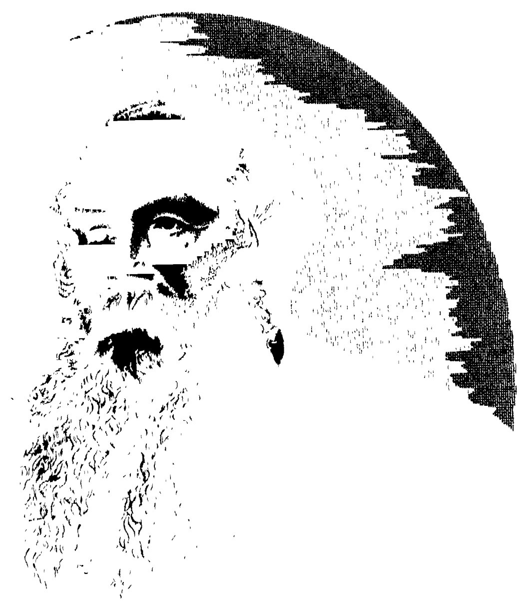

THE SCIENCE

MODERN COTTON SPINNING:

EMBRACING

MILL ARCHITECTURE; MACHINERY FOR COTTON GINNING, OPENING, SCUTCHING, PREPARING, AND SPINNING, WITH ALL THE LATEST IMPROVEMENTS;

ALSO ARTICLES ON

STEAM AND WATER POWER; SHAFTING; GEARING AND AMERICAN SYSTEM OF BELTING COMPARED; GENERATION AND APPLICATION OF STEAM CRITICISED AND EXPLAINED; BOILERS, BOILER EXPLOSIONS, &c.;

ALL TENDING TO SHOW WHERE

THE OUTLAY OF CAPITAL MAY BE ECONOMISED, AND PRODUCTION CHEAPENED.

EVAN LEIGH, C.E.,

MECHANICAL ENGINEER, M.S.A., ASSOC. I.N.A., ETC., OF MANCHESTER, ENGLAND,
INVENTOR OF "COUPLED MULES" WITH "PUTTING-UP MOTION," "SELF-STRIPPING CARDING ENGINE," "LOOSE-BOSS TOP ROLLER," ETC.

Second Edition.

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1873

TO

SIR WILLIAM FAIRBAIRN, BARONET,

LL.D., F.R.S., F.G.S., ETC.,

AS A PRACTICAL AND ACCOMPLISHED ENGINEER, AND VETERAN IN SCIENCE,

WHOSE WORKS

ON MILL ARCHITECTURE, STEAM AND WATER POWER,

STRENGTH OF MATERIALS, ETC.,

HAVE BEEN, AND WILL BE, A LASTING BOON TO MANKIND;

ALSO, TO

SIR THOMAS BAZLEY, BARONET,

MEMBER OF PARLIAMENT, ETC.,

AS A MAN THOROUGHLY ACQUAINTED WITH THE COTTON MANUFACTURE.

WHOSE LONG AND ASSIDUOUS LABOURS

IN PROMOTING

THE GROWTH OF COTTON, AND IN MANY OTHER USEFUL PUBLIC OBJECTS,

HAVE CONFERRED GREAT BENEFITS

ON LANCASHIRE AND THE COMMERCIAL WORLD,

This Work

IS, BY PERMISSION, MOST RESPECTFULLY DEDICATED,

BY

THE AUTHOR.

PREFACE.

THE object of this work is not only to illustrate modern cotton spinning, but to make its theory and practice plain, with a view to assist and interest both the juvenile student and inexperienced manager, by laying down simple rules, and explaining the nature of the various machines, their principles of action, and what constitutes their mechanical excellence or defect, as touching economy of production, which is the great desideratum of the intelligent and expert cotton spinner.

The first source of cost is the interest on capital expended; next the depreciation on buildings, machinery, and general plant; then comes the labour required; after which the consumption of fuel, oils, &c. To economise these, therefore, and bring down the cost of production to a minimum, is the great object in view.

With this aim the author, who has had nearly half a century's personal experience, dwells but little on present examples, which may be seen in every-day operation, but rather points to the inevitable future, taking care to advise no step but what is both safe and practical, and by which large sums of money may be saved in original outlay, and, consequently, in cost of production.

The next thing will be to show the best arrangement and selection of machinery for producing good yarn; also its general management with a view to economy in wear and tear, labour, &c.

It is thought desirable, in order to give the student a thorough knowledge of the nature of cotton, to exhibit drawings showing the length of staple of the different varieties, which the author is enabled to do through the kindness of The Cotton Supply Association; also to give a short history of the plant, with fibres magnified, and to show the mode of "ginning" cotton, as at present generally practised.

In all criticisms of machinery a strict impartiality will be observed, and the names of machine makers will only be mentioned where necessary in connection with some invention or other peculiarity, and wherever this is done it must not be understood as any recommendation by the author. The principal object is to lay bare the truth and science of cotton spinning in its most advanced state, up to the day of publication.

EVAN LEIGH.

MANCHESTER, *January*, 1871.

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FIGURES AND ILLUSTRATIONS.

THE SCIENCE OF

MODERN COTTON SPINNING.

THE COTTON PLANT.

THIS wonderful plant is indigenous to most hot countries. In its wild, as in its cultivated state, it exhibits great variety of staple, which, like other plants, is much improved by careful culture. It grows in the greatest perfection where the climate is hot and the atmosphere humid; hence the SEA ISLAND COTTON of Georgia surpasses all other varieties in length and fineness of staple; that grown on the Edisto Island having the longest staple of all.

SEA ISLAND COTTON.

(This variety always commands the highest price in the markets of the world for general excellence, silkiness, and beautiful gloss.) Some parts of Australia, Tahiti, and other islands in the Pacific Ocean have climates and natural advantages capable of rivalling the productions of Georgia; and would appear to be already doing so, judging from the falling off during late years in the quantity grown on the Sea Islands.

The mean length of staple in the Sea Island varieties of cotton may be classed as follows; viz.—

				Inches.
EDISTO ISLAND COTTON has a mean length of staple of				2·20.
ST. HELENA ISLAND	,,	,,	,,	1·78.
WASSA and HUTCHINSON ISLANDS		,,	,,	1·65.
WODAMALAN ISLAND	,,	,,	,,	1·63.
JOHN'S ISLAND and JAMES ISLAND		,,	,,	1·60.

The total crop grown each year since 1855 of Sea Island cotton will be seen below:—

	Bales.		Bales.
1855-56 . . .	44,512	1860-66 . .	No record.
1856-57 . . .	45,812	1866-67 . . .	32,228
1857-58 . . .	40,566	1867-68 . . .	21,275
1858-59 . . .	47,592	1868-69 . . .	18,622
1859-60 . . .	46,640	1869-70 . . .	26,507

Of this, Florida grows rather more than Georgia, and the latter rather more than South Carolina.

AUSTRALIAN COTTON.

Australian cotton rivals Sea Island in length of staple and silkiness. At present it is grown however, in but small quantities, and the crop is said to be rather uncertain.

Australian of the best quality has a mean length of staple of 1·80.

[*See* PLATE I.]

EGYPTIAN COTTON.

Egyptian cotton ranks next in length and fineness of staple, also in silkiness of feel, but it has not the same bright colour as the Sea Island. When clean ginned, this cotton is said to lose less in carding and spinning than any other variety, that of the Sea Island excepted. It is used most extensively in the production of No. 60's to 90's yarn, or what are commonly called "Bolton Counts," from the fact that this yarn is spun more extensively in Bolton and its neighbourhood than in any other part of the world. Whilst the finest Sea Island can be spun practically into No. 200's to 300's yarn, the Egyptian is seldom used so high as No. 150's, and never now without being well combed.

The invention of the combing machine has made it practicable to spin Egyptian cotton into much finer numbers than formerly, by effectually cleaning it of the nep and dirt so commonly found on it.

Egyptian cotton of the best quality has a mean length of staple of 1·50in.

The quantity of Egyptian cotton at present grown amounts to about 310,000 bales per annum. The crop, however, is somewhat uncertain from occasional blight, high or low Nile. Great efforts have been made by the intelligent and enterprising Kedive, who now rules Egypt, to promote its growth. The Egyptian bale is now composed of six cantars of 93lbs. each, and weighs nearly 600lbs., being the heaviest

COTTON GROWN IN THE SEA ISLANC

COMPARATIVE LENGTH OF STAPLE.

Description.	SEA ISLAND OR LONG STAPLE.								
Place of Growth.	Sea Island.		Edisto Island.	John's Island.	James Island.	St. Helen's Is.	Wadamalan I.	Wassa Island.	Hutchinson

Two Inches, divided into 10ths.

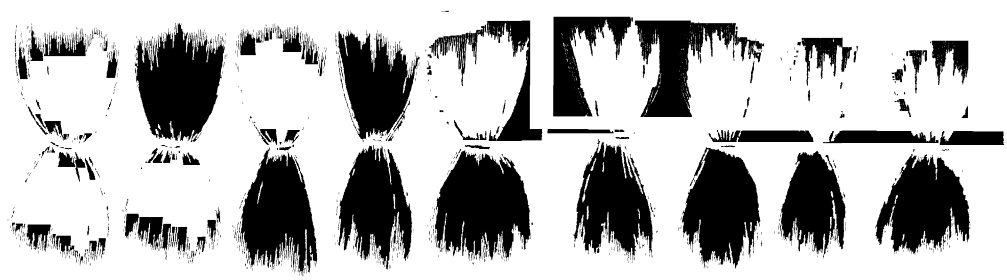
Number . .	1	2	3	4	5	6	7	8	9
Min. Length .	1·60	1·40	1·90	1·40	1·45	1·55	1·40	1·45	1·40
Max. „ .	1·80	1·70	2·30	1·80	1·75	2·00	1·85	1·85	1·90
Mean „ .	1·70	1·55	2·20	1·60	1·60	1·78	1·63	1·65	1·65

SEA ISLAND AND AUSTRALIA

COMPARATIVE LENGTH OF STAPLE.

Description	SEA ISLAND (continued).				
Place of Growth	Bull's Island.	Pinkey Isl.	Bluff Island.	Cat Island.	

Two Inches, divided into 10ths.



Number . .	10	11	12	13	14	1	2	3	4
Min. Length .	1·30	1·20	1·60	1·20	1·30	1·50	1·60	1·40	1·30
Max. „ .	1·75	1·60	2·00	1·65	1·85	1·80	2·00	1·60	1·70
Mean „ .	1·53	1·40	1·80	1·43	1·58	1·65	1·80	1·50	1·50

of all cotton bales. It is interesting to see that useful animal the camel carry two o these enormous bales, slung like a pair of panniers, one on either side, and to watc' it rise from the ground, the bales being saddled on while down.

BRAZIL AND OTHER SOUTH AMERICAN COTTON.

Of the many varieties of South American cotton the Pernambuco is mos esteemed for its length of staple and general good working qualities. Paraiba an Maceo rank next in quality, being both alike in staple, but rather shorter tha Pernam; then come Aracate, Maranham, and Ceara, also alike, but still rathe shorter. The staple, however, of all Brazilian cotton, although long, is much coarse than either Sea Island or Egyptian; hence its unsuitability for very fine number of yarn.

It is seldom spun alone, on account of its harshness and irregularity both i length of staple and cleanliness, but it mixes well with Egyptian and the America varieties, and is one of those cottons, the relative price of which should be watche by the expert spinner, as sometimes it will come in advantageously and effect a savin in the mixing. The author once saved a penny a pound for a considerable time b using Brazilian and Surat cottons together, instead of American, when the latter wa relatively dear. In working extreme cottons together in this way, no alteration shoul be made in the setting of the rollers, but the weight should be taken from the middl roller, as it generally is in thostles.

Surinam and Peruvian cotton rank in staple almost equal with Pernambuco, bu are rather more irregular.

	Inch.
PERNAMS COTTON of the best quality has a mean length of staple of	1·35.
SURINAM and PERU " " " " "	1·30.
MACEO and PARAIBA " " " " "	1·20.
MARANHAM, ARACATE, and CEARA " " " "	1·15.

The total quantity of Brazilian cotton at present exported amounts to about 300,000 bales, reduced to a weight of 400lbs. each; but the bales, as they leave the country, weigh only about 150lbs. each.

ALGERIAN COTTON.

In the French province of Algiers cotton is grown in small quantities, which ranks in staple with Egyptian.

WEST INDIES.

Of the cotton grown in the West India Islands, that grown on the Union Island is the best and longest in staple; the St. Kitt's Island comes next; both of which are fine and regular in staple. After these, the next in quality is the Carriacon, which is both shorter and more irregular, but not nearly so much so as the St. Vincent. Demarara cotton is small in supply, has a fine glossy staple, of good colour, but very irregular in length.

						Inch.
Union Island Cotton of the best quality has a mean length of staple of						1·45
St. Kitt's Island	„	„	„	„	„	1·30
Carriacon	„	„	„	„	„	1·20
St. Vincent	„	„	„	„	„	1·05

It may be generally observed of West India cottons that they have a better colour, and are much finer in staple, than the Brazilian, and hence they mix well with Sea Island for fine spinning; but the quantity grown is very small, therefore few spinners use them regularly, from the precarious nature of the supply. They may however, sometimes be picked up to advantage.

[*See* Plate II.]

AMERICAN COTTON.

American cotton, or that which grows in the Southern States of North America, is generally the most useful of all cottons, and is grown to a greater extent than any other variety. It is comprised under the various names of Orleans, Mobile, Uplands, Apalachicolas, Texas, Boweds, &c. Boweds is a name given formerly to the short-stapled Uplands cotton of Georgia, cleaned with the "bow gin;" but the saw gin, from its rapidity, has now displaced the more antiquated methods of ginning. Cotton, however, is frequently cut and much deteriorated in quality by this rapid ginning with the saw gin, which is also the cause of the small white nep found so frequently in American and other cottons carelessly passed through this machine. These little neps or knots are very difficult to extract in the subsequent process of carding, and many of them are found adhering to the yarn and cloth after being spun and woven.

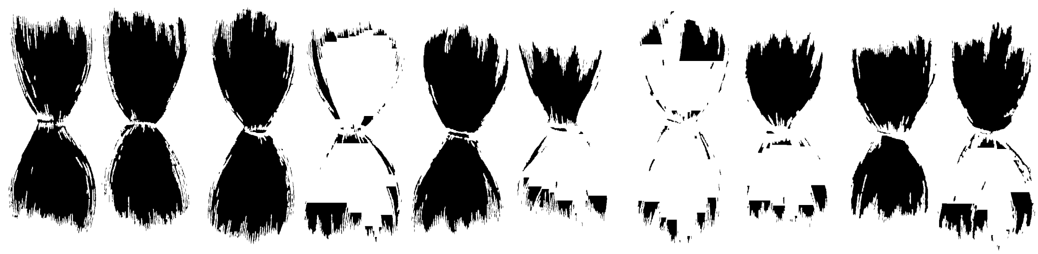
						Inch.
New Orleans Cotton of fair quality has a mean length of staple of						1·10.
Mobile, Alabama,	„	„	„	„	„	1·05.
Georgia, South Carolina, Apalachicola (Uplands)				„	„	1·00.
Tennessee, &c.	„	„	„	„	„	0·98.
Texas, &c.	„	„	„	„	„	0·95.

COTTON GROWN IN VARIOUS PARTS OF THE WORLD.

COMPARATIVE LENGTH OF STAPLE.

Description.	EGYPT.		WEST INDIES.				SOUTH AMERICA.			
Place of Growth.	Egypt.		Union Isl.	St. Kitt's I.	Carriacon.	St. Vincent.	Pernambuco.			Peru.

Two Inches, divided into 10ths.



Number . . .	1	2	1	2	3	4	1	2	3	4
Min. Length .	1·40	1·20	1·30	1·20	1·10	0·90	1·20	1·10	0·90	1·10
Max. „ .	1·60	1·50	1·60	1·40	1·30	1·20	1·50	1·40	1·30	1·50
Mean „ . .	1·50	1·35	1·45	1·30	1·20	1·05	1·35	1·25	1·10	1·30

Description.	SOUTH AMERICA (continued).								ALGIERS.	
Place of Growth.	Surinam.		Aracate.	Maranham.		Paraiba.	Ceara.	Maceo.	Algiers.	

Two Inches, divided into 10ths.

Number . . .	5	6	7	8	9	10	11	12	1	2
Min. Length .	1·10	0·90	1·00	1·00	0·90	1·10	1·00	1·10	1·40	1·30
Max. „ .	1·50	1·20	1·30	1·30	1·30	1·30	1·30	1·30	1·60	1·50
Mean „ .	1·30	1·05	1·15	1·15	1·10	1·20	1·15	1·20	1·50	1·40

The vast amount of cotton grown in the United States will be seen from the following statement of the crop grown in each year since 1821:—

Year.	Bales.	Year.	Bales.	Year.	Bales.
1821-22 . . .	455,000	1837-38 . . .	1,801,197	1852-53 . . .	3,262,882
1822-23 . . .	495,000	1838-39 . . .	1,360,532	1853-54 . . .	2,930,027
1823-24 . . .	509,058	1839-40 . . .	2,177,835	1854-55 . . .	2,847,339
1824-25 . . .	569,249	1840-41 . . .	1,634,945	1855-56 . . .	3,527,845
1825-26 . . .	720,027	1841-42 . . .	1,683,574	1856-57 . . .	2,939,519
1826-27 . . .	957,281	1842-43 . . .	2,378,875	1857-58 . . .	3,113,962
1827-28 . . .	727,593	1843-44 . . .	2,030,409	1858-59 . . .	3,851,481
1828-29 . . .	870,415	1844-45 . . .	2,394,503	1859-60 . . .	4,669,770
1829-30 . . .	976,845	1845-46 . . .	2,100,537	1860-61 . . .	3,656,086
1830-31 . . .	1,038,848	1846-47 . . .	1,778,651	1861-65 . . .	No record.
1831-32 . . .	987,487	1847-48 . . .	2,347,634	1865-66 . . .	2,193,987
1832-33 . . .	1,070,438	1848-49 . . .	2,728,596	1866-67 . . .	2,019,774
1833-34 . . .	1,205,324	1849-50 . . .	2,096,706	1867-68 . . .	2,593,993
1834-35 . . .	1,254,327	1850-51 . . .	2,355,257	1868-69 . . .	2,439,039
1835-36 . . .	1,360,752	1851-52 . . .	3,015,029	1869-70 . . .	3,154,946
1836-37 . . .	1,422,930				

It will appear from the above statement that there is no definite record of the crop from 1861 to 1865, when the great civil war raged; but the crop of 1861-62 was believed to be the largest ever grown. It will also be noticed that the recovery from the disorganisation caused by the disastrous war and subsequent liberation of the slaves has been slow and lingering; but judging from last year's crop, and the receipts at the ports so far this season, it is gratifying to find that the progress is steady, and the time probably not far distant when the enterprising Americans will exceed all their former successful efforts at growing cotton, and that with free labour!

According to the latest information, the number of acres under cotton cultivation in the Southern States of America is as follows, viz.:—

States.	Acres.	Estimated yield.	Bales.
North Carolina	451,714	175 lb. per acre	170,000
South Carolina	601,764	170 lb. „	220,000
Georgia	1,330,991	173 lb. „	490,000
Florida	140,909	165 lb. „	50,000
Alabama	1,437,172	165 lb. „	510,000
Mississippi	1,644,512	205 lb. „	725,000
Louisiana	920,700	250 lb. „	495,000
Texas	900,937	240 lb. „	465,000
Arkansas	711,784	245 lb. „	375,000
Tennessee	626,184	190 lb. „	215,000
Other States	218,823	170 lb. „	80,000
Total	8,985,440	186 lb. average	3,795,000

The foregoing is taken from the Report of the Commissioners of Agriculture, made at Washington, December, 1870, in which they state that about 12 per cent more land is under cotton cultivation this year than last, and the crop is estimated to be larger per acre than previously, which is no doubt owing partly to a favourable season, and partly to improved culture by the use of artificial manures, the stimulus of high prices, &c.*

It remains to be seen what the effect of impending lower prices will have on the future quantity of cotton grown in the States under the new system of free labour. That cotton will recede again to its former level can hardly be expected.

* P.S.—The actual cotton crop of 1870-71, predicted by the Commissioners of Agriculture to be 3,795,000 bales, amounted to 4,352,317 bales, which shows how unreliable early estimates are.

AFRICAN COTTON.

Of African cottons Port Natal cotton has the longest staple. Of that grown on the West coast of Africa, Lagada and Shire Valley are the best, ranking in length of staple with Maranham; Loanda cotton next; while Lagos is much inferior to the others.

						Inch
PORT NATAL COTTON,	of fair quality,	has a mean	length of	staple of		1·20.
LAGADA	"	"	"	"	"	1·15.
SHIRE VALLEY	"	"	"	"	"	1·15.
LOANDA	"	"	"	"	"	1·05.
LAGOS	"	"	"	"	"	0·90.

BORNEO AND JAVA COTTON.

The Sarawak of the former place ranks with Paraiba (South America), in length of staple, being better than the Java.

					Inch.
SARAWAK COTTON	has a mean	length of	staple of	. . .	1·20.
JAVA COTTON	"	"	"	. . .	1·10.

[See PLATE III.]

COTTON GROWN IN VARIOUS PARTS OF THE WORLD.

COMPARATIVE LENGTH OF STAPLE.

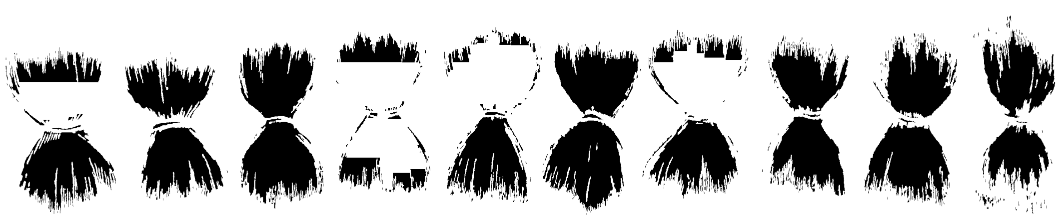
DESCRIPTION.	WEST COAST AFRICA.				PORT NATAL.		BORNEO AND JAVA.		UNITED STATES.	
PLACE OF GROWTH	Lagada.	Shire Valley.	Loanda.	Lagos.	Port Natal.		Sarawak.	Java.	Mississippi.	

Two Inches, divided into 10ths.

Number . . .	1	2	3	4	1	2	1	2	1	2
Min. Length .	1·10	1·00	0·90	0·80	1·00	0·90	1·10	1·00	0·90	0·90
Max. „ .	1·20	1·30	1·20	1·00	1·20	1·20	1·30	1·20	1·30	1·20
Mean „ .	1·15	1·15	1·05	0·90	1·10	1·05	1·20	1·10	1·10	1·05

DESCRIPTION.	UNITED STATES—UPLANDS (CONTINUED)									
PLACE OF GROWTH	Texas.			Louisiana		Tennessee.	Mobile.	Alabama.	Georgia.	South Carolina.

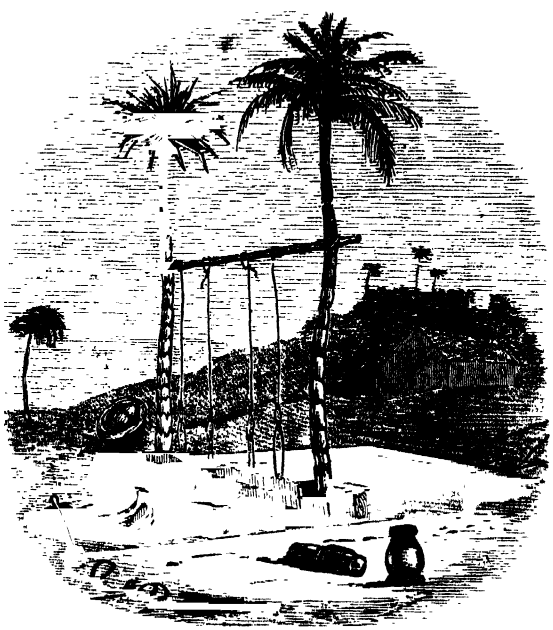
Two Inches, divided into 10ths.



Number . . .	3	4	5	6	7	8	9	10	11	12
Min. Length .	0·90	0·70	0·70	1·00	1·00	0·90	0·90	1·00	0·90	0·80
Max. „ .	1·20	1·00	1·00	1·20	1·20	1·00	1·20	1·10	1·20	1·20
Mean „ .	1·05	0·85	0·85	1·10	1·10	0·98	1·05	1·05	1·05	1·00

EAST INDIA COTTON.

The growth of cotton in India is of very remote antiquity, so remote that history fails to penetrate the gloom, or give any idea of how long cotton has been spun and woven there. The simplest and rudest possible machinery is even now used, each yard of cloth involving a vast amount of human labour; it being a singular and interesting fact that, although thousands of years must have elapsed since cotton was first manufactured in India, the same rude process of ginning, spinning, and weaving exists to a very great extent at the present day.



One can hardly find a term sufficiently expressive to characterise the difference between the natives of the eastern and those of the western hemisphere. "As far as the east is from the west," so widely do they differ in all things. Urged on by a ceaseless activity, the inhabitants of the western world know no rest or perfection in worldly affairs, whilst those of the eastern know no change, but are contented to live the lives of their forefathers over again, using precisely the same implements.

"O happiness! thou pleasing dream, where is thy substance found?"

A very high authority affirms that happiness consists not in the multitude of possessions, but in contentment with one's lot in life, be that what it may. Surely this must be the philosophy of the East, as it is there carried out to perfection.

In the West, however, the human faculties, being sharpened and improved by the pursuit of science and the development of nature's resources, a much higher standard of existence is attained. There can be no question which is right between the man who simply vegetates on the earth, following a sort of instinct as animals do, and he who cultivates his understanding, and so continually raises himself in the scale of creation.

The conquest of India by Great Britain, and consequent introduction of the habits of the West into many parts of the country, has aroused the inhabitants from their lethargic state; and in some districts a vast improvement is now taking place, not only in the growth of cotton, but in the habits of the people.

The late American war also gave a great impetus to the growth of cotton in India, the indigenous varieties being supplanted to some extent, at the same time, by cottons grown from American seed.

Indigenous Cottons grown in India.

Of these the Hinginghaut and Dhollera Surat, Guzerat, Coompta, and Tinnevelly are the best. The best Surat, however, has a mean length of staple of 1·10, which none of the others attain. Next to these comes the Khandeish, which is pretty regular, and after this the others, as enumerated in their order below, in form to be seen at a glance, viz.:—

				Inch.
DHOLLERA SURAT, of the best kind, has a mean length of staple of				1·10.
GUZERAT, COOMTA, and TINNEVELLY	"	"	"	1·05.
KHANDEISH	"	"	"	1·00.
BROACH and BERAR	"	"	"	0·90.
AMEDNEGGAR and MADRÁS	"	"	"	0·85.
TRICHINOPOLY, BELGAUM, GWALIOR, and JEYPOOR		"	"	0·80.
JULLUNDER DOAB	"	"	"	0·75.
AGRA	"	"	"	0·70.
DELHI	"	"	"	0·65.

[*See* PLATE IV.]

Although the above represents the present relative value and length of staple of the well-known varieties of the native or indigenous cottons of India, still it must be borne in mind that, in consequence of the new light now dawning upon Indian agriculture, this comparison may not hold good a few years hence, as improved irrigation, or the introduction of a railway into any particular district may cause a considerably improved cultivation of the soil.

Nearly all the indigenous cottons of India are badly ginned with the rude native machinery which still exists, the seed being crushed in, to a large extent, instead of being extracted, therefore the cottons are full of leaf, sand, and dirt.

COTTON GROWN IN INDIA.

COMPARATIVE LENGTH OF STAPLE.

DESCRIPTION.	NATIVE OR INDIGENOUS.									
PLACE OF GROWTH.	Surat.		Guzerat.	Broach.		Dharwar.			Tinnevelly.	

Two Inches, divided into 10ths.

Number . .	1	2	3	4	5	6	7	8	9	10
Min. Length .	1·00	0·80	0·90	0·80	0·60	0·90	0·90	0·80	0·90	0·80
Max. " .	1·20	1·20	1·20	1·00	0·90	1·20	1·10	1·00	1·20	1·10
Mean " .	1·10	1·00	1·05	0·90	0·75	1·05	1·00	0·90	1·05	0·95

COTTON GROWN IN INDIA *(Continued).*

COMPARATIVE LENGTH OF STAPLE.

DESCRIPTION.	NATIVE OR INDIGENOUS.									
PLACE OF GROWTH	Trichinopoly.	Tinnevelly.	Coimbatore.	Candeish.	Berar.		Amednuggur.	Belgaum.	Madras.	Agra.

Two Inches, divided into 10ths.

Number . .	11	12	13	14	15	16	17	18	19	20
Min. Length .	0·60	0·60	0·70	0·90	0·80	0·70	0·70	0·70	0·80	0·60
Max. " .	1·00	0·90	1·00	1·10	1·00	1·00	1·00	0·90	0·90	0·80
Mean " .	0·80	0·75	0·85	1·00	0·90	0·85	0·85	0·80	0·85	0·70

Cotton grown in India from New Orleans or American Seed.

	Inch.
DHARWAR cotton from American seed ranks the first in quality, having a mean staple of	1·50
TRAVANCORE next, having a mean staple of	1·30
TENASSERIM " " "	1·20
COIMBATORE " " "	1·15
GUZERAT " " "	1·10
BUNKAPOOR, MYSORE, and LINGASOOR "	1·05
SHEOPOOR "	1·00
BELGAUM "	0·95
BOLARUM "	0·90

These are good useful cottons, especially the first-named. They are of a bright colour, and clean when well ginned. They are, however, coarser in staple than the natural American, less kindly to work, and more irregular. Although all the above varieties have been grown experimentally from American seed, only the Dharwar continues to be so grown for commercial purposes.

Cotton grown in India from Sea Island and Egyptian Seed.

	Inch.
DHARWAR of the best quality has a mean staple of	1·65
HOOBLEE " " " "	1 60
MYSORE " " " "	1·57
BENGAL " " " "	1·15
BELARUM " " " "	1·00

All these cottons have a coarser staple by about 10 per cent than the natural Sea Island and Egyptian, and are apt to degenerate without fresh supplies of new foreign seed, which is owing to the more arid climate of India and the want of humidity. Irrigation may do much to supply this want, and, if it cannot alter, may greatly modify the climate. Those parts of India which lie in parallel latitudes with the Southern States of America are probably the best. Still the climate lacks humidity, and the quantity grown per acre falls much short of America.*

* Since the above was in type, the result of some very interesting experiments made by T. Login, Esq., C.E., in the neighbourhood of Delhi, have been thus communicated to the Cotton Supply Association: "These experiments were with native seed, planted at the usual times, on the Egyptian system, and irrigated on the same plan. The result is that already about 300lbs. per acre of clean cotton have been collected, and there is still a period of six weeks of the gathering season left. It is believed that between 500lbs. and 600lbs. will be secured. This is about *four times as much as the ordinary yield* under native cultivation, a result that is sure to arrest the attention not only of the Indian cultivator, but of the cotton manufacturers of England."

According to Mr. H. Rivett Carnac's Report in 1868, the total amount of land under cotton cultivation, in India, was 12,890,000 acres, and the total production was 2,297,500 bales, which were disposed of as follows :—

Exported to Great Britain . . .	1,371,000
Exported to the Continent of Europe .	170,000
Exported to China	135,000
Retained for home consumption . .	621,500
	2,297,500 bales of 400lb. each.

This gives an average production of about 71lb. per acre, which is considerably less than half the American growth per acre. The season for this cotton coming to market is from December to March inclusive.

The following Table will show at a glance where this cotton is grown, and in what proportions :—

Political Division.	Name of Cotton.	Acres.	Estimated yield.	Bales.
Bombay Presidency......	Dharwar			
,, ,, ...	Compta			
,, ,, ...	Broach	2,200,000	80lb per acre	440,000
,, ,, ...	Surat			
,, ,, ...	Khandeish.........			
Sindh	Sindh...............			
Bombay Feudatories ...	Dhollera	2,000,000	80lb ,,	400,000
Central Provinces and the Berars	Hinginghaut.........	750,000	80lb ,,	150,000
,, ,, ..	Oomraotee.........	1,250,000	80lb ,,	250,000
,, ,, . .	Akote..............			
Nizam's Territories	Barsee			
Central India	Bengal	2,000,000	50lb ,,	250,000
Rajpootana, &c.	Oomraotee.........			
Punjaub sends to Kurrachee	Bengal	800,000	50lb ,,	100,000
,, ,, ...	Sindh...............			
N. and W. Madras	Madras	1,320,000	80lb ,,	264,000
,, ,, ...	Mysore	30,000	80lb ,,	6,000
Burmah	British	60,000	50lb ,,	7,500
Bengal N. W. P., and Oudh	Bengal	2,080,000	70lb ,,	380,000
Sundries in Native States	....	400,000	50lb ,,	50,000
	Grand Total......	12,890,000	71lb average.	2,297,500

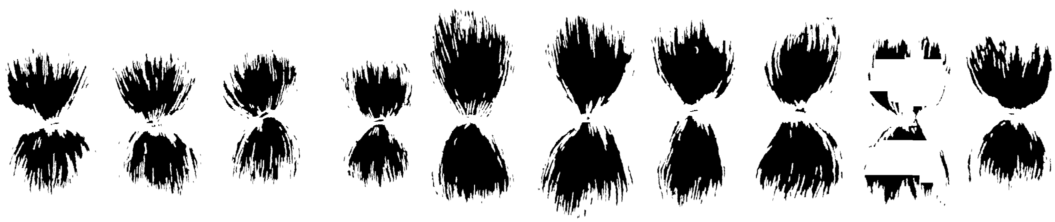
[*See* PLATES V. *and* VI.]

INDIAN COTTON *(Continued).*

COMPARATIVE LENGTH OF STAPLE.

Description.	Native or Indigenous.				From New Orleans or American Seed.					
Place of Growth.	Gwalior.	Jeypoor.	Jullunder Doab.	Delhi.	Dharwar.	Lingasoor.	Guzerat.	Bunkapoor.	Coimbatore.	

Two Inches, divided into 10ths.



Number	21	22	23	24	25	26	27	28	29	30
Min. Length	0·70	0·70	0·70	0·50	1·15	0·90	0·90	0·90	1·10	0·80
Max. „	0·90	0·90	0·80	0·80	1·50	1·20	1·30	1·20	1·20	1·10
Mean. „	0·80	0·80	0·75	0·65	1·33	1·05	1·10	1·05	1·15	0·95

INDIAN COTTON—*(Continued).*

COMPARATIVE LENGTH OF STAPLE.

Description.	From American Seed (continued).						
Place of Growth.	Dharwar.	Belgaum.	Travancore.	Mysore.	Bolarum.	Sheopoor.	Tenasserim.

Two Inches, divided into 10ths.

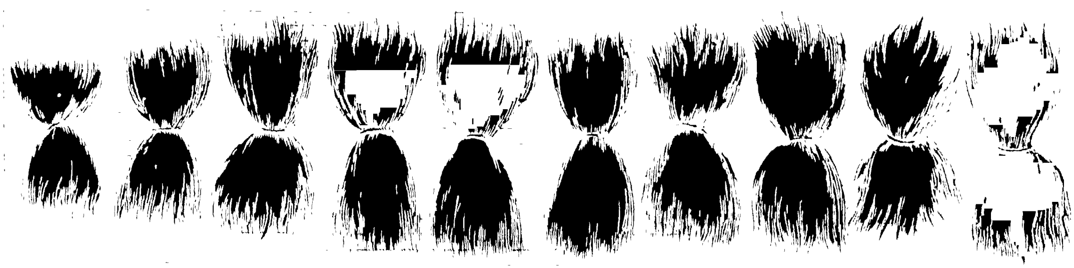
Number	31	32	33	34	35	36	37	38	39	40
Min. Length	1·30	0·90	1·30	0·80	0·80	1·10	0·90	0·80	0·90	1·10
Max. „	1·70	1·20	1·50	1·00	1·10	1·50	1·20	1·00	1·10	1·30
Mean. „	1·50	1·05	1·40	0·90	0·95	1·30	1·05	0·90	1·00	1·20

INDIAN COTTON *(Continued).*

COMPARATIVE LENGTH OF STAPLE.

Description.	FROM SEA ISLAND AND EGYPTIAN SEED.									
Place of Growth.	Belarum.	Bengal.	Mysore.	Dharwar.						Hooblee.

Two Inches, divided into 10ths.



Number . . .	41	42	43	44	45	46	47	48	49	50
Min. Length .	0·90	1·00	1·40	1·50	1·50	1·30	0·90	1·40	1·20	1·40
Max. " .	1·10	1·30	1·75	1·70	1·80	1·70	1·10	1·60	1·50	1·80
Mean. " . .	1·00	1·15	1·57	1·60	1·65	1·55	1·00	1·50	1·35	1·60

SUMMARY OF RESULTS.

From Plates I.—VI

Place of Growth.	Description of Cotton.	Length of Staple. In inches and decimals. Min.	Max.	Mean.	Fractions. Mean.	Diameter of individual fibres or filaments. In decimals of an inch. Min.	Max.	Mean.	Fractions. Mean.
United States . . .	New Orleans or Uplands .	0·88	1·16	1·02	$1\frac{1}{50}$"	·000580	·000970	·000775	$\frac{1}{1290}$
Sea Islands . . .	Long Stapled	1·41	1·80	1·61	$1\frac{60}{100}$"	·000460	·000820	·000640	$\frac{1}{1562}$
South America . .	Brazilian	1·03	1·31	1·17	$1\frac{17}{100}$"	·000620	·000960	·000790	$\frac{1}{1265}$
Egypt	Egyptian	1·30	1·52	1·41	$1\frac{41}{100}$"	·000590	·000720	·000655	$\frac{1}{1526}$
India	Indigenous or Native . . .	0·77	1·02	0·89	$\frac{89}{100}$"	·000649	·001040	·000844	$\frac{1}{1185}$
	Exotic or American . . .	0·95	1·21	1·08	$1\frac{2}{25}$"	·000654	·000996	·000825	$\frac{1}{1212}$
	Sea Island and Egyptian .	1·36	1·65	1·50	$1\frac{1}{2}$"	·000596	·000864	·000780	$\frac{1}{1282}$

The importance of Bombay as a port for the shipment of cotton, in comparison with the other ports, will be seen below. Of the total amount of cotton shipped in 1868, the port of—

		Bales.
Bombay shipped		1,224,000
Cocanada	"	32,000
Madras	"	124,000
Tutocorin	"	84,000
Calcutta	"	200,000
Rangoon	"	12,000
Total exported		1,676,000

The production of cotton in India has fallen off somewhat since 1868, which has been owing partly to bad seasons and partly to a diminution in the number of acres under cotton cultivation. It is probable, however, that this will be made up in the present season from the better cultivation of the soil, as great efforts are now being made in that direction.

CHINA, SMYRNA, AND OTHER COTTONS.

China Cotton.—This cotton is very bright in colour, and clean when properly ginned; but it is difficult to gin, and has an exceedingly short staple. It only made its appearance in this country during the excessive prices caused by the late American war, and was lost sight of immediately on the return of more natural prices.

Smyrna Cotton and other Levant Varieties have generally a good but irregular staple, much cut and otherwise spoiled in ginning. They are scarcely worth notice from their small and inconstant supply. Hope in their extensive production has been hitherto disappointed; but there is nevertheless much land in the Ottoman empire which, under proper management, is well adapted for growing cotton.

Italian Cotton.—This is grown principally in Sicily and Calabria in considerable variety, but small in quantity. One kind is perfectly red in its natural state. The staples range in length between Indian and American cotton. Nearly all that is grown appears to be consumed in the country. According to the Report of the Commendatore Devincenzi there is, however, abundance of land in Italy capable of growing cotton equal in quality to New Orleans, and plenty of cheap labour to grow it profitably, in competition with the United States and India.

In order to give the reader a more complete idea of the nature of cotton generally a view is appended of the fibres of cotton greatly magnified; also the fibres of wool, flax, and silk greatly magnified. The difference between cotton fibres and woollen fibres is very striking, and there is also a great difference between flax and cotton. Silk, however, although an animal product, has fibres more resembling cotton than either wool or flax.

[*See* PLATE VII]

Plate VII.

Fig. 4.

Fig. 7.

Fig. 2.

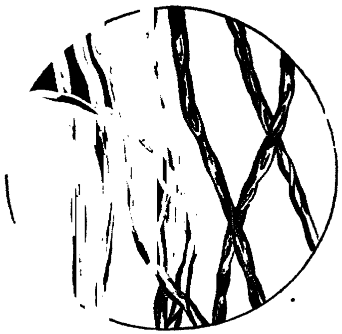


Fig. 3.

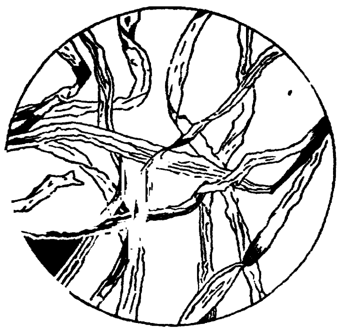


Fig. 5.

