks will principally apply to the hawthorn as a hedge plant, and the notice that may be bestowed on the others will be but to point out advantages of their use under particular circumstances.

The hawthorn will grow in almost any kind of soil of intermediate quality between moisture and dryness; but in order to insure a rapid and strong growth, it should be planted in a deep soil. The plants ought to be transplanted a year or two in the nursery before being planted out in the hedgerow; the plants should be selected for their vigour of growth and equality of size; they should be removed from the nursery with every care to avoid injury to the rootlets, and they should be planted in their permanent situation as soon as possible, without exposure to draught or severe frost, after being removed from the nursery. The best time for planting thorn hedges is the middle of October, but the operation may be continued in open weather throughout the winter until the middle or end of March.

Properly draining the road will always render the site of a hedge forming the fence for a road sufficiently dry for the growth of hawthorn, which should always be planted on the level of the road, or very slightly elevated above it, on a kind of bed or platform, about a yard in breadth. Should the staple of the soil be required to be deepened, such increase of depth will easily be obtained from the surface soil of the adjoining open drain or ditch. If the land be in tillage, a cubic yard of well-rotted fold-yard manure, or half a hundredweight of Peruvian guano to every 100 or 150 yards in length, trenched into the soil in the intended line during the summer previous to its being planted, will very greatly promote the early growth of the hedge. If the land be in grass, the rotting of the turf trenched into the line of hedge will be amply sufficient for the same purpose. In planting there should be no further pruning or trimming of the roots of the plants than the removal of any broken or injured rootlets with a sharp knife. When a hedge is a fence to a road it should be planted in two rows or lines four and a half inches apart, the plants in each line nine inches asunder, and the plants in one line opposite mid-distance between two plants in the other.

After being planted twelve months, and their growth established, the hedge plants should be cut back to two or three eyes from the ground, after which the young hedge should not be pruned or cut until the stems have attained a thickness of an inch in diameter; when the hedge should be headed down to a height of five feet, and pruned to a wedge-shape of two feet and a half of base at the ground and one foot at the top. During the growth of the hedge, especially during its early growth, until the form just specified has been given, its site should be kept constantly clean and free from the growth of grass and other weeds or plants; and until it has become an established and efficient fence it should be thoroughly protected and fenced from the bite of every description of live stock and of wild animals.

The *Common Holly* forms a most ornamental hedge, and resists stock as a fence as well as the hawthorn. The only objection to its use as a hedge plant is its slow growth, and the hedge being liable to be destroyed for the sake of its shoots for whip-crops. The soil best adapted to the growth of holly is a light, dry, deep, and rich loam; and it would be almost futile to plant it in any other description of soil. A holly hedge should be planted in a single line, in which the plants should be from eighteen inches to three feet apart. When the latter distance is adopted, two or three plants of hawthorn may be introduced between every two plants of holly when the hedge is first planted; in which case the hollies will eventually take the places of the thorns, and the hedge become in time entirely composed of holly. The proper time for planting holly is the latter part of May and the beginning of June.

The *Beech* is an excellent substitute for the hawthorn as a hedge plant on a sandy soil, or on a clayey loam incumbent on sand; and it has the valuable property of affording shelter through the winter from retaining its old leaves until the new ones are expanded in the spring. The plants should stand in the hedgerow from nine to twelve inches apart.

Hornbeam is well adapted for a hedge plant. It is extremely hardy, and will grow freely on a soil so poor, and with an exposure so bleak, that the hawthorn would have no chance to exist. It has, moreover, the same advantageous property for a hedge plant as the beech in retaining its leaves throughout the winter. Hornbeam, when planted for a hedge, should be at from nine to twelve inches apart.

The *Elder* is perhaps the only shrub that will thrive under the immediate influence of the sea breeze. Under any other circumstance the elder is not to be recommended as a hedge plant, from its being too soft and weak as a fence to resist stock.

Fences of Roads (*continued*).—**Iron Wire Fences.—Hurdles.**

There are, however, various materials for forming fences, these being used according to circumstances of locality, or position of the road in relation to property of different kinds bounding it, and also varied according to the tastes and notions regarding price. Of these we shall now notice the chief. Although now coming somewhat extensively into use as road-side fencing, wire fences are but of comparatively recent introduction. These are constructed, as most of our readers will have seen practically exemplified in one or other of their rambles in rural or suburban districts, of iron wire stretched horizontally, as at *e e*, fig. 6,

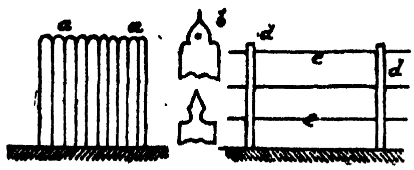


Fig. 6.

between posts, *d*, *d*, placed at intervals firmly in the ground, as shown. Means are taken to tighten up the wires as the fence is erected, and various contrivances are adopted by different makers to keep the uprights vertical and also steady in their seats. Where the fence is of a superior kind the wire is what is called galvanised—that is, coated with zinc—which prevents oxidation. In place of starting at once from the ordinary level of the ground at side of footpath, *a*, fig. 7 (as in fig. 6 at *d d*), the wire fence is sometimes

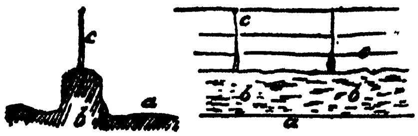


Fig. 7.

raised above the ground level, topping a low mound *b*, as at *c*. What are called "iron hurdles" are short independent lengths of iron fencing, each length being made up of two uprights, between which rods—not wires—of wrought iron are secured by riveting them at their ends to the uprights; the whole are kept in place by struts or braces projecting behind the posts at feet, which give a support behind.

THE STEAM ENGINE USER.

The Different Classes of Engines used chiefly for Manufacturing and Agricultural Purposes.—The Leading Details of Steam Engines—Constructive and Operative.—Their Practical Working and Economical Management.

CHAPTER XI.

In our last we stated at conclusion of chapter that condensing engines required a considerable quantity of water for condensing purposes. This necessitating a large supply of water, and that to be cold or cooling, a reservoir of such dimensions as cannot always be obtained in towns is required. High-pressure steam engines exhaust the steam into the atmosphere after leaving the cylinder, and therefore no further consideration as to additional machinery and accommodation for reserving a large supply of water is required. If there be a greater consumption or evaporation of water there will be a corresponding consumption of fuel. Such engines are in extensive use, but mostly of a small class compared with the condensing steam engine in the manufacturing districts. We shall furnish our readers with an example or two of diagrams from this class of engines, and shall also make a few general remarks upon them. In the former part of this paper we have remarked that in examining a diagram from a high-pressure or non-condensing steam engine, it never shows any power below the atmospheric line. It not only does not go below the line, but it never reaches it. (See fig. 11, in which the line *m n o p* is above the atmospheric line *a b*.)

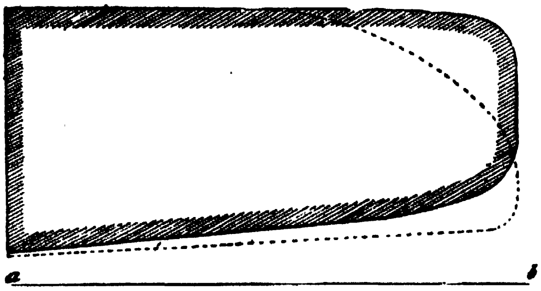
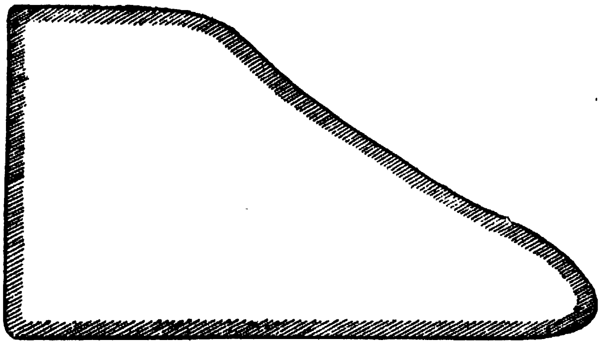


Fig. 19.

The diagram in fig. 19 represents the steam being continued throughout the stroke at the full height; consequently a great amount of steam is thrown into the atmosphere, and steam at a high pressure, say 24 lb. If this could be utilised in an ordinary condensing steam engine it could be supplied free of cost. This, then, is a great waste. Another loss is entailed, for there is a considerable back pressure—say about 10 lb. (in many instances as much as 15 lb.), and in some circumstances, where there is no possibility of increasing the pressure in the boiler, much power is therefore sacrificed. The dotted line on fig. 19 denotes a little gain which could be obtained in a rearrangement of valves, *i.e.*, by cutting off the steam at say $\frac{2}{3}$rds of the stroke. The steam at the end of the stroke would be reduced to 16 lb. when it had finished its work in the cylinder; therefore there would be less back pressure to contend with, and the power lost in cutting off the steam would be otherwise gained (see the dotted line). As we have before remarked, a saving in fuel would be effected, and without any greater strain upon any part of the engine, which is an important consideration. The diagram in fig. 20 shows how the steam can be turned to a profitable account—*i.e.*, by extracting all the strength out of it before it leaves the cylinder, or comparatively so—say about 6 lb. in the place of 24 lb., as in fig. 7. The difference between the back pressure of fig. 19 and fig. 20 is very marked. It is also desirable that the steam should not be put on to the cylinder suddenly; and if the corners were slightly rounded, as in the case of the diagrams of the condensing steam engine, it would keep off sudden shocks, which always have a tendency to shake the cottars or nuts loose, and in many cases break holding-down bolts.



a

Fig. 20.