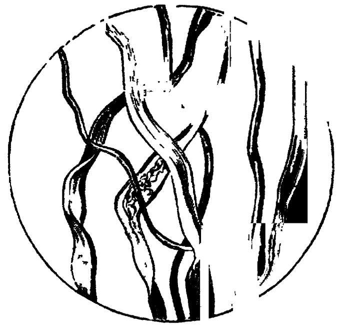
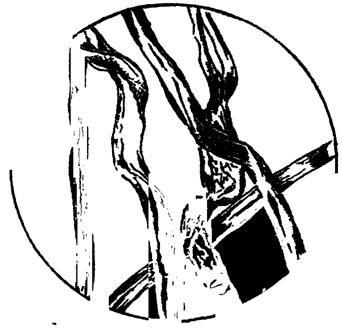


Fig. 6.



Figures 2 to 7, COTTON FIBRES GREATLY MAGNIFIED

Fig. 8.

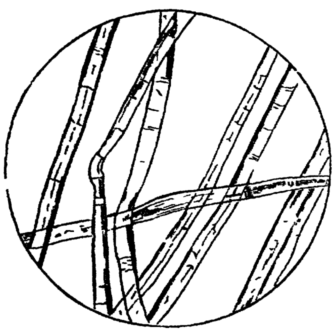


Fig. 9.

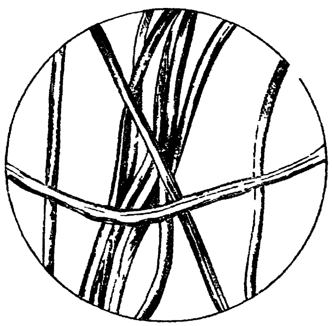


Fig. 11.

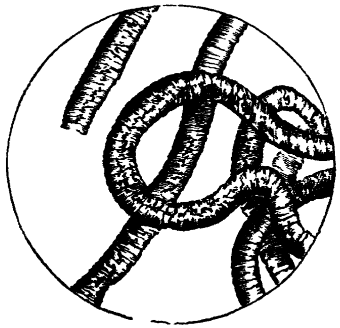


Fig. 12.

Figures 11 and 12, FIBRES OF WOOL GREATLY MAGNIFIED.

Fig. 10.

Figures 8, 9, and 10, FLAX FIBRES.

Fig. 13.

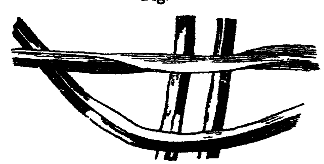


Figure 13, FILAMENTS OF SILK MAGNIFIED.

COTTON GINNING.

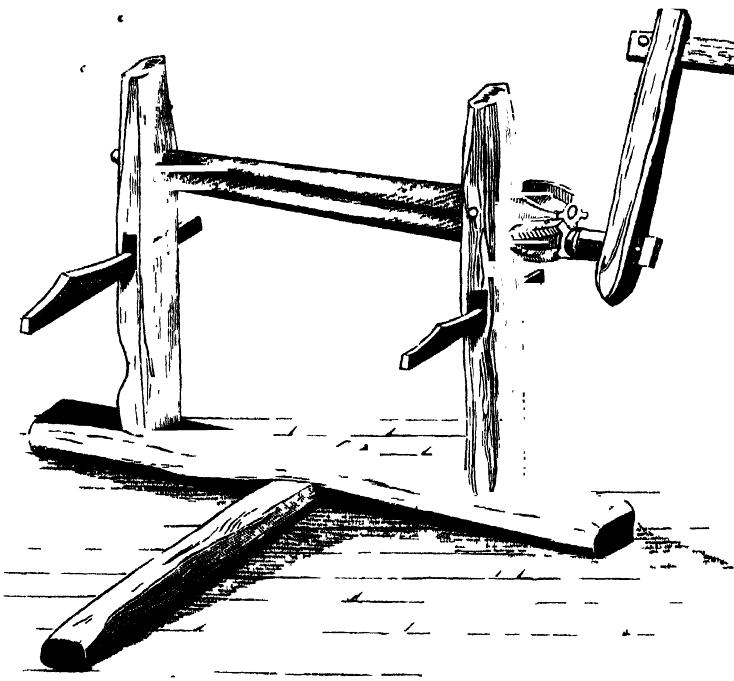
GINNING cotton means the separating of the cotton from the husk or berry, which it most tenaciously adheres; some kinds having green, woolly seed, and others brown seed, like roasted coffee.

Every boll of cotton has a berry inside, which resembles unground coffee. The earliest attempt at ginning of which we have any account, is the crushing of the seed and cotton together, by placing it on a flag and rolling a bar of iron over it with the foot, a method still practised in some parts of India, as seen below.

Fig 14

Next comes the churka or roller gin, which is made of two round pieces of hard wood fixed in a rude frame, as under. This machine is extremely simple, and produces a better quality of work, but with much labour.

Fig. 15.



Below is a roller gin with fly wheel, which requires two persons to work it, one turning the upper roller with a staff, the other working the under roller with a crank and feeding the cotton at the same time.

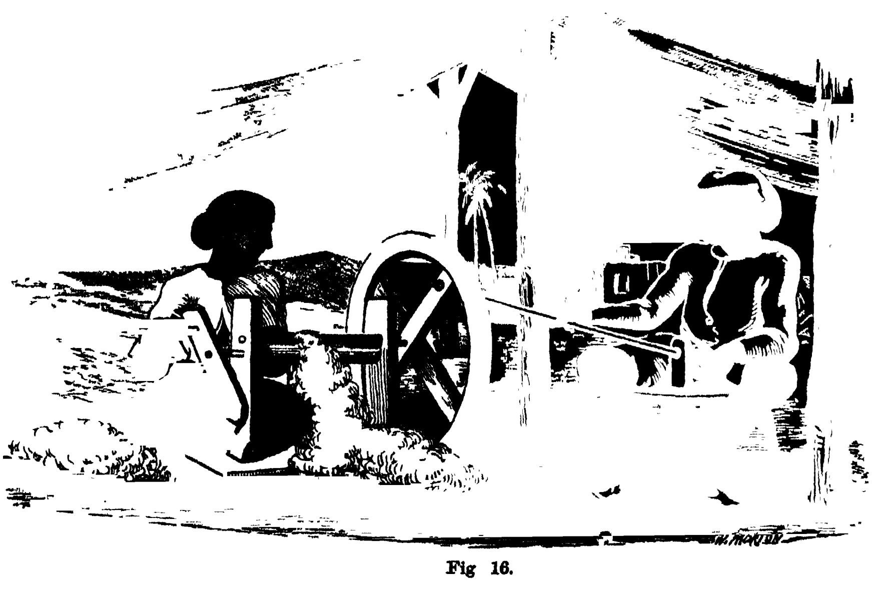


Fig 16.

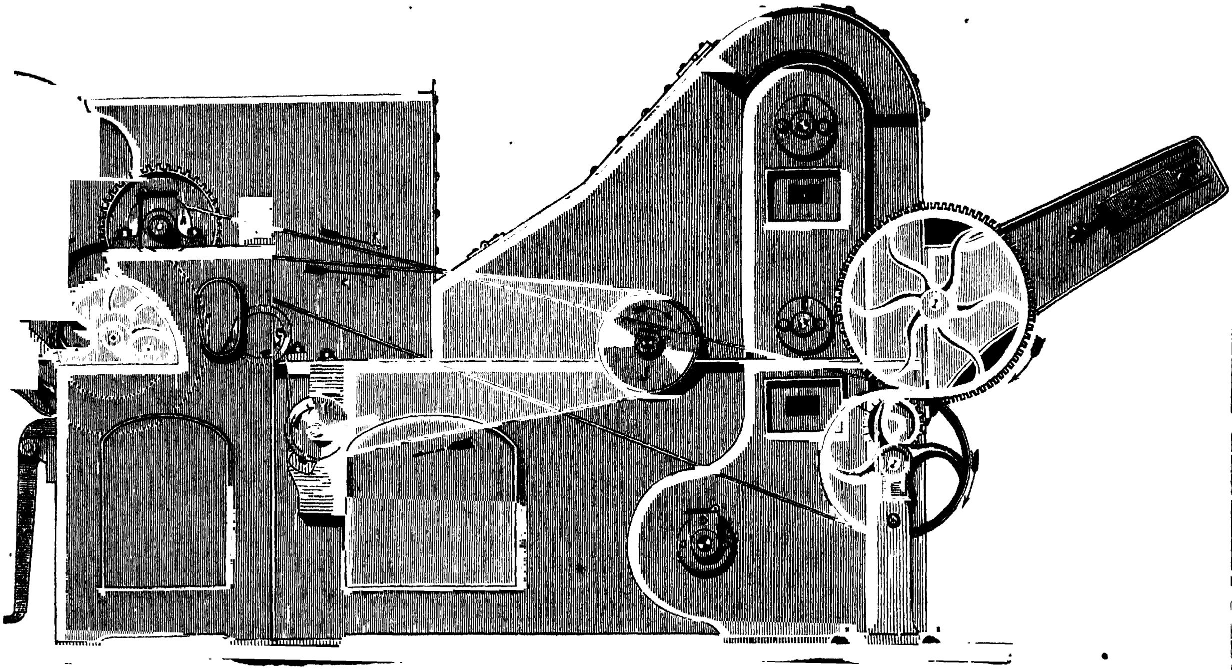


Fig 17.

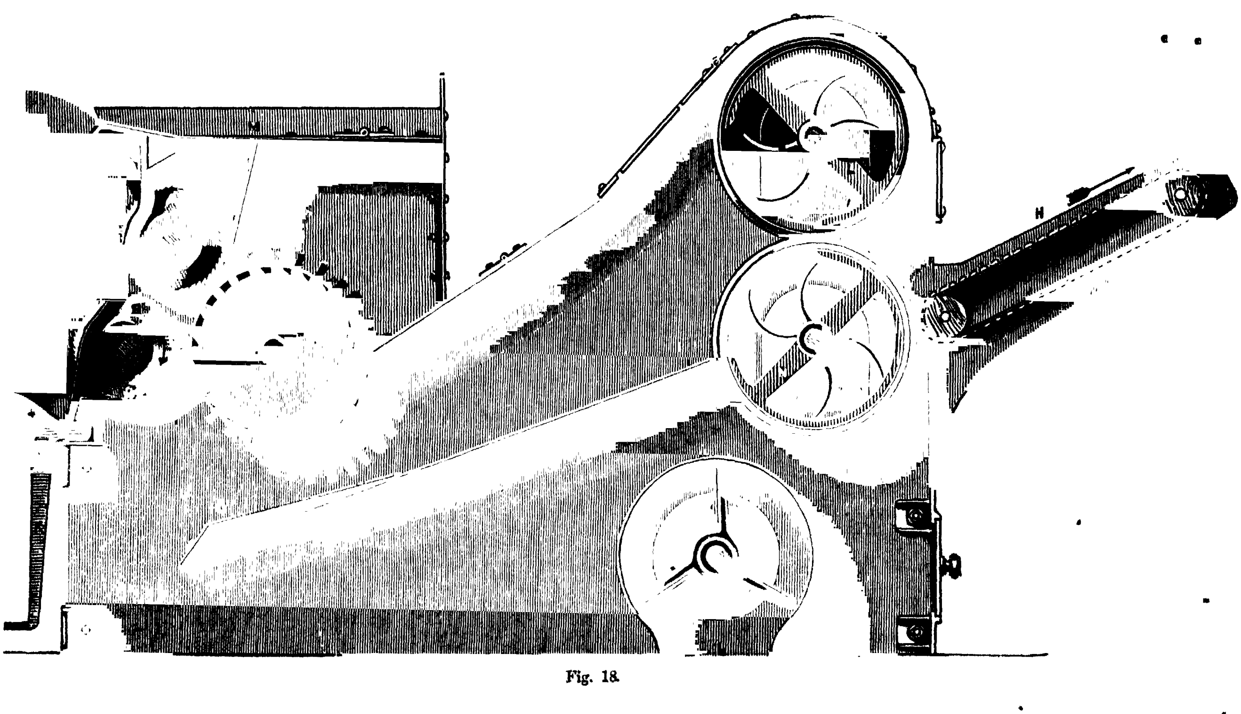


Fig. 18.

Churka gins, with iron or steel rollers, have been made both for hand and power, but do not appear to have come into very extensive use.

THE SAW GIN.—Eli Whitney, an American inventor, made the first great innovation upon the old systems of ginning, by introducing his celebrated Saw Gin. This machine got through the ginning process with great rapidity and at a much smaller cost than heretofore; but unfortunately it cut and nepped the cotton very much, and especially so when carelessly used. Many attempts have been made to improve the saw gin, and to remedy its most glaring defects. These attempts have only been partially successful, as the difficulty to be overcome is inherent in the principle, and can never be entirely removed; the day is probably not far distant, however, when this machine will be superseded by the Macarthy Gin, if nothing better be invented. The author has frequently bought "saw-ginned" Maranham cotton in the Liverpool market 30 per cent cheaper than "roller-ginned" Maranham on the same day, which shows how enormously the interest of the cotton growers must have suffered from defective ginning.

"It is an ill wind that blows nobody any good," says the old proverb, which has been abundantly verified by the cotton growers outside the United States during the war, as they profited largely; and, so long as the excitement lasted, immense numbers of gins were manufactured of a superior description and distributed over the cotton-growing countries of the world, which in due time will work their way, and prove to the cotton planter, that careful ginning, although it may be a little more expensive at the time, will enable him to realize a far greater profit in the end. In the general improvement in cotton gins above alluded to, the saw gin has undergone considerable modification, and is certainly now a much superior machine to what it was in the days of Whitney. The most powerful example of this machine is probably the double-cylinder saw gin, the drawings of which are from a large machine-making firm of Bolton. The cylindrical brush C (*Figs.* 17, 18) clears the saws and prevents a great deal of the nepping so common to saw gins, which, acting in combination with the dust-fan D. and the perforated cylinders or cages E F, is said to make far better work than heretofore besides getting through a greater quantity. In the use of this machine especial care should be taken to keep the circular brush in good order, as it is of the utmost importance that the saws be kept clear. Where the use of the saw gin is persisted in for short-stapled cottons, this appears to be one of its best applications.

THE MACARTHY GIN.—This gin takes its name from the inventor, and is singularly well adapted for long-stapled cottons; it will gin short staples also, either with smooth or woolly seeds. Although it does not get through the quantity of work of which the saw gin is capable, yet the quality is much superior. It is simple in construction, and acts thus:—B *(Fig. 19)* is a roller, about 40 inches long and 5 or 6 inches diameter, covered with strips of leather about one ineh wide, so fixed on as to form spiral grooves. C is a knife or doctor, which is fixed so as to press gently upon the roller B. The box on table K holds the seed cotton, the front part of the bottom of which is a wire grid, for

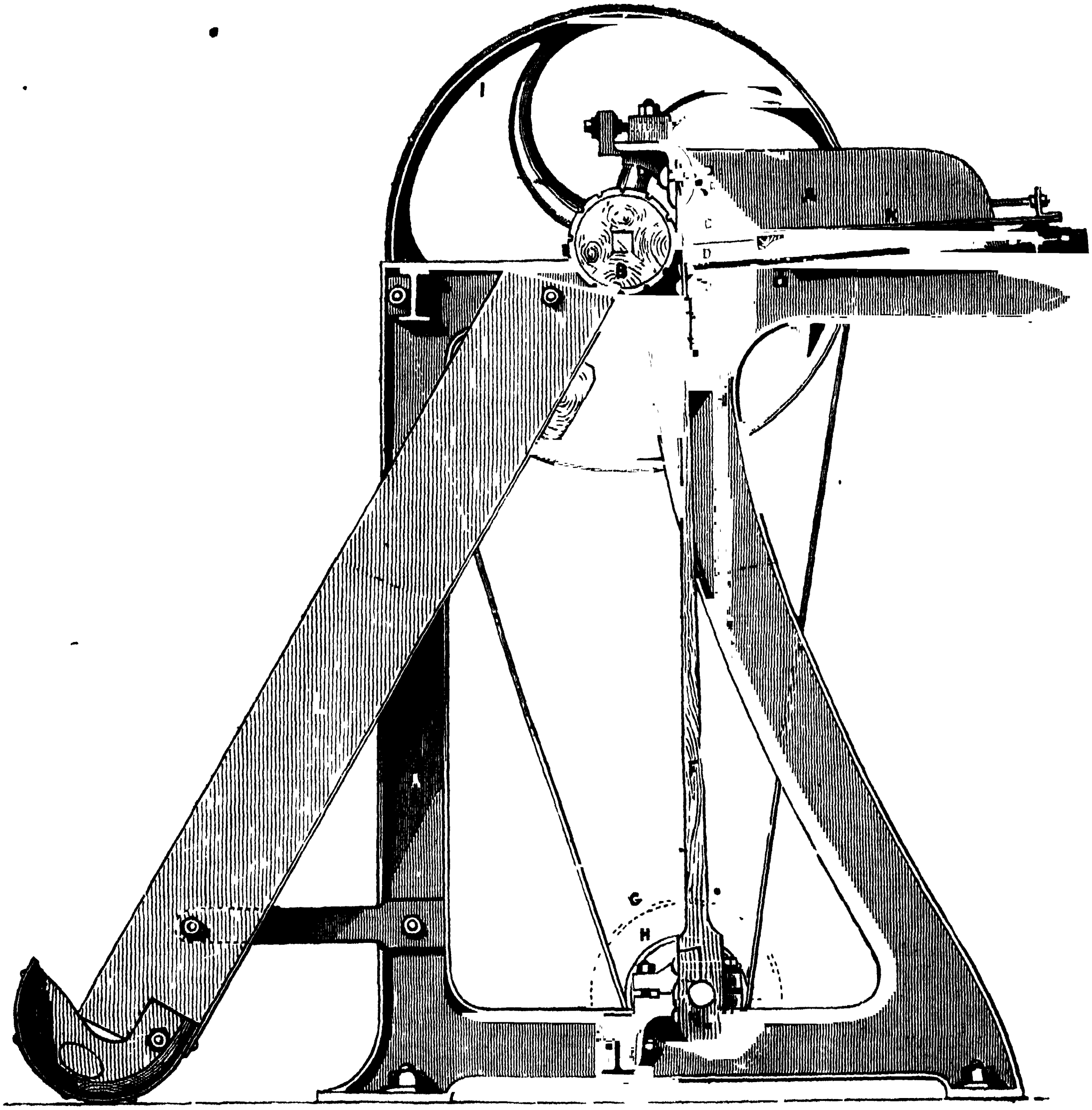


Fig. 19. –The Macarthy Gin.

the seeds to fall through. The beater knife D is worked rapidly by the crank shaft N, and the connecting rods F. The roller B makes about 100 revolutions per minute, and being covered with strips of leather, draws the cotton in under the doctor or steel plate pressing upon it, but the seeds, being unable to get under the doctor, are held at the point of the knife or doctor, when the beater blade D comes up close to the doctor, which it passes slightly, and keeps tapping the seeds and loosens them, whilst the leather-covered roller is continually drawing the fibres through. By the time each seed has been hit two or three times by the beater it becomes denuded of the cotton, and falls down through the grid, under the gin. The beater D makes about 500 strokes per minute. The product of this gin, when in good order, is about 10 to 15lbs. of clean cotton per hour of short staple, and 20 to 60lbs. of long-stapled cotton. A good improvement has lately been applied to this gin, in the shape of a self-feeder, or agitator of the seed cotton. This improvement had its origin in Egypt about five years ago, and is now generally adopted with new machines, and sometimes applied to the old ones.

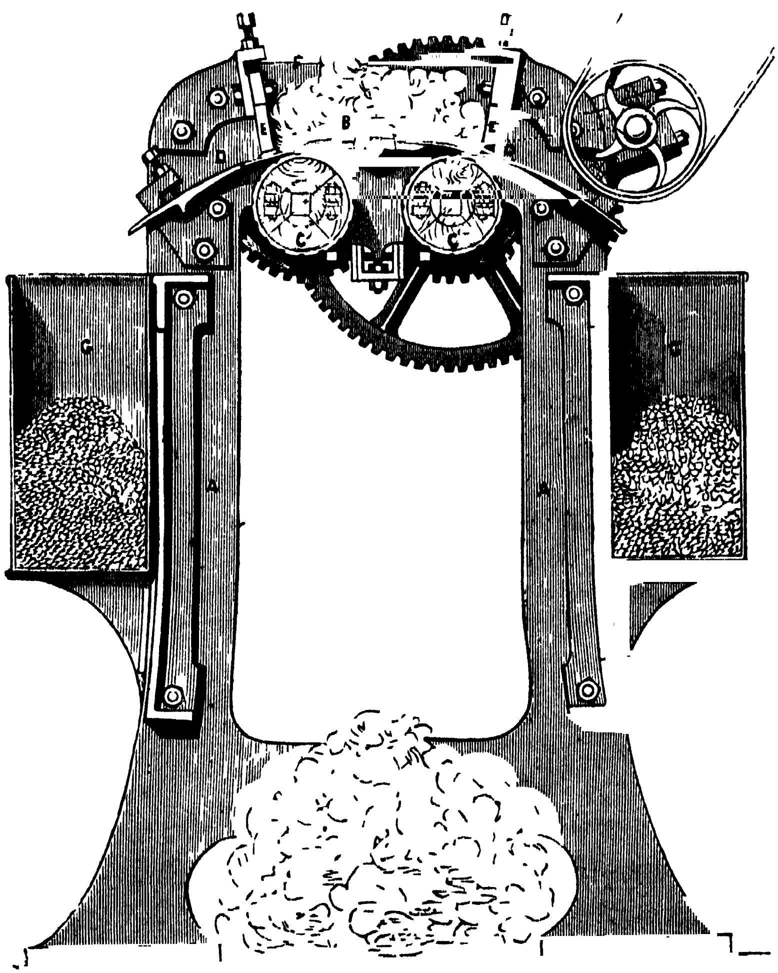


Fig. 20.—The Double Macarthy Gin. (E. & F. A. Leigh's Patent.

Many attempts have been made to improve the Macarthy gin, such as having a double crank with two beaters, by which the beaters not only become balanced, but, with the same speed of crank shaft, would double the number of beats. Theoretically this is a great improvement, and, if cotton ginning were done by skilled labour, no doubt it would be extensively used. It is a very ingenious contrivance, and was brought out a few years ago, by a well-known machine-making firm in Oldham.

Two very promising attempts at improving the Macarthy gin were made simultaneously about seven years ago by two separate Manchester machinists, neither knowing what the other was doing, each inventor having the same object, namely, a Macarthy gin with two rollers. The idea of the first inventor (who had a few days' priority of the other) was to place one roller above the other, and have a sort of double beater acting upon them. The idea of the other inventor was to have the two rollers parallel with each other, with one beater acting on both edges, as seen above (*Fig.* 20), in which AA is framing, B the beater, CC leather-covered rollers, EE grids which press down the doctors DD. The seed cotton is put in the box F, on the top of the beater plate B, which oscillates rapidly to and fro, driving the seeds through the grids EE, from which they drop into the boxes GG, the clean cotton falling under the gin.

The former of these gins made little or no progress; the latter was more successful for a time, and full of promise, from the vastly increased quantity of work it got through—being more than double that of an ordinary gin. It appeared to distance all competitors both in quantity and quality of work, and took the first prize at public exhibitions. Still it proved a failure! Simple as it was, it had too many parts about it to be thoroughly comprehended by the native labouring population of Egypt, who had always been accustomed to single gins, as their fathers were before them. Being prejudiced against this innovation, they drank the oil given to them for lubricating the machines, and allowed the bearings to be cut down and spoiled. When the inventor went to see the first lot of twenty gins, after they had been at work a few months, he found them a complete wreck, which put an end to all his bright hopes of supplying the world with cotton gins.

Macarthy gins are sometimes made of smaller size, to work by hand labour, with two men turning the cranks, and of a still smaller size called "Cottage Gins," which can be wrought by one person; but as the principle is the same, they need not be dwelt upon, so the reader passes on to further attempts at improving this most important machine.

The Knife Roller Gin.—This gin (two views of which are shown below) fi made its appearance in Oldham, but being abandoned by the makers who first to it up, on account of its alleged cutting of the staple, has been subsequently taken hand by a large machine-making firm in Bolton, who assert that they have cured t defects complained of; and the machine, as now illustrated, has been contribut by them

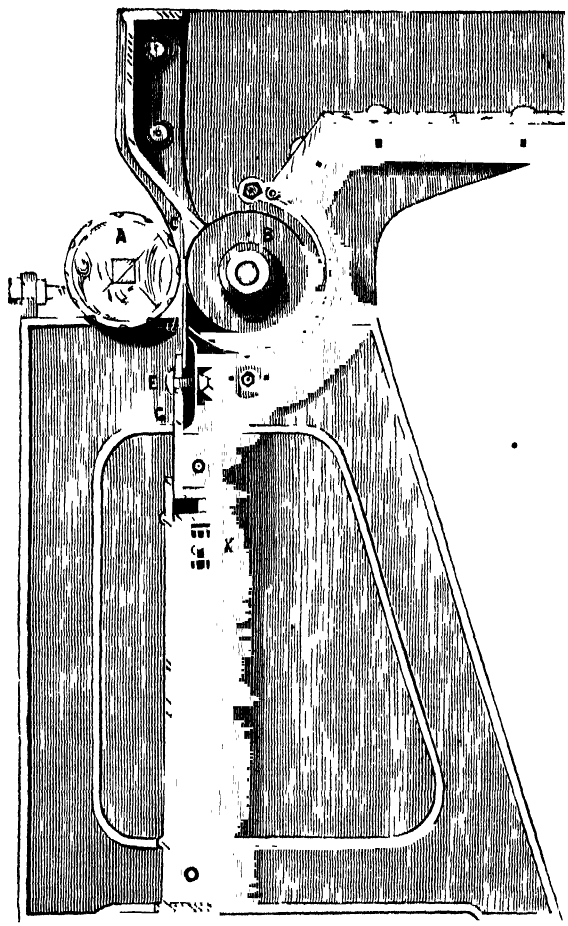


Fig. 21.—The Knife Roller Gin.

Whether they have accomplished all that can be desired or not is a matter o opinion, but it is highly probable that something good will ultimately come out o this principle of ginning. The gin works thus. A (*Fig.* 21) is the leather-covere roller; B is the knife roller, which is simply a shaft upon which a number of discs are fixed in a slanting direction, as shown. The peripheries of these discs are set clos up to the doctor, and by their action, when the shaft revolves, push the seed aside to and fro after the leather roller and doctor have seized the fibres of the cotton. The pushing of the seed aside answers the same purpose as a beater. The seed cotton is thrown into the box L, on the top of the disc roller, which revolves at the rate of about 350 revolutions per minute, and the seeds fall through the semicircular grid H.

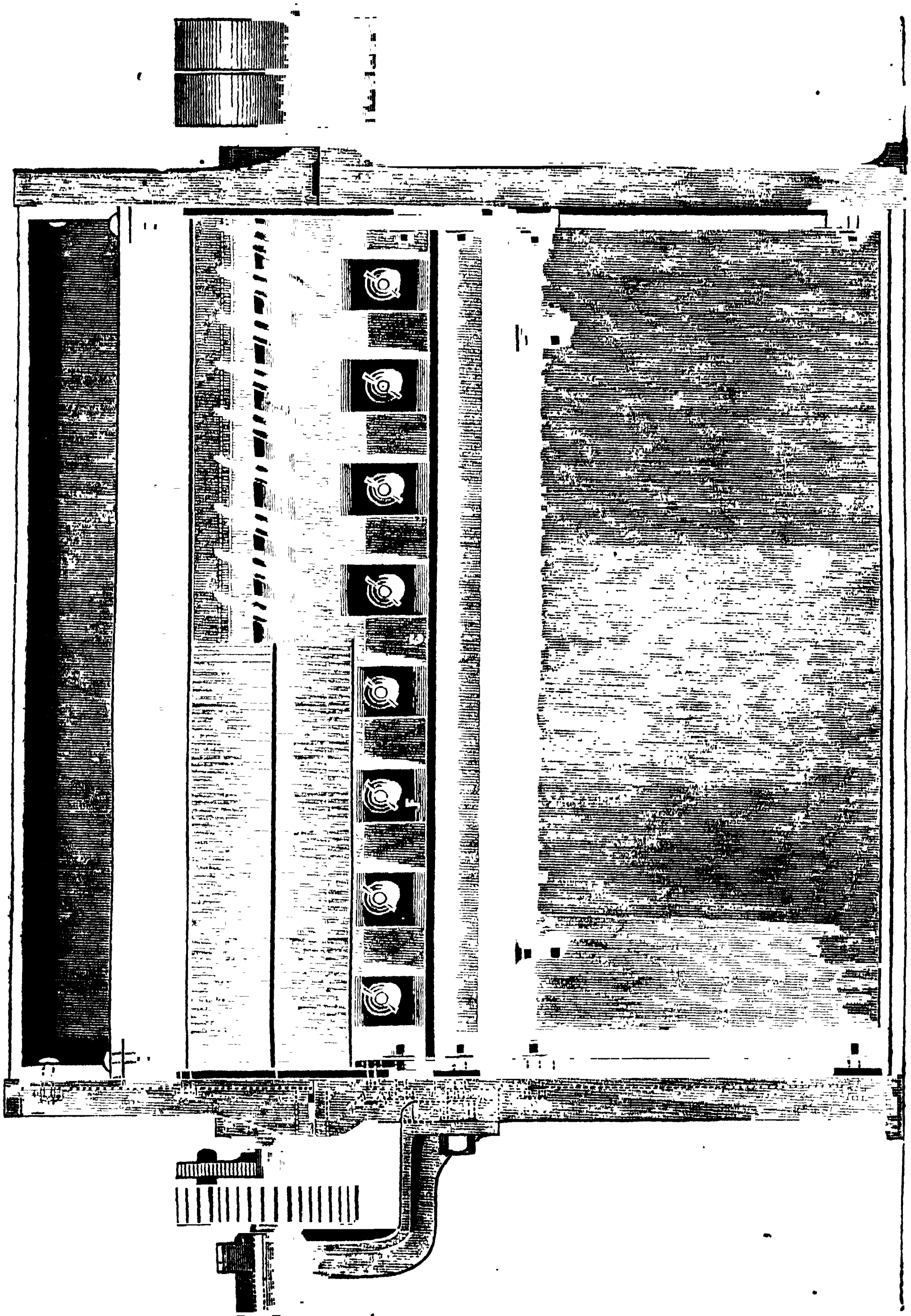


Fig. 22.—The Knife Roller Gin. (Brakell's Patent.)

There is a Patent Ginning Roller sold by the same firm, which they assert is more durable than leather-covered rollers, and that wear improves its draught. The material for renewing the rollers is supplied at one shilling per lb. If there be no mistake about this, it is an important thing, as the wear and tear of leather-covered rollers is a heavy item in a ginning factory. The makers of the new material recommend a small machine for covering the rollers, after which they are turned up and chased. It is not seen, however, why this material might not be put on in strips like sea-horse leather.

THE LOCK JAW COTTON GIN (Cowper's Patent).—This gin has a roller similar to the Macarthy, but it acts in a different manner. In place of the usual "doctor," there

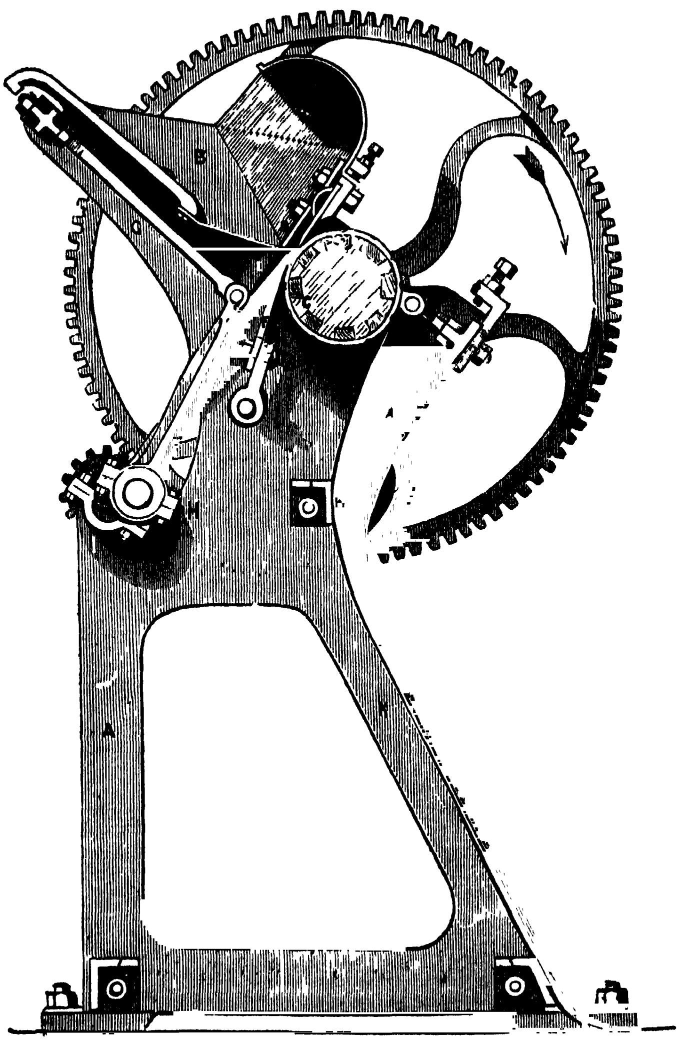


Fig. 23.—The Lock Jaw Cotton Gin.

is a "moving nipping blade," which presses the fibres of the cotton to the leather roller, just at the moment the seed is detached by the action of the beater. The roller has a continuous motion, the same as in the Macarthy, but the "nipping blade," like the beater, is intermittent. There is also a fixed blade in advance of the nipper, which is set close to but not pressing upon the roller.

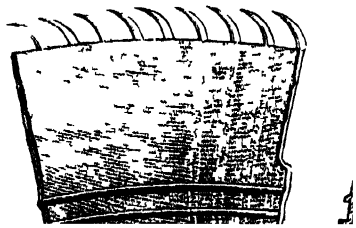
The object sought to be accomplished by this is to prevent the gin choking, and effect a saving of power, as well as wear of the leather-covered roller, by avoiding the constant pressure which an ordinary doctor has upon it. In order that the nipping blade may hold the cotton down to the roller a sufficient length of time for the beater to strike, and still avoid the rubbing friction on the leather, it is made to move a short distance with the roller, after making its nip, and pulls the cotton through.

The idea in this machine is very good, and its application scientific, but the extra parts required to effect these different movements tell against it, as well as the additional cost, and the danger is that it may be found too far advanced for the cotton-growing countries, and, without even a fair trial, be consigned, like the double-roller gin, to "the tomb of all the Capulets," as many other excellent inventions have been, that were both intended, and well calculated under more intelligent management, to ameliorate the present rude system of ginning.

Such of these inventions as are based on true principles will not lie for ever dormant, but in due time will appear again, under a new garb it may be, simplified and improved, but practically the same.

Postscript.—Just before going to press, the author has had his attention called to two important improvements in the ginning of cotton which have recently come out. One of these has originated in India, and is the joint production of Mr. E. Jones, superintendent of the Dharwar Ginning Factory, and Dr. Forbes, of India, who some years ago brought out an improved Roller Churka Gin, to work by treddle or power. What the precise nature of this invention is does not appear from the report of it just published in the *Times of India*, further than that it is the working out by Mr. Jones of an improvement suggested by Dr. Forbes on his Roller Churka. This novelty is said to combine cheapness with simplicity, and will not cost one-half the Macarthy. One account says it is to be called "Dr. Forbes' Excelsior Gin," another states that its name will be "Jones' Eureka;" all agree, however, that it is an improvement of considerable importance.

The second invention above alluded to is of American origin, and is simply better method of making the "saws" of saw gins. Instead of the rough teeth cut the circular saws, the outer edges or peripheries are formed of steel wire set in blc tin thus—



This wire being round and pointed at the top, not only gives a nice sharp toot for picking the cotton from the seed, but leaves the bottom of the teeth round ar smooth, and is said to prevent much of the "cutting" and "nepping" of the fibre which takes place under the old system. The larger figure is the side elevation, ar the smaller one a cross section, showing the way in which the teeth are fixed b running block tin round them.

The combined effect of these two improvements may have an important bearin upon the ginning of cotton ; and if to this be added the rapid recovery of the Souther States of America, the further development of the railway and irrigation systems i India, and the wonderful promise held out by Mr. Login's experiments, it become highly probable that the dreary depression which for nearly ten years has hung ove the cotton manufacture, occasioned by the short supplies of the raw material, wi now speedily pass away.

COTTON MILL ARCHITECTURE.

THE great improvement in mill architecture of late years cannot fail to strike the stranger visiting the manufacturing districts of Lancashire, and impress him with astonishment at the wonderful development and importance of cotton spinning.

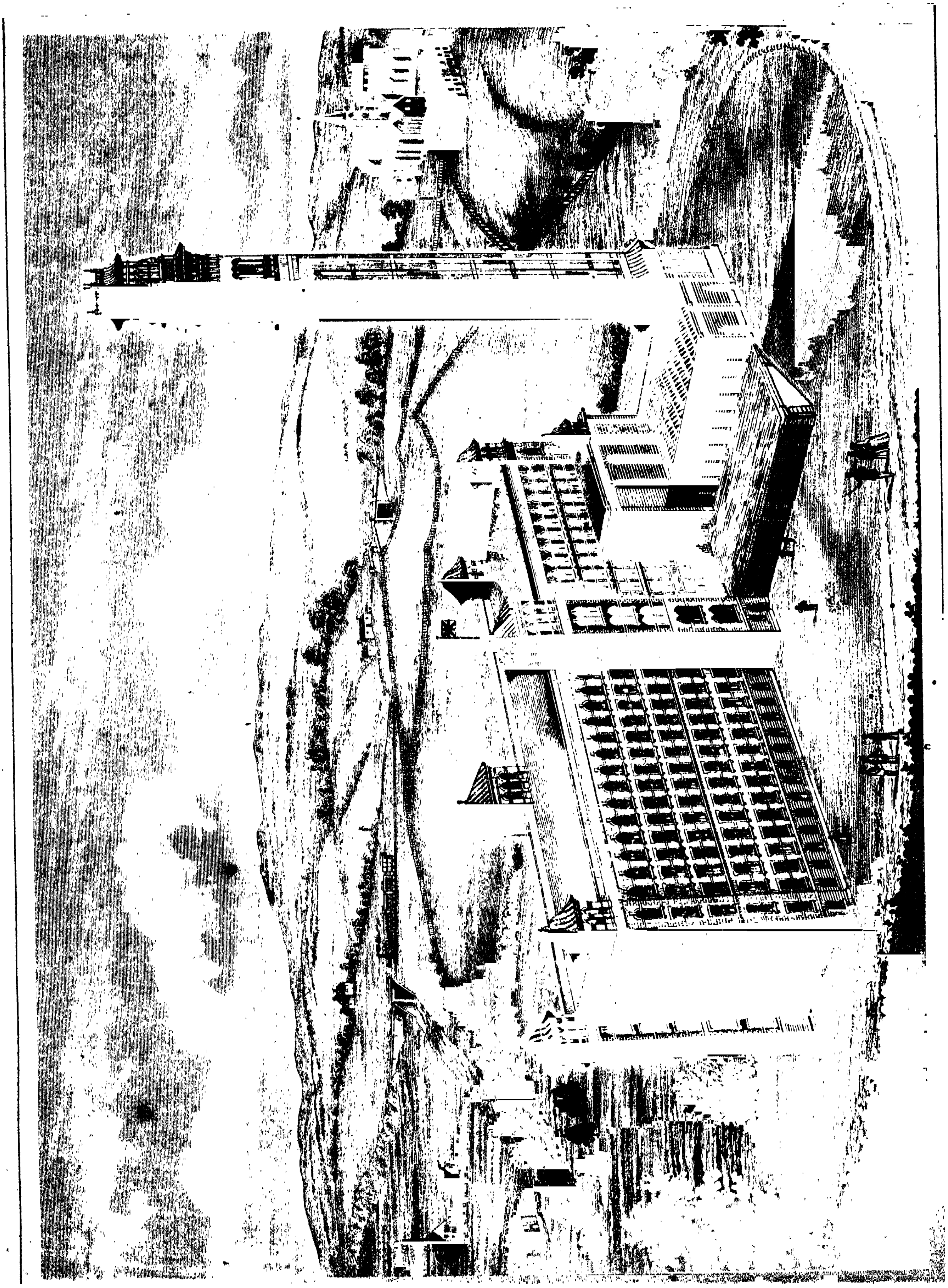
On the continent of Europe, in America, and even in India, new and gigantic establishments have sprung up, giving profitable employment, directly and indirectly, to millions of industrious people wherever they set foot, diffusing civilisation, raising the value of property, converting the wilderness into smiling and prosperous villages, towns, and cities.

Seeing that Cotton thus reigns supreme, any light, however feeble, that can be thrown upon the best mode of its manufacture becomes important.

Before passing on to a description and critical examination of the various ingenious machines employed in the manufacture of cotton, it is submitted that, although certain mills are pointed out as specimens of improved mill architecture, none of them reach the acmé of perfection, as regards either their construction or the application of their moving power. Therefore whenever an advantage can be gained, be it ever so slight, no matter, provided it *is* an advantage; be it a saving of outlay, of fuel, or of anything else, it is of consequence in a business so extensively practised.

A modest amount of architectural display is not condemned; it distinguishes the educated man from the vulgar, civilisation from barbarism; but what is contended for is economy with equal efficiency, having a due regard for practical and *known* science.