Concluding Remarks on the Indicator.—Horse Power.—Nominal Power of Steam Engines.

In treating of the working of steam engines, the remark is often made to the effect that, although sold and spoken of as for a given power, they can be worked to a much higher one. Thus, six horses' power may be got out of a four-horse engine. The uninitiated may wonder, and they often do wonder, how this can be. A brief examination of the points involved will explain this. When Watt took up the steam engine, and by the aid of his mechanical genius made it the powerful machine we now know it to be, the work done at coal pits was done mainly by the power of horses. He very naturally, then, in pointing out the power of his steam engines, which were to supersede the animal labour, told the mine proprietors that they could do the work of so many horses. By experiments, he found that a horse was capable, on the average, of lifting a weight of 33,000 lb. one foot high in one minute. The value or efficiency of an engine is obviously the amount of useful work it can perform in a given time, the useful work being represented by the amount of weight or of resistance it can overcome, multiplied into the space through which that is moved in a given time. In this, the time or speed, and the pressure or power, exerted in the piston are the elements of importance in calculating the power of a steam engine. Watt determined that the normal speed at which the piston was to work was 220 feet per minute, and the average pressure of steam upon the piston 7 lb. per square inch, deducting friction. Here the speed and the pressure are two fixed quantities, giving a certain result, so that the size of the piston at once defines the power of its engine—twenty-two square inches giving, in condensing engines, one nominal horse-power. But if we increase the speed with the pressure of a given engine, we at once alter the conditions of its working, and obviously, in like proportion its power. The speed at which the piston travels is easily ascertained, by simply multiplying the number of the revolutions of the engine by twice the length of its stroke, one revolution being obviously produced by a full stroke up and a full stroke down of the piston. But the pressure of the steam on the piston, the other element in calculating the power of an engine, is not so easily known. If the pressure indicated at the boiler by the safety valve, or by the pressure gauge, was that given to the piston, we should easily calculate; but many circumstances come into operation to reduce the boiler pressure. The length of the steam pipe conveying the steam from the boiler, affording room for loss by radiation, tends to reduce the temperature, and correspondingly the pressure, of the steam. This is attempted to be prevented by clothing the steam pipes with felt or other non-conducting material; but with all such precautions a loss of pressure does result. Again, the steam, in passing into the valve casing, meets with the obstruction of the throttle valve, and is "wire drawn," as the phrase goes—that is, it is drawn out or thinned, or "throttled," as the technical term is—and its pressure is consequently reduced. The same happens, to some extent, in passing through the ports, which are not opened at once, but opened gradually, through the varying motion of the eccentric. Expansion, where carried out, also tends to reduce the pressure; so that seeing these elements cause a reduction in the boiler pressure of the steam, it is important to know exactly the power we have given out by the piston through all its movements. All this is known by using the indicator, which in preceding paragraphs we have fully described and illustrated.

The taking of diagrams is not, however, an operation within the easy command of all users of steam engines, though there are certain indications which are within the reach of any close and patient observer as to whether an engine is really doing its work well. We remember, when in our apprenticeship, the man who was attending to the blast furnace, and who was therefore anxious to get plenty of power for his work, telling the foreman that there was a vast deal more steam passing out at the exhaust than work was being got for. To a tyro it seemed an odd thing that steam could be passing through the cylinder of the engine without giving out its full effect. It so happened that the engine had been under repair, and had been only started that day; and the foreman knew at once that the workman to whom had been intrusted the repairs had not set the valves right, or had put the piston in badly. The former conjecture was right, and the matter was adjusted. We never forgot the lesson we learned then, that an engine might be working beautifully, so far as the eye could see, and yet be working wastefully. The internal disarrangement of a steam engine arises from two causes chiefly—a piston badly fitted, or valves badly set. Where the piston is badly fitted, steam may pass from the steam side to the exhaust side, and from thence right away to the exhaust pipe and funnel, and give out, of course, no work at all; where the valves are badly set, the exhaust at top and bottom strokes may not be equal, or the slide valve may be passing steam into the exhaust directly. If these defects are suspected, one way to detect them is by setting the engine to work—but this so slowly that it shall suffice to turn the centres merely—and listen attentively for the "beat" of the engine, that is, the noise made by the steam passing out of the ports into the exhaust. If the piston is tight, and the valves properly set, each beat will be sharp at the end of each stroke. But if they are badly set, the beating will be irregular—as, for instance, a short sharp puff, and then a long blow: this condition of matters proves that the valves are so badly set that they do not exhaust equally for top and bottom strokes. Thus the top may exhaust well and sharp (thus —), but the bottom long (thus ——), or *vice versâ*. But the beatings may be regular, and give at each stroke the same kind of beat: yet, if these beats are in themselves indistinct, and followed by a constant or steady blow, it indicates that the slide valve is so set that it passes steam not only in the steam port, but also into the exhaust directly; or it may indicate also a leaky piston. A leaky piston may be ascertained by turning the engine till it is on its centre, or so that it will be receiving steam; if the piston is leaky, the steam will pass out of the exhaust.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XII.

Referring to the definition of the projection of a curved line, as given at the conclusion of last chapter, it is obvious that however accurate this definition is—and it is precisely accurate—the accuracy of the line actually obtained depends upon the way in which or *how* the series of lines are drawn. So far as that part of the definition is concerned which states that the projected points are to be joined by a series of lines, this would be met by joining, for example, the two points *a*, *c*, fig. 21; or say *i*, *j*, which correspond in position to *a*, *c*, by a *straight* line, as shown between *i* and *j*. But it is clear that this rendering of the definition would be quite inaccurate, as even the most uneducated or untrained eye would at once perceive that the true line between *i* and *j* is a *curved* line, shown as joining *k l*, which corresponds to *a* and *c* as do the points *i* and *j*. Although this would certainly be a curved line, it would not be *the* curved line required, as shown between *a* and *c*. This even the untrained eye and hand of the draughtsman would at once perceive; he would therefore make another attempt, which we suppose to be shown at *m n*. This, although approaching in accuracy more closely to the true curve between *a* and *c*, would obviously be still far from accurate. Another attempt, and perhaps many attempts, would be made before the true curve, as between *o* and *p*, would be obtained; and it might be a very possible result that the attempts of the draughtsman would be in the end failures, so far as getting an accurate copy was concerned. The more sharply defined the curve of the true line was — that is, the further removed in its characteristic feature from that of a straight line—the greater would the difficulty be in the pupil getting an accurate copy of it, or, to use

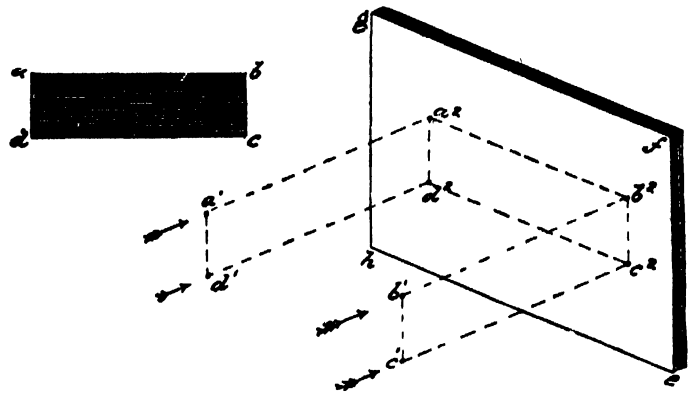


Fig. 22.

as shown between *a* and *c*, and not a straight line, as between *i* and *j*. Now, the direction of this line could be found, in the example before us, only by the eye taking in an *accurate* estimate of what the curve really is, and by a manual dexterity in doing what the eye dictated (see the series of papers entitled "The Ornamental Draughtsman," and some remarks at the beginning of a recent chapter in the present series). If untrained in the art of "copying"—that is, drawing curved lines dependent upon the accuracy of the eye and the dexterity of the hand—the true curved line joining the points *a* and *c*, fig. 21, would be obtained, in all probability, by a series of tentative efforts, more or less inaccurate in conception (eye estimate), and in execution (hand dexterity). Thus, while clearly seeing that the line actually required to join the two points between *a* and *c* was not in any sense a straight, but a curved line, the only result, by the pupil inexperienced in ornamental drawing, might be the line the strict term here, a "true projection" of it. And in thinking the matter out, the beginner would perceive this to be a leading principle as affecting the obtainment of a true projection, and that the greater the distance between any two points in a given curved line, the greater will be the difficulty in joining those points by a line which will be the true curve. And from this he would deduce this fact: that by breaking up, so to say, the long curve required into short distances or lengths, the short curves then required would be more easily drawn than would longer curves, and this precisely in proportion to the shortness of the curves. In other words, the greater the number of points projected in a given curved line, the more accurate would be the general curve obtained, as the short lengths of curves would be more easily drawn. This is graphically illustrated at *q r*, where by taking and projecting two points, as at 1, 2, between *s* and *t*, we have the three short curves to draw, as between *s* 1, 1 2, and 2 *t*, in place of two only; and those two intervening points 1 and 2 obviously give guiding or directing points, which mark out to the pupil the course of the line he has to draw. By increasing those directing points in number, as between *w* and *v*, corresponding to *a* and *c*, we obviously make the accuracy of the curve obtained by joining those points a matter of more certain attainment. A further illustration is met with in the part of the curve between points *d* and *b*, where *w*, *x* are the points corresponding. Here the two may be obviously joined by a straight line, as shown by the dotted line: but this is far out of the curved line required, which is shown at *y z a'*, where its direction is obtained by the points "projected" between *y* and *a'*, as at *z*.