Circumspection is only required in applying known laws and principles which are daily manifested. It matters not if never employed before in such a particular way, so that they are *truths*, mechanical or architectural; and it should be remembered that truth has no sympathy with narrow-minded prejudice. For what is an inventor but a man following close upon the track of Science, patiently waiting for her to unfold her hidden treasures? Bringing to light a hitherto undiscovered fact, his inventive power creates some means of developing it into practical utility; and, so



anticipating the future, he fills the place of pioneer in the economy of human existence. His cares are many, his responsibilities and difficulties great; the most formidable, perhaps, of which is to overcome the prejudices of the age in which he lives when he brings forth a truth his patient research has discovered, but which, for a long time, the public fail to appreciate. Diverging from the beaten track, he is constantly seeking new and easier paths to facilitate the onward march of society. Often baffled, he learns to maintain a stoical equanimity of temper in success or failure. Always thinking, his mind becomes acute and his vision penetrating, as the smith's arm acquires strength by constantly wielding the hammer. His motto is "Nunquam Dormio." His intentions are good, and his judgment seldom errs, but life is too short for him to carry out all the creations of his gorgeous fancy. He usually benefits society, sometimes amazingly, but generally more than himself. He is never satisfied; were he so he would not have the ring of the true metal!

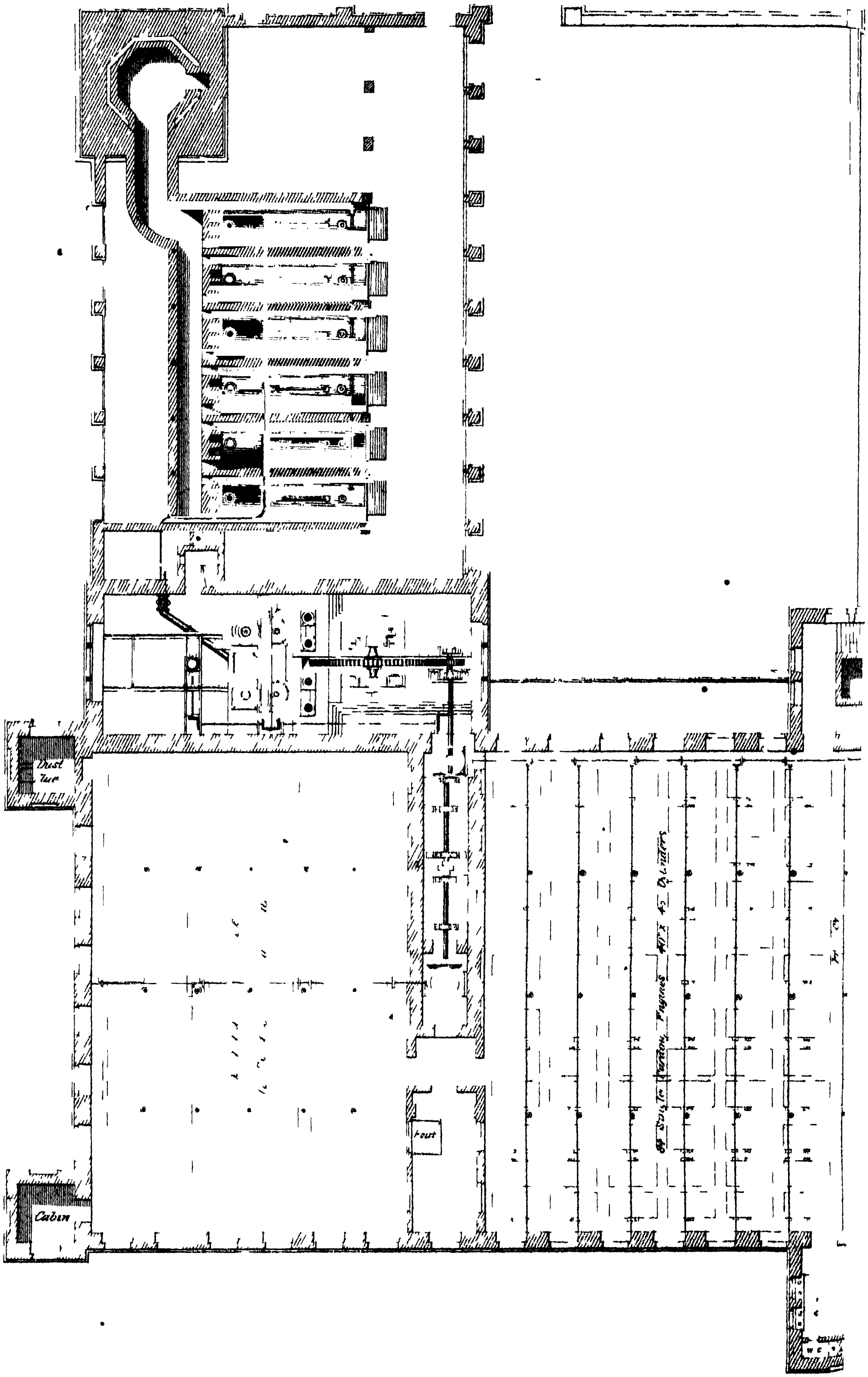
In this country, where iron and building materials are cheap, it is better that cotton mills be built fire proof for two reasons: firstly, because they are more comfortable and require less heating; and secondly, that when all the anxiety of completing, filling, and starting a mill are over, the proprietor need not have his sleep disturbed by the fear of finding his property destroyed in the morning, and may leave it when necessary for business or pleasure without his mind being haunted by misgivings as to what may happen during his absence. Business is a pleasure when all is secure; but a corroding care when insecure. To remove a cause of anxiety is surely worth something; therefore, if it can be shown that a good and substantial mill can be constructed, fire-proof, at very little extra cost to one that is not so, argument on the subject is at an end, since it becomes a positive saving of capital by economy of insurance, at the same time lightening the cares of business.

There are, however, differences of opinion upon this subject amongst spinners; some contending that the modern system of lofty rooms so much diminishes the risk of being burned down, when a fire occurs, that it is hardly worth while now to build fire-proof. Both systems will therefore be illustrated in this work, and examples given of what is considered the best mill architecture of the present day, with some hints for its improvement in certain particulars; after which the essays on and description of machinery will follow, with the best examples extant. But as the subject of improved mill architecture has a most important bearing on the object of this work, it will be recurred to again in future parts, when steam power and its transmission are discussed. A sweeping change will then be shown to be impending, not in the system of spinning cotton, or in the machinery employed therein, for the day has passed for great and striking improvements in spinning machinery. Whatever is done now in that way is only in detail, bit by bit, which, by the way, is not to be despised, but cannot produce a revolution in the system. What is really "looming in the distance," and likely to produce a great change, is a better application of steam power, a rescue of useless buried capital, and a saving of about one-half the fuel at present expended (on the average) upon every pound of yarn produced.

THE "INDIA MILL" AT DARWEN.

Previous to entering upon any new ideas as to what will probably be done in the construction of Cotton Mills ere long, the reader's attention is directed to the frontispiece of this number, showing an engraving of one of the noblest specimens of mill architecture which this country affords. This mill, which has recently been erected by Messrs. Eccles Shorrock, Brothers, & Co., may fairly be considered as a first-class type of the engineering skill of the day, as applied to manufacturing establishments. However opinions may differ as to the expediency of employing beam engines in modern cotton mills, there cannot be two opinions as to the quality of work here displayed, and the superb manner in which everything is carried out. For general excellence and solidity of workmanship this principle of driving had never greater justice done it; nor, perhaps, have these engines and millwright work ever been exceeded in elegance of design, as displayed by the proprietors and the engineers who have executed the work. The following description is partly taken from the *Building News*, published some time since, and partly from further particulars kindly furnished by the proprietors:—

"The main building is 330 feet long, its width is 99 feet, and its height 90 feet, consisting of six storeys. The engine house, boiler house, and chimney stand against one side of the mill. The size of the engine house is 80 feet by 28 feet, and the engine bed contains 20,000 cubic feet of ashlar stone foundation. The boiler house is 100 feet by 75 feet, being intended for ten boilers. There is a cotton shed and twist warehouse 100 feet by 80 feet. The engineering and mill gearing are being executed by Messrs. Yates, of Blackburn; all the entablatures and pillars being carefully got out to architectural proportions, more correctly than is usual in machinery. The total height of the chimney shaft, from the bottom of the foundation to the top of the iron cresting, is 310 feet, and from the ground line 300 feet. The base, of solid ashlar, is 20 feet square at ground line, and 42 feet high. The massive stone cornice is 35 feet long on each of the four sides. The shaft itself is built with red, white, and black bricks, with sand gritstone dressings, and is 24 feet square, and built perfectly plumb. The walls are 3 feet thick at top of stone base, reduced by "set-offs" on the inside to 23 inches at the commencement of main cornice, which is 255 above the ground. Many of the stones used in this cornice weighed as much as five tons each, and were hoisted by steam power. The balusters surmounting this feature are of cast iron, as



W E KOONS, DEL

INDIA MILL, OVER DARWEN.

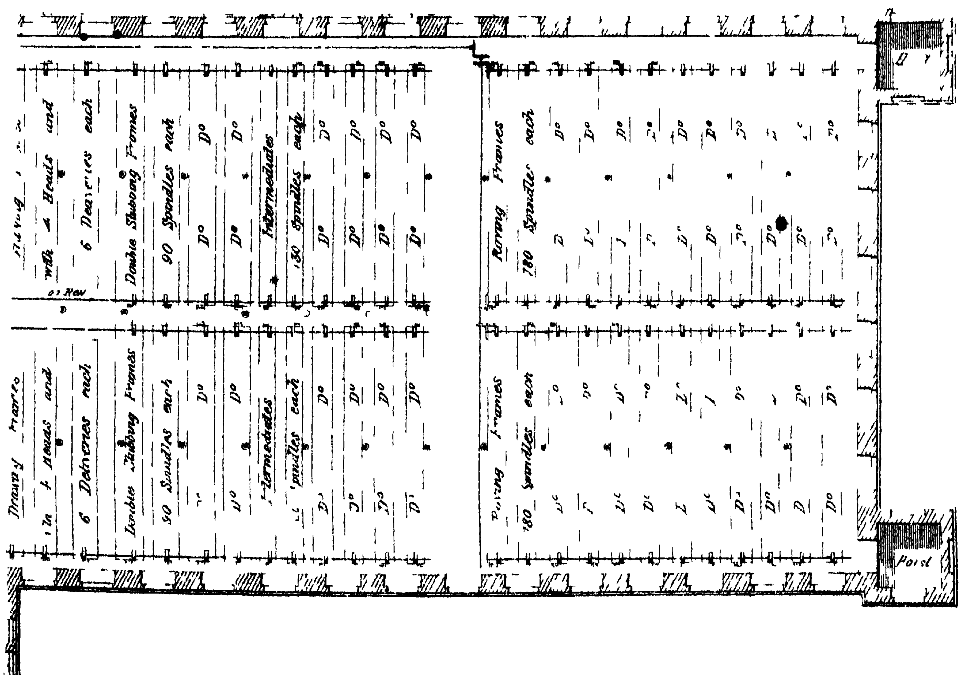
GENERAL PLAN

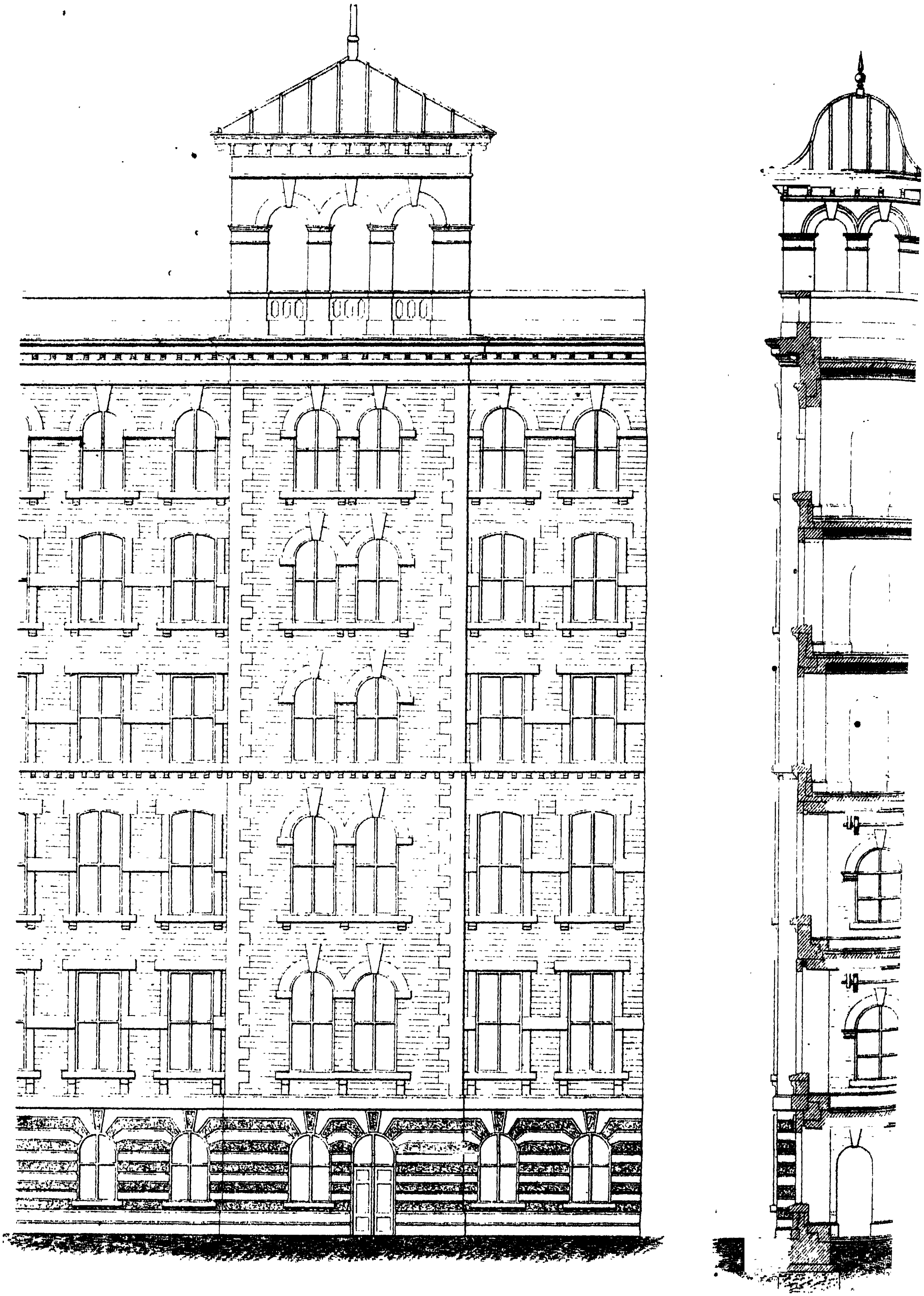
OF

CARD ROOM ENGINE AND BOILER HOUSE

SCALE OF FEET

50 60 70





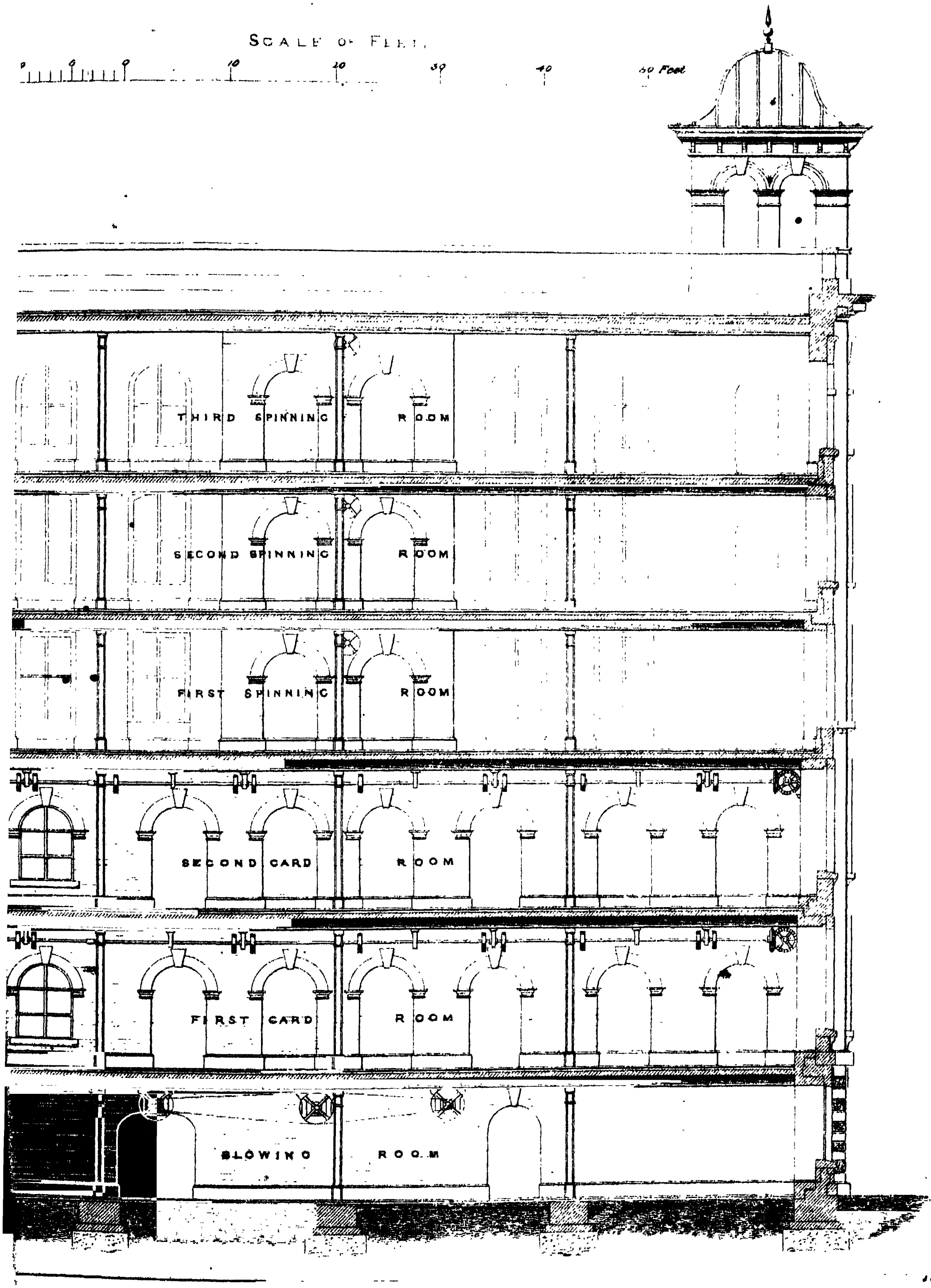
W. E. KOCHS, DEL.

PLATE, XI.

NDIA MILL. OVER DARWEN.

SCALE OF FEET.

0 6 9 10 20 30 40 50 Feet



J. GALLOWAY, LITH: MANCHESTER.

INDIA MILL,

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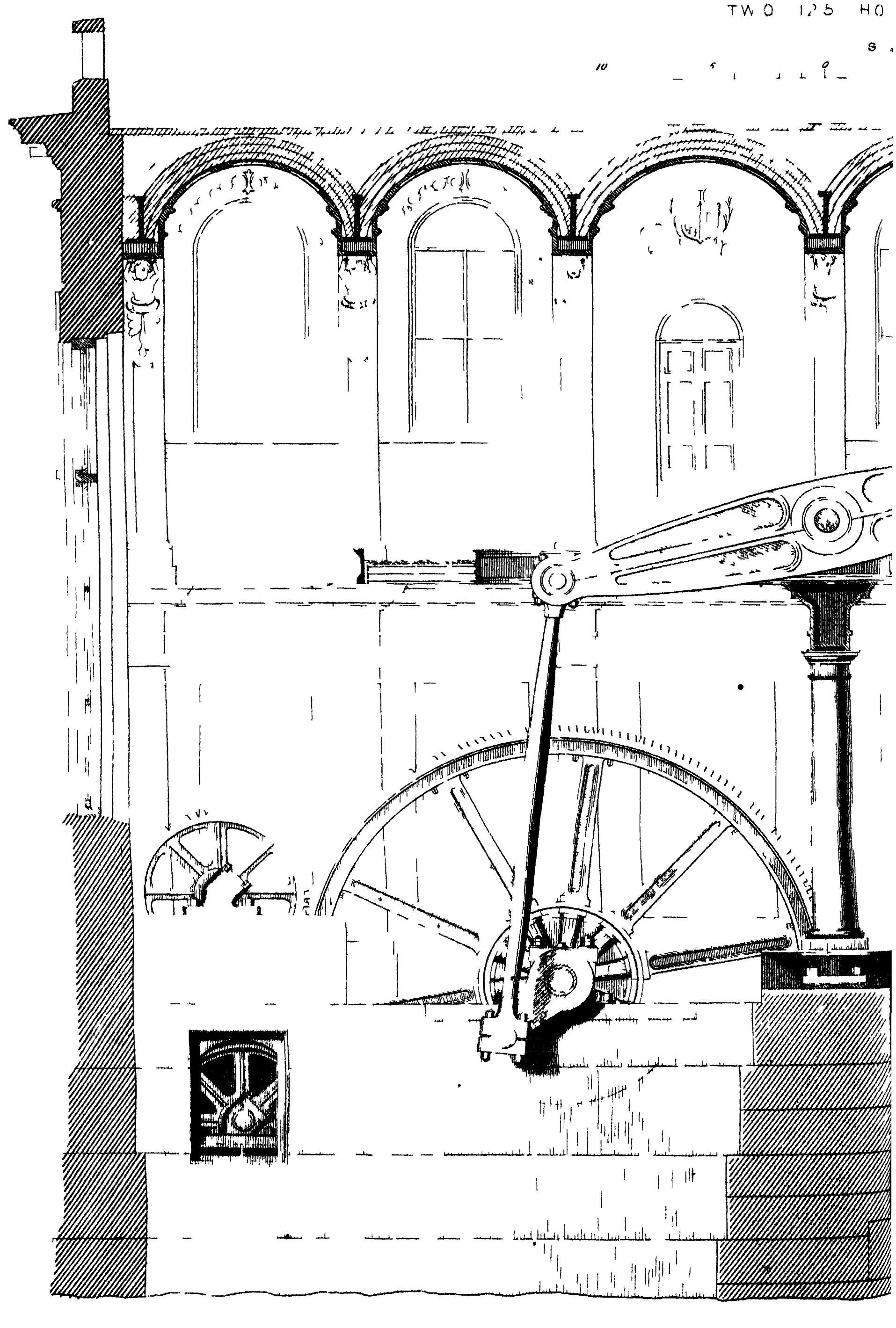

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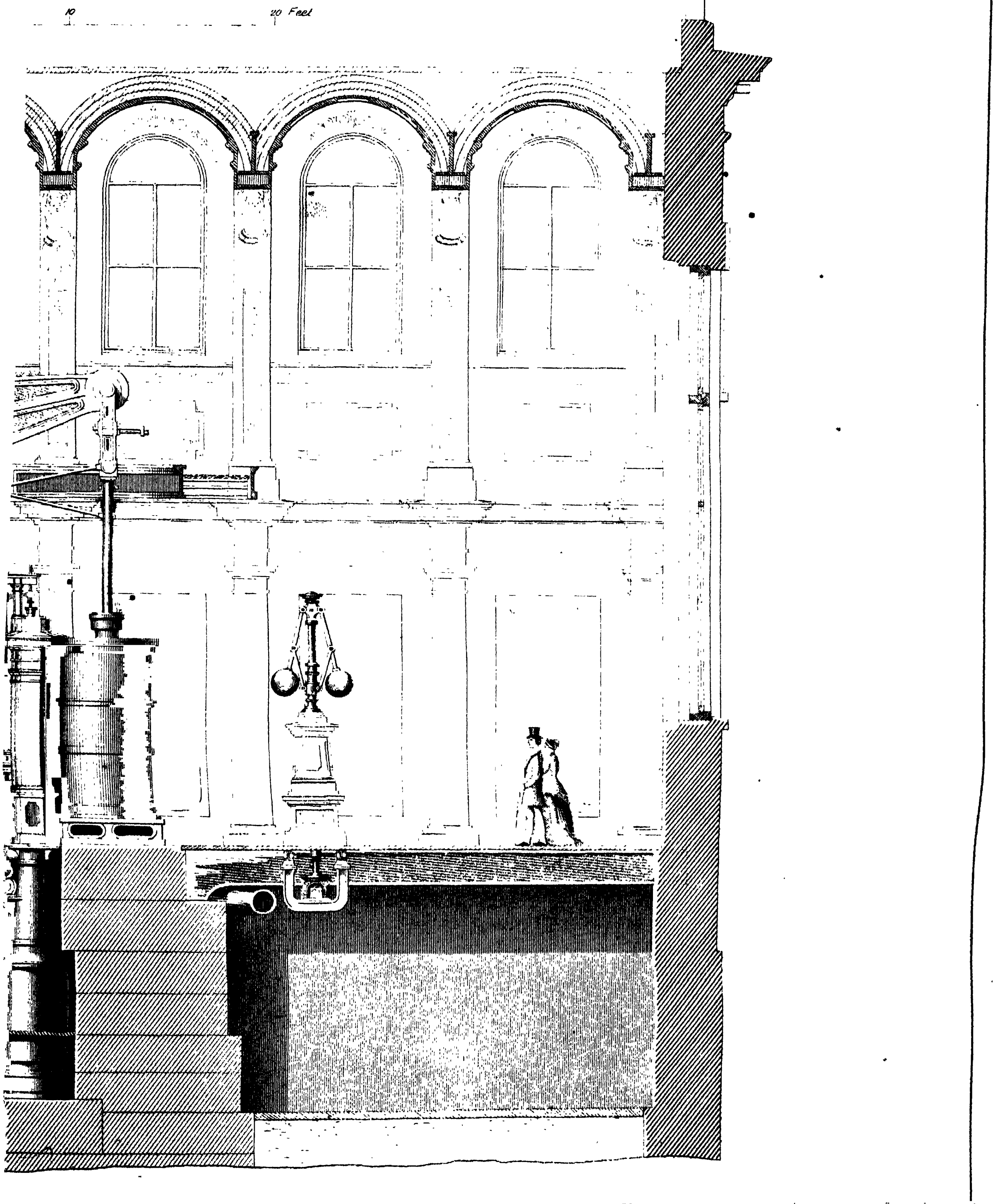
PLATE, XII.

R DARWEN.

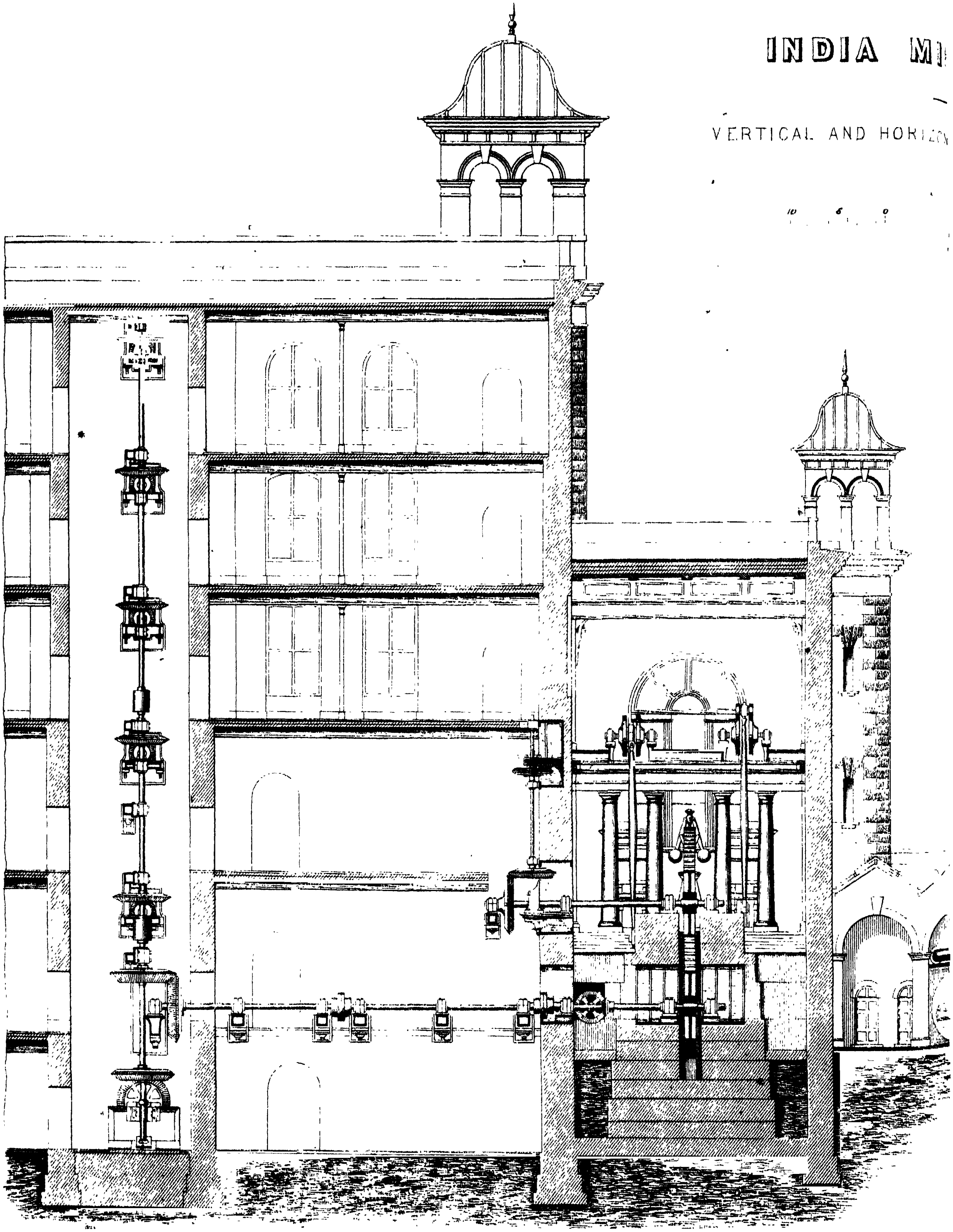
ER ENGINES.



J. GALLOWAY LITH. MANCHESTER.

INDIA MI

VERTICAL AND HORIZON



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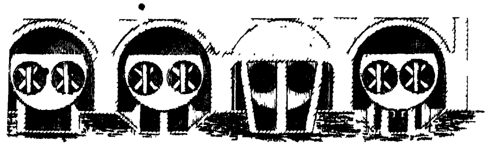
OVER DARWEN.

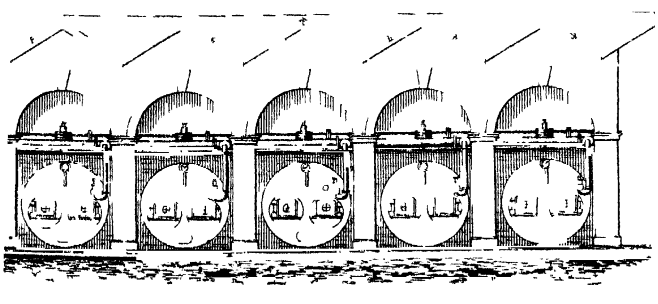
APTING ENGINE AND BOIL R HOUSE

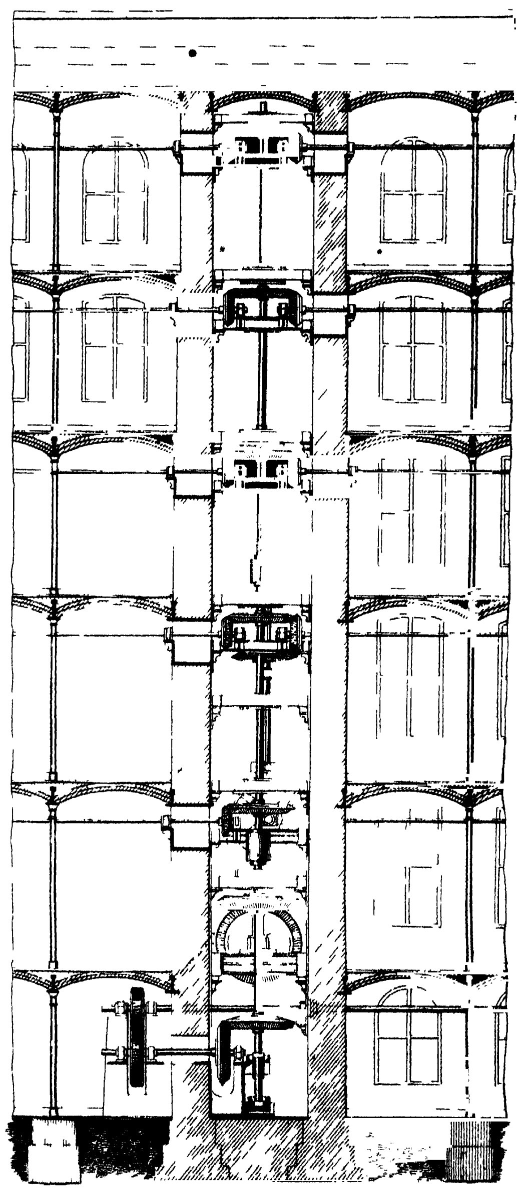
LE OF FEET

20 3 40 50 Feet

on ver e Sections of Boilers and Flue







J. GALLOWAY, LITH.

also are portions of the four vases at the corners. The crown mould of the cornice at the top of the shaft projects more than three times as far over the wall as its rests on it; and was kept in its place by iron cramps until the cast-iron cresting was fixed upon it. This cresting contains about 20 tons of metal, and is composed of more than 300 castings. There is no bolting nor any particle of wrought iron in this portion of the work, the parts being kept together by slots and lugs. The whole weight of this cresting stands upon the brickwork, and keeps the upper stone cornice firmly in position. There is an interior and totally independent shaft, 180 feet high, to prevent the great heat from the boiler furnaces subjecting the wall of the outer and main shaft to unequal expansion and contraction. Mr. Ernest Bates, of Manchester, is the architect; and the whole of the work has been done by day work, by workmen under the superintendence of Mr. Robert Edwards, clerk of the works, no contractor being employed."

General Plan.—Shows the arrangement of the machinery in first and second card rooms, with shafting, engine and boiler houses, &c. The bottom room is occupied by cotton stores, blowing and scutching, warerooms, &c.; and three upper rooms by mules. It will be noticed that a strong double wall goes up to the third storey of the mill, which boxes off and gives solidity to the pedestals, &c., of the heavy gearing.

[*See* Plate X.]

Elevation of Central Tower and Transverse Section of Mill, through blowing, card, and spinning rooms, showing partition wall to support the vertical shafting, likewise shafting in blowing room, transverse shaft in first and second card rooms, and shafting in spinning rooms.

[*See* Plate XI.]

Longitudinal Section through Engine House and Elevation of Steam Engines.—The engine house contains two condensing steam engines, with cylinders each 51-inch diameter, on the beam principle. These engines have a 7-feet 6-inch stroke, and make 23·1 strokes per minute, which gives a piston speed of 346½ feet per minute. No labour or expense has been spared to give solidity to the engine bed, which contains 20,000 feet of ashlar stone, as already mentioned, but unusual care has been observed in working the blocks to a true surface, examined by an iron straightedge, which had been carefully planed. Afterwards the stones were rubbed upon their beds and laid in cement. Some of these stones weigh over ten tons each.

[*See* Plate XII.]

Elevation of Vertical and Horizontal Shafting; also Section through Engine and Boiler House, likewise Transverse Section through Boilers and Flues.

[*See* Plate XIII.]

Attention is called here to the great judgment shown in having all the driving bevels on the upright shaft placed above the driven bevels on the line shafts, which arrangement completely takes away the pressure of the heavy upright shaft from the footstep; by which much power is saved, and also wear and tear.

Had these bevels been placed on the under side, as they are very generally found in other mills, the whole weight of the upright shaft (which with its bevel wheels and couplings will weigh about twelve tons), would have rested on the footstep, causing it to heat and wear away. In many mills the heating of footsteps from this cause is very troublesome; and as they wear away, the upper bevels are thrown too ebb in gear, and the bottom pair too deep, which sometimes causes a breakdown.

Boiler House.—The boiler house contains six boilers, each of which is 28 feet long by 7 feet diameter, with two flues of 3 feet diameter each, the same having transverse connecting tubes; room also being left for three smaller boilers when required. These boilers are manufactured of Bessemer steel plates of sufficient length to form the whole diameter of the boiler, leaving only one joint to each plate, which is double-rivetted, as well as those connecting the plates together. The flues are jointed upon Adamson's patent principle, which is effected by turning up the ends of the plates while hot, and then rivetting the two flanges together. This plan not only strengthens the flue and makes a more perfect joint, but gives a slight longitudinal elasticity for taking up the expansion and contraction. The boilers are intended to carry 100 lbs. steam pressure. The feed pipes are perforated tubes, which extend some distance into the boiler, so as to diffuse the feed water, according to a patent taken out some time ago by Levi Leigh and Daniel Adamson.

Machinery.—The mill contains the following machinery:—

Blowing Room.

2 Cotton Openers, with 1 Toothed Cylinder and 1 Beater each.
8 Lap Machines, with 3 Beaters each.
8 Finishing Machines, with 2 Beaters each.

First Card Room.

84 Carding Engines, diameter of cylinders 45 inches; of doffers, 22 inches; of lickers-in, 10 inches. They have each 2 Carding Rollers, with a Clearer to each; and 44 Self-stripping Flats. Single carding.
6 Drawing Frames of 4 heads each, with 6 deliveries to each head.
8 Slubbing Frames, of 90 spindles each, in double rows.
12 Intermediate Frames, of 130 spindles each, in double rows.
24 Roving Frames, of 180 spindles each, geared at both ends.

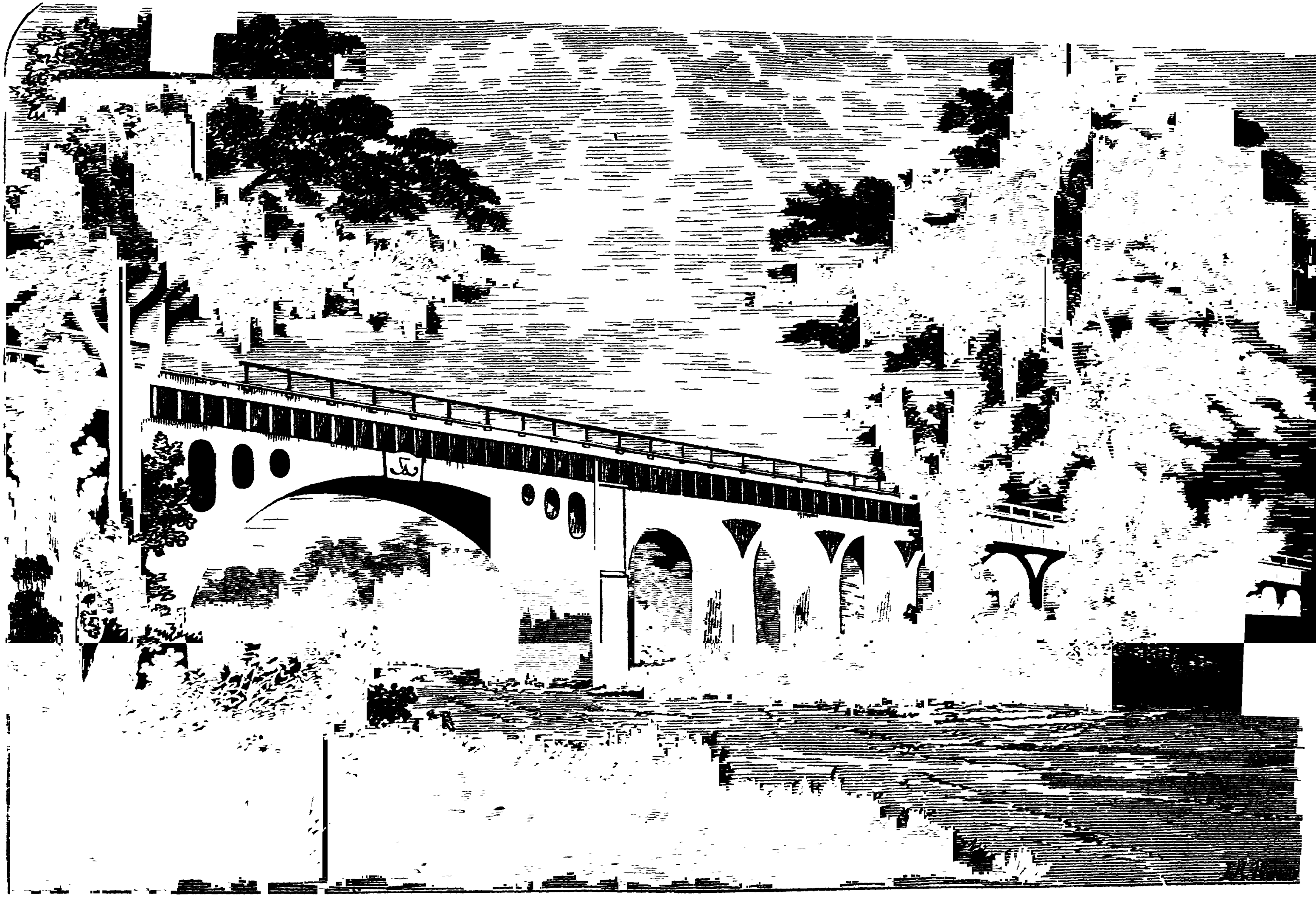


Fig 25 —"Grande Maitre" Aqueduct

Second Card Room.

Contains exactly the same as the first. Loose boss top rollers are used in drawing and first slubbing only.

Spinning Rooms.