The points may be so close together that the lines joining them may be straight lines, which are the easiest to draw correctly; or such an approach to a straight line, and possessing practically so little of the character of a curved line, that even a draughtsman knowing very little of the work of ornamental drawing (see the paper entitled "The Ornamental Draughtsman") will be able to draw them accurately. This resolving of a curved line into a series of straight or nearly straight lines is well illustrated in the problem showing how even a circle can be obtained very nearly absolutely accurate by drawing straight lines, which will be found in the paper entitled "The Geometrical Draughtsman," in that part connected with the problems of circles. The pupil must not suppose that we have occupied his attention too long in connection with this department of projection; he will not be long engaged in its practice before he will have ample proof of its importance.

Principles of Orthographic Projection (*continued*)—Projection of Solid Bodies.—Elevations, Plans, Sections.

Returning to the points connected with the projection of straight lines, we have shown, in fig. 19, how a surface or "figure" bounded by straight lines can be projected. The rectangle *a b c d* in that figure may be assumed to be the upper or lower side or surface of a solid block of wood, or the top of a box of greater length, *a d*, than breadth, *a b*. This projection being made or projected upon a horizontal plane, is therefore termed a "plan," and as in the supposed block the top and bottom surfaces are equal, *a b c d* would be the "plan of top" or "plan of bottom," as the case might be. But this projection gives no clue, as it were, to the dimensions of the other part of the block —namely, its thickness. Suppose that in like manner we project the four points of a rectangle *a b c d*, fig. 22, in the direction of the arrows, so as to strike or cut a *vertical* plane of projection *e f g h*, thus obtaining the projection of the points a^2 b^2 c^2 d^2: joining these by right lines, we have a rectangle, which, being on a vertical plane, is therefore an "elevation," and a^2 b^2 c^2 d^2 may be supposed to be the side elevation of the block, of which *a' b' c' d'*, fig. 19, is the top and a^2 b^2 c^2 d^2 the bottom. In like manner we can project four points, *a b c d*, fig. 23, in the direction of the

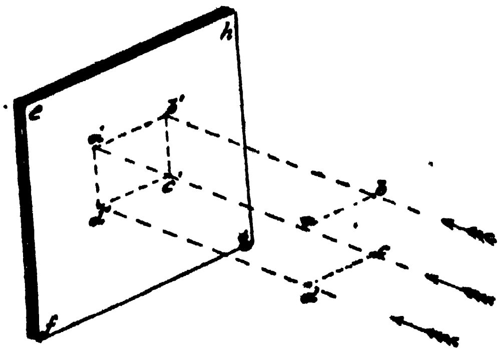


Fig. 23.

arrows; obtaining the projection of these, as *a' b' c' d'*, and joining these by right lines, we obtain a rectangle which, being on a vertical plane of projection, is also an "elevation," and may represent the "end elevation" of the block, of which *a' b' c' d'*, fig. 19, is the "plan of top," a^2 b^2 c^2 d^2, same fig., "plan of bottom," and a^2 b^2 c^2 d^2, fig. 22, is "side elevation." Here we thus have the three "projections" of the solid object, having length, breadth, and thickness, and which in this case we suppose to be a block of wood or a box. In working drawings another view is required frequently—namely, a "section," the object of which is to show the internal construction of the solid body; and, according to the direction in which the section is supposed to be made, it is called a "transverse section" or a longitudinal section. Sections are also either "vertical" or "horizontal"; illustrations of these we shall explain as we proceed.

In the practice of projection we have, of course, only one flat surface—the sheet of paper—we draw upon; hence it is usually called, or supposed to be the equivalent of, the theoretical "plane of projection." Strictly speaking, it is the union of the two planes in one, all "plans" being supposed to be projected on to "horizontal planes," and all "elevations" on to "vertical planes." The forming of the two planes into one is illustrated in fig. 25, which is simply the diagram in fig. 16 spread out, and the vertical plane *a e f b* being supposed to be turned down till it lies flat, as at *a e f b* in fig. 24, *a b c d* being the horizontal plane in fig. 16, the line *g h* is a line in "plan," the line *h i* is a line in "elevation."

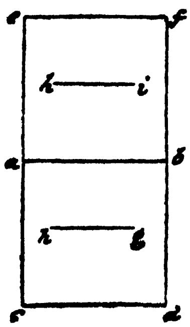


Fig. 24.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER VIII.

Continuing our problem connected with lines perpendicular to one another, we show now to the pupil how to drop a perpendicular on a straight line B C, fig. 33 (p. 225), from a point A given outside of this straight line.—Here again we assume two positions. First, where there is room to right and left of the point given, and also above and below the straight line. In this case, from the given point A as centre, with any convenient opening of the compasses, but sufficiently extended, describe an arc of a circle which cuts the straight line B C at the two points *m* and *n*. From these two points as centres, with the same opening of the compasses, describe two arcs of circle, which intersect at *x*. Join A *x*; this line is perpendicular to B C. It follows from the construction that the two points A and *x* are equidistant from the points *m* and *n*; the line A *x* is then perpendicular in the middle of *m n*, and consequently upon B C. In the second of our two positions the point A, fig. 34, is situated towards the extremity of

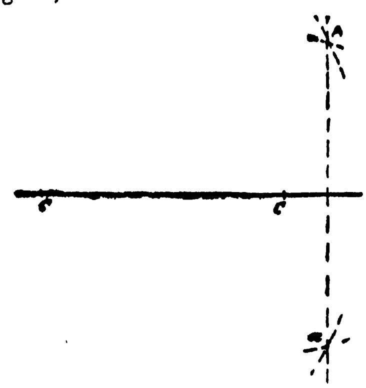


Fig. 34.

the straight line, but there is room above and below the latter. Take any point *c* on the straight line, and from this point as centre, with a radius equal to *c* A, describe a first arc of a circle below the line given. From any second point, C, describe, with a radius equal to C A, a second arc of a circle, which cuts the first at A. Let us join A *a*; this line is the perpendicular wanted. The line A *a* is, in short, the common arc of the two circles which have their centres at *c* and C, and we know that this common arc is perpendicular on the line *c* C of the centres. In a third position which we assume, the point A, fig. 35, is situated towards the extremity of the straight line B C, and there is no room below the latter. Through the point A let us lead any straight line which cuts the straight line B C at the point *m*. By the construction illustrated in fig. 29, find the middle, O, of the straight line A *m*. From this point O, as centre, describe an arc of radius O A = O *m* (this is called describing a circle on the line C *m* as

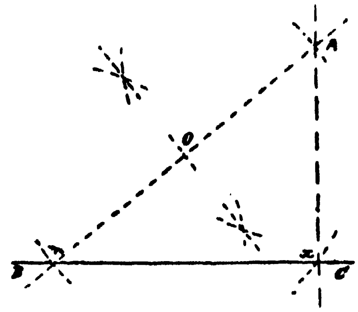


Fig. 35.

diameter). This circle cuts the straight line given, B C, at the point *x*. Join A *x*, and we have the perpendicular wanted. In short, the angle A *x m* is right, as being inscribed in a semicircle. A perpendicular can be raised at the end *b* of a line, as *b*, fig. 36, by describing

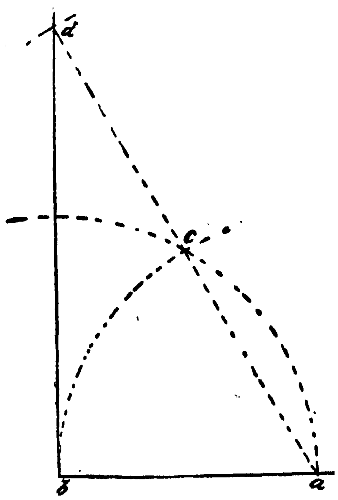


Fig. 36.

from the point *b*, and with any convenient radius whatsoever, a quadrant of a circle. From the point *a*, and with the same radius, describe a second arc, which will cut the first at a point *c*. Then join the points *a* and *c* by a straight line sufficiently produced; take the distance *a c* on this produced from *c* at the line *a c* in *d*, and the point *d* will be that through which the perpendicular to be raised to the point *b* will pass when the line *b d* is drawn.

Problems connected with Angles.

We now come to the consideration of problems connected with angles; and first to bisect an angle —that by a line drawn, from the apex *a*, or point where the lines *a b*, *a c* (fig. 37) meet; this point being accessible. In this case, from the point *a*, with any convenient radius, describe an arc of circle which cuts the sides of the angle at the points *r* and *i*. From these points as centres, with the same opening of the compasses, describe two arcs, which intersect at *x*.

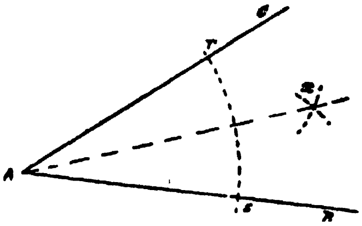


Fig. 37.

The line *a x* is the bisecting line required. We may, in fact, easily see that this line *a x* divides the arc *r s* into two equal parts: the two angles *c a x*, *b a x*, are then equal, since they are angles at the centre which comprise equal arcs.

If we now suppose a condition in which the second apex, *a*, fig. 38, of the angle is inaccessible. We have shown that the bisecting line of an angle occupied or intersected the geometrical position of the points equidistant from the sides of this angle. Consequently, any point that we can construct equidistant from the two sides *a b* and *a c*, will belong to the bisecting line required. At any two points, *c* and *b*, of these sides, raise to them perpendiculars in the interior of the angle, as B *r*, C *q*, and take on these perpendiculars lengths B *s*, C *p*, of any convenient length, but equal one to the other, and through the points *p* and

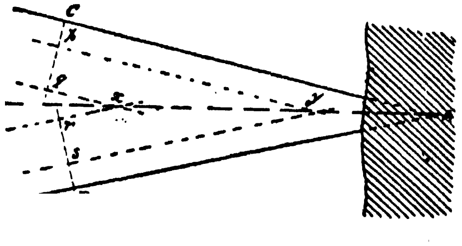


Fig 38

r draw parallels to the sides of the angle: the point *y*, where these parallels meet, is equidistant from the sides A C and A B; it is placed, therefore, on the bisecting line required. We obtain a second point, *x*, by the points *q*, *r*, of this line and by a similar construction. This solution requires or presupposes a knowledge of the method of drawing through a given point a line parallel to a given line. As we proceed, we shall see this position exemplified, that problems or constructions more or less complicated involve the knowledge of certain simpler or elementary problems, which knowledge is, for obvious reasons, assumed.

To Describe an Angle equal to a given Angle.

Through a given point A, fig. 39, on a straight line A B, to draw a second, A C, which makes, with the first, an angle equal to a given angle. Let *b a c*, fig. 40, be the angle given; from its summit or apex at *a*, as centre, with any convenient opening of the compasses, describe an arc of circle which cuts at the points *b* and *c* the

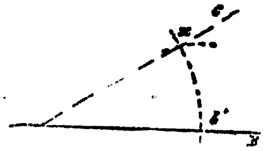


Fig. 39.

sides of the angle *b a c*. With the same opening of the compasses, describe from the point A, fig. 39, an arc of circle which cuts the line A B at the point *b'* then take the distance of the points *b* and *c*, in the compasses, from fig. 40, and from the point *b'*, fig. 39, as centre, with this distance for radius, cut at point *x* the arc *b' x*, by an arc of circle, and join A *x*. The angle B A C, fig. 39, thus constructed, is equal to the angle *b a c*, fig. 40. It follows from the construction

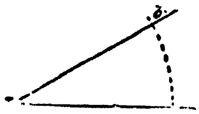


Fig. 40.

that the arc *b' c*, fig. 39, is equal to the circle *b c*, fig. 40; the arcs *b' x*, *b c*, subtended by these arcs, are then equal, since they are taken in circles of the same radius, and consequently the two angles, B A C, fig. 39, *b a c*, fig. 40, are equal as angles to the centre, corresponding to equal arcs in equal circles.

The Two Angles of a Triangle being given, to find the Third.

This problem is an application of the principle of the preceding. At a point *o* (fig. 41) of a straight

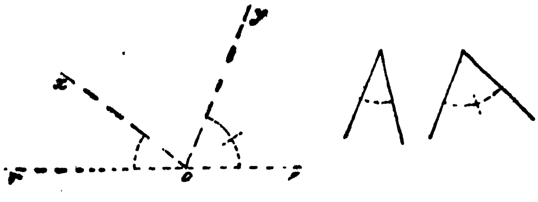


Fig. 41.

line *r s*, make, on one side, an angle *r a x* equal to one of the two angles given; construct also to the right an angle *s o y*, equal to the second of these angles. The sides, *o x* and *o y*, of the two angles which have just been constructed form between them an angle *y o x*, which is equal to the angle wanted, for *r o x* + *x o y* + *y o s* = two right angles; and we know that the sum of the angles of a triangle is equal to two right angles.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

The Technical Points connected with the Varieties or Breeds of Cattle—Their Breeding, Rearing, Feeding, and General Management for the Production of Butchers' Meat and of Dairy Produce.

CHAPTER XII.

General Remarks on Breeding (*continued*).—The "Crossing" Contrasted with the "In-and-In" System.

At the conclusion of last chapter we stated that while intermarriage of close relations did tend to the degeneracy of the human race, it did not follow that this was physical degeneracy,—often, indeed, the contrary. Doubtless the opposite qualities are known; still the weakness is a mental, not a physical one. Considerations connected with mental characteristics and diseases in no way concern our animals. They, so far as we know to the contrary—and certainly all experience goes to prove its truth—are absolutely free from all those mental affections and disturbances which in the case of human beings go far, as we all but too painfully know, to bring about causes which operate but too disadvantageously to the general well-being of the individual, and often to the mere physical animal health. Such health disturbances, so arising in the case of human beings, cannot exist in that of animals. In stating the case, we do it thus broadly inasmuch as we do not desire to give the reader the notion, or to narrow the question so much, that we would assert that "in-and-in" breeding of animals does not give a tendency to weakness of constitution and to barrenness. Only, if this be found so, we maintain that it is owing to want of attention on the part of the grazier, who either chooses bad animals, or neglects to get rid of animals which he knows, or ought to know, possess bad qualities, whether those be weakness of constitution, smallness or defective size, or possession of positive defects of form. Attention being paid to these points, and to others which we have given in preceding paragraphs, we venture to maintain that the evils which some attribute to "in-and-in" breeding will practically have no existence. And this although we as readily admit that the highest effects of pure breeding—that is, in "line" or "in-and-in" system—are better exemplified in the case of cattle than in that of sheep, which in many cases seem to do better with the system of crossing.