48 Pairs of Self-acting Mules, 708 spindles in each mule, or 67,968 spindles, are contained in the three upper rooms and two small rooms near the carding, as shown on the Plan, all being twist gauge.

It is contemplated eventually to raise the mill one storey higher, when, no doubt, the two smaller rooms will be filled with carding, and the six pairs of mules they at present contain be removed to the upper room, where eight pairs more could be added.

At present the mill is expected to consume about 160 bales of cotton per week; and when the other storey is added, about 200 bales will be consumed.

ARTIFICIAL STONE.

The cost of a building, especially if fire-proof, depends in a great measure upon the locality in which it is erected, and whether the place selected be abundantly supplied with brick or stone, or with clay to make bricks. In situations where bricks can be made on the spot, or where stone is plentiful, it has hitherto been difficult to rival them as building materials. Taking an extended view, however, of what is going on in different parts of the world, it will be found that in France wonderful things have been done with "Bêton Aggloméré," or Artificial Stone, which is much cheaper, and better for mill purposes and cottages, than either common bricks or natural stone—that is, if properly made. The manufacture of this material also is perfectly easy if proper rules be observed, but, like most things, it may be spoiled by carelessness and ignorant manufacture.

Works of great magnitude and importance have already been executed with this material in France, where it was at first cautiously employed, but having been found to stand the roughest tests and improve with age, it is now extensively used. As an example of this a view is given (*Fig.* 25) of the "Grande Maître" Aqueduct across the valley at Fontainebleau (the largest arch being 115 feet 9 inches span), for conveying water to Paris, which appeared in *Engineering* some time ago. It is also extensively used in France for railway viaducts, &c., and in Paris for public buildings, and even for spiral staircases in shops, from basement to garret—a monolith.

In Egypt the successful construction of the Suez Canal may be largely attributed to the huge blocks of artificial stone forming the breakwaters and walls which connect it with the Mediterranean Sea, &c.

Lower Egypt is a country in which building materials are scarce, and it has often been suspected that many of the vast monuments of that interesting land must have been formed of artificial stone. This, however, is proved not to have been the case by the discovery, in the quarries of Upper Egypt, of immense blocks of stone, partly wrought into pillars, &c., thousands of years ago. By what mechanical means they were transported and raised in their places is not known. That the art of building among the ancient Egyptians must have attained a high standard will be seen from the following description of Alexandria:—"This once great city, built by Alexander the Great after the fall of Tyre, 333 years B.C., was, in its meridian glory, the most beautiful city in the world. The grandeur of its design may be judged from the description given of it by its conqueror Amon, who, when he took it 190 years later, described it as of immense extent, containing 4,000 palaces, 4,000 baths, 400 theatres and places of amusement, and 12,000 shops." But even this was exceeded by the grandeur of the still more ancient cities and monuments of Upper Egypt, such as Luxor, Thebes, Karnac, the Pyramids, &c. In one hall at Karnac there one hundred and fifty columns, some of which are 66 feet high and 30 feet in circumference; and the statue of Memnon is estimated, when complete, to have weighed 887 tons! Without digressing further, enough has been said to show not only that the art of building was well understood in those days, but the great probability is that the Egyptians possessed some mechanical power of which we know nothing.

The works already executed, and thoroughly tested, in artificial stone are sufficient to convince the most sceptical of its rising importance to mill and cottage architecture: to the former, as tending to cheaper and drier establishments; and to the latter, as far more comfortable and convenient dwellings for the operatives employed, without increase of rent. Solicitude for the happiness and well-being of all those engaged about a manufactory should never be wanting in the owner or manager, as it tends to success. It is like sowing good seed on fertile ground, which springs up and flourishes, producing sometimes fifty-fold, sometimes one hundred-fold. This care may be carried with advantage much farther than the mere comfort of dwellings; and wherever the experiment has been tried of looking after the moral and intellectual wants, as well as the amusements, of those families located on the spot, it has always been gratefully appreciated, and redounded to the honour and satisfaction of the employer.

BRICKS AS A BUILDING MATERIAL.

As before observed, where bricks can be made on the site of a mill and cottages, they have hitherto formed one of the cheapest and most substantial of building materials; but this necessarily indicates a cold clay subsoil, which ought to be carefully guarded against. If this be neglected (which has almost invariably been the case), a cold, damp mill, requiring considerable more heating, is the sure result; also damp, unhealthy cottages. This arises from the great absorbent power of common bricks, each one of which is capable of absorbing about a pint (or, say, one pound) of water; and when set on clay, with indifferent mortar, water is drawn up by capillary attraction to a height of about thirty feet. If the reader would see how this is done, let him take a piece of lump sugar, the larger the better; holding this in a vertical position over a glass of water, let the sugar just touch the fluid, when immediately it will be drawn by the capillary attraction to the highest particle of the sugar. As this drawing up of water, with bricks or other porous building materials, is continued until the weight of water they contain balances the pressure of the atmosphere at about thirty feet high; it has, therefore, been estimated by Mr. Edwin Chadwick, C.B., and other scientific authorities, that a common cottage with external walls of one brick thick, consisting of 12,000 bricks, is capable of containing six and a half tons of water! Stone is no better, some of the softer and more workable sorts of which will retain even more moisture than common bricks; sandstone, deemed fit for building purposes, may contain as much as half a gallon per cubic foot. These are startling facts, which should never be forgotten when a mill and cottages are being put up. When buildings are erected on a sandy or gravel foundation, the absorbent power of the building materials need not be regarded, as there is no constant supply of moisture from below; but when a clay foundation is unavoidable, the precaution of putting in a concrete foundation, made with a hydraulic lime, *should never be neglected.* When this is done properly, no moisture can penetrate it; and if the ground floor be laid with a good concrete, the mill or cottage will be as dry as if built on sand.

MORTARS.

It is very important in all buildings to have good and uniform mortar. This, however, is seldom attended to as it ought to be, but left haphazard to ignorant labouring men to mix lime, sand, and water together at a guess, regardless of proportion to poor or rich limes; and, consequently, their setting energy is sometimes nearly destroyed. In the erection of a tall chimney, for instance, the want of a proper knowledge of limes and mortars often becomes very conspicuous, and shows itself in the form of a crooked chimney.

A *leaning* chimney may arise from the giving way of the foundation, when the whole column leans; but a *bent* chimney is always caused by ignorance or carelessness. If a slow-setting mortar be used, made from common lime, mixed on different occasions as the work proceeds, regardless of due proportions, it is evident that some mixings will have more setting energy than others; or if a slow-setting mortar be used, although carefully and uniformly mixed, it is almost certain that the chimney will be bent. It will be noticed that chimneys generally bend towards the west or south-west, because rain or moisture most frequently comes from that direction. Now it is evident that the porous building materials, be they brick or stone, absorb more wet on one side of the chimney than the other; thus keeping the mortar soft on one side whilst it dries on the other; and the soft mortar getting compressed by the weight it has to sustain, naturally throws the chimney out of its perpendicular. This may be avoided to some extent, at an increased expense, by building only a few layers at long intervals, and so giving the mortar a chance of drying sufficiently before bearing the increasing weight. A little knowledge, however, comes in very useful here; and by the simple use of an hydraulic lime, which sets quickly and independently of wet, the chimney may be erected with any desirable amount of rapidity, and at the same time the possibility of its bending be prevented.

LIME.—As a knowledge of the nature of lime, which forms the cheapest matrix for building purposes, is essential to the builder, a short description of its properties and chemical constituents is here given.

Lime, before being burnt or decarbonised, is a bluish hard stone, found in many parts of England and Wales, of which the blue lias variety is one of the best. The analysation of this limestone shows that it contains about—

72	per cent	Carbonate of Lime.
20	„	Silica.
3½	„	Alumina.
2¼	„	Oxide of Iron.
2¼	„	Carbonate of Magnesia, &c.
100		

About 75 per cent of this is soluble in acids, and the other insoluble.

What are termed "rich limes," being nearly all pure carbonate of lime, have the least "setting energy." It is the silica and alumina which give the setting energy.

Hydraulic limes, or those which set in or out of water, have about 80 per cent of carbonate of lime, 6 of alumina, and 14 per cent of silica.

It is not expected that the millowner can enter deeply into the chemistry of limes when erecting his building; but what he can do with the lime it is most convenient for him to procure is, to ascertain by trial the amount of sand and ashes it will bear and still retain a moderate amount of setting energy, and then see that it is mixed with the aggregates in proper and uniform proportions, and well ground in a mortar mill not less than twenty minutes, or from that to thirty minutes, using at the same time no more water than is absolutely necessary to give it proper consistency. Great care should be taken that sufficient water is given to moisten all the particles, otherwise it becomes a crumbly mass; and if too much be given, its setting energy is destroyed.

In foundation work on clay, however, unless a good hydraulic lime can be procured that will set under water, lime must be rejected altogether, and Portland cement used in its stead. This can be procured in barrels in any part of the kingdom, and must be mixed with sand, broken bricks, furnace ashes, gravel, or other suitable aggregate, so as to form a good concrete foundation. When properly done, this will form a good solid foundation, and set in a few days, becoming as hard as stone, but (unlike it) impervious to water.

CONCRETE.—Attention is particularly called to the value of concrete, which can be used advantageously, more or less in all buildings, whether of mill or cottage, in any situation, wet or dry, if properly manufactured.

There are several ways of making concrete, but the best and safest is that made with Portland cement; say,

5 parts Portland cement.
15 to 20 parts sand, according to quality of the Portland cement.

Let the above be well mixed together in a dry state, then sprinkle the mass with water gradually whilst being turned over, after which add about 75 parts of small or broken stones, all being well mixed together, so that the sand and cement fill up the interstices between the stones, which can all be done by turning it over by the hand; on a large scale it may be done by machinery.

In France "Bêton Aggloméréś," or concrete for building purposes, is made on a large scale, by a machine having a hopper, at the bottom of which is a revolving disc. The materials, after being mixed in a dry state, are thrown into this hopper, and whilst being agitated, receive a definite quantity of water from a small tap, and are then thrown into a trough, and passed on by an Archimedean screw to the end, where the concrete drops off into buckets. This is an ingenious machine, but it is possible to contrive something simpler and cheaper, that will do the work as well.

The difference between rich limes and poor, or hydraulic limes, may easily be ascertained. When fresh from the kiln rich limes have a great avidity for water, and when slaked throw off considerable heat, with a hissing noise, some of the water applied being converted into steam by the caloric which was lying latent in the lime being now liberated; the lime in the meantime crumbles and falls. If slaked in a pit, with a large quantity of water, the whole mass forms a pasty substance, or hydriate of lime, which of itself has very little setting energy, as there is a want of inherent power to throw off the water, for which it has so great an affinity. Moreover it is liable to expand; and as the particles are not sufficiently separated or diffused by the mere slaking, it should always be passed through a fine sieve, or be well ground before being used.

Poor limes do not exhibit the same action on the application of water as the rich, because the poor, or hydraulic limes, contain a larger amount of foreign matter, such as silica and alumina, which is absent in the rich; therefore they do not swell in bulk when mixed with water, but are quiescent, throwing it off again, and setting with a determined energy; the reason of which appears to be that the foreign matter being thorougly diffused through the lime, keeps its atoms apart. The theory of setting seems to be to separate thoroughly the particles of lime, which, in ordinary or rich limes, is done by an admixture of sand well amalgamated, when a common mortar is the result, this having however only a very moderate setting power.

When broken bricks are ground to dust and mixed with the sand and lime a much stronger mortar is obtained, because the clay from which bricks are made contains silica, alumina, and generally oxide of iron, the very materials wanted to give rich lime setting energy. Foundry slag, and even cinders, strengthen mortar in the same manner, by giving the lime a hydraulic character; likewise pounded stone of volcanic origin, or oolitic stone; in fact, anything that contains alumina, silica, or carbonate of iron.

When quick lime is used for the manufacture of concrete, it should be merely fallen, by applying a small quantity of water, then ground to fine powder, in a dry or nearly dry state, so as to give the greatest possible diffusion of the particles; the lime then, being mixed with an aggregate of pounded bricks, and sufficient water to make it into a mortar, it will be found to possess considerable setting energy, and form a concrete cement that may be increased in bulk by adding broken stones, broken bricks, sharp sand or gravel, to any amount not exceeding the capacity of the mortar cement to fill up all the interstices, as little water as is possible being used. What is meant by sharp sand or gravel is that which is free from soil or dirt, such as is found in the beds of rivers. If this be not at hand, it may be made sharp by washing the gravel or other aggregate, and thereby freeing it from soluble matter. Good concretes gain in induration or hardening with age, and are impervious to moisture, but more especially so when the matrix is Portland cement, to which preference should be given when it can be had at moderate cost.

Portland Cement.—This most valuable of all building cements has displaced Roman and other quick-setting cements to a great extent, the latter more costly article being used only where very rapid setting is required under water. Both Portland cement and Roman cement are hydraulic; and the former, like the latter, will set under water as well as out of water, but is much slower in hardening. Portland cement may, however, be made to set rapidly, but is never as strong when so manufactured.

Its quality is determined more particularly by its weight per bushel, and its weight per bushel is determined by careful grinding after it comes from the kiln. If ground so as to weigh only about 70lb. or 80lb. a bushel it sets quickly, but gains less in indurating strength. It may be ground to so impalpable a powder as to weigh 140lb. per bushel or more, but that which weighs from 105lb. to 115lb. per imperial bushel is the most useful for general purposes, as it will set in about two or three days either in or out of water.

Portland cement is merely an improvement upon what is termed Roman cement. Towards the latter end of last century an attempt was made to produce a cement or mortar which would vie with the ancient mortars of Greece, Rome, and Egypt; these showed on analysis certain chemical constituents that were found in the London and other clays and the chalky cliffs which abound in the southern and eastern counties, also under the earth's crust in many parts of this kingdom, likewise in France and other countries. The clays contained the requisite silica and alumina, and the chalk contained the carbonate of lime.

The result of these experiments was the production of Roman Cement, so called because it was supposed to have been before discovered by, or known to, the Romans when they were masters of Britain, as the mortars of old buildings erected by them in this country had similar constituents. It was made from about 45 per cent of clay, calcined and pulverised, and 55 per cent carbonate of lime. About thirty years later the improvement in the manufacture which got the designation of Portland cement took place. It is supposed to have obtained this name from its resemblance to Portland stone. Its chemical contents are about 60 to 65 per cent of lime, 20 to 25 silica, 10 of alumina, and 5 per cent oxide of iron,—being about the same as a natural cement found on the French coast.

This cement is nearly all manufactured in the neighbourhood of London, because of the abundance and cheapness of the requisite clay and chalk found there. A similar cement is also manufactured in Germany and other places, and it can be made anywhere, if the necessary materials exist, or something approaching thereto.

After being properly manipulated and thoroughly pulverised, it is burned in kilns and then ground, and sold in casks. The manufacture and use of this cement is largely on the increase, and will probably alter the whole character of our buildings as its useful properties become more generally known.

Artifical Stone is simply a mixture of sharp sand and Portland cement in various proportions, according to the strength required (say from one part of each, to four or five parts sand to one of Portland cement), which are carefully mixed together in a dry state, and then water is added whilst the mass is still being turned over from a fine rose degging can, so far similar to the manufacture of concrete before described. It is then filled into moulds, a thin layer of the sand and cement mortar being put in first to form a face, or fill a fancy mould or ornament. Broken stones, or clean gravel shingle, or other suitable aggregate, may then be put in to fill up and make bulk, along with the other cement mortar, after which the whole can be topped up with the cement mortar to make a finish, and stamped down. It is better if the aggregate be mixed separately, with a little of the Portland cement, before being put into the mould, so that the particles of cement come in contact with the aggregate. No more aggregate should be used than the interstices of which can be filled by the cement mortar. The quantity of aggregate has little to do with the strength of the stone if all the interstices be filled, but the quantity of sand mixed with the cement at first has everything to do with its strength. Assuming the cement to be good of itself, the relative strength will be about as follows at different ages after mixing, viz :—If the breaking strength of cement mortar be at—

	One week.	One month.	Six months.	Twelve months old.
Neat cement say...	100lb.	150lb.	220lb.	240lb.
One of cement and 1 sand ...	22 „	70 „	123 „	157 „
„ „ 2 sand....	12 „	30 „	98 „	103 „
„ „ 3 sand ...	6 „	13 „	52 „	72 „

It still goes on gaining in strength and induration with age, but less rapidly every year after the first twelve months. It becomes harder and much more durable than stone; and when laid down alongside with granite, in steps or flags where there is considerable traffic, the granite wears first, and leaves the artificial stone apparently uninjured after years of wear.

GEARING VERSUS BELTING.

> " Seize upon Truth where'er 'tis found,
> On friendly or on hostile ground ;
> The flower's divine where'er it grows,
> Be it on thistle or on rose."

SIMPLICITY, which in all mechanism is desirable, is more especially so in mill gearing. Heavy, cumbrous, and rumbling gearing should be avoided as much as possible. It is always disagreeable and dangerous, because the breaking of a cog from any hard substance getting in the wheels often causes a fearful crash. The constant greasing required is also expensive, and produces much filth and unpleasant smell.

Where capital is abundant and prejudice rife, men follow the beaten track. Where engineers abound, and there are stores of beautiful wheel patterns, together with cheap metal, the spinner seldom concerns himself much about this important subject, but leaves it to the judgment of his millwright, who often, in a roundabout way, turns this and that shaft at the speed he requires, and the thing passes off without further question or thought that unnecessary things entail a continual expense in driving.

As youth is more daring and enterprising than age, so also is a young nation. Looking around, one must accord to America the honour of many useful inventions. There, men's wits are sharpened by the higher rate of interest on capital, and less facility for performing any given undertaking. Give a man a certain thing to do with limited means, and his ingenuity suggests a way of doing it; so in America heavy gearing is almost entirely discarded, and broad double belts or straps substituted.

Much may be said, *pro* and *con*, on this subject. The wisdom or folly thereof depends upon the mode of application.

When *properly applied*, there is no question that the noiseless and practical way in which belts do their work is preferable to gearing.

If belting be *improperly* applied it makes all the difference. A main driving belt, to be rightly applied, should go through 3,000 or 4,000 feet of space per minute, and be sufficiently wide to drive all the machinery and shafting it has to turn quite easily, when running in a slack state. A wide belt, moving with that velocity, on drums of large diameter, possesses enormous power. After a new belt has been tightened up once, it should work many years without again requiring tightening, and will do so if properly applied, and made of good material; saving in the meantime all the grease, and labour of putting it on, which gearing requires, to say nothing of the horrid noise which heavy gearing makes. In America, the main driving belts are open straps, worked in this manner, and neatly boxed up, so that nothing is seen, nothing heard; whilst in this country, the disagreeable rumbling noise of the heavy gearing of some mills can be heard, in country places, a mile off. Ask "John Bull" whether he would prefer driving his machinery by gearing or belting, and he will shake his head, and tell you he never minds the noise, he likes to be *sure*. "John Bull" is generally a shrewd fellow, but, as a rule, he does not, at present, understand what a belt is capable of when it runs through three or four thousand feet of space per minute.

Driving by belt or band has ultimately to be resorted to in all cotton spinning machinery; therefore the question of certainty goes for nothing, when properly done, as one way is just as certain as the other. To apply belting to slow running shafts would be simply ridiculous. As speed has finally to be attained, it should be gained, as much as possible, at once from the periphery of the flywheel of quick running engines. The speed of engines, and diameter of flywheel, should be so adapted to each other that the rim of the latter will give off a speed of 3,000 to 4,000 feet per minute at least; it being borne in mind that the power of a belt is exactly as the speed or space it runs through per minute. For example, a belt or strap of six inches wide, running through 4,000 feet of space per minute, will turn as much machinery, or give off as much power, as a belt of twenty-four inches will do that moves only at the rate of 1,000 feet per minute; just as a man can lift four times more weight with a lever four feet long than he can lift with a lever one foot long; therefore the quicker the speed the less is the expense of the belt.

What has been said about slack straps applies to all heavy running machinery throughout; it will be found also a great saving of power to have larger pulleys than is usual both on the shafting and frames, so that the straps can do their work easily. This saves wear and tear also to a great extent. When a strap is obliged to be tight in order to do its work, it pulls down at the shafting and up at the pedestals of the frame it is driving, thereby wearing out the steps, consuming more oil and absorbing power, besides pulling itself to pieces, in addition to which it slips and loses time. After a mill is settled to work there ought to be scarcely any piecing or tightening of straps; and if the precautions above enumerated be taken at the commencement, production will go on with greater regularity, and a very large saving, in the aggregate, will be effected.

As an example of what may be done with belts, the first which the author saw in an American factory was one driving 140 horse power from a drum of 9 feet diameter, and going at the speed of 130 revolutions per minute, and driving a shaft which had a drum of 7 feet diameter upon it. The strap was 24 inches wide, of double leather sewn together. It was asserted that this strap had run for seven years without piecing or tightening, having been tightened only once since it was newly put on. Being surprised at this statement, further inquiry was made in different mills, which fully confirmed what had been said as to the durability and ease with which these large belts do their work. If reflected upon, what an impressive lesson this teaches!

How delightful it would be in a mill if all the straps would run so long without piecing or giving trouble! Yet so it would be were the same conditions observed. How much we vary from those conditions will be seen upon examination. For instance, we often see carding engines, with pulleys on the main cylinders 12 inches diameter, running at a speed of 140 revolutions per minute, which is equal to barely 440 feet per minute of space through which the strap moves, whilst the big driving strap, above alluded to, goes more than eight times faster, being at the rate of over 3,673 feet per minute The straps which drive frames and other machinery are not much quicker than those which drive the cards. Therefore the lesson taught by the big belt is imperative, namely, that there should be very light shafting run at a very quick speed with larger drums and pulleys; then very little would be heard of strap-piecing or wear and tear of belts, working with less power and steadier production all the while. "Our American cousins" have taught some good things, and this is one of them.

In new countries men have new ways, and do not fix their principles by inheritance as they do in old countries—defending them with all the strength of prejudice, as being born heirs to them, and thereby missing many excellent things because they had never seen them done before. However true and palpable a new mode may be, it requires a long time to bring it into general use

In some American factories, one long belt is made to run the whole round from bottom to top of mill, turning every main shaft, passing where necessary over carrier pulleys, and working its way to and fro. This is not a good plan, as the belt is required to be of enormous length, and having all the stress upon it, is required to be sufficiently wide to take off all the power. It is likewise more costly than necessary, besides having other disadvantages. The simplest and best method of driving by belt, also the cheapest and most durable, is to convey the power from the main driving shaft direct to each room by a separate strap (as shown on the next page); and if more than one shaft is wanted in any of the rooms, to drive it from the other direct by a separate strap, apportioning the width of each strap to the power it is required to drive, and wherever a belt is necessarily short, allowing a little extra width.

The example below shows the best method of driving a mill of four storeys, in which two shafts are required in the bottom room, which may be driven direct from the first strap, as will be seen in *Fig.* 26, in which *a* represents the main driving

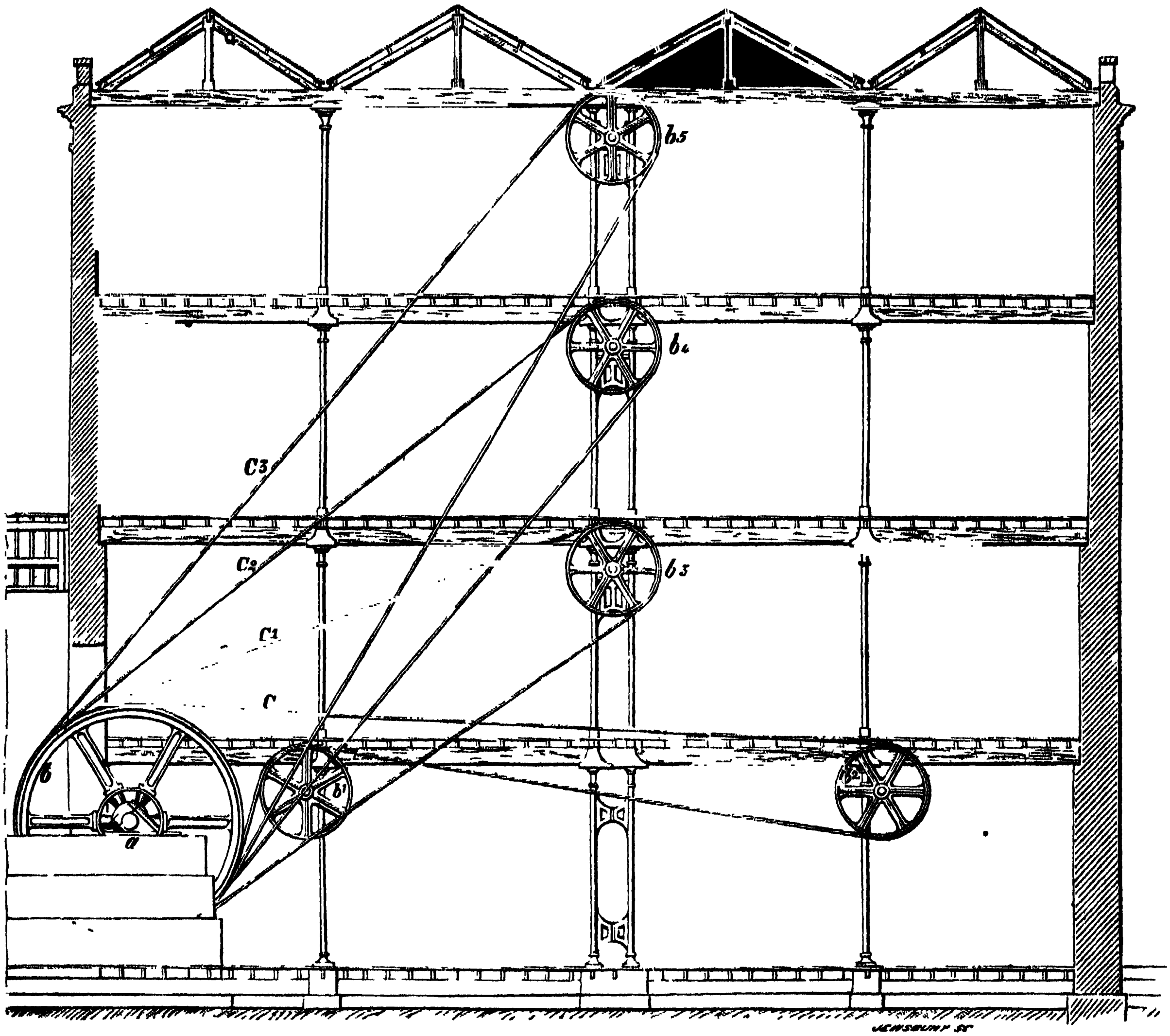


Fig. 26.

shaft, running 80 revolutions per minute, driven direct from the steam engine or other motor; *b* is a strong well-balanced drum, of 15 feet diameter, and about 3 feet wide, keyed on the shaft *a*, which, in making 80 revolutions per minute, gives off a speed on its periphery of 3,768 feet per minute *b* 1, *b* 2, *b* 3, *b* 4, *b* 5, are strong pulleys about 6 inches wide, and 6 feet diameter, keyed on the respective shafts they have to drive, which will, in this case, make 200 revolutions per minute, but may, of course, be varied to run faster or slower by putting on smaller or larger pulleys, but whatever else is done the speed of the straps must be kept up, for in that lies the whole secret of success in belt driving.

The shaft *a*, if the power be steam, will be the crank shaft, and the drum upon it will act as flywheel, and have great centrifugal force, without being heavy, by reason of its speed. The pulley must be turned a little convex at the top, where every strap comes upon it, having a little flat space of 3 or 4 inches between every hump, to admit of boxing up each belt separately, and ensuring them running in their proper places.

Should any belt break, as it runs in a separate box all the way up, it cannot in any way interfere with the other. When a belt wants piecing or tightening (a very rare occurrence), the ends are fixed in crams, which are drawn together by screws.

As the straps or belts *(C)* in the above example are supposed to be 6 inches wide, each belt is capable of driving horse power, as the following rule for calculating the power of belts will show.

Rule to find the horse power that any given width of double belt is easily capable of driving.

Multiply the number of square inches covered by the belt on the driven pulley by *one half* the speed in feet per minute through which the belt moves, and divide the product by 33,000, the quotient will be the horse power.

Example: On referring to *Fig.* 26, it will be seen that the pulleys *b*2, *b*3, *b*4, and *b*5, are each covered over by the straps *C*, *C*1, *C*2, and *C*3, to about one half their circumference, which, multiplied by 6, the width of the strap, gives 673 square inches, and the half of 3,768, the speed in feet per minute, being 1,884, it will be found thus:

$$1{,}884 \times 673 \div 33{,}000 = 38\,422 \textit{ Ans}$$

Or nearly 38½ horse power, which each of these double belts is capable of driving.

The strap on the pulley *b*1 only covering one-third of the drum, or 448 square inches, the power will be thus:

$$1{,}884 \times 448 \div 33{,}000 = 25{\cdot}567 \textit{ Ans}$$

A little over 25½ horse power.

Rule to find the proper width of belt for any given horse power:

Multiply 33,000 by the horse power required, and divide the product first by the length in inches covered by the belt on the driven pulley, and again by *half* the speed of the belt.

Example: Suppose a double belt is intended to pass through 4,000 feet of space per minute, and it clips the driven pulley 22 inches, what width of belt would be required to drive 15 horse power?

$$33{,}000 \times 15 \div 22 \div 2{,}000 = 11\tfrac{1}{4} \text{ inches wide, } \textit{Ans}$$

If these rules, which the author has devised after very careful study of the subject, be compared with the single straps as at present used in cotton mills, it will be found that they considerably overshoot the mark, yet theoretically, single belts, being so much weaker and more liable to stretch than double ones, ought to have less strain upon them. The secret of the wide double driving belts running so mysteriously long without attention, will at once be seen when it is considered that *single* belts are, as generally used, made to drive three or four times more than they ought to do for their width and speed.

For existing establishments where it is not convenient to alter the speed of shafting or size of drums, in driving machines with single straps, the following will come nearer to actual practice.

Rule to find the width of belt for any given horse power:

Multiply 33,000 by the horse power required, and divide the product, first by the length in inches covered by the belt, and again by its speed.

Example: Suppose a machine requires $1\frac{1}{2}$ horse power to drive it, and the strap runs 1,210 feet per minute, covering 20 inches on the pulley, what width of strap will be necessary?

$$33{,}000 \times 1\tfrac{1}{2} \div 20 \div 1{,}210 = 2 \text{ inches, } \textit{Ans.}$$

If this rule is reversed, as per previous example, it will show that a two-inch strap moving at a speed of 1,210 feet per minute, and covering 20 square inches of the driven pulley, will turn $1\frac{1}{2}$ horse power.

This, and more than this, is what *single* straps are made to do when driving machinery. Comparatively then, the strong double belts, working as per first rule, have exceedingly light work, which can be done with great ease while running in a slack state. Hence their durability; and the nearer a user of belts can approach the rule given for double driving belts, the longer his straps will last.

PIECING AND TIGHTENING STRAPS.

A new and very simple method of piecing straps has recently been introduced, termed "Harris's Patent Strap Fastener," which dispenses with laces or stitching; and as it is said to answer the purpose very well, it is shown here. It consists of a light malleable iron casting, with inclined teeth, set as in sketch.

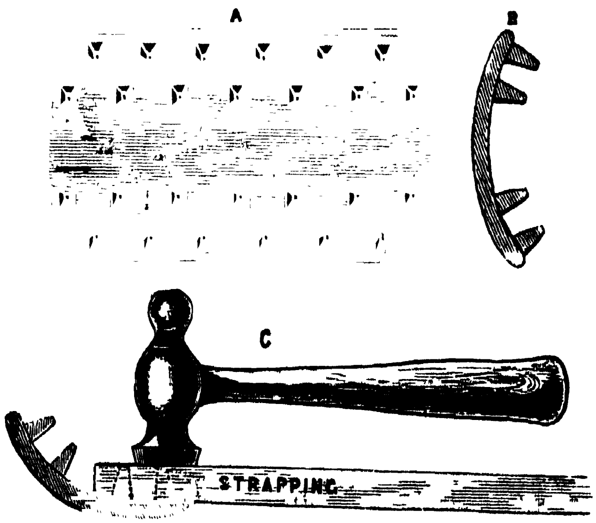


Fig. 27.—A, B, C.

Instructions for Use: Lay the casting, A, teeth uppermost, on something solid, and put one end of the strap on one of the sets of teeth, as seen in section at B, and force or hammer it firmly on to them, as seen at C; then place the other end of the strap on the opposite set of teeth, and force it down firmly in the same manner; this done, the strap is ready for use.

In applying this fastener, the strap not being weakened by making holes or bevelling, the joint is necessarily stronger than when laces are used. Care must be taken not to strike over both sets of teeth at the same time, otherwise the *curve* would be destroyed; and the *curve* is that which gives the requisite angle to the teeth to prevent them from working loose.

N.B.—In case of broad straps—say 6-inch,—use two 3-inch fasteners. To separate the strap from the fastener, run a knife between the teeth from end to end.

MOVING POWER.

AS steam power is now the most extensively used for driving cotton mills, it naturally comes first under consideration. An enthusiastic poet, some time ago, wrote the following prediction:—

> Then shall thy powerful arm, O steam, afar,
> Drag the slow barge, or drive the rapid car;
> Or, on wide-spreading wings, triumphant bear
> The flying chariot through the fields of air!

The first two of these predictions have been abundantly fulfilled; but the last, with steam, is as impossible as the perpetual motion.

When the justly-renowned James Watt so far perfected the steam engine as to admit steam at the top and bottom side of the piston alternately, and condense it in a separate vessel, driving his machinery and pumps through a beam, to one end of which hung the connecting rod, the piston and piston rod at the other, like a pair of scales in equilibrium, giving motion to the pumps by its oscillation, and converting the arc of the circle described at the piston end of the beam into a nearly perpendicular line, by his exquisite parallel motion, it was thought that science had reached its limit, and Watt's engine was accepted by the users of steam power as the acmé of perfection. But in those days of hempen-packed pistons, it was neither considered safe or desirable to let the piston travel faster than 220 feet per minute, the standard speed fixed by Watt. So for a great number of years, say more than half a century, any innovation upon his principle and arrangement was looked upon with incredulity and disapprobation.

When the hand of genius gives its final and triumphant touch to a machine that has wrought miracles and astonished the world, it is no wonder that an admiring public look upon it as almost divine, and consider it heresy to attempt to disturb it, as the whole subject is thought to be practically exhausted by so great a master. But "the light of other days" gradually fades like a dissolving view, as, little by little, innovations creep in. Perhaps the general introduction of the metallic piston and the advent of the locomotive were the first means of arousing the public from its comfortable nap of fifty years' duration, by showing on our railways that a metallic piston could work practically at a far higher speed than 220 feet per minute.* This ancient barrier therefore is now broken down, and only used as a basis from which to calculate the nominal power of an engine and its value commercially.

The alteration of speed and higher steam pressure are superseding the beautiful arrangements of the beam and parallel motion of Watt, together with the noble columns, side pipes, and entablature, which give his large engines such a majestic appearance! Alas! for the perpetuity of the greatest efforts of human ingenuity.

Fig. 28.—Portrait of James Watt.

However perfect and satisfactory an invention may appear to the contemporaries of the discoverer who produces it, as viewed in the light of his day, still changeful and imperfect are man's greatest efforts to Nature's simplest works, such as the smallest blade of grass, the hexagonal cell of the busy bee, which are the same yesterday, to-day, and for ever.

How or why, then has this beautiful construction of Watt's failed? A mechanical truth never fails; but, like the law of gravitation, will endure to the end of

* A locomotive piston sometimes attains a speed of 1,000 feet per minute, notwithstanding the short strokes.

time: it has merely, for some purposes, been superseded by another mechanical truth that was not known in his time. Watt's beam engine is as capable now of performing that service for which it was designed as it ever was; nay, more so, because of the better workmanship in these modern days than was possible when its Inventor lived.

It would be a very ungracious task to disparage the great ability and splendid constructive powers of Watt, or to write a word that would sully the fair fame of a man whose name will always be held in reverence as a benefactor of his species. As long as his theory of limited speed and low pressure steam held good, so far was his engine perfect. But now that a greater speed is attained, and steam used at a higher pressure, it is found inexpedient and dangerous to transmit the power through a lever, mounted on stilts, to the main shaft. Though some engine builders still persevere in the use of the beam, and vainly hope, by adding strength to the different parts, to surmount these difficulties, it is quite plain however, that the position is untenable. Although Watt's condensing engine has been made for so long a period with a beam, it must not be forgotten that Watt himself suggested dispensing with that appendage in some cases.

The beam of a steam engine is simply a compound lever, the natural vibration of which is equivalent to a pendulum of half its length; therefore, as a pendulum of 39 inches long beats 60 strokes in a minute (according to the latitude of Greenwich), the proper motion of a beam is found by subjecting it to the same law, in proportion to its length from the centre. Now, whenever that motion is unnaturally accelerated, the momentum, acquired by its mass and heavy appendages, requires checking at every half stroke, which is a waste of power and a strain upon the parts—the more violent the greater the speed and weight. Therefore, adding strength and consequent weight to the beam and appendages, to sustain these shocks without breaking, is only aggravating the evil, and struggling, as it were, by brute force to overcome science and natural laws.

Doubling the speed of a steam engine simply means doubling the power at the same cost; or rather, it should be said, that the cost of a steam engine, per indicated horse power, is in the inverse ratio to the speed of piston.

When an engine runs slow, massive foundations are required to hold it down, with heavy gearing to get up speed, and a ponderous fly-wheel to help it over the centres. These things are very costly.

It is especially undesirable for driving machinery at its present rapid rate to commence with a very slow motion, not only on account of the extra outlay in engines, gearing, and foundations, but the jerking caused in getting over the centres, loss of power, and various other inconveniences. For instance, a great and unsuspected loss of power occurs with slow running engines, through the chill which the internal surfaces of the cylinders acquire by being so long in communication with the condensors. Another loss is caused through the enormously extra weight of fly-wheels required and the friction of heavy shafts.

Disastrous breakdowns often occur also with power established on this principle, when so much speed has to be brought up. It is like taking a short lever to lift a heavy weight. Ponderous beams may do very well for pumping engines where only slow motion is required, but it is thought erroneous to employ either the beam or heavy gearing when a rapid rotary motion is wanted. That modern practice has been tending in this direction may be seen in many new mills in which the beam engine, though not all of the heavy gearing, is altogether discarded. The greater the speed of the first motion shaft the lighter the fly-wheel required, and the danger is less. Double the speed of a fly-wheel shaft, and *one-fourth* the weight of fly-wheel will suffice, the centrifugal power being as the square of the velocity. It should be particularly impressed on the mind of the student that a heavy fly-wheel is not only a loss of power, but that the enormous force concentrated in its momentum cannot be suddenly checked when anything goes wrong—such as the breaking of a large driving wheel or shaft,—it goes off at an accelerated speed, tearing down all before it. Hence so many fearful and expensive crashes where beam engines with heavy rumbling gearing are employed. Cannot all this be avoided, and power be made relatively as safe as a fire-proof mill over one that is not so?

This most certainly may be done, and the anxiety removed. Good and desirable things, generally, are only to be dearly purchased; but here is a notable exception, for this great benefit may be had for less money, less consumption of fuel, and steadier turning withal, which is of especial value. How then shall this desirable end be attained? Let prejudice be cast away and a common sense view be taken of the existing appliances of steam to a thousand other purposes than the driving of mills, and it will be perceived that as to the propelling of works without the expensive paraphernalia of beam, or heavy and noisy gearing, there is no mystery. Simplicity is always charming, but especially so about an engine and millwork. It saves the pocket, it adds to security, it lessens the interest of capital and depreciation. Example: Suppose it is required to run the main shaft in the bottom room 100 revolutions per minute; take hold of that shaft at once with the engine connecting-rod, or with the piston-rod, if the engine be an oscillating one. A very light fly-wheel only will then be necessary to get the engine over the centre, and no gearing, or very massive foundation work will be required. The noise also will disappear. Theoretically, a fly-wheel of only *one-sixteenth* the weight would be required to what would be necessary for an engine making only 25 strokes per minute; but as a smaller diameter of wheel would be put on the fast engine, the real difference in weight might be about nine-tenths less metal, and perhaps nine-tenths less cost for the fast than for the slow running fly-wheel. Nor does the advantage end here, for such an engine, complete, only costs about one-fourth, or less than a fourth of the price of the 25-stroke engine per indicated horse power, and the turning is steadier. The consumption of coal is likewise much less, for the power lost in turning the heavy fly-wheel, ponderous shafting, and gearing of the slow running engine is saved, and the cooling of the internal surface of the cylinder, already spoken of, is to a great extent prevented by the velocity.

Much more will be said further on upon this important subject, but as the present part of the work is intended rather to illustrate mills as they are at present than as, it is believed, they ought to be established, the reader's patience will not now be further taxed on the subject of steam power and its application.

When recurred to again, complete plans will be shown of engines and boilers capable of working with far greater security than at present upon $1\frac{1}{2}$ to 2lbs. of coal per indicated horse-power per hour.

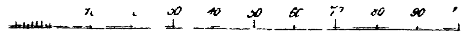
This statement will, no doubt, be received with incredulity by many, but when it is considered that the amount of latent heat in half-a-pound of coal is sufficient, if it could all be utilised, to work a horse-power one hour, the surprise is rather that so great a waste should continue to be made through common ignorance of natural laws.

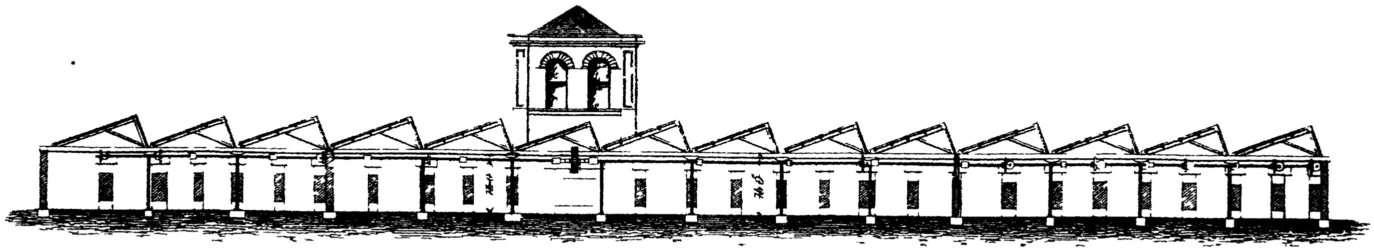
What is meant by working a horse-power one hour is equal to the raising of a weight of 33,000lbs. sixty feet high in that time, or one foot per minute. Now, if with all the skilful appliances in generating and working steam to use up this heat (which is merely "sunshine" absorbed by plants, carbonised and stored up for man's use, in the bowels of the earth), a great portion of it is nevertheless wasted, and if, according to the calculations of a celebrated engineer, the coal fields of Great Britain will only last one hundred years at the present constantly accelerated rate of consumption and export, and England's glory sets with the exhaustion of her minerals, surely it is high time, both patriotically and commercially, to arrest this enormous waste, and thus lengthen the brief space of time left her as foremost of manufacturing nations. It is believed, however, that these calculations about the duration of the coal supplies of Britain are very inaccurate; but when it is considered that the consumption of coal in one year is probably as much as Nature required a thousand, or it may be ten thousand, years to produce and store up for the use of man, it becomes evident that the end of its lavish consumption for manufacturing purposes must come sooner or later by reason of advanced price, long before utter exhaustion takes place.

BOMBAY SPINNING & WEAVING COMPANY.

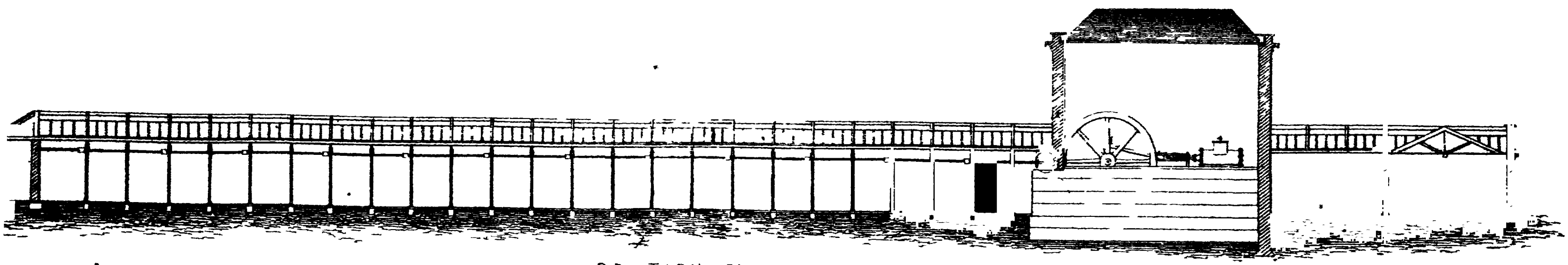
MILL OF 3104 SPINDLES

SCALE OF FEET





SECTION ON LINE A B



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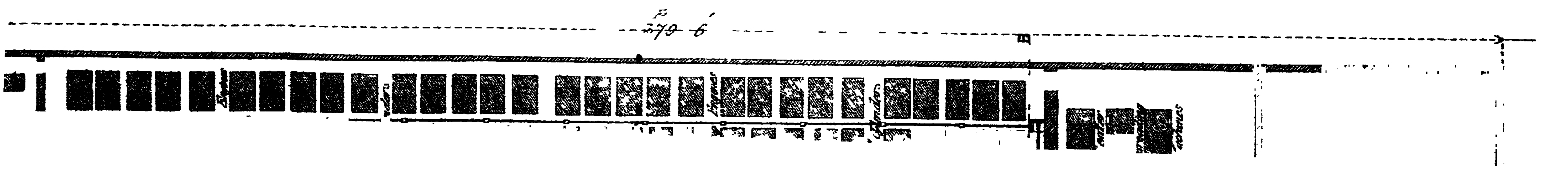
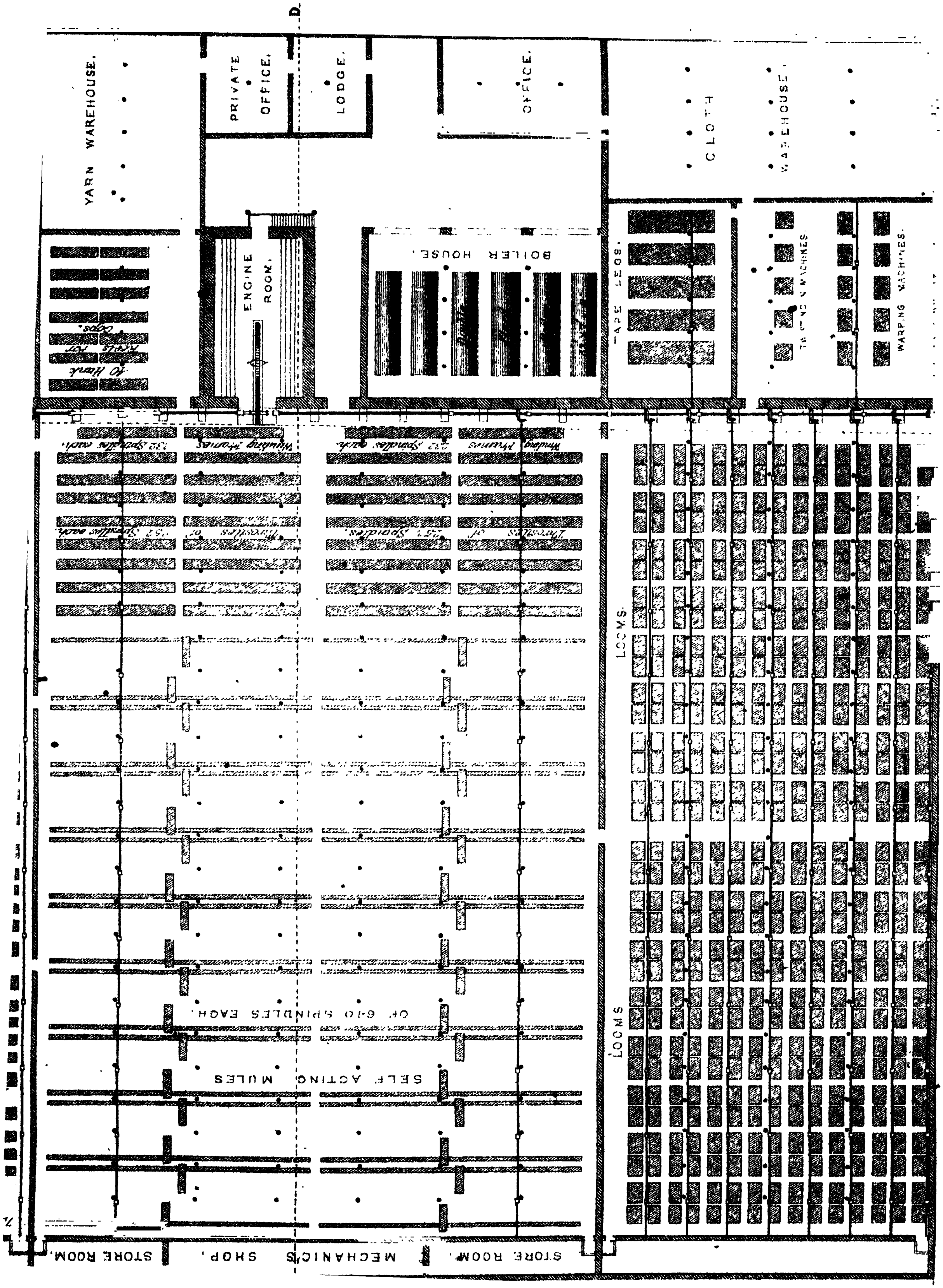



D
YARN WAREHOUSE.
PRIVATE OFFICE.
LODGE.
OFFICE.
CLOTH WAREHOUSE.
ENGINE ROOM.
BOILER HOUSE.
TAPE LEGS.
WARPING MACHINES.
40 Hank Reels for Cops.
132 Spindles each.
Winding Frames
252 Spindles each.
Winding Frames
Throstles of 132 Spindles each.
Throstles of 252 Spindles.
LOOMS.
LOOMS
SELF ACTING MULES
OF 640 SPINDLES EACH.
STORE ROOM.
MECHANIC'S SHOP.
STORE ROOM.

COTTON SPINNING IN INDIA.

COTTON MILL OF ONE STOREY ERECTED AT BOMBAY, INDIA.

From the Design of Messrs. JOHN HETHERINGTON & SONS, *of Manchester.*

accompanying plan and two sectional elevations show a complete mill, with machinery, consisting of 23,040 mule and 8,064 throstle spindles, making a total of 31,104 spindles altogether; with an entire manufacturing establishment of 480 looms to convert the yarn into cloth, as under, viz.:—

Blowing Room:

2 Cotton Openers.
3 Scutchers, with two beaters each and lap attached.
3 Finishing Scutchers, or Spreading Machines, with one beater each.

Card Room:

60 Carding Engines, with cylinders 48 inches diameter.
9 Drawing Frames, of three heads and four deliveries each.
12 Slubbing Frames of 60 spindles each.
24 Roving Frames of 120 spindles each.

Spinning Room:

32 Throstles, of 252 spindles each.
36 Self-acting Mules, of 640 spindles each, $1\frac{1}{4}$in. gauge.
4 Winding Frames, of 232 spindles each.

Warping Room:

10 Warping Machines.
5 Twisting-in Machines.

Sizing Room:

5 Tape Leg Sizing Machines.

Weaving Shed:

480 Power Looms.

Reeling Room:

14 Cop Reels, 40 hank.

Engine House.—Pair of Condensing Steam Engines, 80 horse power nominal.

Boiler House.—Six Double-flued Boilers, 7 feet diameter, 32 feet long, each.

GEARING.—The following is a list of the Gearing, with pitch of Wheels, diameter of Pulleys, &c.—Main driving shaft 80 revolutions per minute.

LIST OF WHEELS AND SPEEDS.

	Speed.	Diameters Ft. in.		Ft. in.	Speed of Driven Shafts	No of Teeth.	Pitch	Breadth
Bevel Wheels AAAAAAAA	80	3 0	into	1 11	120 Cross Shaft over Looms	$\frac{76}{48}$	$1\frac{1}{2}$ in.	$4\frac{1}{4}$ in.
Mortice Wheels BBB	80	4 $7\frac{1}{4}$	„	2 $3\frac{3}{4}$	160 „ „ over Spinning ...	$\frac{80}{40}$	$2\frac{1}{8}$ „	8 „
Do. Do. C	80	4 $8\frac{1}{8}$	„	1 $7\frac{3}{8}$	231·1 do. over Roving & Slubbing	$\frac{78}{27}$	$2\frac{1}{8}$ „	$7\frac{1}{2}$ „
Do. Do. D	80	4 $0\frac{1}{2}$	„	1 $10\frac{3}{4}$	173·3 do. over Drawing & Blow'g	$\frac{78}{36}$	2 „	5 „
Do. Do. E	80	3 6	„	2 3	124·4 do. over Carding Engines ...	$\frac{70}{45}$	$1\frac{7}{8}$ „	5 „

LIST OF PULLEYS.

	Speed.	Diameters Ft. in		Ft in	SPEEDS			
Driving Pulley	173	3 0	into	1 8	310	Revolutions	of	Counter Shaft for Opener.
„ „	310	2 $7\frac{1}{2}$	„	1 0	800	„	„	Opener.
„ „	173·3	3 0	„	1 $4\frac{1}{4}$	385	„	„	Counter Shafts for Scutchers.
„ „	385	2 $7\frac{1}{2}$	„	0 $7\frac{1}{2}$	1600	„	„	Beaters in Scutchers.
„ „	173·3	2 10	„	1 9	270	„	„	Rollers in Double Scutchers.
„ „	138·5	1 3	„	1 9	275	„	„	Rollers in Single Scutchers.
„ „	160	2 $10\frac{1}{2}$	„	0 10	560	„	„	Drums in Throstles.
„ „	160	2 0	„	1 4	232	„	„	Rims in Mules.
„ „	231	1 $7\frac{3}{4}$	„	0 11	415	„	„	Pulleys on Roving Frames.
„ „	231	1 $1\frac{1}{4}$	„	1 1	235	„	„	Pulleys on Slubbing Frames.
„ „	173	1 4	„	1 0	226	„	„	Pulleys on Drawing Frames.
„ „	124·4	1 7	„	1 6	130	„	„	Pulleys on Card Cylinders.
„ „	124	1 7	„	1 0	200	„	„	Grinding Machine.
„ „	160	0 11	„	0 $9\frac{1}{2}$	180	„	„	Winding Machine.
„ „	120	1 0	„	1 0	120	„	„	Looms, 9-8th wide.
„ „	120	1 0	„	0 11	132	„	„	Looms, 7-8th wide.
„ „	120	0 6	„	1 $2\frac{1}{2}$	50	„	„	Beam Warping.
„ „	120	1 11	„	1 1	210	„	„	Tape Leg Sizing Machine.

The plan, common in India, of having all the machinery on the ground floor is undoubtedly the best in all hot and dry countries, and it may fairly be questioned if, where land is cheap, it can be beaten, in an economical point of view, by any other method, if the floors be of concrete, and the roof also, with lofty windows in the side walls, and a few dome lights, if those be not sufficient.

Buildings of one storey, however, do not admit of architectural display in the same manner as mills built in several storeys, and all the instances we have hitherto had of them look paltry compared with the general plan of building in storeys, besides which they have not been either so dry or comfortable. Those lighted from above, on the same principle as weaving sheds, whilst well adapted for looms, are totally unfit for spinning machinery in our humid climate. The plan of building mills only one storey is, however, susceptible of great improvement both for comfort and appearance, and will be alluded to again hereafter.

LIST OF MILLS.

The following List of Spinning and Weaving Mills, in the Bombay and Bengal Presidencies, was drawn up by the Cotton Commissioner, Mr. Harry Rivett Carnac, and issued from his office, at Nagpore, 12th August, 1869:—

Town	Names of Millowners or Company.	No of Spindles.	No of Looms.	Annual Consumption of Cotton Bales of 400lbs
Bombay.........	Albert Mills Company	18,000	......	3,400
	Bombay United Spinning and Weaving Company	21,000	335	4,800
	Bombay Spinning and Weaving Company..................	31,000	480	6,600
	Great Eastern Spinning and Weaving Co. Limited	30,000	608	6,000
	Oriental Spinning and Weaving Company..................	40,000	800	7,000
	Alliance Spinning Company...........................	22,000	......	5,000
	Victoria Spinning Company Limited	9,000	......	1,800
	Bombay Royal Spinning and Weaving Co. Limited......	33,000	680	7,600
	Manickjee Petils Spinning and Weaving Company	60,000	840	10,000
Coorla	Bomanjee Hormusjee Spinning and Weaving Co. Lim...	27,000	469	6,200
Ahmedabad...	Ahmedabad Cotton Spinning and Weaving Company...	5,000	......	1,000
Duskcohie ...	Behadar Spinning and Weaving Company.............	15,000	......	3,000
Broach.........	Broach Cotton Mills Company..................................	17,000	......	3,400
Surat	Jaffer Ali Spinning and Weaving Company Limited ...	12,000	......	2,000
	Total Bombay....................	340,000	4,212	67,800
Calcutta	Goosery Cotton Mills.........................	15,000	70	3,800
	Fort Glo'ster Cotton Mills..	27,500	......	2,800
Cawnpore......	Elgin Cotton Mills	10,000	150	3,000
	Total................................	392,500	4,432	77,400

It will be noticed, from the list of mills above, that cotton spinning is making considerable progress in India; and how far it will ultimately extend becomes an interesting, if not momentous, question as affecting the demand for that important market for home manufactures. It may be observed, however, that as the prosperity of India increases so will the consumption of cotton goods increase amongst that vast population, and ages may elapse before the manufacturers of the western hemisphere feel the effect of the competition. The wants of mankind are insatiable as means increase to gratify them, and no probable increase of mills in India can keep pace with the augmented demand. Moreover, as India is more of an agricultural than manufacturing country, the same universal law which gives the greatest reward to capital when naturally invested may be expected ultimately to prevail, and it will be found that if the same amount of capital had been invested, and energy expended, in cultivating the soil, a better return would have been made. Moreover, the cost of transit between Europe and India is gradually being lessened and the speed accelerated, which must increasingly tell in favour of the western manufacturer.

COTTON MIXING, OPENING, AND SCUTCHING.

OPINIONS somewhat differ as to the best method of mixing cotton when different kinds are used, some preferring to mix a number of bales of each kind together, before willowing or scutching, and after making laps of each kind, mixing them on the second lapper by running one lap of long staple with two of short, or *vice versa*, as the case may be. Others, and by far the greater number, prefer to mix as large a number of bales together in a stack as is possible, in layers one upon another, and when used, raking them down, with an iron rake, from the top to the bottom, by which the mass is thoroughly blended. On the whole the latter plan is considered the best, and those spinners who have sufficient room and capital to make the largest mixings, spin the most regular numbers of yarn, the little loss in interest on capital which this occasions being amply repaid by extra and more regular production. It is found practically impossible, however good a judge of cotton a spinner may be, to select in the market another lot of cotton that will work, in all respects, the same as that just consumed; therefore a careful trial should be made every time a fresh stack of cotton is commenced with, as to the *weight* it will deliver *at the carding engine*, before the working or carding of it is proceeded with. It is unsafe to rest satisfied with the weight in which the laps come out, as some cottons lose more from sand, &c., in scutching, and less in carding, from better staple. When fully ascertained, after carding, it is better to put a little more or less weight on the weighing scales at the first scutcher, than to change pinions on the carding engine or drawing frame, as will shortly be shown.

Another plan of mixing cotton (the invention of Mr. Edward Lord, of Todmorden, to whom cotton spinners are indebted for the very ingenious device of a "self-regulating feeder"), is exceedingly well adapted to concerns where it is not convenient to mix a large stack of cotton together,—indeed, on the whole, it is questionable whether it be not more economical in any establishment than the stacking system. The way alluded to is to open six or eight bales of cotton, laid side by side, and for the mixer to take alternately a quantity from each bale, and deposit it in the mouth of a tube or funnel, which has a double bottom, the inner one of which is grated, and the lower or outer bottom hinged so as to open when required, and close air-tight. The other end of this funnel is connected to a powerful fan, which, in drawing air, takes the lumps of cotton deposited in the mouth of the tube rapidly along with it, and being rolled over the grating, a good deal of sand and heavy seeds fall through the interstices, which are cleaned out occasionally, by opening the hinged bottom. This tube or funnel can either be placed in a horizontal or diagonal position, or be made of any required length, in a straight line or to turn a corner, so it is a very convenient application of pneumatics, and may be made to answer the purposes of conveying, opening, and cleaning cotton at the same time. A drawing of this machine will be shown in its proper place, under the head of

COTTON OPENING AND SCUTCHING.

In the process of cotton opening regard must be had to the kind or description of cotton to be operated upon, as what is suitable for long staple cotton would be out of place for short staples. It is, therefore, proposed to take the various kinds in the same order as they are described in the article on the "Cotton Plant," the long staples coming first.

Before scutchers were invented,—in the palmy days of cotton spinning, when mills were small, and profits large on each pound of yarn produced,—a halfpenny or a penny a pound spent on "batting" and "picking" cotton could well be afforded. The old "Batting Flake" was a sort of stout frame, about three feet square, and stood about the same height. It had cords of rope tightly strung in parallel lines, about half an inch apart. These batting flakes were generally kept in the cottages about a mill, and the women would take out "buntings" of raw cotton to bat and pick. The batting was done with two willow sticks, each a yard long. About half a pound to a pound of cotton was put upon the "flake" at a time; the woman then beat it with a batting stick, in each hand, skaking it up at the same time. She then stopped to pick out the motes, the heavy seeds generally falling through the ropes on the floor. After she had finished her bunting of 10 or 20lbs. of cotton, she took it back to the mill, with the pickings, when it was examined, re-weighed, and entered in the books to her credit.

The following laughable incident once occurred in those early times of the cotton manufacture:—A poor woman was bringing back to the mill her bundle of cotton; the wind being very high, her package was blown from her grasp, and, coming open, the cotton was carried away high in the air, and scattered about the fields and hedges in all directions, a number of boys being sent to chase it. After a hot run of about an hour all came back with pockets full of cotton; after all, King Æolus got the greater part of it.

This ancient mode of opening and cleaning cotton is only alluded to here because the *quality* of work produced by this method has never been exceeded for long stapled cotton used in fine spinning. The cotton was thoroughly opened in this way without being "stringed," or the staple broken and damaged; therefore, any opening machine which comes nearest in its action upon the cotton to the old method of batting is the best for quality.

The primitive method of cleaning and preparing cotton for spinning with the distaff in India is not unlike batting, as will be seen below, in *Figs.* 29 and 30.

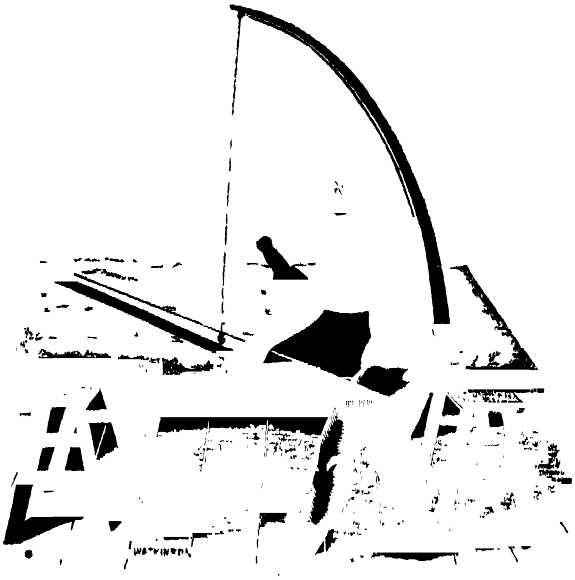


Fig 29.

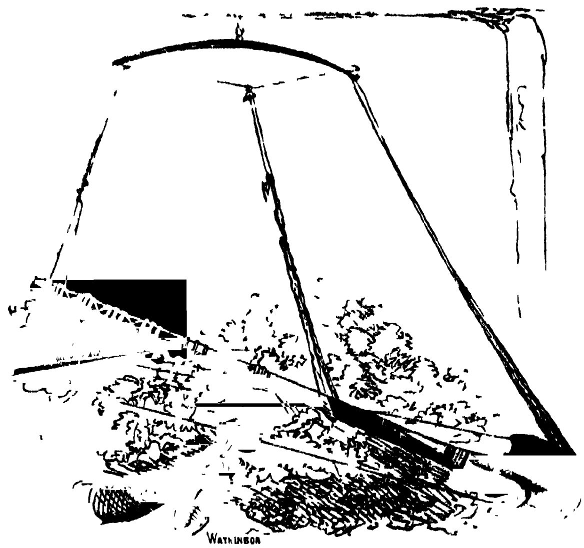


Fig. 30.

As mills were built larger, and competition increased, the great expense of batting and picking, which involved also hand feeding of the carding engines, could not be tolerated, and the Blower or Scutcher machine was invented, and subsequently the "Lap Machine" and Dust Fan were attached, which effected so great a saving that the old batting system rapidly disappeared from all mills except those where the very finest numbers of yarn were spun.

The first Scutcher was made by a person in Scotland, of the name of Snodgrass, who brought out many other useful inventions. His machine was worked for a considerable time without any lap apparatus, the cotton being taken from it and spread upon a feed table at the back of each carding engine. The late Mr. John Crighton, of Manchester, was the inventor and first maker of a Scutching machine with a lap apparatus attached, about the year 1814. These machines were afterwards made with two, three, and in some cases as many as six beaters.

The quality of work from the first made "blowers" was so inferior to batted cotton that an attempt was made by the late Mr. de Jongh, of Warrington, to construct a machine which would bat cotton by power with iron rods. It was, however, a very dangerous machine to approach, and proved a failure. The same inventor was one of the earliest pioneers of the "self-acting mule."

The addition of the fan and dust cage, however, to the blower made a wonderful improvement by drawing the cotton away from the beater, and preventing the "stringing" so much complained of at first, and which originated in the cotton being carried round by the beater.

Another great improvement in cotton opening machines, on the scutcher principle, was the employment of spiked feed rollers of about three inches diameter, instead of the usual fluted rollers. This improvement was brought out by the late Mr. Robert Hyde, of the firm of Hindley and Hyde, of Ashton-under-Lyne. Mr. Hyde made a pair of feed rollers as an experiment, by putting cast-iron spiders on shafts of about one inch diameter. These spiders had about eight teeth, with a pap about $1\frac{3}{4}$ inch diameter, projecting about three-quarters of an inch from one side, and were bored out to fit the shafts on which they were fixed with keys, or with sunk set screws, thus:—

Fig. 31.

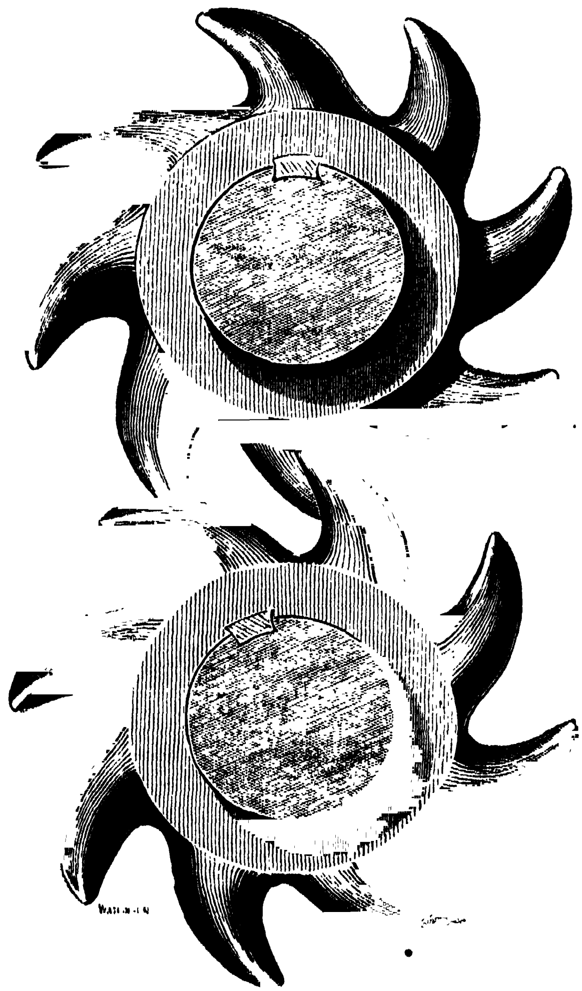
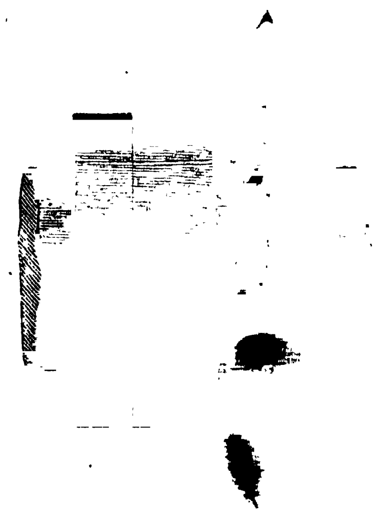


Fig. 32.



This plan has been thought worthy of illustration, because it is doubtful whether any principle of opening raw cotton surpasses it for simplicity and effect. It is applicable alike for both long and short staples, the latter when taken from the bales being often compressed in hard lumps difficult to separate, but when passed through feed rollers of this description, and met by a rapidly revolving beater or toothed cylinder, the action of the spiked rollers is something similar to pulling the lumps of cotton separate by the fingers without breaking or injuring the staple. An opening machine of this description is capable of getting through a large quantity of cotton in a short time, if backed by a powerful fan, with large dust cages and good grids. The less long-stapled cottons are blown or scutched, the better; as when overdone they are apt to get "stringy," and card neppy afterwards. As they must be scutched, however, before a level lap can be made, especial care should be taken not to feed the cotton too thick.

THE "CONE WILLOW" COTTON OPENER.—This machine was invented about the year 1832, and had a great run as a powerful cotton opener and cleaner. It consists of a cylinder of a conical form fixed on a shaft or axis, to which motion is given. This cylinder has rows of pegs or teeth about three inches long and about four inches apart. It works in a conical casing, which has also similar teeth that are stationary, and set so as to come between those on the cylinder. There is an

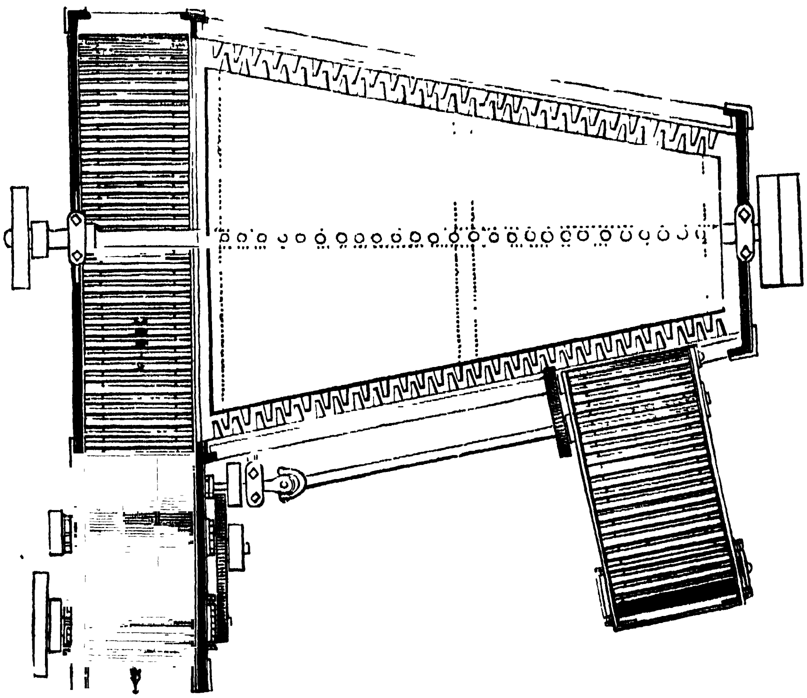


Fig. 33.

internal casing of grids for the motes, seeds, and sand to fall through. These grids are set wider apart near where the cotton is fed at the smaller end of the cone. The cotton travels by the centrifugal action and the aid of a fan to the larger end of the cone, where it is thrown off. This machine is capable of opening a large quantity of cotton per day, and is used now in many mills, where it is preferred to anything else for opening American, Surat, and other short-stapled cottons.

The "Oldham Willow" consists of a cylinder A (*Figs.* 34, 35), about 40 inches diameter, and about the same in width. It is furnished with several rows of pegs or teeth, the same as the Cone Willow, and works in a sheath or case furnished with stationary pegs. At the underside of the case there is a semicircular wire grid B,

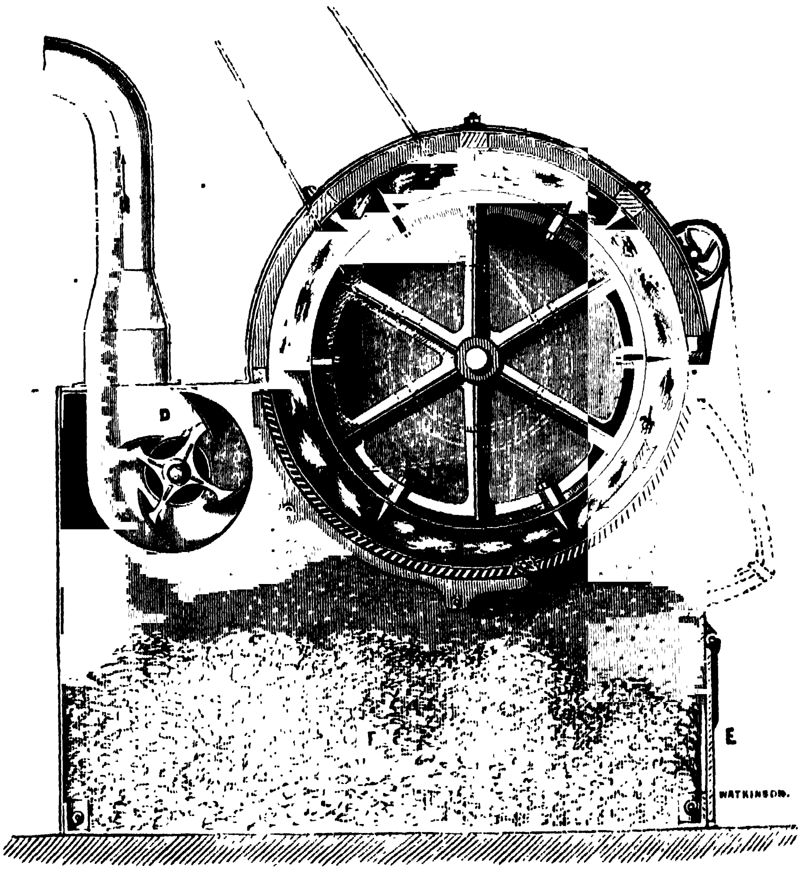


Fig. 34.—The Oldham Willow (1).

hinged at one end. There is an opening in the front of the machine where the cotton or waste (for which it is mostly used) can be thrown in upon the wire grid C when the grid is let down from the cylinder. It is then closed up, and the grid, with the cotton upon it, raised up until it comes in contact with the spikes on the cylinder, when it gets well shaken up, for a few seconds; the door is then opened, and the wire grid let down, when the cotton is thrown out; after the opened cotton is removed,

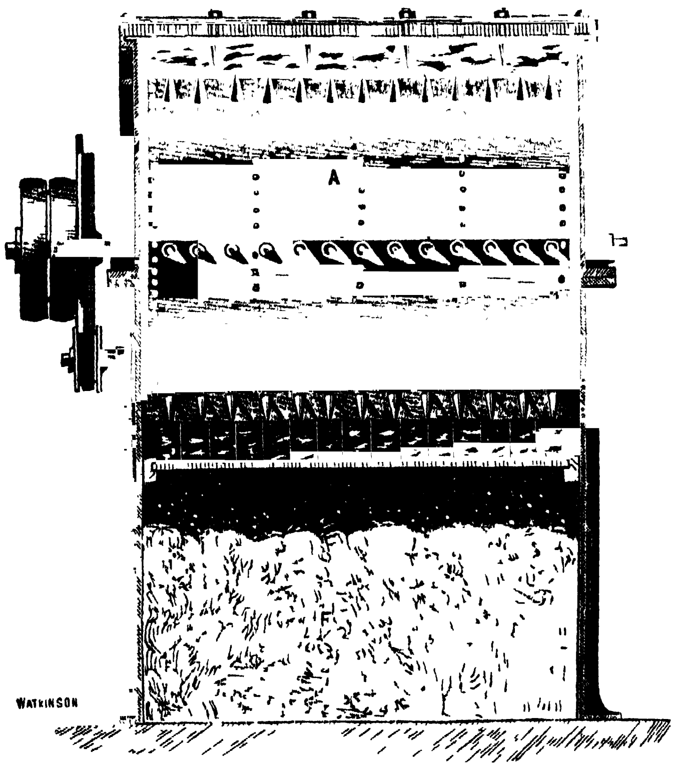


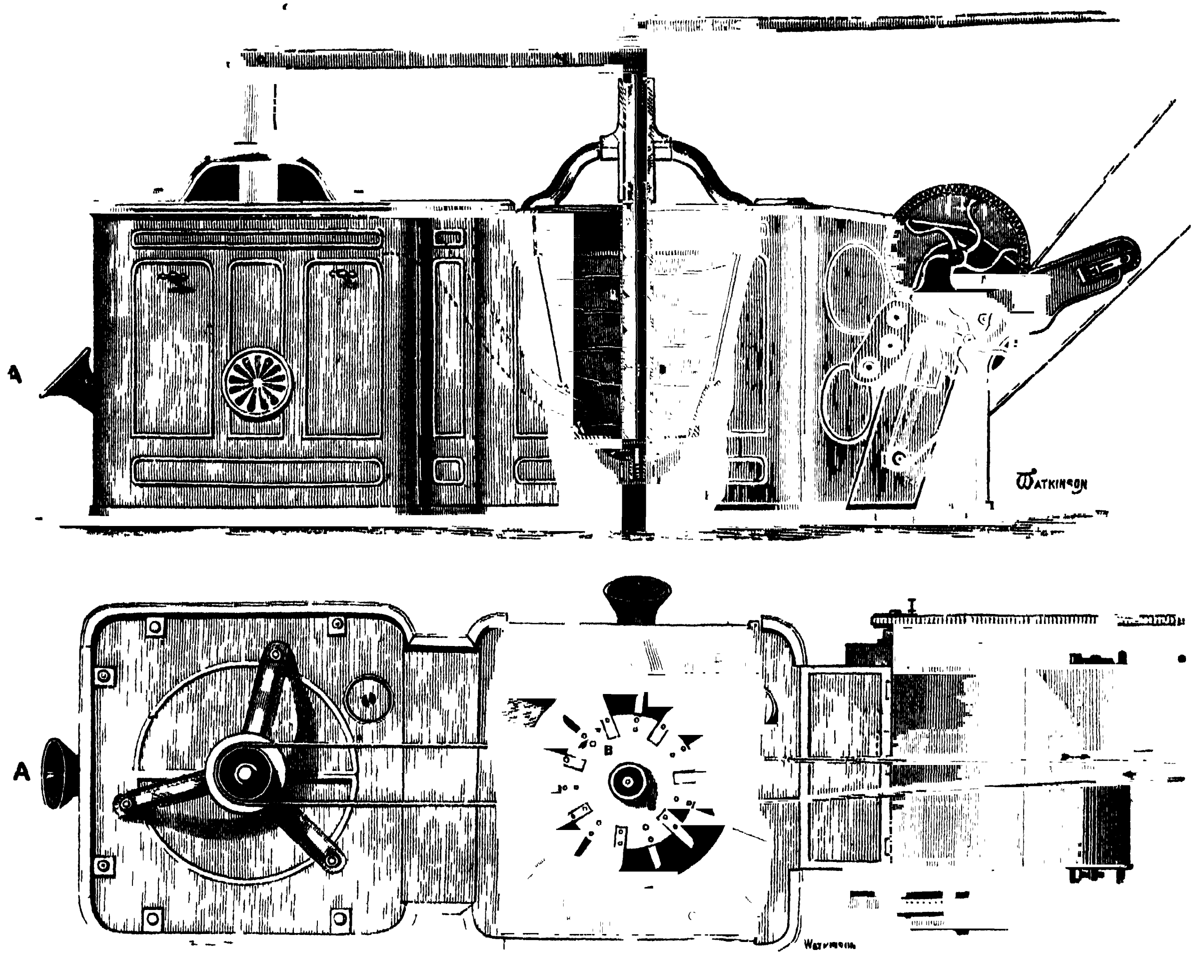
Fig 35 The Oldham Willow (2)

the operation is repeated. This machine is very useful for cleaning blower droppings, and some spinners use it for shaking up and opening raw cotton in small concerns.

HARDACRE'S COTTON OPENER.—This machine, which takes its name from the inventor, was an attempt to imitate the batting stick before spoken of, and consisted of a vertical shaft, on which were fixed arms or rods of iron, the whole revolving in a double case, the internal one being a circular grid through which the seeds and motes were thrown. Cotton being fed in at the top soon came in contact with the revolving arms or rods, and was beaten against the grid in its descent.

It had not been in operation very long before it was improved upon by Mr. Crighton, of Manchester, who made the beater of a conical form, and fed the cotton in from the bottom, thus :—

Raw Cotton is fed in the mouth of the pipe A when it comes in contact with the lower part of the first beater B, which is of a conical form. By the centrifugal action of the beater arms and aid of the fan F, the cotton is drawn upwards and thrown out at the top, when it passes down a pipe to the bottom of the second beater, when the same thing is repeated, and it finally passes out at the top of the dust cage



Figs 36 and 37.—Crighton's Cotton Opener.

and lattice creeper, which conveys it away. This machine may be used with one of the beaters only. As the footsteps of these machines have been rather liable to heat, some improvement to prevent this has been effected by Messrs. Hetherington & Sons, and also lately by Messrs. Crighton & Co., the makers. The beaters are surrounded by grids, through which the dirt and motes are thrown.

This machine has had a considerable run, and has been produced in the double form, as shown above, and is said, by the makers, to be capable of getting through 40,000lbs. of cotton per week. There is no doubt that that quantity of cotton may be *put through* the machine in the time named, but no wise spinner ought to attempt any such thing.

It has also been constructed in connexion with a scutcher, to which the cotton traverses and comes off in a lap. This arrangement has certainly one advantage, viz., that the cotton put through is limited to the quantity the scutcher will do; for although this opener will get through a large quantity of cotton *per diem* if given to it, when forced, like all other openers and scutchers, there is danger of stringing.