That the position we have taken above in favour of the "in-and-in" system of breeding is correct, we have an exceedingly wide range of practical experience to fall back upon in proof of. It is to the system of "in-and-in," or that of "nearest affinities," or of "line breeding," that we owe our best breeds of cattle. We did not obtain, and could not have obtained, the fine animals we now possess, and which the early breeders created, so to say, in the magnificent animals they bred and reared, had we not adopted the great principle of "like begets or produces like," which is the essential or vital one of "in-and-in breeding." Indeed, it is worthy of special note here that the opposite or rival system of "crossing" could not be carried out without the previous existence of the "in-and-in" system. For as the object of a "cross" is to produce a good animal by the intermixture of the good qualities of the two animals, those good qualities have to be at command, and these in all practice are so, by falling back upon animals of good breed, or, as it is termed, pure blood; and this is only obtainable by the system of "in-and-in" breeding. It would be useless to cross with defective animals: good crosses are only obtained by using good animals; and these are taken from good herds of established breeds or blood, and those herds have been created by the most careful selection and the closest "in-and-in" breeding. When a good cross has been established—and in general the shorthorn always plays an important part in the crossing—if it be rigidly followed out for some years or generations of animals, the good qualities which it originally possessed begin to disappear—the "blood," so to say, vanishing, being strained, as it were, through a succession of animals. So that we see that the conclusion appears inevitable that to maintain a good "cross" we are compelled to renew the blood, so to say—that is, fall back upon the original or pure-bred animal. The good blood received by the cross gradually dies out, and this in a much faster ratio than might be supposed. Thus, the first cross gives a half, the second cross or generation a fourth, the third an eighth, the fifth a sixteenth, the seventh a thirty-second, and so on, till, by the time the tenth cross is reached, there is but the one thousand and twenty-fourth of the blood existing in the breed. It is not, of course, maintained that this has no exception: the decrease may, and often will, follow a less rapid rate, and the physiological condition of the animal at certain stages may materially retard the dying out of the original strain; but that it will and does die out in a marked way is beyond a doubt, so that it is not a long period, comparatively, before all the marked features of the cross or blood disappear. But if this gradual yet certain decrease may in some instances be slower than in the ratio we have above named, still, on the other hand, it is to be observed that the ratio may be increased, and the loss of the strain the quicker; the more marked the contrast between the characteristics of the two animals employed to give the cross, the more quickly do the characteristics disappear. In some instances, where the one parent—as, for example, the bull—has given a more decided character to the cross than the other parent, the cow, the effects of the cross will be more lasting, and will or may not die out so rapidly as we have above stated; but while this holds true of the decided features given by the stronger animal, it does not hold good of the characteristic features given by the other,—and it may be and generally is desirable to retain the characteristics of the female. The necessity for the cross breeder to return to the blood or strain he desires being thus obvious, gives him however, the power to obtain all the advantages of the system of "crossing," and to avoid what he deems the evils of the opposite or "in-and-in" system. We have shown how exaggerated are the views held by many as to those evils, some of which have really no existence. The real evil arises from forgetfulness of the essentially vital principle of the "in-and-in" system—namely, that "like begets like," which of necessity involves the principle of deterioration as well as that of the improvement of stock. If the good qualities are perpetuated, no less so are the bad ones. Hence the necessity for the breeder to exercise the utmost caution in noticing defects, so that they may be weeded out. And from this, it will also be observed, arises a necessity quite as strongly resting upon the "cross" as upon the "in-and-in" breeder—that he shall take care that he uses only good, if possible the best, animals to get his cross breed from. It is but poor practice to effect a cross with bad, or even with but indifferently good animals. One may as well aim at getting the best products from his labour. By selecting good animals at the beginning—good in the possession of valuable points, and as descended from a good stock, that is, having a good "pedigree"—and by taking care not to carry the cross too far down, but to return to the original blood, all the defects, or most of them, of the system of crossing may be avoided. At the same time the reader should observe that there is not the same temptation or inducement to adopt the crossing system in the case of cattle as in that of sheep. In the case of the latter certain special characteristics are often required which can only, at least can best, be obtained by "crossing." On the other hand, the "in-and-in" system of breeding can be rigidly carried out, inasmuch as cattle are generally required to possess certain definite qualities, such as a capability to fatten quickly and economically in the shortest time and with a minimum of food, as in the case of the shorthorn; or, as in the case of breeds such as the Devon, to be good for working—that is for draught purposes, as in the plough or the waggon—and at the same time to fatten well and quickly. Again, in the case of cows, the peculiarities required are very special and well-defined: good milking qualities, which keep well up to the paying point while in full milk, and while "drying up" and getting useless as a dairy cow, a capability to get quickly up to a certain point of good, moderately fat condition, so as to be sold to the butcher. Although fattening is antagonistic to milking, still another point in dairy cattle is that while milking they keep in moderately good condition, even while giving full milk, without deteriorating the milking character. These conditions being so special and well-defined, are those which make the temptation to adopt the crossing system in cattle less than is the case in sheep. On the subject of "crossing" one thing is very clearly defined, both by experience and common sense: that it is very unwise in any grazier or breeder to cross simply for the sake of crossing—that is, because he may have a strong prejudice in favour of the system, and believes in the "in-and-in" system. When crossing is to be carried out let there be a specific object in view—the obtaining in the animals of certain peculiarities which are deemed desirable. But if there be no special characteristic aimed at by crossing, as in the case of sheep, it will, to all practical purposes, be the best policy to adopt the "in-and-in" system. And as we have shown it to be one of the essentials in effective crossing that good animals should be chosen for the cross, let the breeder remember, however prejudiced he may be in favour of the crossing system, that without the "in-and-in" system he could not have those good animals to cross with. Those have been and are still the product of the "in-and-in" breeding system.

Some Points connected with Cattle fed Exclusively for the Butcher.

The principal work of the grazier is the breeding, rearing, and feeding of cattle for the production of beef for the public market. He looks out, therefore, for a breed of cattle furnishing the two points or qualities which are essential to the success of his business as a paying one. The first of those qualities is that the animal should give the largest proportion of weight of beef for the size of the animal, which is technically called "the carcase weight," to the dead or whole weight, which is called the "live weight." The second point desired is, that the beef shall be laid on those parts of the frame of the animal which yield the best quality, or give what are called the "best cuts," such as in the case of the rump, which yields what are known and valued everywhere as rump steaks. We have seen that of all the breeds of cattle which give these two desiderata of the grazier—and that moreover in the quickest time, and at the least cost—the shorthorn stands pre-eminently the first, though, as we have also noticed, other breeds, specially the Hereford and the Devon, are highly valued by the grazier and his customers. But the shorthorn ox is essentially a butcher's beast. Almost every point about him in build, and bone in constitution, tends to make him so.

THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Work—The Principles and Details of its Practice.

CHAPTER IX.

In more perfect work, however, the joint is made in the way shown to the left of fig. 38: in the lower piece, *a b c d*, a groove, as *e f g h*, is cut right across, and of a depth, as in *e f*, in proportion to the thickness of the upper piece, as *g o p h*. The plan of the lower piece, with groove, as *e′ f′*, is shown at *a′ b′ c′ d′*. The upper piece, as shown by the partly-dotted lines, as *g o p h*, is passed into the groove as *e′ f′*, which is made a little less than the section of the piece, as *m n*, so that it requires to be driven tightly into the groove. No joint is perfect which is loose and admits of any "play" between the parts.

In fig. 39 another form of joint in this class is illustrated. In this a groove or slot, as *b*, is cut across the lower edge of the upper piece *a a*, or a groove *d d* is cut in the upper face of the lower piece, as *e e*, of width enough to admit tightly the edge of upper piece *b b*, the one, as *a a*, going into the groove of the other,

Fig. 4, Chap. I. (page 12, vol. i.), illustrates another joint of this class, as used to connect the "tie beam" *a a* of roof truss (see further on in illustrations and descriptions of Roofs) which is connected with the wall plate *b*, built into the wall *c c*. A groove is cut in the under side of "tie beam" of sufficient width

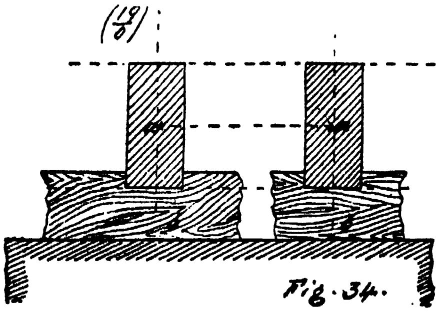


Fig. 40.

to embrace tightly the wall plate, as at *b* in fig. 4; or there is a groove cut in the face of the wall plate sufficiently deep to receive half of a key *b*, or in plan at *d*, leaving the other half to project from its face. This other half goes into a corresponding wide groove cut in the lower edge of the "tie beam," and the key,

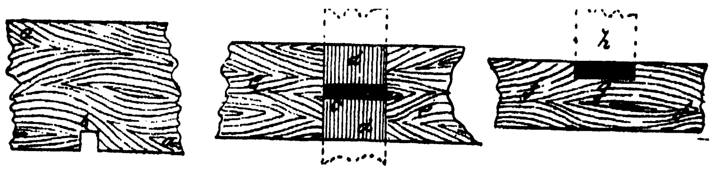


Fig. 39.

as *e e*, in the manner shown at *g h* in *f f*, which is a side view of the assemblage corresponding to *e e* in plan, *h* to *a a* in end view *g*, showing the depth to which the piece *f f* encloses *h*. But in place of the groove in lower piece *e e* being cut out with a level base or floor face, there is a projecting part, as *c*, left in the centre of the face of groove *d d*. The height of this, or its projection from face to groove, is equal to the depth, *b*, of the groove cut in the lower edge of upper piece, *a*. This projection *c* goes into *b*, and the young carpenter will see that the sides or cheeks of the groove in *e e* prevent the piece, as *d d* or *a a*, from being moved in the groove in the direction of its length.

In fig. 5, Chap. I. (page 12, vol. i.), we illustrated another form of joint of this class, used in connecting a flooring joist, as *a a* or *c c*, to a "sleeper," as *d*, which rests on the wall *e e*, a groove, as *b*, being cut in the lower edge of the flooring joist *a a* (or *c c*), of width a little less than that of sleeper *d*, this being passed on to *d* keeps the joint *a a* in position. In place of the groove being cut in the joint it is sometimes cut in the upper edge or face of the sleeper *b b*, fig. 40, and the joists, as *a a*, are let into this.

as *d*, keeps the two in contact. Fig. 41 shows a joint more in detail: *a* is the wall plate, *b b* the tie beam, with key *c*; *a′* is side view of wall plate, *c′* of key, *e e* being plan of wall plate with mortise *d* cut in its face to receive key, of which *f* is a side view and *g* an end or cross section.