OPENING OF EAST INDIA COTTON.

This cotton comes packed so tightly in bales, screwed down by hydraulic power, that when taken out it is so matted together as to make it very difficult to separate without breaking some of the fibres.

In reference to Plate VII., showing the fibres of cotton greatly magnified, it will be seen that cotton is to some extent tubular, and must therefore be flattened with the enormous compression to which it is subjected, and, to a certain extent, injured.

In order to restore it to its original state, an ingenious Cotton Steaming Apparatus

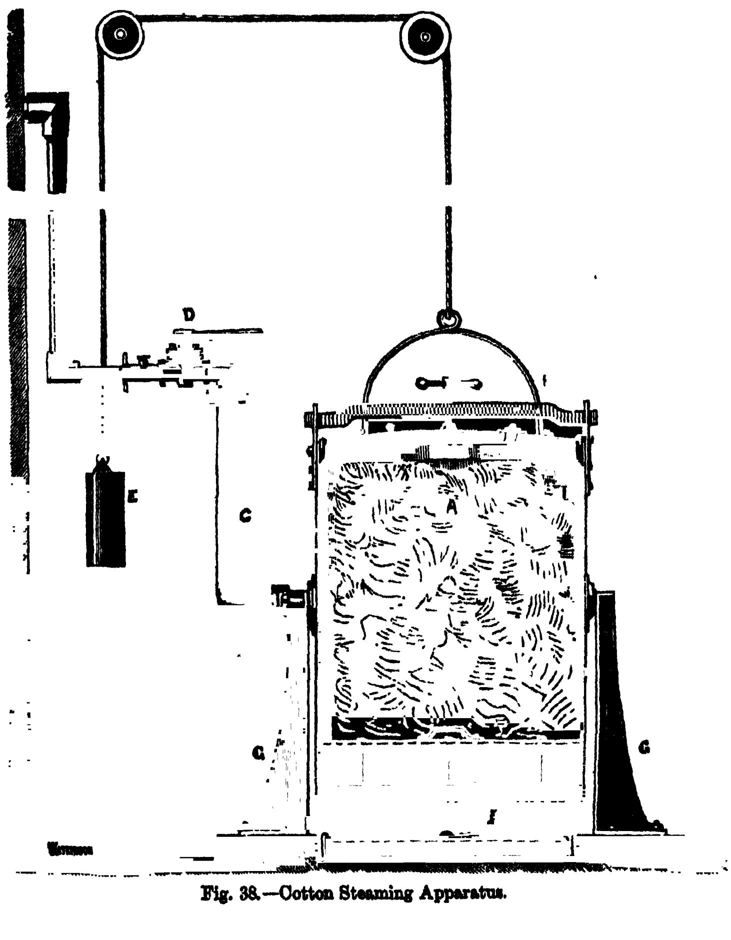


Fig. 38.—Cotton Steaming Apparatus.

was invented, a few years ago, by Mr. Wanklyn, of Bury. It consisted of an iron cylinder, about 24in. diameter, and about 34in. long, hung on gudgeons, a little above the centre. Through one of these gudgeons a steam pipe is passed to the bottom of the vessel, which is furnished with a perforated plate about four inches high, and a lid at the top, which is made to screw down after the vessel is filled with hard lumps of cotton as taken from the bale. High-pressure steam being then turned on for about one minute, a wonderful effect is produced upon the cotton by the expansion of the fibres and opening of the lumps, without wetting the cotton, as might be supposed, the water arising from condensation, which is very small in quantity, being retained at the bottom of the can, and drawn off by a tap. After this treatment, the tightly compressed East India cottons are said to card and spin much better, and can be mixed with other cottons in the scutching room more freely.

LORD'S PATENT COTTON OPENER.—This machine has a beater B with seven crossed arms fixed on a horizontal shaft, as seen opposite (*Fig.* 39). These arms are of cast iron, with steel plates bolted firmly to the ends, the first being about 18 inches and the last about 28 inches diameter, so as to form a sort of cone, and are surrounded by a conical

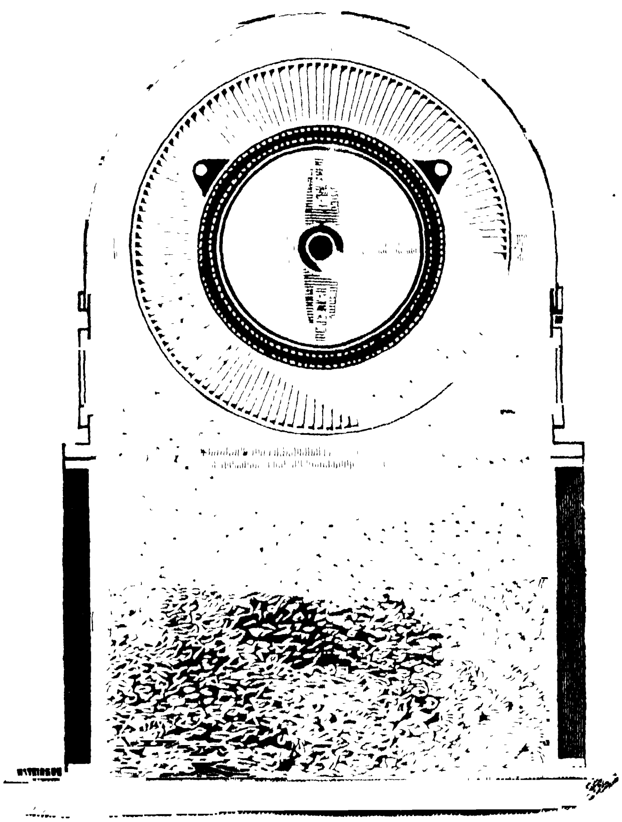


Fig. 40.– Section of Lord's Patent Cotton Opener.

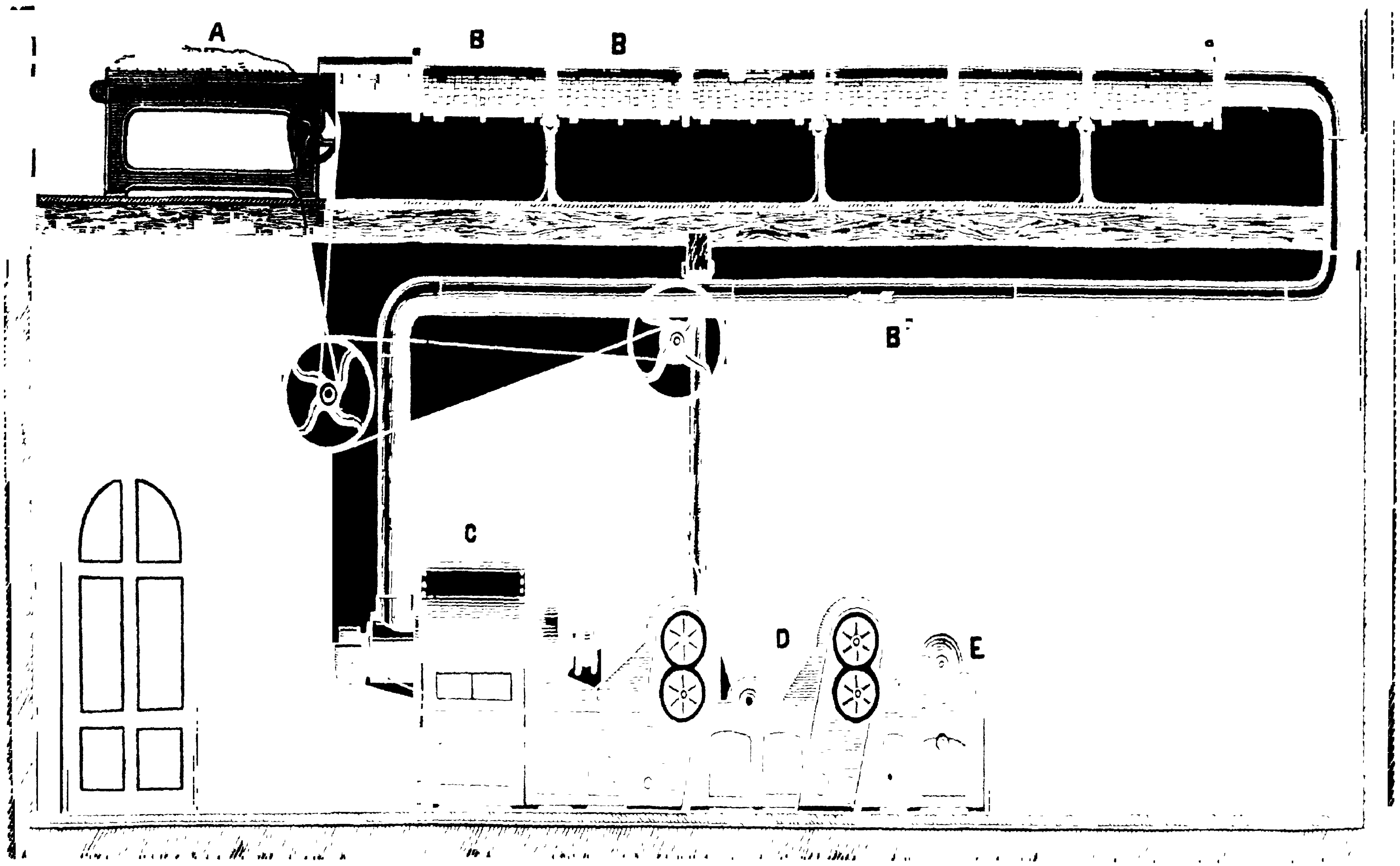


Fig. 42.—Lord's Patent Opener and Scutcher, with Pneumatic Tube.

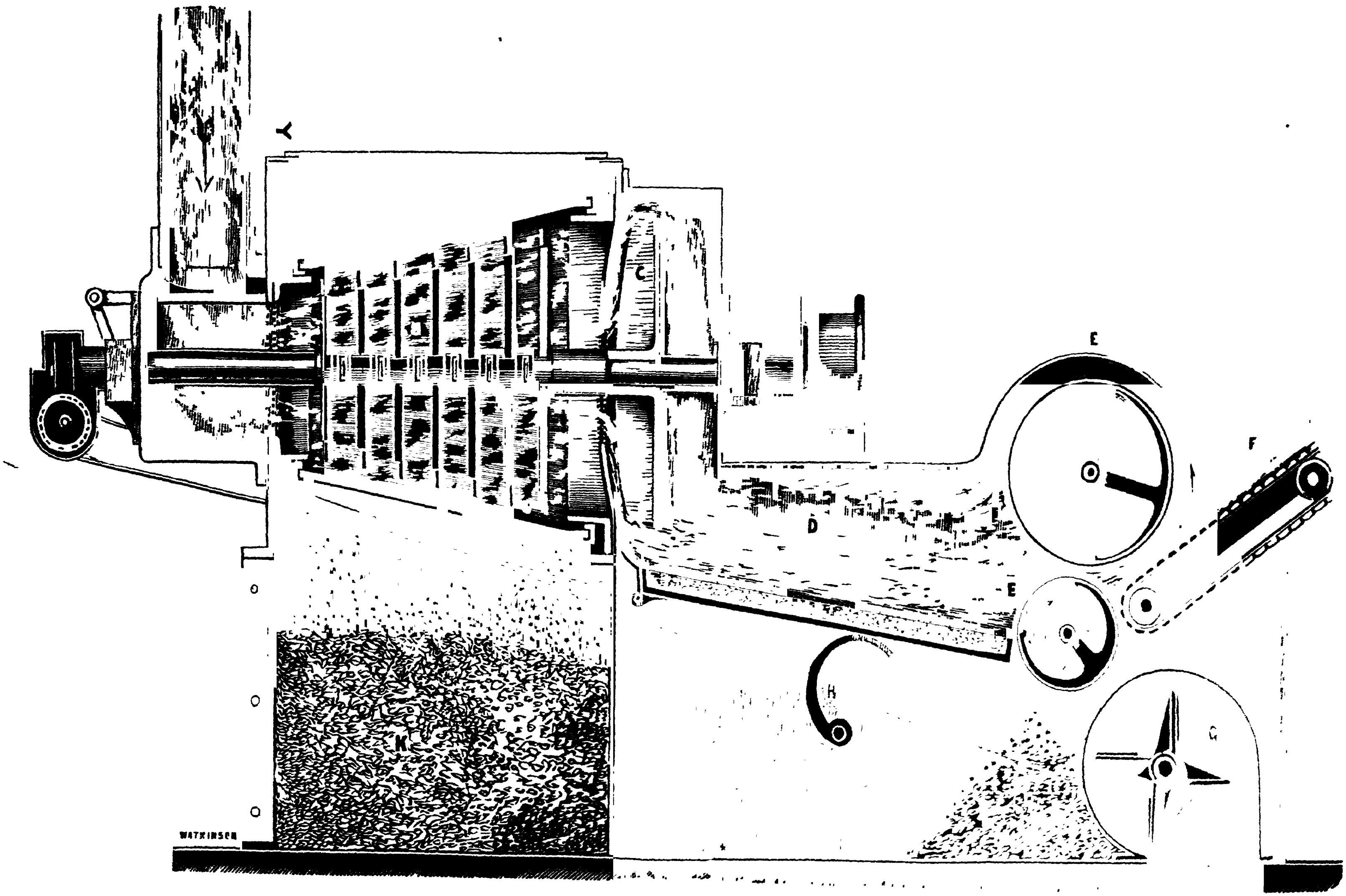


Fig. 39 —Lord's Patent Cotton Opener

grid. The bars of this grid are stationary at the delivery end, but capable of adjustment by the lever I, at the smaller or feeding end, to vary the distance of the grid from the beater, according to the nature or quality of the fibres to be opened. At the upper end of the beater B is a disc fan C, a plan of which is shown at *Fig.* 41. This

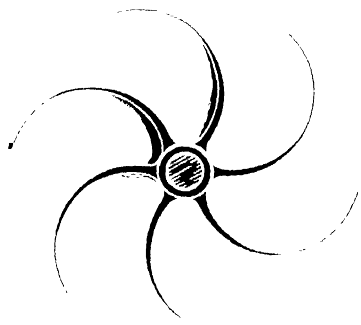


Fig. 41.

fan and the fan G, which exhausts the dust cages E and E1, draw the cotton with great force through the machine from the feed pipe A, which may be extended a considerable distance to the cotton mixing room, as mentioned under the head of "Cotton Mixing." The sickle H holds the hinged bottom of a dust box, which can be let down to discharge the motes and dirt that escape being deposited in the box K.

A further illustration is given in *Fig.* 42 of this scientific application of pneumatics to a useful purpose, in which the cotton, instead of being carried away by the endless creeper F, and deposited in a loose state, is passed through another beater, and comes out in the form of a lap.

On reference to the above it will be seen that the cotton is fed on the creeper at A, which carries it to the mouth of the trunk or funnel B B, when it is immediately carried away by the current of air through the grated trunks and pipe B 1 to the machine opener shown in sketch, which is exactly the same as the one already described except the extra beater and lap machine attached, as seen at D E. Although the feed part of the machine is represented here in the room above the opener, it must be understood, as before explained, that it may be a hundred yards or more off if required, and in any direction, above or below.

THE PORCUPINE OPENER.—This has two horizontal cylinders, with teeth, as shown below. The first of these cylinders, marked A (*Fig.* 43) has twelve rows of cast-iron teeth; and the second, A 1, which is set immediately to follow, has only four rows of teeth. These beaters or cylinders run about 1,000 revolutions per minute. The raw cotton from the bales being fed by hand, on the lattice in front, which moves at the rate of about six feet per minute, is drawn through the fluted feed rollers to the cylinder beaters, and passes over the stationary grid D to the dust cages B, B1, which are exhausted from the interior in the usual manner by the fan C. It then passes through the pair of rollers E, and is carried away by the creeping lattice F, which has a surface speed of about 60 feet per minute, the same as the dust cages B, B1, and the stripping rollers E. The stationary grid D is fixed on the top of a box, the bottom of which is hinged and held in its place by the lever G, which is occasionally removed to let out the motes and leaf as they accumulate in the box.

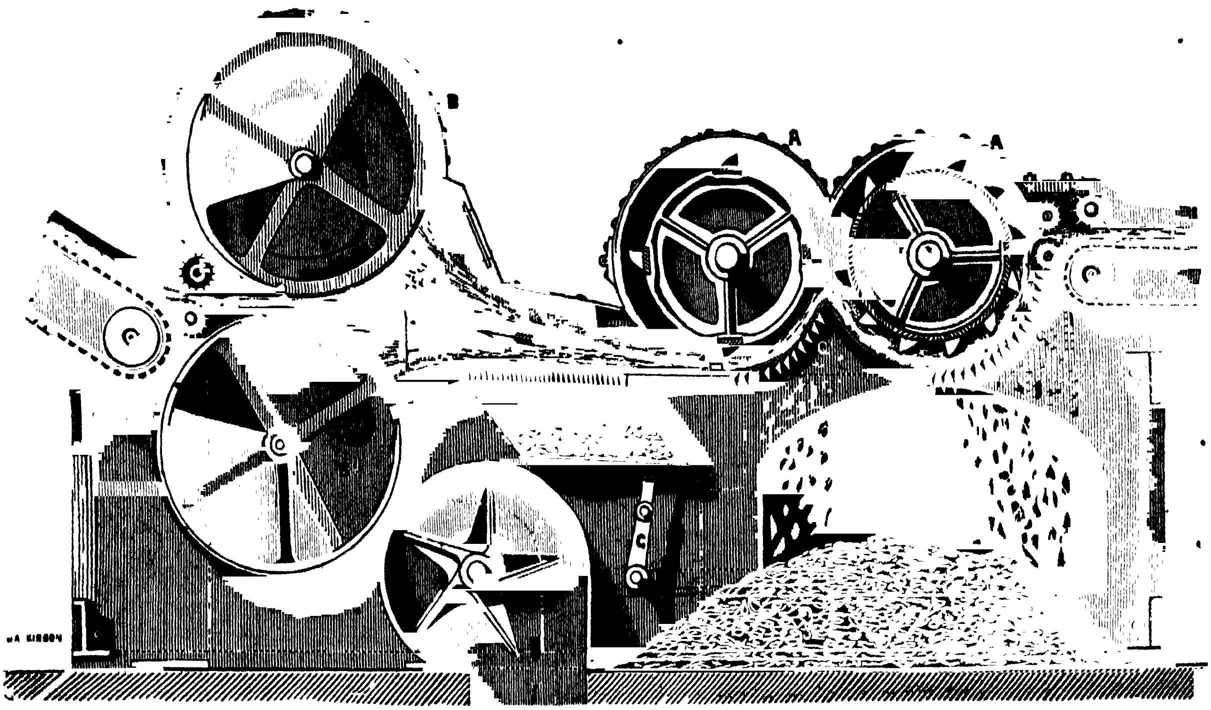


Fig 43 —The Porcupine Opener.

A plan of the cylinder or porcupine beater is shown at *Fig.* 44.

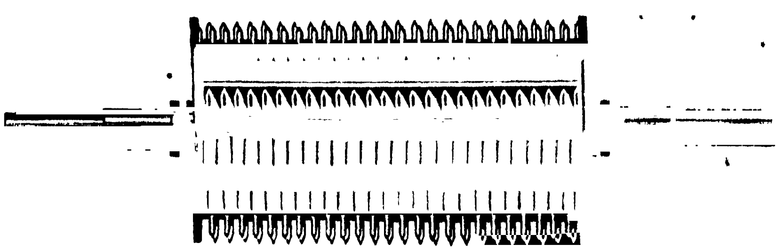


Fig. 44. —Cylinder of Porcupine Opener.

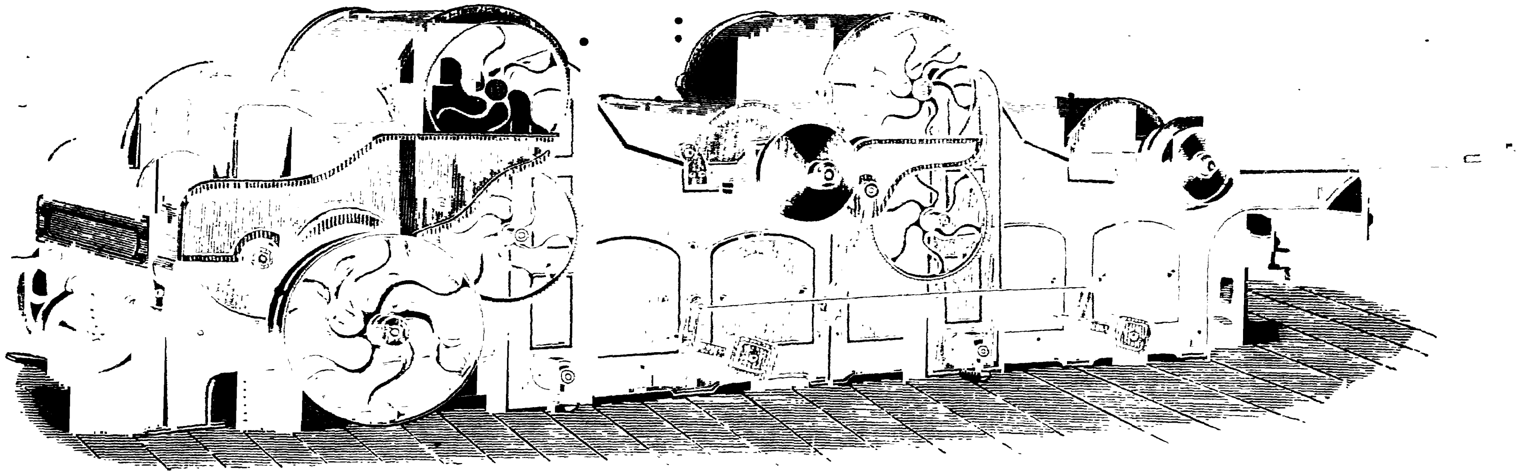


Fig. 45.

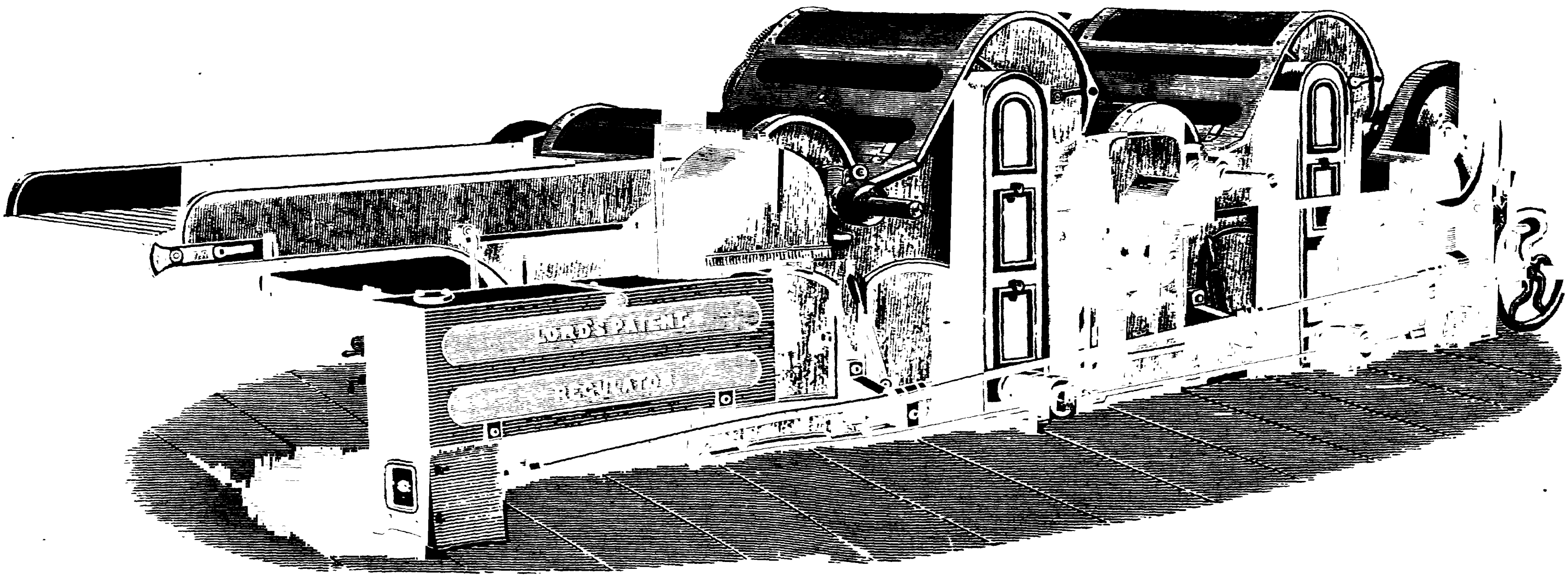


Fig. 46. External Views of Double Scutcher with Lap attached, as made by Howard and Bullough.

This plan of one beater being placed immediately behind the other seems plausible. If examined practically, however, the advantage of the arrangement vanishes, as the cotton after it leaves the first beater is drawn rapidly forward by the action of the fan; and as it is going along at about the same speed as the periphery of the second beater, the latter can have but very little effect upon it.

THE SCUTCHER.

After the opening machine comes the "scutcher," or "blower,"—termed generally "picker" in America,—about the principle and general build of which public opinion seems now to be definitely settled, and machinists differ very little one from another in the construction of this machine, a fair type of which is given opposite, in *Figs.* 45 and 46.

Although the general outward appearance of the different builds of Scutchers is much the same, still there are some details, of considerable importance, which should not be carelessly passed by; therefore, in order that the student may thoroughly understand this machine, and observe what constitutes its excellencies or defects, a number of sectional drawings, showing the internal arrangement by different makers, will follow.

It will be noticed that there are several plans of leaf extractors shown in these machines. About these it may be observed, that those which clean themselves automatically, whether by vibration or otherwise, are all good,—far better than when the bars are stationary and boxed up, the simplest method being probably the best. In one example of these various scutchers the feed rollers are placed considerably above the centre of the beater, which is an undoubted advantage, as more of the fixed grid in front of the beater thereby comes into play, and the beater knives, which strike the motes and seeds with great force as they come through the feed rollers, have a fair chance of driving them through the bars immediately in front, whereas in the general mode of placing the centre of the feed rollers in a line with the centre of beater, two or three of the best bars in the grid are lost for any useful purpose. It is a good plan, also, to have serrated edges on two or three of the first bars in the grid, which assist materially in opening the cotton and loosening the seeds and dirt.

In regard to the dust fans, a new plan has recently come out of having half fans, being vanes cast on a disc—one on each side—by which a more equal draft appears to be produced. This disc fan is similar to the one illustrated on page 64.

The first section (*Fig.* 47) is that of a Double Scutcher, with internal arrangements for extracting leaf and dirt, according to Lord, as given opposite. This machine, which is for making first laps, has the lever or piano feed motion, with single roller, but without the regulator attached; and the first feed roller, F, is placed above the centre of the cylinder beater A, in what is considered a favourable position to allow the beater to knock out the dirt through the bars G; whilst the second beater A1 is not so favourably situated to the action of the grid G. The leaf extractor is of longitudinal bars, and the bottom of the box is held up by a sickle, which lets it down for cleaning out, as shown. The first beater, A, has eight rows of teeth, and the second beater, A1, is an ordinary two-knife beater. The top dust cage, B, is about 20 inches diameter, whilst the lower one, B1, is only about 12 inches diameter. It will be noticed also that the top cover is set eccentric from the cage.

Fig. 48 shows a front view of LORD'S FINISHER SCUTCHER, exhibiting the action of the self-regulating feed, commonly called the Piano Motion. *Fig.* 49 is a side view of the same; and *Figs* 50 and 51 show the levers and rods. Referring to *Fig.* 51, it will be observed that the short end of the lever C hooks under the feed roller; and the extreme end of it is either beveled off sharp (as shown) to suit short-stapled cotton, or rounded off if the staple be long, so that there will be a greater distance between the nip of the feed roller and the beater. The action of the piano motion is thus, viz.:—When a lump of cotton comes under any one of the levers C, it presses it down and raises the rod D. All the rods D are tapered at the bottom, and pass between two plates or castings of the trough form. Between each of the rods D is placed a small bowl, as shown in dotted lines, *Fig.* 50. Now it is evident that if any of these rods are lifted, the taper part, coming between the bowls, thrusts the whole of the pendant rods D aside, and the loose bowls also; but as the rods are only free to move in one direction, the last of them, which is slotted to hold a connecting rod E, is immediately thrust aside, when it shifts the cone strap through the lever F, as seen in section of cone box, *Fig.* 49. By placing a sector wheel H at the short end of the strap lever, it moves another similar strap lever, as seen, and the strap is guided close to each of the cones K and L, the latter of which gives motion to the feed roller N through the worm M. By this very scientific and ingenious arrangement, the slightest variation in the thickness of the feed is instantly indicated, and every lump of cotton which passes under any of the levers C, is felt, and has its proportionate effect in regulating the feed.

Mr. Lord has recently brought out another method of self-regulating feed to do without the cones and strap. This has not been sufficiently tried to find a place here, but will be illustrated further on if it proves a success.

The next example *(Fig.* 52*)* shows section of a Single-beater Finisher Lap Machine on Crighton's principle, in which it will be seen that the beater A has two knives; and the feed rollers E are placed a little above the centre of the beater. The leaf extractor D is a travelling lattice with transverse bars, between the interstices of which light leaf is collected and emptied out under the machine as it revolves in the

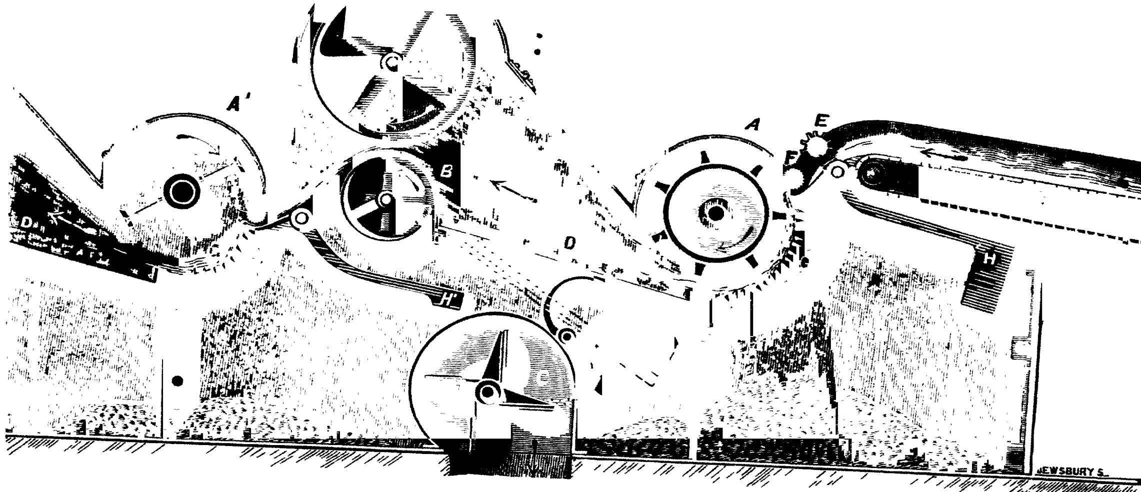
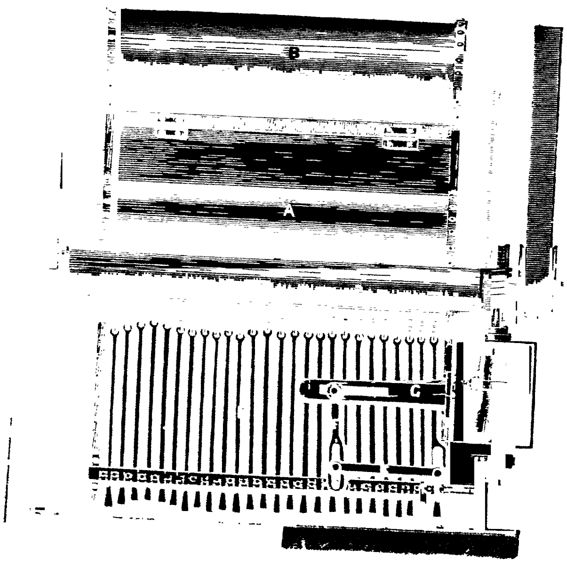


Fig 47 Section of Lord's Scutcher (Scale ¾ inch = 1 foot)



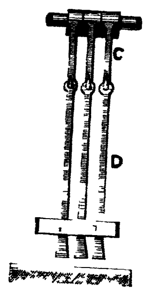


Fig 50

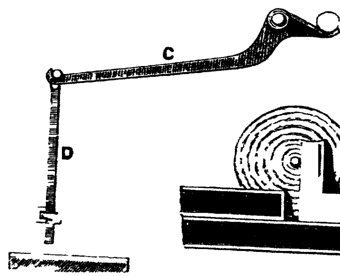


Fig 51

Lord's Feed Regulator

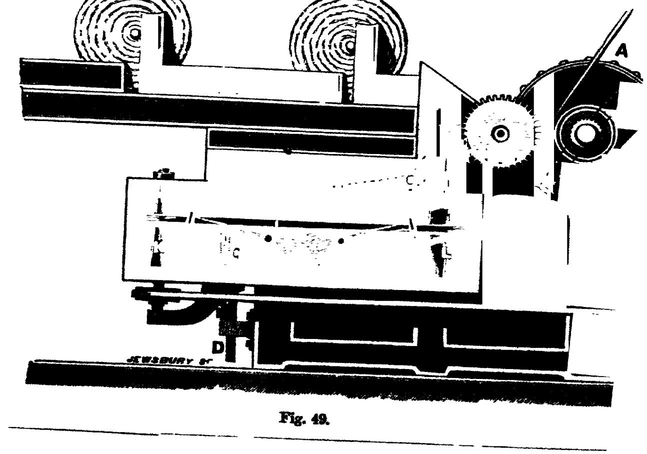


Fig. 49.

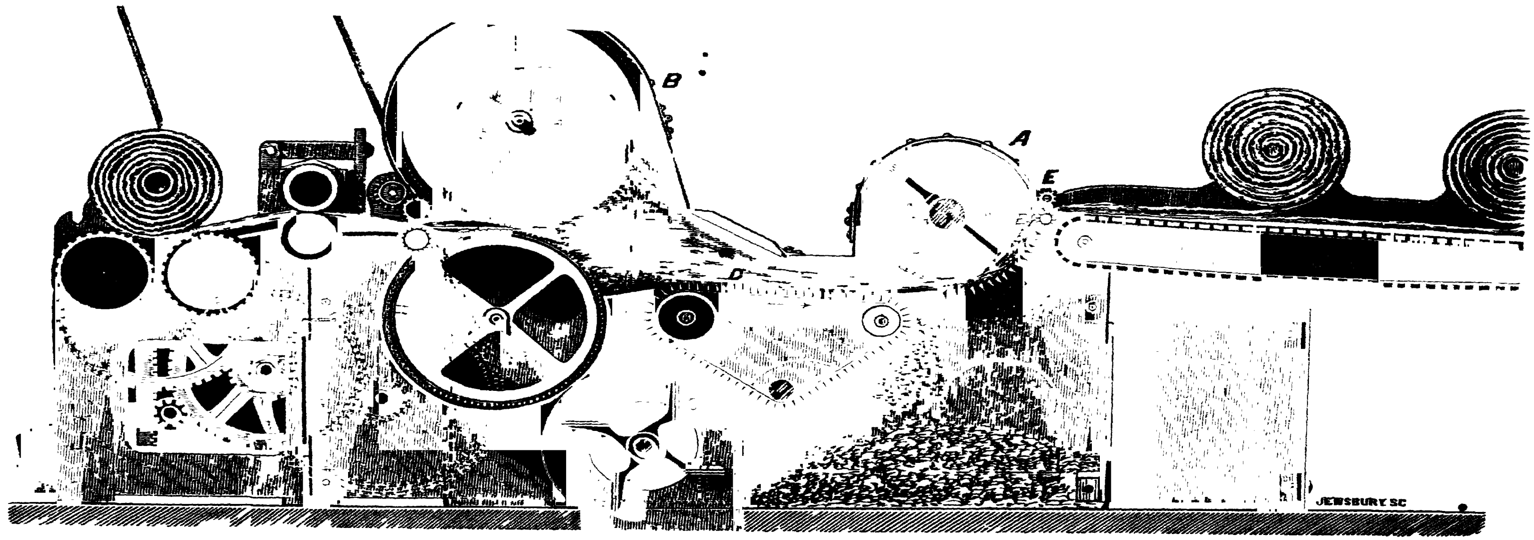


Fig 52 —Section of Single beater Finisher Lap Machine on Crighton's Principle

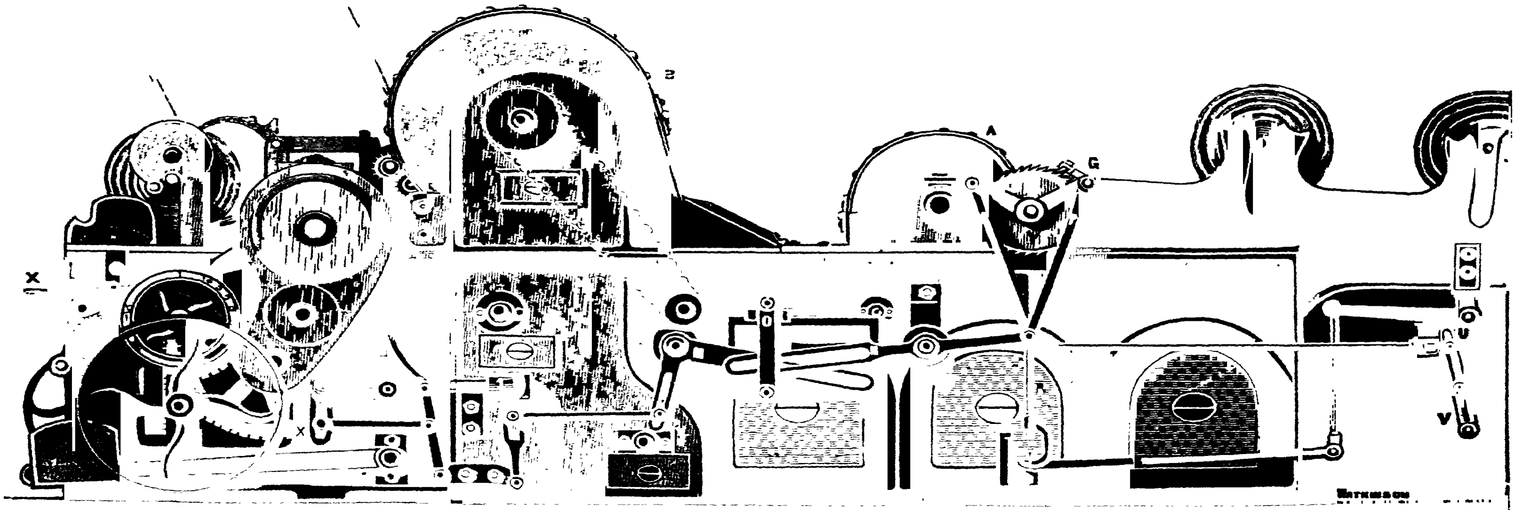


Fig. 53.—Side Elevation, showing Crighton's Feed Regulator (Scale ¾ inch = 1 foot).

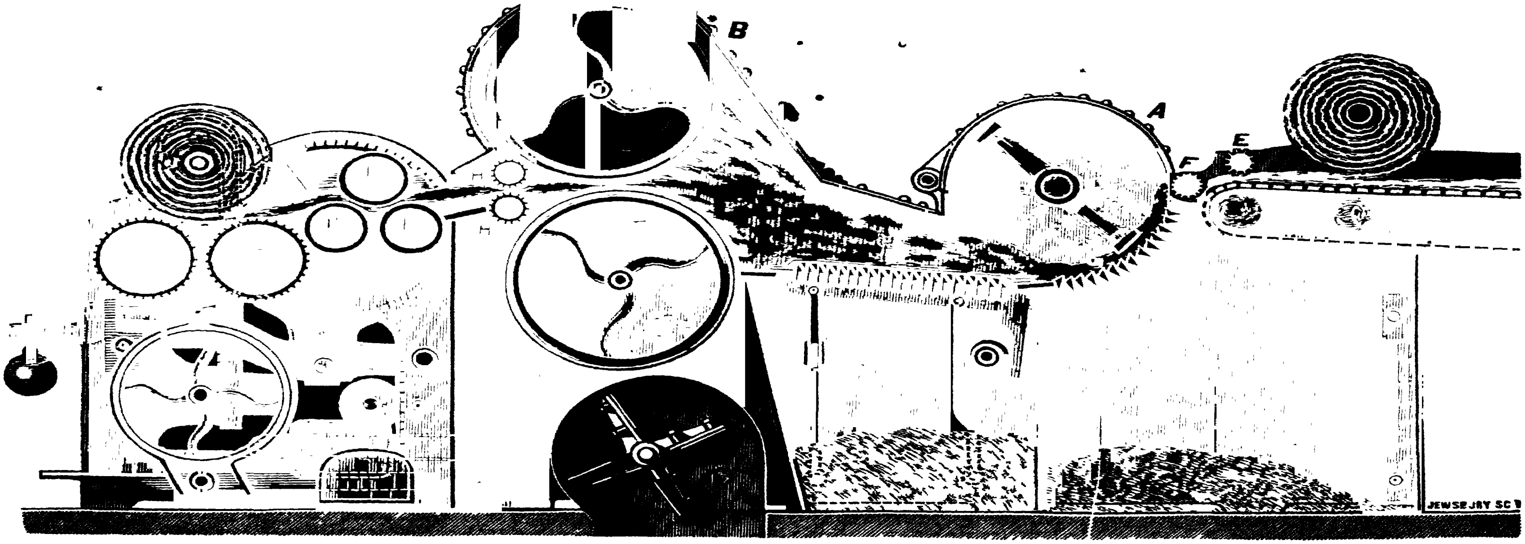


Fig 54 (Scale ⅜ inch = 1 foot)

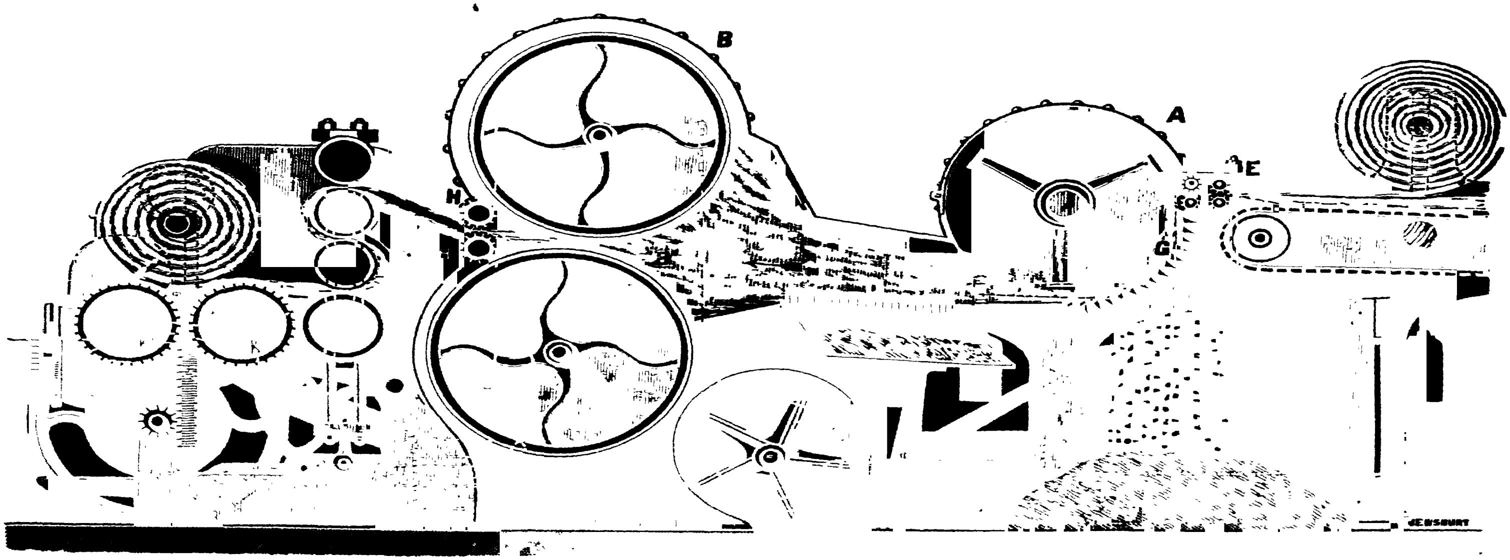


Fig. 55.—Finishing Lap Machine (Scale ⅜ inch = 1 foot).

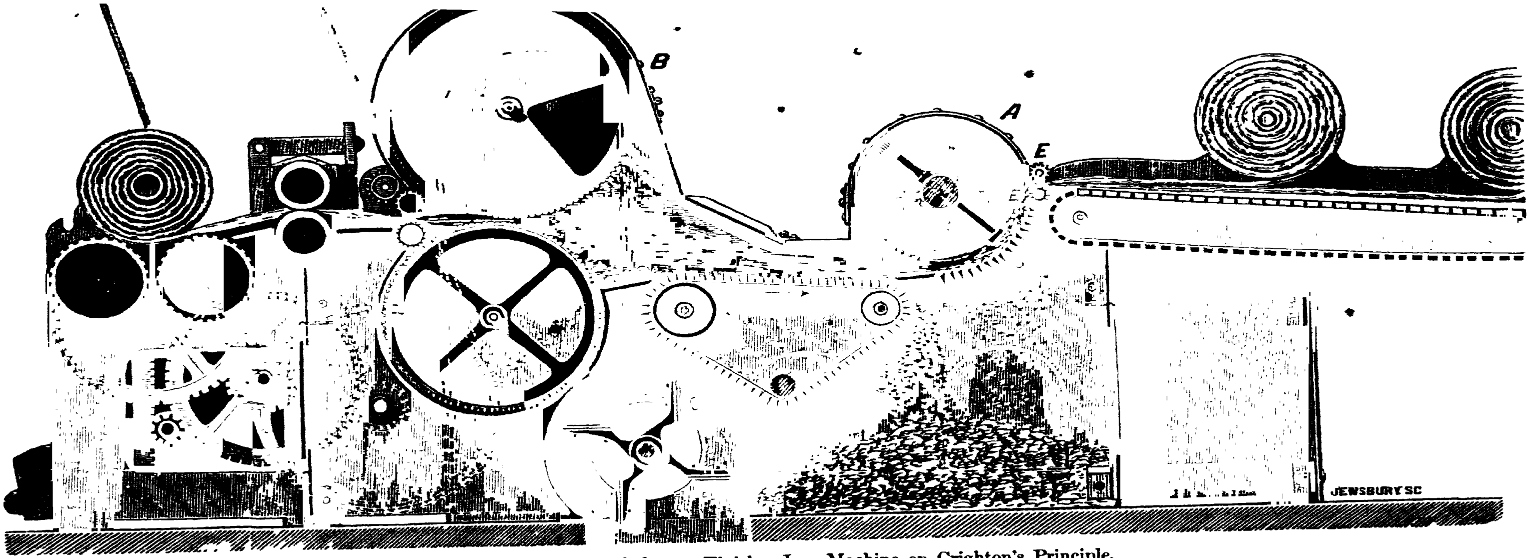


Fig. 52.—Section of Single-beater Finisher Lap Machine on Crighton's Principle.

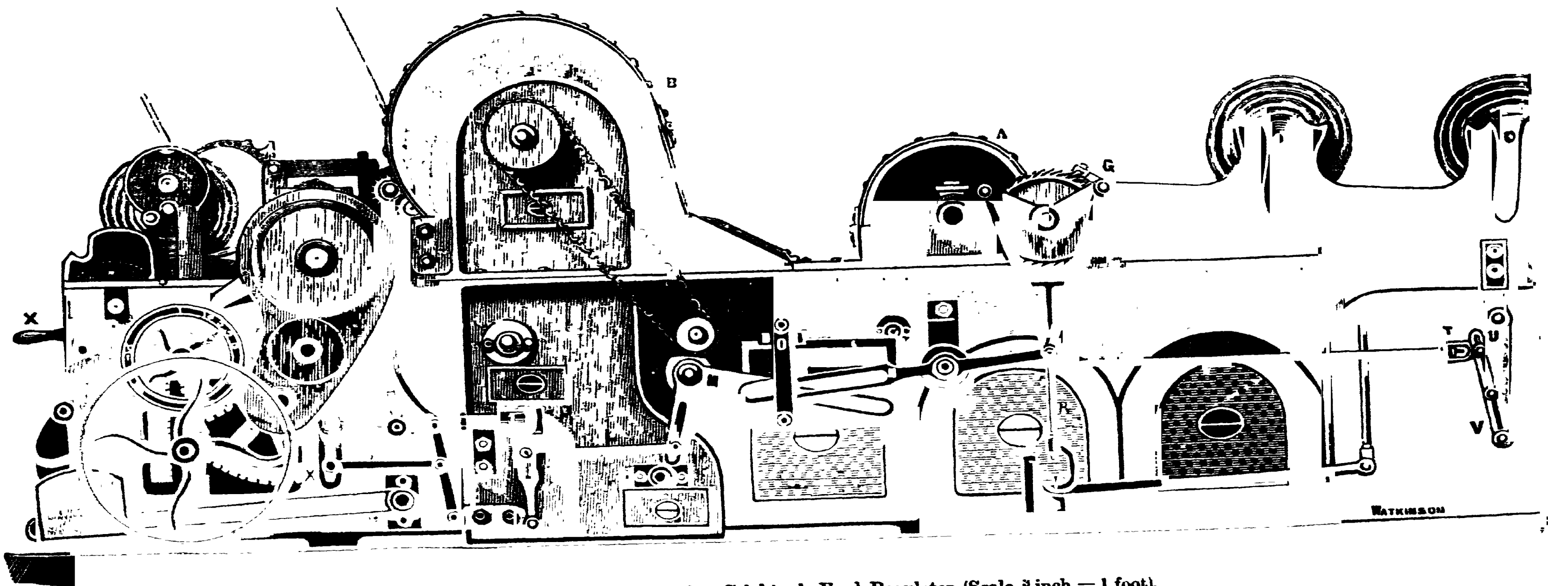


Fig. 53.—Side Elevation, showing Crighton's Feed Regulator (Scale ⅜ inch = 1 foot).

opposite direction to the course of the cotton. In this example the upper dust cage B is about 22 inches diameter, and the lower one 19 inches; and there is only one pair of heavily-weighted callender rollers to condense the cotton before it goes on the lap.

A side elevation of this machine is shown in *Fig.* 53, that also exhibits Crighton's Feed Regulator, which acts thus:—H is a small mitre wheel on the first motion shaft which drives the cam I through another small mitre made to slide in and out of gear on moving the lever X, when the lap knocks off. When in motion the cam I oscillates the levers K and M through the connecting rod L. The lever M transmits its motion to the compound lever N through a movable pin or slide O. This compound lever has two connecting rods, P and P1, which operate on two catches fixed on the ends of two loose arms that rest on the feed roller end. These catches take into the ratchet wheel Y, keyed on the bottom feed roller, to which they give motion by both up and down stroke. When too much or too little cotton comes under the feed rollers, the rod R is lifted or dropped; and through it the lever S which, having a short fulcrum, multiplies the space considerably, and transmits its motion through the levers T, U, V, and the connecting rod W, to the movable pin or slide O, which slackens the feed or increases it, as the case may be.

Another example (*Fig.* 54) is section of a Finisher Lap Machine as made by several makers. It has a triple knife beater (18 inches diameter), a stationary box leaf extractor with a let-down bottom, dust cages of equal diameter (about 23 inches), and four callender rollers to condense the cotton before being rolled up into a lap. It has two pairs of plain fluted feed rollers, to prevent slipping or snatching of the cotton. It is hardly necessary to refer in detail to all the letters in the figure, as it will be understood from the preceding descriptions. It may, however, be remarked that the plan of condensing the cotton by four callender rollers, by which the cotton gets pressed three times before being rolled on the lap, appears to have some advantage and works well in practice.

The next illustration (*Fig.* 55) is section of a Single-beater Finisher Lap Machine, which differs in several particulars from those previously described. The first point is in the feed roller, which is a single roller *a* (*Fig.* 56) working in a shell *b*, which will be understood on reference to the enlarged drawings below.

A

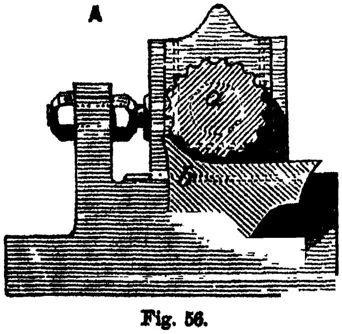


Fig. 56.

B

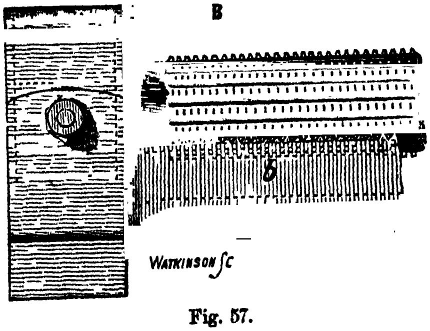


Fig. 57.

C

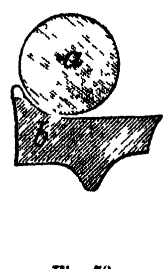


Fig 58.

D

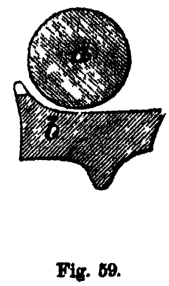


Fig. 59.

The shell *b* (*Fig.* 56) is serrated on the edge, and being set up to the beater, is screwed down fast to the framing. The pedestal which carries the feed roller *a* is made to move independently of the shell *b*; and for short-stapled cotton is set close up to the edge of the plate, as seen in *Fig.* 58, but for long-stapled cotton is set as in *Fig.* 59. The serrated edge of the shell *b* may be best seen in *Fig.* 57, and is supposed to have a rough combing action upon the cotton, which contributes somewhat to loosen the leaf and dirt, and more effectually break it up. The feed roller *a* is what is technically termed a "dog-tooth" roller, which is made by fluting the roller first with a deep, coarse pitch flute, and then cutting grooves in it the whole length of the flute (as shown in *Figs.* 56, 57), which converts it into a sort of spiked feed roller. This kind of feed roller has many excellent properties, and ought invariably to be used in scutchers in place of fluted rollers. A pair of such rollers would be quite as effectual in preventing snatching as the two pairs of fluted rollers shown in *Fig.* 55.

The next thing to be noticed in *Fig.* 55 is the vibrating grid D, which is supposed to clean itself, being operated on by the cam or snail L. It will be seen that this machine has three callender rollers; the top one being heavily weighted, the cotton gets pressed twice. In practice the serrated edge of shell, or feed roller dish, has worked well, but it has been found to wear away fast when made of cast iron. This defect might probably be remedied by having a steel plate with a serrated edge screwed on in front of the dish *b*, which after being finished, could be case-hardened, and easily changed when worn out.

The right and left hand view of a modern scutcher here exhibited shows the external appearance of this machine as now generally manufactured. It has, however, only arrived at its present state of perfection by slow degrees. When first brought out by Snodgrass it had simply a travelling lattice to take the cotton away as the beater delivered it. The next improvement was the addition of a fan, placed overhead, and *one* dust cage or perforated cylinder, which was a great improvement. After this the lap machine was attached by Crighton, of Manchester, which saved the hand feeding of the carding engines. Next came one or two important improvements by Lord, of Todmorden, who placed the fan below within the machine itself, and added a second dust cage, thereby dispensing with the creeper lattice between the beater and dust cages, which made a much more perfect and complete machine; and, finally, the same inventor added the self-regulating feeder, which brought the machine up to its present state of perfection.

It will be seen from the preceding illustrations that in all blowing rooms, as at present established, the finishing lap machine is fed by three or four laps of cotton from the first lapper, with the idea of getting a more perfectly level lap at last. Theoretically this looks right, but practically the evenness of the finished lap depends very much on the action of the fan and dust cages. If the draught happens, from any cause, to be stronger on one side of the dust cages than the other, the finished lap will be thicker on the side where the draught is greatest. There is another cause of irregularity, which is not suspected, in finished laps made in this way, viz., the expansion of the first made laps from the preparing scutcher. Sometimes it happens that there are a number of laps on hand from the first machine; these laps are continually expanding, the older they are the thinner they become. After the mill has been stopped at meals the finished laps will be lighter for a time; they will also be irregular, from the three or four laps fed to the finishing machine moving off at once, or nearly so, as the top part of a lap is always thinner than the bottom from the same cause—expansion. Singular as it may seem, a much more even lap may be made upon the first machine, where a regular given weight is fed upon a given length of the lattice feeder, than can be made upon the finisher machine, fed from three or four laps doubled. Even if the cotton be fed on one side of the first machine, or in a zigzag line, no matter, provided the right weight be put on as the lattice feeder moves, the lap will be regular in all parts. As the revolving dust cages draw the cotton against them, wherever a bare place presents itself it immediately gets patched over by cotton delivered from the beater; and as soon as a bare place on the dust cage gets covered, the draught ceases at that point, and the loose cotton flies to the next bare place, no matter from which side of the beater it is delivered.

From the foregoing remarks, and what has been said generally of the mischief occasioned by the overfeeding of scutchers, the reader will be prepared for the very strong and, what may seem, singular opinion, that cotton is best when opened and finished at one operation, so far as the scutching room is concerned, or at the most at two operations, viz., the opener and the lap machine. At the first blush this may seem erroneous, but it will bear examination; thus:—

Suppose a mill is producing 16,000 lbs. of yarn per week, and, besides the cotton openers, there are four double-beater lap machines, two of which are used for first lappers, and the other two for finishing machines, being fed by three or four laps from the first; in this case each machine will have to scutch 8,000 lbs. per week (besides the loss in spinning), the beaters in all these machines making, say, 1,500 revolutions per minute. Now if all these lappers were so altered, that the feed rollers were run at only half the speed, the beaters being kept at 1,500 revolutions per minute, as before, the cotton would get just the same amount of scutching, with these important advantages, viz.: 1st. The cotton would never get stringed, as it would be sucked away from the beaters at once to the dust cages. 2nd. The dirt would be more easily extracted, as the beaters could strike it out better than when crammed through at double speed. 3rd. The machines would take far less power than when coming in contact with a thick layer of cotton like three or four doubled blankets pushed rapidly through. 4th. The feed rollers could be set closer to the beaters without the cotton being jammed between them and the beaters. 5th. There would be less hurry in the room and less labour required. 6th. The cotton would be certain to card better, as no neps would be made from stringing. Practically, the feed rollers might go at less than half speed, as the loss of time in taking off the laps would be reduced one-half, as well as the labour in carrying them about the room and feeding the machines a second time. Any spinner who doubts the accuracy of the above reasoning may soon convince himself by trying the plan with one of his scutchers, which can be done by simply altering the feed rollers to about 7-16ths of their former speed, setting the feed rollers up a little closer to the beater at the same time. If the machine has a good "regulator" it will make a much more uniform lap than before; if it has not, the cotton must be weighed when fed by hand. If a comparison be made at the carding engine between a lap so made against one on the ordinary plan, the difference will be sufficiently striking to convince the most sceptical.

Lap Selvages.—There are few things in a mill of greater consequence than good lap selvages. When they are jagged and torn a great waste ensues at the carding engine by the continual dropping of cotton fibres at the ends of the doffers. Sometimes the fibres curl up and form little lumps, after which they leave the comb and come off in the web, making an uneven place, which causes cloudy drawing, and those which fall either accumulate on the web plate until caught up and carried through, or fall on the floor to be converted into sweepings, which, besides making untidy work, amounts to a large loss in the aggregate. These jagged selvages arise from the faulty construction in the lap machine, and are produced thus:—The dust cages of lap machines have usually brass hoops at each end, soldered on to secure the wire web. These sheet brass hoops, as at present put on and used, are a source of infinite mischief, causing spinners a large amount of loss annually that might just as well be saved. If, instead of the sheet brass hoops, wrought-iron hoops were shrunk on and turned up true to a given diameter, and the framing of the machine sufficiently recessed, as seen at *Fig.* 60, in which A represents the framework, D the dust cage, C the hoop turned up true, and working in a recess in the framework A, with a margin of about 1-16th of an inch clearance all round. Being bored out 1-8th of an inch larger in diameter than the hoops, the selvages of the laps would be as thick as any other part, with corners as sharp as if cut with shears. The reason

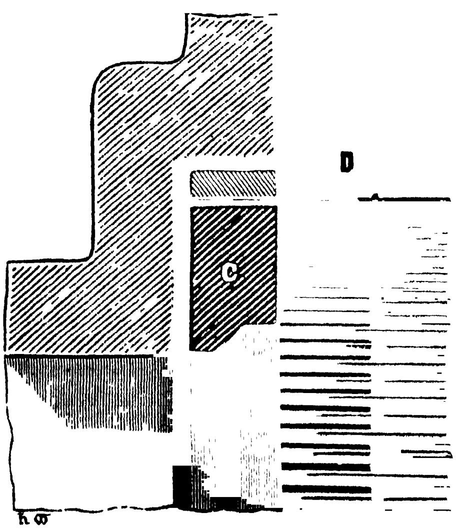


Fig. 60.

of this is that there is a margin of 1-16th of an inch of draught space round the hoop, which, together with the hoop being hid entirely in the recess, causes the draught of the fan to act close up to the framing, and produces, with certainty, this important result. In boring out the recess it becomes more perfect still if the framing be faced up true where the dust cages act.

It unfortunately happens, however, that most of the lap machines at present working have the dust cages only just long enough to stretch across the machine, hoops included, and have the ends made up with a strip of leather, as seen at B, *Fig.* 61, in which A is the framing, D the dust cage, and B the leather or segments of wood, screwed to the framing, the acting part of the cages, or wire gauze, being narrower than the lap. Now as no air can be drawn where the hoops are, the edges of the lap are torn by being dragged along the leather stopper or wood segments as the case may be. Where such is the case it would pay the spinner to have longer cages made and cut the framing, so as to let the hooped ends in, care being taken to turn them up true; and where this cannot conveniently be done, the next best thing is to line the framing with polished iron plates, the same thickness as the breadth of the hoops on the dust cages, leaving the margin of 1-16th of an inch between the hoops and the plates. A good selvage can be made in this way, and if the laps are then too narrow it is much better so than with jagged edges. Above all, however hooped, the ends of the dust cages should be turned true, and the plate or recess fitted as above described.

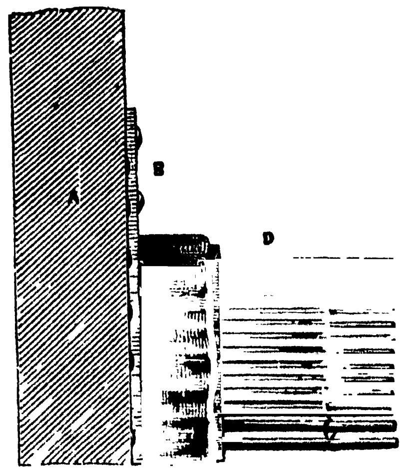


Fig 61

The dust cages should be so fixed that there is a space of 3-4ths of an inch between the two cages, so that the cotton passing between them will not cause too great a pressure up and down, and they can revolve with ease. This will also admit of the iron plate which guards the ends passing between them; thus in *Fig.* 62 A is the framing, A 1 the polished metal plate, D the dust cage, and C the hoop working in the recess formed by the plate A 1.

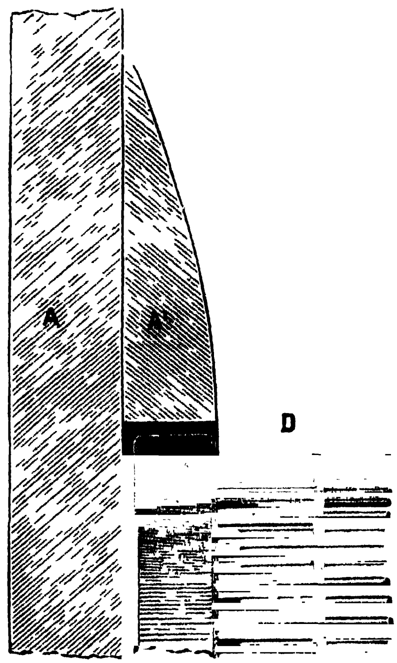


Fig. 62.

In the section *(Fig. 63)* drawn to a smaller scale, D is the upper dust cage, D 1 the lower cage, A 1 the front plate, and B the back plate.

It is hoped that this diagram will enable the reader to understand thoroughly this important point. Care must be taken that there is a back plate B as well as a front plate A, and the two must meet together, forming a close joint between the two cages, as shown at D 1. When the back plate B is omitted, cotton is apt to be drawn through by the fan after it has passed the point D 1, which is the case in those mills where bits of cotton are seen flying about the premises, and falling like flakes of snow, in a slovenly manner.

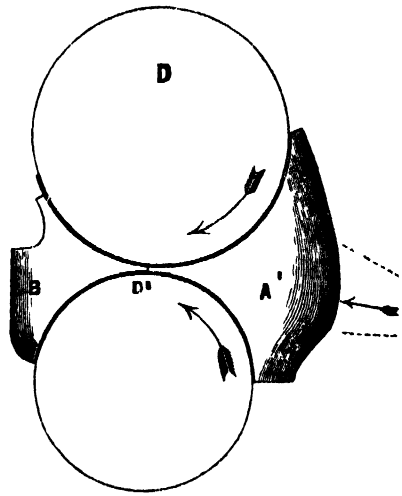


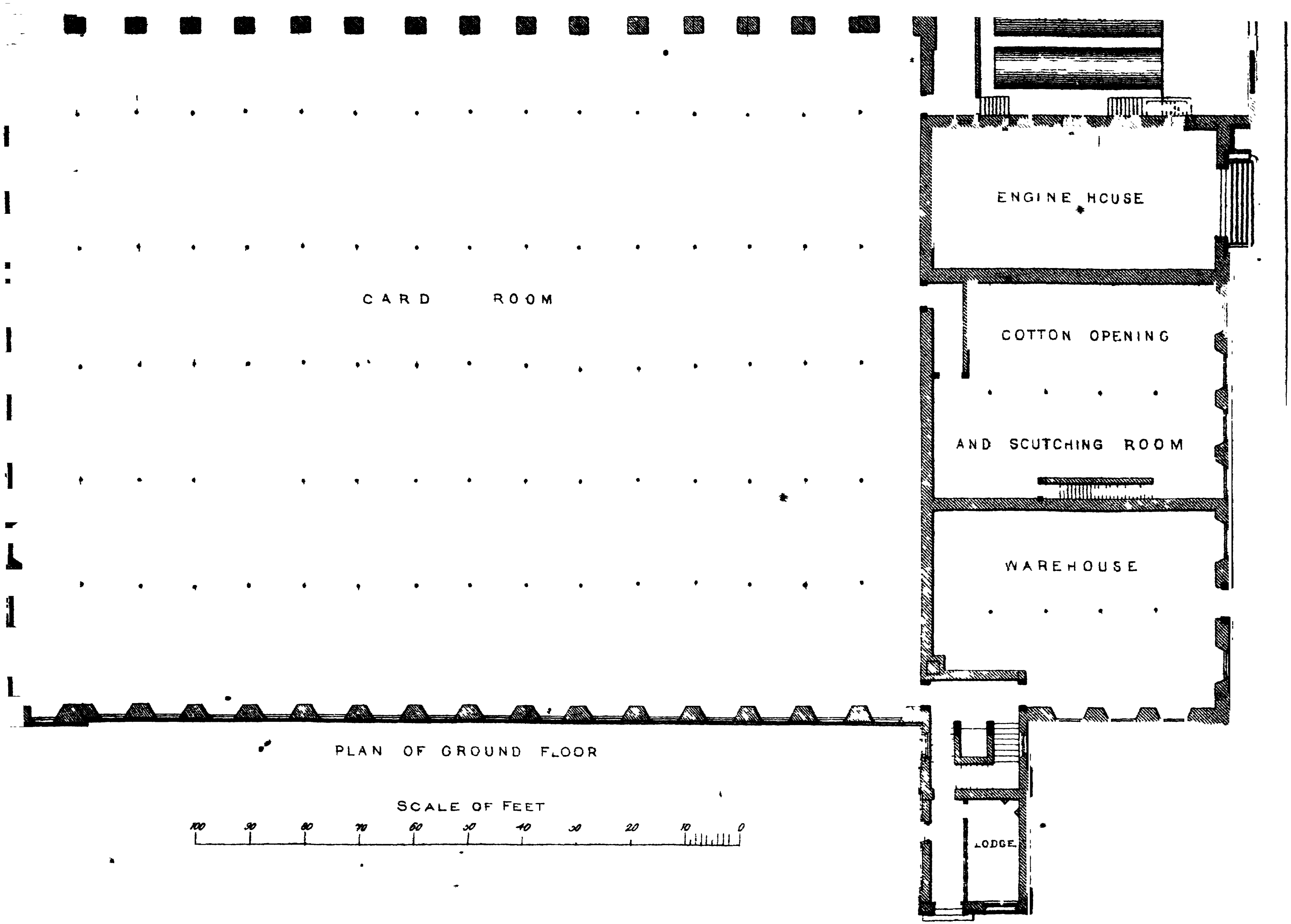
Fig. 63.

In new machines the hoop C *(Fig. 60)* should not only be turned true and run within the framing, but the latter should have a facing cast upon it to admit of planing where the dust cages fit in, which will make the selvage as perfect as possible. This point in a lap machine is really of so much importance that its proper construction cannot be too strongly insisted upon. It is believed that the loss, in various ways, arising from any machine working with leather packings, as in *Fig.* 61, is more than would suffice to buy a new scutcher every six months. The plan shown of recessing the framing to receive the hoops of the dust cage is not new, having been acted upon for some time by several of the best makers, but the turning of the hoops and careful boring of the recesses so as to leave the right margin of 1-16th of an inch has not hitherto had the attention it deserves.

THE SCUTCHING ROOM.

The general formation of this room depends, in some measure, upon the kind of cotton intended to be used, the quality and numbers of yarn intended to be spun, and if for single or double carding.

There can be no doubt that the operation of the scutching process is next in importance to that of carding. Generally speaking, the longer the fibre the less scutching it requires, on account of long-stapled cottons being liable to "string" or get knotted, which is very mischievous; but it always happens to fine Sea Island, Egyptian, Brazilian, and other long-stapled cottons, if handled too severely in the blowing room.



PLAN OF GROUND FLOOR

PL TE

SIDE ELEVATION

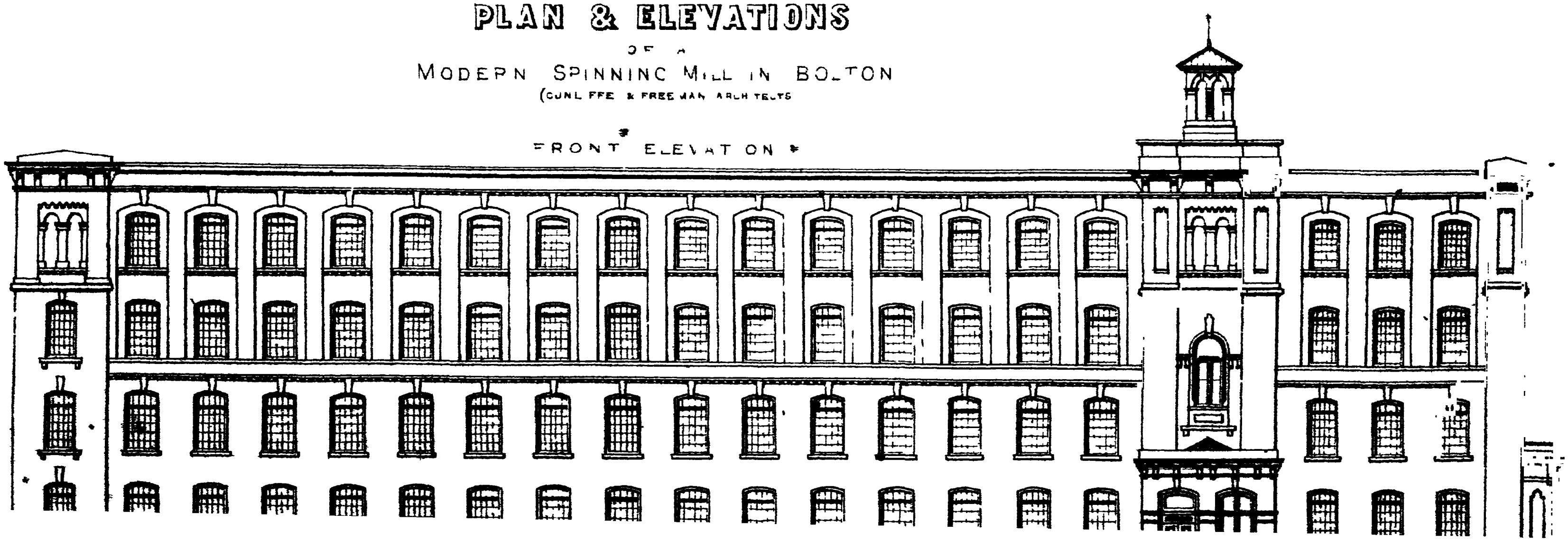
PLAN & ELEVATIONS

OF A

MODERN SPINNING MILL IN BOLTON

(CUNLIFFE & FREEMAN ARCHITECTS

FRONT ELEVATION



The fibres of cotton have a natural tendency to curl, and if carried round the beater of the machine get knotted, or *stringed*, as it is termed. This stringing of the cotton is very injurious, because it forms neps that cannot all be removed by any subsequent operation, and therefore appears in the yarn.

Various are the opinions of practical men as to the most desirable class of machinery in this operation; but before selection, in order to form a correct judgment, it must be decided as to what numbers of yarn are intended to be spun, and what kind or quality of cotton is intended to be used.

If long-stapled cottons, such as Sea Island, Egyptian, Pernambuco, Maranham, &c., are to be used exclusively, very little scutching will be required, which is best done at one operation, being weighed from the mixing as it is fed on the lattice, marked in length for the purpose, and the feed rollers run slowly. The machine should have three beaters. The first beater should be a drum with teeth, the second and third plain beaters. The first feed rollers should be spider, the next dog-tooth, and the last feed should have one dog-tooth roller only, working in a shell with serrated edge. One or two of the bars in the grids of the two first beaters should have serrated edges, and all the grids between the beaters and the dust cages, which are usually stationary, should be made to move so as not to get choked. The second pair of dust cages and feed rollers should go 50 per cent faster than the first pair, and the third pair should go 20 per cent faster than the second pair. The reason of this accelerated speed of the dust cages and rollers is because the cotton comes from the first beater in larger flakes, and consequently does not cover the dust cages as they revolve so completely as it does when more perfectly broken up, and is more apt to fly to the sides where the draft is strongest.

For short-stapled and lumpy cotton, such as Surat, it is necessary to make a greater difference than this

The same machine and plan may be used for American cotton. In concerns where the machines have only two beaters, a cotton opener is necessary; and the double beater machine should have a pair of dog-tooth feed-rollers to the first beater, and one dog-tooth roller to the second, with shell and serrated edge-feeder.

SURAT AND OTHER SHORT-STAPLED COTTONS.—In opening and scutching these, at least two machines are necessary, and a steaming apparatus besides; for the hard lumps and cakes of tightly-compressed cotton, which sometimes stick as if glued together, cannot be separated without injury by any means so readily and safely as they can by steaming.

The plan of the scutching room will have to be arranged, as a matter of course, to suit the machines it is decided to use, and wherever practicable it should be so contrived that the cotton will pass straight on from the cotton store to the opening and scutching machines, and the laps from these delivered at the most convenient point for the cards; all turning back should be avoided as a waste of labour. Where it is intended to stack the cotton the bales should be elevated and opened in a room over the bins it is mixed in, and the latter be as convenient as possible to the scutchers.

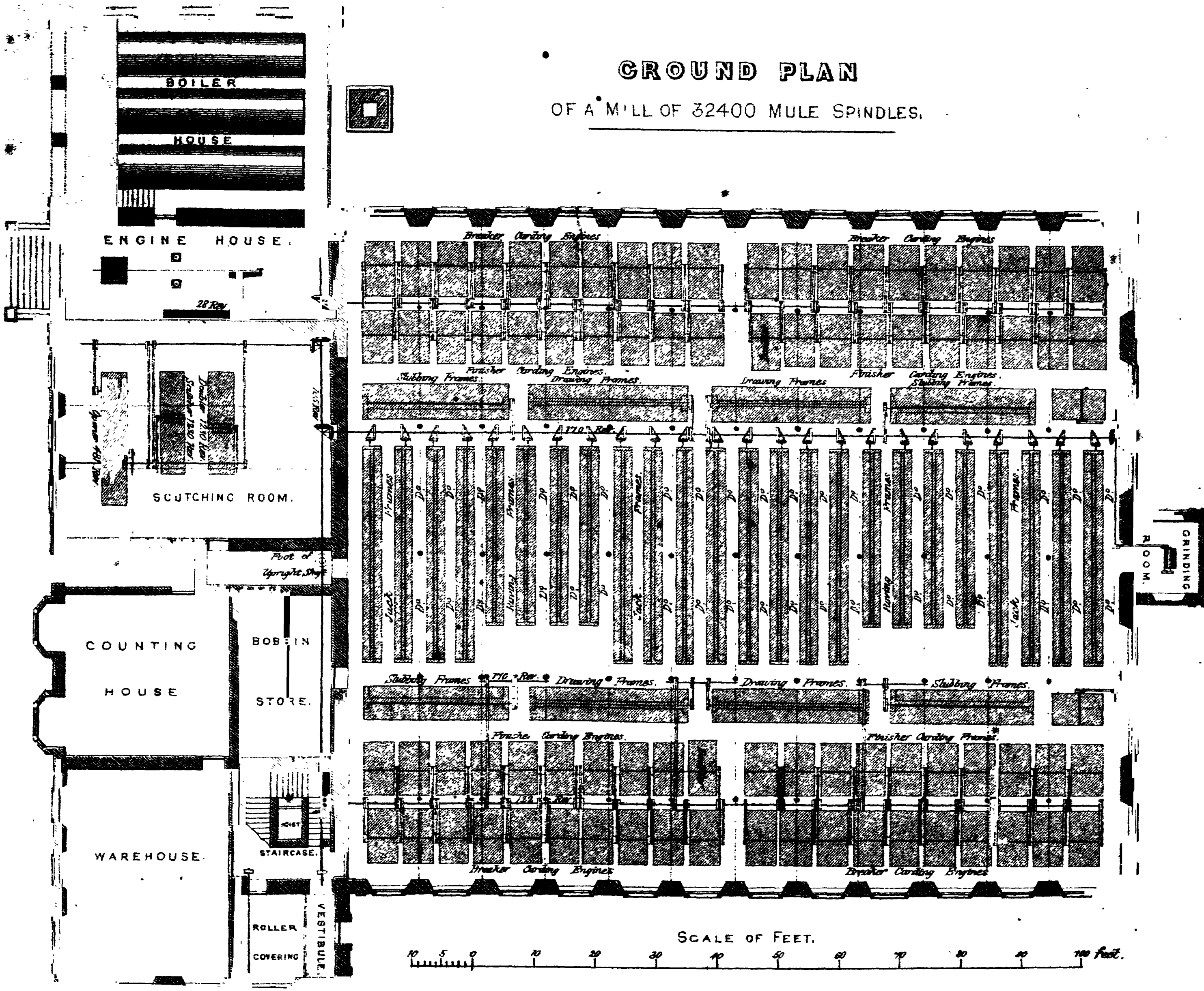
Some spinners prefer to hoist the bales of cotton to the top of the mill at once, and have their cotton store, mixing, and scutching in the attic, the card room being next below, then spinning all the way down, ending with throstles or looms on the ground floor; the object being to save the labour of carrying the bobbins from the roving frames, when full and heavy, up stairs to be spun, and the sets of cops down again.

This should never be done where the mill is not fire-proof, and, since the establishment of hoists, it becomes altogether unnecessary; indeed such arrangement of machinery is very properly discarded in modern mills. Under any circumstances the scutching and mixing rooms should be fire-proof, as fires very often take place through hard substances, which have been packed up in the cotton, coming in contact with the beaters.

PLATE, XVI.

GROUND PLAN

OF A MILL OF 32400 MULE SPINDLES.



A MODERN SPINNING MILL IN BOLTON:

PLAN AND ELEVATION.

[*Contributed by Messrs.* CUNLIFFE & FREEMAN, *Architects*.]

PLATE XV.—This shows a very neat and convenient arrangement of mill buildings for spinning the Bolton counts, and is a fair type of the new factories recently erected in that thriving seat of the cotton manufacture. As breaker and finisher cards are invariably employed in the Bolton system, as well as drawing, slubbing, roving, and jack frames, it has been found convenient for mills of four storeys to add a shed to the card room, so as to get space sufficient for the whole of the preparation machinery in the same room as the cards. This will be seen, on referring to the ground plan, as a continuation of the outer wall of the boiler house to the end of the mill, which adds about 24 feet to the width of the card room.

Plate XVI. shows the ground plan and arrangement of machinery in another Bolton factory, so far as the carding and preparation goes. This mill contains 32,400 spindles (mules) for spinning No. 60's twist; the machinery in card room being divided into four systems or preparations, each of which is as under, viz.:—

10 Breaker and 10 finisher carding engines, 38 inches on wire, with Wellman's self stripper.
1 Drawing frame, with three heads of four deliveries each.
1 Slubbing frame, of 64 spindles, bobbin 5in. by 10in. lift.
2 Roving frames, 130 spindles each, or 260 spindles, bobbin 3½in. by 7in. lift.
4 Jack frames, 200 spindles each, or 800 spindles, bobbin 3in. by 6in. each.
9 Mules 890 spindles each, or 8,010 spindles to each preparation, $1\frac{6}{10}$in. gauge.

Between breaker and finisher cards is a doubler, or "cheese" machine, wherein 50 breaker ends are coiled into a lap or "cheese," of which two are placed behind the finisher card, so as to run off alternately, one lap being full, the other will be half. One doubler serves two systems.

Drawing frame doubles 8 ends thrice, and draws 8 ends thrice; part of hank $\frac{2}{9}$.

Slubber draws or extends sliver $4\frac{3}{4}$ times, and winds it on bobbin $1\frac{1}{8}$ hank.

Roving frame doubles two ends into one, with a draft of 7, giving $3\frac{2}{3}$ hank; six revolutions of spindle to one of roller.

Jack frame takes two ends into one, with a draft of 6; hank bobbin 11; $10\frac{1}{2}$ revolutions of spindles to one of front roller.

Mules double two ends into one, with a net draft of 5·45, producing 16 hanks per spindle weekly.