The same kind of joint described in fig. 38 is

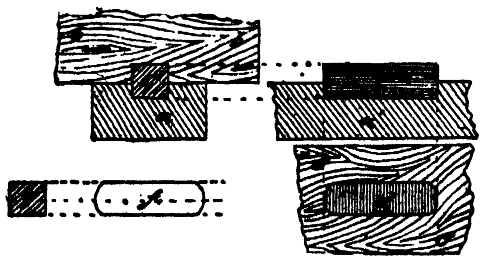


Fig. 41.

used to connect ceiling joists (see further on for illustrations of floors), as *a*, with the "binding joists" or "binders" *b*; if a double floor, the ceiling joists, as *a a*, carrying the lath and plaster of the ceiling, as shown at *e e*. Fig. 43 shows how a piece is cut out, as at *a*, across the under face in edge of binding joist *b b*, to receive the ceiling joists, as *a a*, in fig. 42;

c c is plan of groove or cut *a* in piece, *d d* the plan of lower edge of binder *b b*.

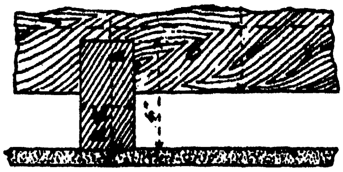


Fig 42.

Joining of Two Horizontal Pieces one at Right Angles to the Other.

Proceeding with our illustrations of joints used in carpentry, we now take up those in classes not

Fig. 43.

hitherto glanced at. In fig. 44 we illustrate the method of joining two horizontal pieces, one of which, as *a a*, is at right angles to the other, as at *b*. In place of merely inserting the piece *a* into a groove or chase cut under the upper side of the face of piece *b b*, and sufficiently wide to admit the piece *a* when drawn tightly into it, the groove does not go right across,

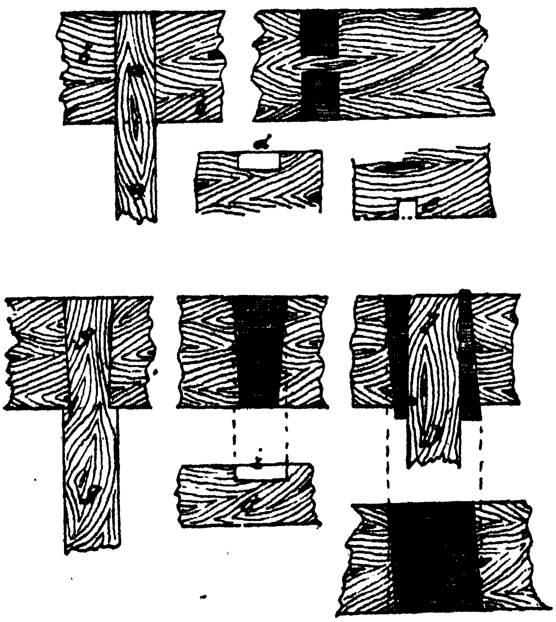


Fig. 44.

but is intercepted, so to say, by a feather shown at *c*, end view of groove being at *d*. The end of the piece *a a* has a groove or chase cut out in its lower edge, as at *e*, at a point sufficiently far from its end to allow the feather *c* to pass into it. The piece *a a* by this arrangement is so secured to the piece *b b* that it cannot be moved laterally, being restrained by the sides or cheeks of the cross groove, and motion in the direction of its length being prevented by the feather *c*.

The Use of the "Dovetail" and "Wedges" in the Preceding Joint.

Wedges are sometimes used to prevent movement in those directions, as also the form of joint known as the dovetail; those two methods are illustrated in the lower part of fig. 44. The dovetail joint completed is shown at *g g*, *h* being detail in plan of the groove cut out in the face of upper side of the piece, *i* being edge view, and into which the end of *g g* cut with corresponding shape is inserted or drawn in tightly. When wedges or tapered keys, as *e k l*, are used to keep the piece from moving, as *g g*, the groove is cut of the form as at *m*.

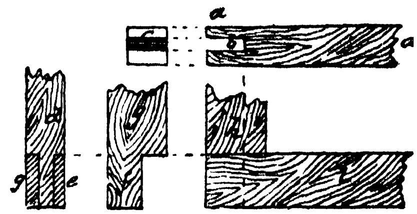


Fig. 45.

In this joint there is no alteration made in the form of the end of the piece *j j*, as at *g g*; it is left square, but the shape of part cut out, as at *m n*, admits of spaces being left at each side of the piece *j j*, when placed in it, for the wedges *k* and *l* being driven hard up, it will be seen that they are entered from opposite sides, so that by giving corresponding blows to each wedge, as *k* and *l*, a uniform pressure is placed upon the piece *j j*.

Fig. 45 illustrates a joint in which a vertical piece, as *h*, is joined to a horizontal piece, as *l*; but at the extreme end *a a* shows the upper face of the piece *l*, having a part cut out, as at *b*, shown in end elevation at *c*. *f f* shows the side view of end of vertical piece *h*, and *d e g* the end view of the two pieces as joined.

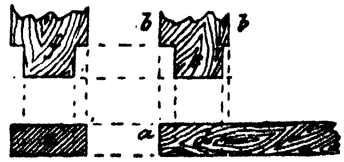


Fig. 46.

Fig. 46 illustrates method of joining a vertical piece, as *b b*, to a horizontal piece, as at *a a*, and at its extreme end; the end of vertical piece being mortised into the horizontal piece.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER VIII.

Yellow Pigments (*continued*).—Tin Yellow.

ANOTHER yellow sulphide which was at one time somewhat largely used may be mentioned: that of tin—now rarely used. It is a bisulphide generally known as Mosaic Gold, and is represented by the formula SnS_2. It is of a rather pale but bright orange-yellow shade. It is obtained by precipitating a stannous soluble salt, such as tin crystals or stannous bichloride, $SnCl_2$, by sulphuretted hydrogen.

Aureolin.

This is an excellent pigment, composed chiefly of nitrite of cobalt and potassium, of a beautiful bright and pure yellow shade, possessing great stability, and largely used by artists. It is rich in tint, and unusually transparent, and for some departments of painting is specially adapted. It may be used in mural painting, owing to its resistance to the action of caustic alkali.

It is obtained by precipitating pure acetate of cobalt with nitrite of potassium in slight excess. This pigment is of course not employed in common painting nor printing.

Cadmium Yellow.

Another sulphide of brilliant yellow colour, and largely used by the artist, is that of cadmium, CdS. It is of an exceedingly rich and pure yellow shade; it is very stable, and is unacted on by exposure to foul air and sunlight. It is prepared by precipitating a soluble salt of cadmium with sulphuretted hydrogen, or by igniting the oxide with flowers of sulphur. This pigment was some years ago proposed to be used in calico printing, and extensive experiments were made with this end in view. It has not, however, justified the expectations entertained regarding its use in this branch of industry, owing partly to cost and partly to difficulty of application.

Chloride and nitrate of cadmium have lately found extensive use for the same purpose as tartar emetic added to lead yellow colours—namely, to prevent them from blackening by sulphur. We have found the cadmium salt to be more effectual than antimony salt for this purpose.

"Unsulphurable" Yellows.

Under this name appear in the market chromates of lead pigments to which a small quantity of acetate or other soluble salt of cadmium or of antimony has been added, as a protection against blackening by sulphur fumes. The "cadmium yellows" of commerce are generally not sulphide of cadmium, but simply lead chromate mixed with a cadmium salt. It is easy to test pigments of this description. If lead is present, a large excess of ammonium sulphide blackens, and the cadmium may be washed out on a filter, and the filtrate tested for in the usual manner for cadmium,—namely, sulphuretted hydrogen yields a white precipitate insoluble in dilute acids. The larger the amount of cadmium salt the pigment contains, the greater is its resistance to the blackening effects of sulphur, the sulphide of cadmium being formed in preference to that of lead.

Naples Yellow.

The pigment formerly sold under this name, and which was held in high esteem by artists, was an antimoniate of lead, represented by the formula $SbO + Sb_2O_5$, and of doubtful value as a pigment. The pigments now sold under the name, and similar to it in shade, are generally mixtures of lead and zinc chromates with white lead or zinc white. The latter mixtures are, indeed, preferable to the antimony-lead compound. The latter is best prepared by fusing together one part tartar emetic, two parts nitrate of lead, and three parts common salt, and then grinding, washing and filtering.

Turner's Yellow

(also termed Montpellier's, Cassel and Verona yellow, and sometimes "mineral yellow") is an oxy-chloride of lead of doubtful value as a pigment, $PbCl_27PbO$. It is obtained by the action of common salt or sal-ammoniac on litharge or red lead. It is of pale buff-yellow colour, of good body, but unstable, and is out of use.

Yellows now never Used.

Some of the yellow pigments treated above are out of general use (in such cases stated); but we have thought it advisable to notcie them, as exhibiting by way of comparison what good pigments are. The following yellow compounds are never employed, and possess but scientific interest.

Iodide of Lead.

A beautiful yellow compound, heavy, and insoluble in cold but soluble in hot water; obtained by precipitating iodate of potash with white sugar of lead.

Massicot.

Chiefly protoxide of lead, varying in shade from buff to orange according to composition, etc. It is prepared from white lead by calcination in an open furnace. It is an excellent drying pigment.

Thallium Yellow.

Chromates of thallium form yellow and orange pigments of some brilliance, but slightly soluble in water, and costly.

Thwaites' Yellow.

Chromate of cadmium is a yellow body of exceedingly pure shade, partially soluble in water, and unstable.

Uranium Yellow.

A yellow pigment of considerable stability, and of pure shade, but costly. If the ores of the metal uranium are ever found in large quantities, and a permanent supply can be relied upon, this and other compounds of uranium will probably meet somewhat extensive application in the arts.

Platinum and Mercury Yellows.

Platinum yellow is a very costly pigment; it is of a beautiful golden yellow, and very stable. When a neutral solution of chloride of platinum is mixed with excess of platinum chloride, and the mixture evaporated to dryness with alcohol and washed with alcohol, the pigment is obtained in great beauty, of composition $PtCl_3(KCl)$. It is not materially injured by sulphur fumes, nor exposure to a damp atmosphere.

Mercury yellow, or Turbith yellow, is another expensive yellow, a basic sulphate, of the formula $HgSO_4(HgO)_2$. It is highly poisonous.

Green Pigments in Common Use.

It is convenient to classify the large number of green pigments that are in use into four general divisions—firstly, those containing chromium oxide, secondly, those containing copper oxide, thirdly, those miscellaneous greens containing neither of these bases, and fourthly, mixed greens. The first of these classes includes the greens in most extensive use, and those which for beauty and permanence recommend themselves above all or the majority of the others.

The following list of green pigments includes all those in ordinary use in fine-art painting, decorative painting, in cotton, carpet, wax-cloth and paper painting and staining, and in pottery and glass colouring, etc.

1. Greens containing Chromium.

Oxide of Chromium, Cr_2O_3, which occurs in nature as chrome-ore, along with earthy impurities, but for artistic use is always prepared artificially—for which numerous methods are in use. Various preparations of oxide of chromium are known by different names. *Veridian*, or chrome *Emerald green*, consists of more or less *hydrated* oxide of chrome, $Cr_2(OH)_6$, etc., together with phosphoric or boracic acid. This is also known as *Vert de Guignet*. The name "Emerald" is also applied to Scheele's green. *French Veronese green* is an oxide of chromium, frequently containing impurities of arsenic. *Transparent Oxide of Chromium green* is a hydrated oxide, containing more water than any of the above, and being deficient in body. Oxide of chromium is a very stable body, and not injured by sulphurousfumes, or by prolonged exposure to the atmosphere either by the action of light or moisture; it does not act on other colours, in combination with which it may be safely employed.

2. Greens containing Copper.

Malachite green, or *Mountain* or *Hungary green*, is a hydrated carbonate of copper ($CuCO_3 + CuOH_2$). *Green Verditer*, or Bremen green, a hydrate of copper. *Emerald* or *Schweinfurt green*, an aceto-arsenite of copper, $Cu(Cu_2H_3O_2)_2$, $CuHAsO_3$. *Scheele's* or *Swedish green*, an arsenite of copper, $CuHAsO_3$. *Verdigris*, a sub-acetate of copper, $Cu(C_2H_3O_2)_2CuO(H_2O)_6$. *Stannate of Copper*, a compound of tin and copper. *Brunswick green*, an oxychloride of copper.

3. Miscellaneous Greens.

Cobalt or Rinmans' green, is a compound or mixture of the oxides of cobalt and zinc (CuoZnO). *Green Ultramarine* will be treated under Blue Ultramarine, as it is obtained merely by a modification of the process for the production of the latter.

4. Mixture Greens.

Many shades of green are obtained by mixtures of blue and yellow, or green and yellow, or green and blue.

Chrome Greens.

Before treating of these it is instructive to glance at the most notable properties of the salts of chromium. Chromium is a metal resembling iron in its properties, and its salts consequently frequently present a resemblance to the corresponding salts of iron. Let us dissolve some pure chloride of chromium, Cr_2Cl_6, in water in a test tube: the solution is of a pale green colour; add a little ammonia—insufficient to make the mixture alkaline—and a pale green gelatinous flocculent precipitate forms. This is chromium hydroxide or hydrate, $Cr_2(OH)_6$, corresponding to the gelatinous red precipitate of $Fe_2(OH)_6$ given by adding ammonia to ferric chloride, Fe_2Cl_6. These hydrates differ, amongst other ways, in that the first dissolves to a red-greenish clear solution on addition of an *excess* of ammonia—*i.e.*, sufficient to make the mixture strongly alkaline—and on now *boiling* the liquid the precipitate is again thrown down; whereas the precipitate of $Fe_2(OH)_6$ is not, as we have already seen, acted on by excess of ammonia, whether cold or hot. If we collect the precipitate of chromium hydrate on a filter, wash it well and let it drain, we get a *very pale* green pigment, in a state of fine division, and well suited for the manufacture of paints etc.; but such a shade of colour is of no value, and to get any considerable depth of it a very large amount of the pigment would be required. This corresponds exactly with thecase of ferric hydrate, $Fe_2(OH)_6$, pale brownish-yellow or *buff* being obtained under similar circumstances. If now we dry the pale green precipitate, and finally ignite it, we get a fine deep-green perfectly insoluble powder of chromium oxide, Cr_2O_3, which only requires grinding, etc., to form an excellent fast pigment of a rich green shade.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

148. Belt and Pulley Gearing.

HAVING in preceding paragraphs gone somewhat fully into the leading points connected with the system, we propose to glance at a few of the minor details, such as the junction of belts, and other practical points. These, although thus classed, are by no means unimportant: rather the reverse of this, bearing in mind the mechanical axiom that the strength of a machine lies in its weakest part. These details will not be given in regular sequence, but will be taken up just as space and opportunity serve. But before giving them it will be well here to register a caution in regard to the purchasing of the leather which is to be used in the making of the belts; or of the belt or coil or roll if this be bought of the width required ready to be used. And the caution is simply stated: Have nothing to do with cheap material. Simply because it is cheap—a condition which with some seems to exercise a most powerful, with others an irresistible influence—a material will be bought which will prove dear at any price; but it is surely scarcely necessary to say that there is as vital a necessity to have the driving belt of a given machine strong and practically trustworthy as any part of the machine which is to be driven, or the shaft and its bearings on which the driver pulley is fixed. The hope that a cheap bargain will be a good one, in the matter of belt or leather for belt, is utterly fallacious. We, of course, do not here include the circumstances which may sometimes arise when, as in the case of a bankrupt or other stock being disposed of, materials may be had decidedly cheap: this case does not come within the scope of our caution, as the best material under it may be really purchased at the lowest price. Some may have faith in one or other of the new methods, more or less recently introduced, by which leather is prepared other than by tanning. The good old system of oak-bark tanning gives, beyond all doubt, the highest quality of leather; and of the systems of tanning with oak-bark, which vary only in points of detail, the old "English" method is the best, and leather produced by it stands highest in the market. For in this, as in other departments of industrial work, the name of old England attached to any product gave it the stamp of superlative excellence. True, it is to be feared that this attribute obtained only in the times of the past; it is to be feared that the desire for having cheap things on the part of the purchaser, and in some cases a carelessness on the part of the producer to keep up to the grand old English standard to give the best work possible to be done, have put, and daily put, into the market material for leather belting which, although the stamp or mark of being the "Best English tanned" may be attached to it, by no means will come up to the true standard. To get over this difficulty, or the chance of not getting the best material even after purchasing it at the highest price, the only true safeguard is to deal with the best houses. Those who are at the head of these are men of probity, who would not do bad work if they could; and who, moreover, take the common-sense view of the case which tells them that, even if they would or could send out bad material, it would not pay in the long run—it would be found out. Good houses cannot, in short, afford to give out knowingly bad material. We say "knowingly" with a direct purpose in view in using the word; for although the belting leather may be sold honestly as the best, and although a sample may stand the highest test, it must not be assumed that the whole bulk or length is equally good throughout. At one time machinists almost universally assumed that, given a sample which stood satisfactorily a test, the whole piece or length was of the same strength or quality throughout. It is now generally understood that leather, like other material, such as iron or steel, possesses its weak points. Nor need this be wondered at; for though the closest inspection may afford evidence that a whole piece is of uniform good quality, certain parts may possess points which deteriorate this, and these are occult or hidden. These may never reveal themselves, or they may only be made known by a subsequent failure. But for these occult causes of weakness no maker or producer is or can be responsible: they concern natural causes over which they have no control; or if they could control them, they have no means of ascertaining their existence or locality. Hence it comes about that the appearance, or result of a close examination, of leather or leather belting which indicates "high quality," and the "strength" which shows this, are not, as they were at one time, convertible or synonymous terms; and the only way to guard against any future possible discrepancy between them is to give a large margin of safety on the calculated or theoretical strength of the belting. The highest authority recommends a working strain of only one-fourth of the strength which even admittedly bad or poor leathers submitted to test show; and this strain—some 100 lb. to the inch of width—may be assumed to be in every sense practically safe when one deals with leathers of avowedly good quality. Some practical men, however, in order to be "sure," arrange their belting to be subjected to a strain of much less than the above —not far off one-half of it—that is, one-eighth of the theoretical strength. This, however, seems to be excessive in its caution, and adds, so far as it is so, to the expense of the belting, as stronger leather must be used for the same work to be done by it. These hidden or occult causes of weakness in leathers which stand the test of a close and minute examination, and even of other tests, make themselves evident in some instances by the belt, under the wear-and-tear of working, becoming warped and crooked; and this under conditions which do not throw any suspicion of external causes as being the operative cause. Those conditions may be such, and so uniform, that theoretically the belt, if of leather of equally good quality throughout, ought to remain in good even condition, but if it does not, the parts which change are obviously at or near the points where inequality obtains in the leather. What the chief conditions above referred to are, we have in preceding notes under present head detailed, as we have also described some of the methods by which unfavourable conditions of working may be, if not altered, amended favourably. If it be desired to know the length of the belt required for certain circumstances, without measuring by the tape—and if not carefully done the result is apt to be deceptive—the following rule will be found useful, where the diameter of the driver and the driven pulleys are known, and also the distance from centre to centre of shafts. Take the sum of the two diameters, divide by 2, and multiply the quotient by 3·25 or $3\frac{1}{4}$. Multiply the distance between centre and centre of the two shafts by 2, and add the product above obtained to this: the result is the length of belt required. It is sometimes necessary to know the length of a "coil" of belting. Each coil or turn of the belt in the coil represents a circle; and by measuring the diameter of the respective coils we can obviously obtain the length of their circumferences, which added together will obviously give the length of the coil as a whole when stretched out. This process is clearly a tedious one; but by taking the sum of the diameters of the outside coil and the inner coil, which may be called its core, we obtain the mean of the extreme diameters of coil; and if we multiply this mean diameter by the well-known multiplier 3·1416, and the result by the number of the coils, we obtain the whole length of the coil. By putting the length required as L, the diameter of outside or largest coil as D, that of the smallest coil, or core, as C, and N the number of coils or turns, the following formula has been given by an authority:—

$$3·1416 \times N\frac{(D \times C)}{2} = \text{length of complete coil, or L.}$$

In this case L, D, and C are all represented by the same or like units of measurement, as inches. The same authority gives the formula in a simpler form, as thus:

$$1309 \text{ N } (D \times C).$$

We now take up the points connected with the junction of the two ends of the belts, in order to form the continuous wrapping or endless belt, when passed round and stretched upon the peripheries of the two pulleys, the driver and the driven. And in connection with this point of detail in belt arrangement we find a great diversity of opinion as to what is the best plan, and a consequent variety in the methods by which the views of different machinists are carried out. We have called the belt, as practically it is when working, an endless or continuous wrapper. It is not absolutely or theoretically so; this could only be obtained by having the material without any break in the continuity of the strip of leather—a theoretical condition of leather belt represented by the familiarly known bands of vulcanised indiarubber, which are used to bind papers or letters together. But we have to deal with a material which is naturally and only met with in the condition of a flat surface—the skin or hide of the animal—and are therefore placed under different circumstances than when we have to deal with a material like the rubber, which we can mould, so to say, into whatever shape required. There must, therefore, to any strip of leather cut out of the flat, be two open or free ends. Theoretically the best junction of these two free ends would be where the faces of the ends could be joined together so that the two surfaces or faces would be perfectly flush with each other. If the section or surface of the faces or ends of the belt were large enough to be cemented together so strongly that the joint would be able to resist any tension which was put on the belt, we should then have the nearest approach to a perfect joint, in which the continuity of the leather body or surface would be uninterrupted. For, being in contact face to face, or end to end, the lines of upper and lower faces would be such that the surface of the one end would be coincident with the surface of the other end, and there would be no projecting part next the pulley. But the conditions of belt gearing are not in this simple and effective condition. There must be an overlap at one end of the belt before the junction between the two can be made, as there would without it be no grip between the two sufficient to resist tension; and the overlap must be securely fastened together. There are various modes of fastening the two ends together thus overlapped. Whatever be the method adopted, one point is essential—namely, that the ends or "butts" be perfectly square—that is, cut at right angles to the length of the belt: and this in order to put a perfectly even drag or strain upon the belt in the direction of its breadth; for if the butts be not square, there will, when the junction is completed, be a greater pull at one side than at the other. The methods of securing the ends of the belt together at the overlap may be classed as three,—lacing, riveting, and metal-clip work. The lacing or sewing is done almost universally with leather thongs, although hemp cord well waxed is also employed. That the lacing or sewing with leather thongs is the best seems to be pretty widely conceded. One great advantage possessed by the thong is that it is elastic, and possesses generally the same characteristics as the leather of the belt itself; and the junction parts, moreover, ride easily over the surface of the pulley as they come up in contact with it. This flexibility cannot possibly be obtained in the junction of belts when copper riveting or metal clip work is employed: the metal is rigid, and although its surfaces as presented to the pulley face are smooth, and so arranged that the minimum of projection is secured, still they cannot ride over the pulley face as smoothly without jar as the leather thongs do. There is considerable art in the lacing or sewing of belts together; and this lies chiefly in the form and disposition of the holes through which the thong is passed. In the cutting out of holes of any kind in the face of a belt, as they are made in rows which of necessity go across the breadth or width of the belt, its strength must be lessened in proportion to the number of holes or parts cut out. There is more room, so to say, for cutting out—that is, the belt will be less weakened—by having holes running in the direction of its length; the object is therefore gained of minimising the loss of leather by giving the holes for the thongs an elliptical shape, the greater or conjugate diameter of which runs in the direction of the length of the belt, the transverse or short diameter of the ellipse-shaped hole being across its breadth or width. By this plan the greatest amount of leather is cut out of the stronger, the smallest amount from the weaker direction of the belt. After the butts are cut square and the ends put together, or overlap formed, care must be taken to punch out the elliptical holes in the two free ends so that they will be exactly opposite to each other. The holes, in place of being in rows parallel to each other, should be disposed so that they go zigzag. This necessitates the thong being threaded, so to say, in diagonal lines; and this diagonal or oblique direction of the fastening thong gives greater power to resist tension or pull or drag on the belt, while it tends to equalise the strain thrown upon it. In a belt three inches in width a good plan is to give four holes in each end, two in each row. A six-inch-wide belt should have seven holes, four of those in the row nearest the end. A ten-inch belt should have nine holes similarly disposed. In punching out the holes care should be taken not to place them too near the outer edges of the belt: the distance from this should certainly not be less than three-fourths of an inch, and from the ends or butts not less than an inch, though seven-eighths of an inch is adopted by many as the safe distance. The distance between the rows of holes—that is, the outside ends of the holes, not measured from their centres—should not be less than one-and-a-half inch, thus giving this length of solid leather between the holes. The keeping of the holes a right distance apart is of great importance, as it helps to distribute the rupturing strain tending to tear the lacing and belt ends asunder. In beginning to lace or sew the two ends, it is best to start in the centre of the belt, keeping the butts exactly square,—the thong being laced with equal tightness on both sides of the belt, care being specially taken to have the thong perfectly flat on the pulley side of the belt, thus avoiding all crease or roughness where smoothness is so much required. In diagonal or crossing arrangement of the thong in lacing belts, it appears to be the safer way to keep the crossing to the upper side, and not to cross on the pulley side. The tying together of the two ends of the thong should be done at the centre of the belt. A very good plan for lacing has been introduced by an American engineer, giving all the advantages of the diagonal or oblique disposition of the thong without actual crossing. In this the holes are so punched in the belt that those on one half of the thong lie in lines parallel to each other, but which are oblique to the direction of the length of belt, and which lie sloping from left to right on the upper side of the belt—the rows sloping in the opposite direction on the pulley side, the lower row of holes of this being midway between the oblique lines of the other row. There are thus two rows parallel to each other, but oblique to the width of the belt, on the upper side; and two rows also parallel and oblique, but running at an angle in the opposite direction, on the pulley side of the belt. Taking the strength of the solid leather of a belt some $\frac{7}{32}$nds of an inch thick—or, say $\frac{3}{16}$ths, which may be taken as the average thickness—at 675 lb. the square inch, the strength through the lacing line may be taken as 210 lb., that through the copper riveting lines at 382 lb.,—in these cases the ultimate or rupturing strength being taken at 3086 lb. per square inch; as a safe working strain, one-third of those strengths only should be relied on.

INDEX.

The Figures refer to the Pages and the Numerals to the Plates.

END OF VOL. II.

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