The gross weight of cotton used per week is about 11,360lbs., which gives in net scutched laps about 10,678lbs., supplying 2,670lbs. to each system, equal to 267lbs. per breaker card, producing, less 10 per cent waste, 240lbs., or 4·44lbs. breaker carding per hour for 54 working hours per week. 2,400lbs. behind finishers equals 216lbs., or 4lbs. per hour finisher carding. Part of hank, $\frac{2}{9}$.

The net weight of yarn produced per week is about 8,520lbs. from 11,360lbs. gross weight of cotton. When cotton is at 9*d*. per lb. the total 2,840 lbs. of waste of all kinds will sell for about £35. 10*s*., which would restore 947lbs. of cotton at 9*d*. per lb. This, being deducted from 11,360, leaves 10,413lbs. of cotton actually consumed for 8,520lbs. of yarn produced, being at the rate of nearly $19\frac{1}{2}$oz. of cotton to each pound of yarn. Of course, when the cost of cotton is higher or lower than 9*d*. per lb., the relative loss is greater or less. It is also affected by the fluctuations in the waste market.

THE CARDING ENGINE.

THIS machine is one of the most important employed in the whole system of the cotton manufacture; indeed it may be said to hold the very first rank.

Although the principle of carding remains virtually the same as it was in the days of Arkwright, still the opinions of spinners differ so widely on this subject that carding engines continue to be made in a great variety of forms.

The plans of scutching, drawing, slubbing, roving, and spinning have been tolerably well established, and become questions of mere excellence or quality of construction by different machinists, who have competed with each other for public favour, showing but little variety in detail, and none, or next to none, in principle, spinners having long ago made up their minds as to the *modus operandi* of converting cotton into yarn; but whenever a man professes to enlighten the public on the subject of *carding*, he soon gets himself into a hornets' nest.

Deduction from facts, philosophy, and reason, so powerful in elucidating the truth in other matters, seem in this to lose their potency, and leave the question still debateable, as if by common consent spinners had herein agreed to differ. Nor can this be wondered at when one looks around and sees the great variety of constructions by ingenious and earnest men, who have laboured hard and patiently to excel in this most important branch of the cotton manufacture. Every inventor clings to his own production and defends it with all his might; faults it may have, plain enough to others, but he sees them not—

> "O, wad some power the giftie gie us,
> To see oursels as ithers see us!"—BURNS.

But, lacking this power and despairing of the ability to settle the question, it is proposed first to give a short historical account of the invention of the carding engine, and then proceed to describe, analysise, and criticise the most recent inventions and alleged improvements in carding engines, and leave the reader to form his own opinions thereon, premising that whatever system be adopted, very much depends upon management.

Carding, as practised with rude machinery, is of so great antiquity that history fails distinctly to trace its origin.

After cotton is ginned, picked, and prepared—whether this be done by the old Indian bow, the batting flake, or the modern system of opening and scutching by machinery—its fibres are found matted together and lying in all directions; therefore, before they can be twisted into a thread it is necessary to stretch them out and lay them parallel side by side, but as they have a tendency to curl, frequent combing or brushing is required, both to lay the fibres straight and to take out the light motes, nep, and other impurities.

The earliest account we have of this is as follows:—Two wire brushes were made, with the wire bent to an angle; they were about four inches wide and about twelve inches long; one of them being nailed to a bench, the other having a handle to be held by the operator in passing it to and fro over the fixed card, upon which the cotton to be operated upon was placed. After sufficient carding or combing it was stripped off the cards by a rod set with spikes or needles, termed a "needlestick," after which it was spun upon the one-thread wheel or distaff. The first improvement recorded upon this rude machine appears to have been made by James Hargreaves (the inventor of the spinning jenny), a weaver, of Blackburn, and contemporary of Arkwright. This improvement consisted in suspending the top or movable card by two cords which passed over pulleys and had a weight attached to the other end; which simple contrivance relieved the operator so much that the "stock cards," as they were termed, were made considerably longer, and much more as well as better work could be produced by them with less labour; the movable card board having a handle at each end was brought down upon and gently passed over the cotton on the lower card, which had its wire teeth bent in the opposite direction, the weight then raised it up again, and the operation was repeated. It also gave a longer sliver when taken off by the needlestick.

The important invention of the carding cylinder has been ascribed by some authorities to Sir Richard Arkwright, and by others to Lewis Paul. It does not appear, however, that either the one or the other are justly entitled to the merit of being the first who used cylinders to card cotton, but to Daniel Bourn, of Leominster, who took out a patent in May, 1748, which is about seven months prior to Paul's patent in the same year. As this is a matter of considerable interest, from the wonderful effect produced by the application of the *rotary* principle of carding, it has been thought worth while to insert both Bourn's and Paul's specifications as filed by them, together with the drawings of each machine respectively, which clearly proves Bourn's priority, whose specification runs thus:—

A.D. 1748.—No. 628. MACHINE FOR CARDING WOOL AND COTTON.

Bourn's Specification.

To all to whom these presents shall come: I, Daniel Bourn, of the borough of Leominster, in the county of Hereford, dealer in wool and cotton, send greeting.

Whereas His Most Excellent Majesty King George the second, by his letters patent under the great seal of Great

Britain, bearing date the twentieth day of January, in the one and twentieth year of his reign, did give and grant unto me, the said Daniel Bourn, his especial licence, that I, the said Daniel Bourn, during the term of years therein expressed, might make, use, exercise, and vend my new invention of "A Machine for Carding Wool and Cotton, either by Hand or Water;" in which said letters patent there is contained a proviso obliging me, the said Daniel Bourn, by a writing under my hand and seal, to cause a particular description of the nature of the said invention, and in what manner the same is to be performed to be inrolled in His Majesty's High Court of Chancery within four kalendar months after the date of the said recited letters patent, as in and by the same (relation being thereunto had) may more at large appear.

Now know ye, that in compliance with the said proviso, I, the said Daniel Bourn, do hereby declare the said machine for carding of wool and cotton does consist and is to be performed in the manner described in the plan and explanation thereof hereunto annexed.

In witness whereof I have hereunto set my hand and seal this fourteenth day of May, one thousand seven hundred and forty-eight. DANIEL BOURN. (L.S.)

And be it remembered, that on the said fourteenth day of May the aforesaid Daniel Bourn came before our Lord the King in his Chancery, and acknowledged the aforesaid writing, and everything therein contained and specified, in form aforesaid; and the said writing was stamped according to the Act of Parliament made in the sixth year of the late King William and Queen Mary, and so forth.

Inrolled the fourteenth day of May, in the said twenty-first year of the reign of his Majesty King George the Second.

With this specification Bourn deposited a rude drawing, of which *Fig.* 64 is a copy, with the following description and plan of a machine for carding wool and cotton:—

The properties by which this machine of carding differs from any other method hitherto invented are principally these—that the cards are put upon cylinders or rollers, and that these act against each other by a circular motion, and that they may be moved either by hand or by a water wheel.

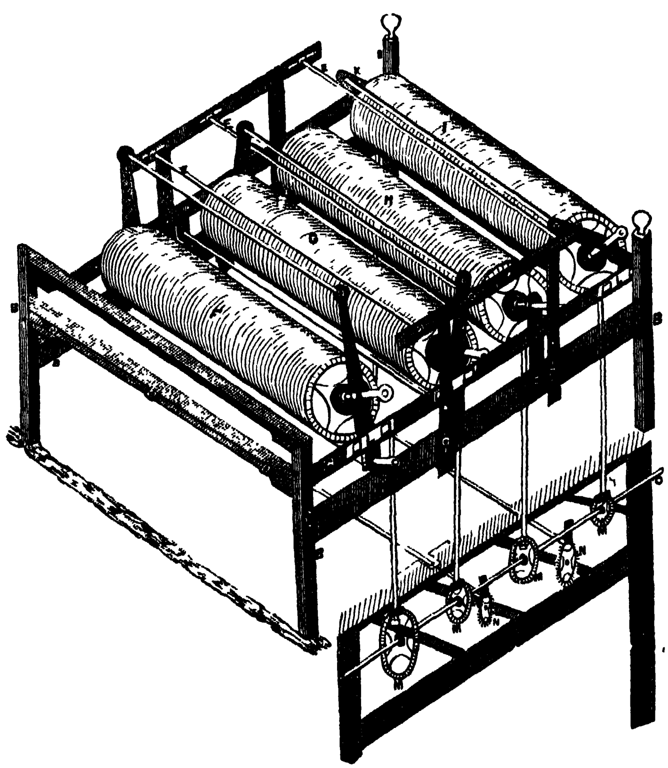


Fig. 64.—Bourn's Carding Engine.

It may be observed that more or fewer may be put in a machine than four cylinders, though that number is found to be most proper.

The cards are wrapped round the cylinders, which by their circular motion, and at the acting upon one another card the wool or cotton sufficiently fine for spinning.

A. The place where the girl sits to take off the wool or cotton when carded on cylinder No. 1.
B. A large wooden frame upon which all the work is fixed.
C. An iron frame screwed to the wood end.
D. The side irons to which the iron bars are screwed, which keep the cylinders at a proper distance from each other.
E. The aforesaid iron bars that are screwed to the side irons.
F. The first cylinder or roller.
G. The second ditto ditto.
H. The third ditto ditto.
I. The fourth ditto ditto.
K. Distinct frames belonging to each cylinder.
L. Sliding plates to which each cylinder is fixed, and by means of which they may be set at any distance from each other.
M. Wheels that turn the upright shafts or arbors, and so communicate motion to each cylinder.
N. Two wheels with cranks that by levers or rods draw the second and fourth cylinder to and fro in a side-long motion, in order to disperse the wool or cotton equally over the cards.
O. The end of the shaft or arbor, that by a windlass or water wheel gives motion to the whole work.

N.B.—A frame of three cylinders is the same with this model when the fourth cylinder is taken away.

DANIEL BOURN.

Such was the rude beginning of cylinder carding, which, as Bourn states, could be turned by hand or power—water power as mentioned; steam power being unknown or never dreamt of for manufacturing purposes in those days, although but the short span of one hundred and twenty-three years separates that period from the present.

In the same year, A.D. 1748, but seven months later, Lewis Paul, of Birmingham, took out a patent for carding, in which he shows two carding machines (*Figs.* 65 and 66). Ten years before this, viz., in 1738, Paul had patented a spinning machine, which will be noticed under its proper head, but he made no mention of carding cotton in his first patent.

Paul's patent for carding is numbered 636, and as it is drawn up in the same form as Bourn's it will only be necessary to give the specification, which runs thus:—

Paul's Specification. No. 636.

Now know you that, in compliance with the said proviso, I, the said Lewis Paul, do hereby declare that the said machine for carding wool and cotton does consist and is to be performed in the manner following. To wit:

The card is made up of a number of parallel cards with intervening 20 spaces between each, and the matter being carded thereon is afterwards took off each card separately, and the several rows or fillaments of wool or cotton so took off are connected into one entire roll. A further explanation of the cardi g engine, and the manner of working, is set forth in the plans and specification hereunto annexed. LEWIS PAUL.

16th December, 1748.

Fig. I. A A, the frame of the machine, to which the necessary apparatus is fixed. B B, a board on which the card is nailed. The length and breadth of card is quite arbitrary, having been used from 3ft. long by 2ft. wide to 2ft. long and 14in. wide. The card is not one continued surface, but consists of a number of parallel cards, with spaces between each card. The parallels *n n n n* represent the cards, and the intervening spaces the distance between each card. The breadth of the cards, as well as the intervening spaces, depend upon the character of the work to be done, sometimes requiring to be an inch, sometimes only an eighth of that breadth; and the wires that compose the cards may be finer or coarser, longer or shorter, in order to be capable of being applied to a variety of work, and according to the different circumstances of the business to be done, to the underside of which is fastened an arbor whose bottom is seen at C, and whose point runs in a hole at D. In the cross-bar E E the upper part of the arbor is confined in its place by a keeper on the back of the upper part of the frame A 1, yet so as to be capable of revolving in a horizontal direction. On the card arbor, a little above C, is fixed a warve or pulley, F, round which a string is put and fastened to the points of the treddles Y and Z. The treddles Y and Z have their centre of motion at 2 and 3, at the bottom board of the frame A A A A. By means of these treddles the card is turned from right to left; but it is necessary the rows of the cards should lay in a direction parallel to the frame. The corners of the card board B B are cut off in a proper inclination, as at *b b*, at the upper of which inclined part has a notch *c c*, into which a snap or latch falls when the card board comes parallel with the frame. This snap or latch is held in its place by a spring, and the tail of the catch communicates with the treddle by a string, by which it is capable of being drawn out of the notch *c*, and then by setting the foot on the treddle Y. The card will turn half way about, and the latch falls into the other notch *c*. The card being thus put about, the wool (or whatever matter is to be carded) is put on the rows of cards and the upper card drove over it lightly till the wool begins to look even on the card. Then the card must be brought into the situation the drawing represents by pushing the treddle X with the foot to discharge the catch, and

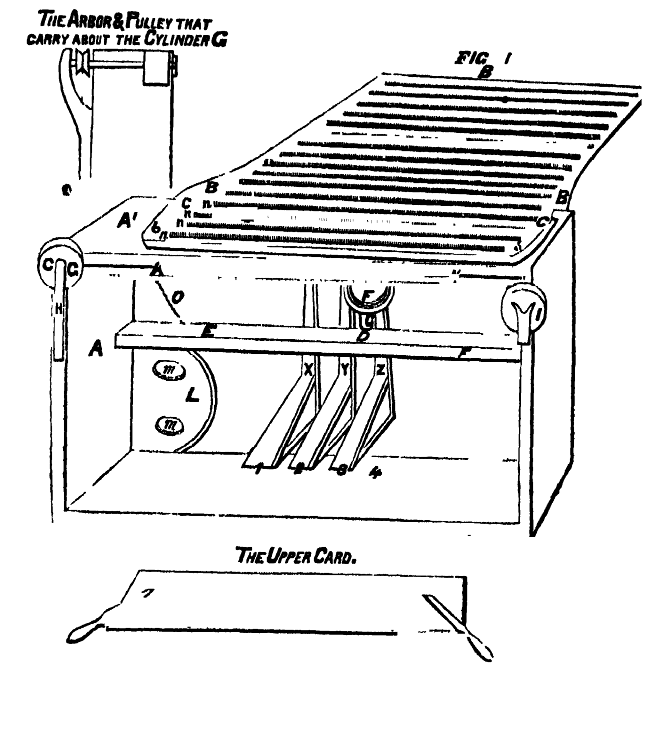


Fig. 65 —Paul's Carding Engine (No. 1).

then pressing on the treddle Z. The card will come about again. Then by drawing the upper card over the lower the wool will come off the lower to the upper card, because the wire that constitutes the rows now stand pointing to the person at work. Then the card must be turned again and the upper cord applied as before. These acts must be repeated until the wool is equally dispersed as is necessary. At the left-hand side of the card frame is an arbor, with a warf or pulley not represented in the draft, but its use is to carry the cylinder G about, one of the pivots of the cylinder going into a hole at the end of the arbor, and the other pivot sustained by a spring H. Below this arbor is a wheel L, on the ambitus of whose periphery is cut a groove O, for a bandage to go round it, and the pulley of the arbor that carries the cylinder G about. In this wheel are holes cut, *mm*, so that the person sitting at the engine may turn it with his foot, and by this means the cylinder is carried about. At the right-hand side of the card frame is another cylinder, I, capable of revolving on its axis or pivot. Upon the cylinder is rolled a quantity of ribband, the end of which is fastened to the cylinder G; now by turning the wheel about, the ribbands will be wound from one cylinder to the other. The cylinders can be taken out and others substituted. Under the ribband that passes from cylinder to cylinder is a bench to sustain K K. The cylinders being in their places as described in the figure, the wool is to be took off the rows of the cards and laid down on the ribband by means of a stick with needles in it parallel to one another, like the teeth of a comb. The wool being on the ribband, the wheel and, consequently the cylinder G are turned about by the foot, and the wool and the ribband wound upon the cylinder, so far that you have enough of that row out to connect the next row of the wool or other carded matter that is took off with it. The next row being took off, the end of it must be laid on the end of the last, and so on till you have made an entire roll or fillement of all the rows you have taken off the carding, and then it will be fit for use. The upper card is about a quarter of the breadth of the lower, and exceeds it somewhat in length, and has one continued and even surface. The breadth and length must always be proportionate to the lower card, and the wire is made in general of the same length and fineness.

LEWIS PAUL.

Fig. 2 represents a card wrapped on a cylinder or roller, which is to revolve on its axis vertically, and able to be moved from right to left and from left to right horizontally. This card consists of parallel rows of cards with intervening spaces as before described, instead of the upper card used to the engine *Fig.* 1. There is a concave lying below the cylinder in which a card is fastened ; this concave has an arbor that, going through the top of the frame and also through a crossbar, rests on a lever. This concave is capable of turning about horizontally, and rising and falling perpendicularly, by raising or depressing of this lever. By means of a windlass and arbor which communicate with the end of the lever by a string, the concave is made to press harder or easier against the cylinder, and by the lever being lowered sufficiently, the concave card will be lowered so far as to be turned about by means of treddles, as in *Fig.* 1, and is properly stopped by a catch when it comes parallel to the cylinder. The concave turning answers the same end as the flat card in *Fig.* 1. By the vertical rotary motion given by the windlass, the wool is carded and equally distributed on the card by sliding in its horizontal direction, the concave being properly applied to it. After the wool is properly carded it must be took off the rows by the needlestick and wound upon cylinders, as directed in the description of *Fig.* 1 of the engine.

FIG 2

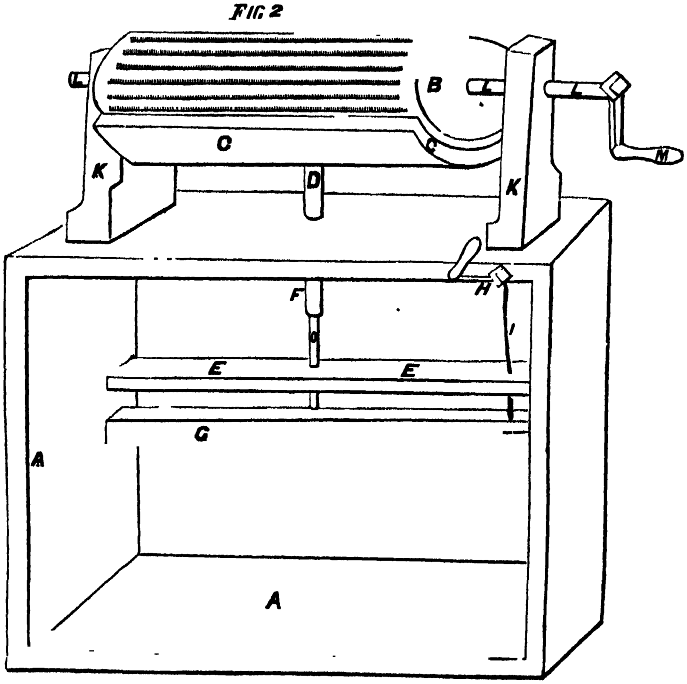


Fig. 66.—Paul's Carding Engine (No. 2).

Although Paul is clearly not the first who used rollers or cylinders for carding cotton by a rotary motion, he appears to have been the first who used a cylinder in conjunction with fixed cards or "flats."

Lewis Paul and his partner Wyatt appear to have been the only parties to use Paul's patent carding engine of 1748, for a considerable time, and it was not introduced into Lancashire until about 1760, after Paul and Wyatt's establishment at Northampton was broken up, through being unsuccessful. It was then tried for carding wool for hats, and afterwards again for cotton at Wigan. After this Mr. Peel adopted some modification of it by the aid of James Hargreaves; but it was so defective even then that Mr. Peel laid it aside for some years.

Richard (afterwards Sir Richard) Arkwright was the next and greatest improver of the carding engine, as well as of drawing, roving, and spinning machinery. The successful inventions, and the improvements upon other inventions, made by this extraordinary man, will be noticed severally under their proper heads.

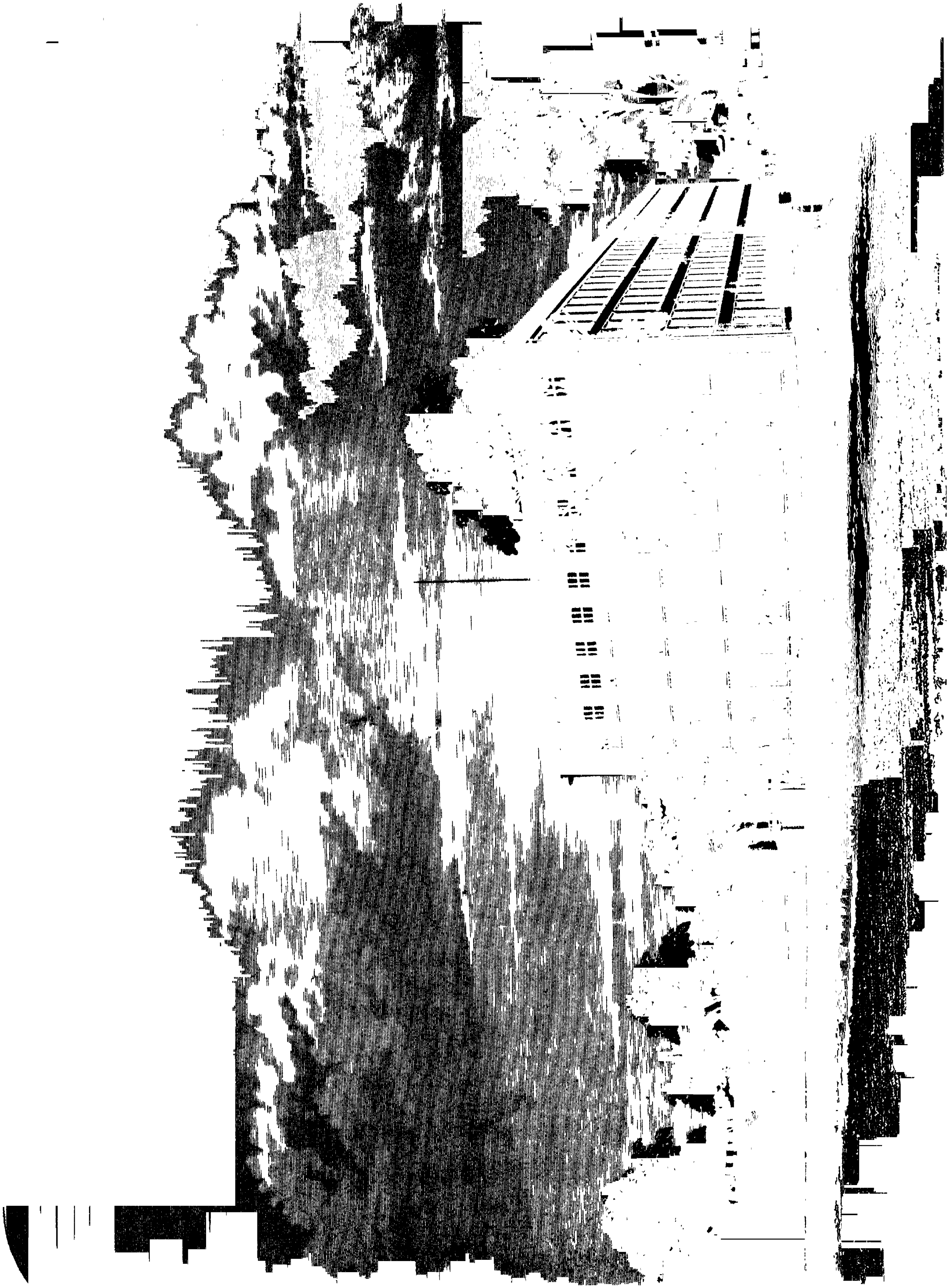
Men of genius and talent are not confined to any particular age, country, or occupation; and it is curious to think that remarkable ability is often found and observed to develop itself in the most unlooked-for situations; but of all the unsuspected places that could be imagined, it is almost ludicrous to think that a light so effulgent as to have the most weighty bearing on the social and commercial progress of the world, and this country in particular, should emerge from a barber's shop! Yet so it was, for the great Arkwright began the world as a poor barber. Well may it be said that—

> "Honour and shame from no condition rise;
> Act well your part, there all the honour lies."

Born at Preston on the 23rd December, 1732, Arkwright was the youngest of thirteen children. His parents being very poor, he scarcely received any education, but was apprenticed to a barber at Kirkham. At the age of eighteen he commenced business at Bolton as a barber, and at nineteen he married, choosing a wife from Leigh, near Bolton. Arkwright soon found the monotonous life of a barber uncongenial to his lofty aspirations. His restless and ambitious spirit could ill tolerate the way in which he found himself now tied down. Mechanical ideas ever flitting through his brain by day and haunting his imagination by night, it is probable that as soon as he heard of the experiments of Thomas Highs of Leigh, Hargreaves of Bury, and others in attempting to create or improve machinery for spinning cotton, he entered with all the ardour of his nature into the same endeavour. Ill adapted, however, was his barber's shop for this kind of work,—unsuited altogether were experiments in mechanism to his slender means and the pressing wants of a wife and now increasing family. Imprisoned as it were in a cottage, and bound down by domestic trammels, his position became one of great difficulty. Perhaps at no time was the pursuit of knowledge under difficulties more strongly exemplified than in the indomitable perseverance of this true son of genius. Without money, tools, or opportunity,—all the means he could earn by his humble occupation being swallowed up, as fast as his industry could produce them, in supporting his wife and family,—Arkwright had the sagacity to see the impossibility of carrying on experiments under such distressing circumstances; yet what was to be done? Shaving for a penny and cutting hair for three-halfpence would never supply the necessary means he required, even if he took for his experiments all he earned. To borrow money was impossible, for he had no security to offer; and without that, who would lend a barber money to experiment with in mechanics! However unpromising it might be, Arkwright had no alternative

Richd Arkwright

but to turn his own business to account, for he could not change to any other occupation. So he set his wits to work and began to make wigs, which were fashionable in those days. He also invented or got the secret of making a hair dye, which he went about the country to vend, and at the same time collected human hair for manufacturing his wigs. By these means he not only saved a little money for his experiments,



but by travelling about the country saw what was going on. Nevertheless, it required so rigid a self-denial and perseverance to carry on his experiments, that his wife's temper at length gave way under the severe ordeal of his repeated failures. From her point of view, she saw that the family could be tolerably comfortable now that her husband was earning a little more money, but for his unfortunate fascination for, and hankering after mechanics. After having expostulated with him often and in vain, suffering privation after privation, she one day, in a fit of desperation, took the law into her own hands, and broke up all his models, which caused a violent quarrel and lasting separation between them. He frequently buoyed up his wife's spirits under their severe sufferings by telling her that he should one day ride in his carriage! But her endurance could last no longer, and she "refused to hear the voice of the charmer, charm he never so wisely." So long as a man is consoled by the sympathy of a faithful wife, who suffers uncomplainingly the privations he has himself to endure in the pursuit of a particular object, he is encouraged and armed with a giant's strength to struggle on and break through the most formidable difficulties; but when the partner of his life forsakes him, it is like "a house divided against itself which cannot stand." His arm is paralysed, his feelings wounded, and it required almost superhuman efforts to bear up and press forward against so crushing a discouragement. This, however, was poor Arkwright's lot during the time he was bringing out his most important inventions of the carding engine, spinning frame, &c.

The greatness of a man's soul never shows itself more conspicuously than when his evenly-balanced mind remains undisturbed, and the course of his thoughts unimpeded, by the difficulties that surround him. So it was with Arkwright; he pressed onward, however, through good report and evil report, surmounting all obstacles, until he became *Sir Richard Arkwright*, rode in his carriage and four, and attained greater wealth and honours than had ever been pictured to his most sanguine imagination, when he tried in vain to solace his wife.

The world is about as much indebted to Arkwright (taking his inventions and improvements altogether, and the indomitable energy with which he pushed them into practical use,) as it is to his great contemporary James Watt, who simultaneously made such vast improvements on the steam engine. But for these two highly-gifted and industrious men, the world might have remained in comparative darkness for another century;—but for them the property of this country might not have stood at half its present value, or the people have been half as well clothed and fed. In Munich there is a colossal statue of Bavaria, which stands 60 feet high, and is set on a pedestal 40 feet high, being naturally an object of great attraction. If Manchester, the metropolis of manufactures and centre of the enormous wealth created by the genius of these two men, would erect to them similar statues, it would be a suitable and graceful tribute to their memory, and commercially speaking, it would pay to do it.

Arkwright does not appear to have turned his attention to improving the carding engine till about the year 1773, when he was settled in Derbyshire, working his spinning machinery profitably in partnership with Mr. Strutt. Up to this time several modifications of Paul's carding engine with cylinders had been working in Lancashire and elsewhere, in a very imperfect manner, the cotton when carded being stripped off the cylinders by hand.

Although Arkwright was not the first to have conceived the idea of nailing cards to a cylinder to which a rotary motion was given, and then fixing stationary cards to transverse pieces of wood, technically termed "flats," which were adjusted by screws to the cylinder, still he may be said to be the first who made continuous carding practicable by his doffing comb and other improvements. His great success and fame were not altogether owing to his own inventions, but to his indomitable perseverance, sound judgment, and practical common sense, as well as to the originality of his ideas; hence he got the credit of having invented many things which, strictly speaking, he only improved and brought to a commercial issue,—inventions which might have lain dormant for ages but for his energy and industry in developing them.

Cotton, after being batted and picked, was, in Arkwright's first engine, fed to the cylinder by a pair of fluted rollers having a slow motion, so that it was carried round the cylinder in thin films, and coming in contact with the cards on the flats it got broken up and carded more perfectly and expeditiously than before. When the cylinder, which was turned round by a handle, was sufficiently filled, it would be stopped and stripped off by hand like a fleece. The next improvement was to place alongside, and parallel with it, another cylinder of smaller diameter (also covered with sheet cards). This being set close up to the larger one, and revolving at a much slower speed, took off the carded cotton from the latter, and was termed the "doffer." By this means it became practicable to strip the main cylinder while in motion by the doffer, which turned very slowly round, compared with the other or larger cylinder. When the doffer sheets got full of cotton the engine was stopped, and the carded cotton taken off the doffer in as many thick fleeces as there were sheets on the doffer.

The next step was the addition of the doffing comb, at the same time covering the doffer with a narrow fillet card wound round spirally, thereby producing a continuous sliver. The latter invention threw a new light on the whole process; for it then became practicable to work the carding engine by power, and keep it in motion continuously except for occasional stripping and brushing out.

ARKWRIGHT'S COMPLETE CARDING ENGINE.—Simple as the first complete carding engine looked *(Fig. 68)* it must nevertheless have cost a large amount of study and perseverance to get it to act. A considerable time elapsed before the framing was made of iron, as shown below, it being generally constructed of wood.

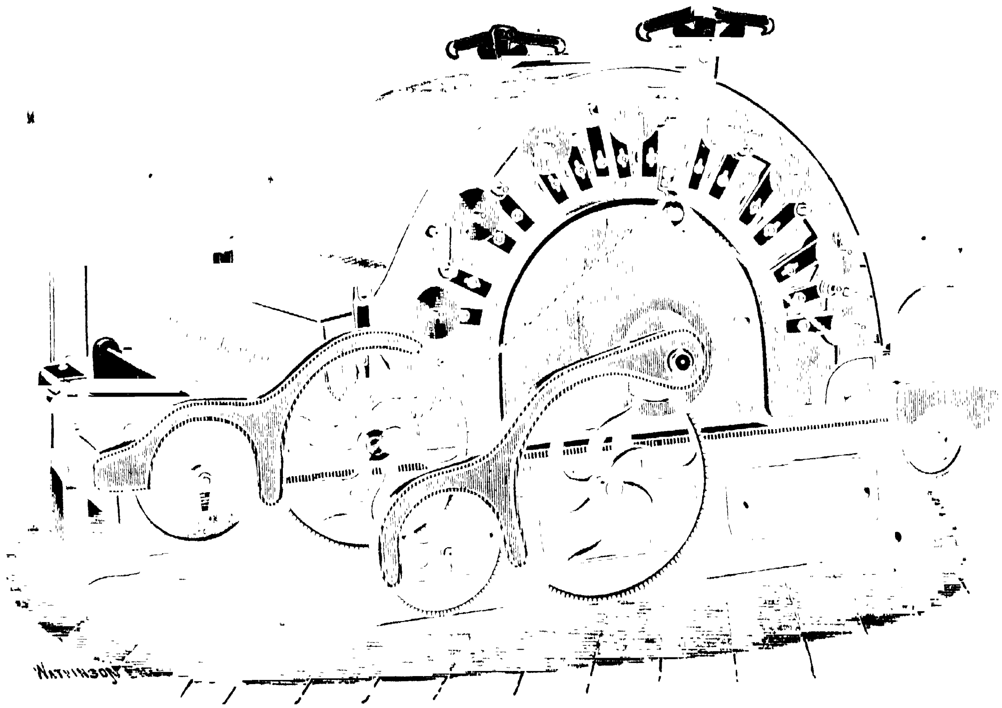


Fig. 69. Single Roller Carding Engine, as made by John Tatham.

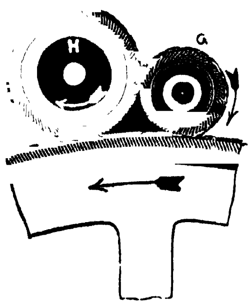


Fig. 71.

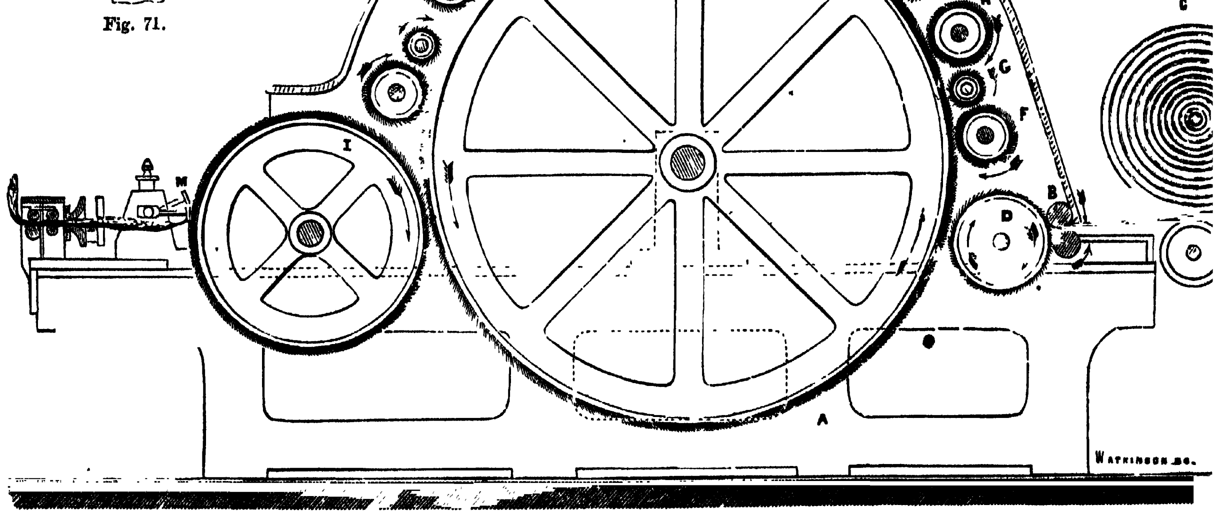


Fig. 70. Section of the above (Scale ¾ inch = 1 foot).

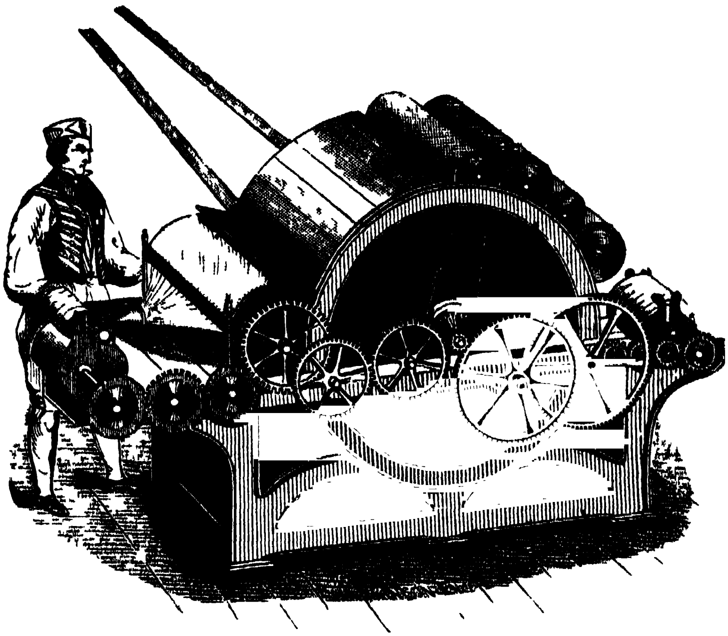


Fig. 68.—Arkwright's Complete Carding Engine

Great modifications and improvements in the construction of this machine have since taken place, to bring it up to its present comparatively elegant and effective form; but the *principle* of carding with revolving cylinders clothed with cards working point to point, and the produce doffed off in a continuous fleece, by the ingenious contrivance of the doffer and stripping comb, remains essentially the same as established by Arkwright, and probably will do so, like a fixed law, for an indefinite period.

THE ROLLER CARDING ENGINE.

This very popular modification of the carding engine has been, and is now, extensively used, almost exclusively for low numbers. The most general form in which it is made is as shown in perspective in *Fig.* 69, and in section *Fig.* 70, in which *a* is the framing; *b* the feed rollers, which take in the cotton from the lap *c*, and move at a surface speed of from 6 to 12 inches per minute; *d* is the taker-in, which has a surface speed of about 800 feet per minute; *e* is the main cylinder, the surface speed of which is about 1,600 feet per minute. The cotton, after being taken from the feed rollers *b*, is stripped off the small cylinder or taker-in by the superior speed of the main cylinder, and comes next in contact with the dirt roller *f*, which has a surface speed of about 16 feet per minute; it then passes under the clearers *g* and rollers *h*, the former having a surface speed of about 400 feet per minute, and the latter of

20 feet per minute. Portions of the cotton are caught only by the rollers *h*, which have their card teeth pointing in a direction opposite to those on the main cylinder, whilst the teeth on the clearers or strippers *g* are set in the direction of motion. The cotton which is caught and brought round by the rollers or workers *h*, is stripped off them by the clearers, and put on the main cylinder again, afterwards it is finally caught by the doffer *i*, which also acts powerfully as a carder, having its teeth set in the same direction as the rollers *h*. The surface speed of the doffer *i* is from about 60 feet to 70 feet per minute, according to the amount of carding required and the nature of the cotton operated upon. The feed rollers *b* are driven from the doffer, through a side shaft; the slower the doffer goes the less cotton is taken in by them, and the greater the amount of carding, and *vice versâ*, as the main cylinder *e*, which is turned direct from the shafting, always maintains the same speed it is set to. All changes, therefore, to more or less carding (without altering the thickness of the sliver) must be effected by altering the spur pinion which drives the doffer; and if a thicker or thinner sliver is required, from the same lap, the bevel pinion which drives the feed rollers must be changed. The fleece of cotton caught by the doffer is stripped from it by the oscillating comb *m*, and after passing through the trumpet *n* and callenders *o*, by which it is consolidated, is neatly deposited into a can by the well known coiling motion, invented some years ago by Messrs. Tatham and Cheetham. In some cases this coiler and can are dispensed with, and the slivers from a row of engines are carried forward to a draw box head, which, after passing through, are caught in a very large can.

The dirt roller *f* is generally stripped by hand card after it gets full of motes, which happens at a greater or less interval, according to the nature of the cotton operated upon. It is sometimes, however, stripped by a comb, which of course makes more waste, but keeps the roller clean and more effective. The same roller is sometimes used as a "fancy" roller for stripping the cylinder, in which case it is set as shown in the drawing (but with the fillet reversed), and run at a surface speed exceeding that of the cylinder.

The oscillating comb *m* makes from 500 to 1,000 double beats per minute, its speed being regulated to suit that of the doffer in light or heavy carding. Owing to the rapid motion required from the comb, it is very essential that it should be well made, properly balanced, and the journals be well fitted and case-hardened, otherwise it soon knocks itself to pieces and gives much trouble. A great improvement has latterly taken place in its manufacture by having it so arranged that the working parts run in a box filled with oil. *Fig.* 71 shows on a larger scale the action of the rollers *h* and clearers *g*.

The principal points to be observed, in order to ensure the best work of which this form of carding engine is capable, is—firstly, to see that the main cylinder, doffer, taker-in, and carding rollers are well balanced; secondly, that the cards be put on tight and well ground up; thirdly, that the engine be set perfectly level, and the carding rollers exactly parallel with the main cylinder; and lastly, that the taker-in, doffer, and carding rollers *h h* be set as close as possible to the main cylinder, without touching. The setting of the clearers *g g* is not of the same vital consequence; care must be taken, however, that they do not touch either the rollers or cylinder; a clearer will strip a roller if set 1-8th of an inch from it, quite as well as if set closer. It must be remembered that there is no carding effect produced on the cotton by the action of the clearers; and when set before the workers, as they generally are, they occupy a large portion of the surface of the cylinder, being apt to catch the cotton on the next worker, unless a wide space be left between them.

The above form of carding engine has, for a long time, been very popular, and is in extensive use, especially for the lower numbers of yarn.

The theory of its advocates is plausible. It is alleged to be simple, easily managed, and readily set. Another favourable point is one which is unanswerable in argument, as a principle, viz., that clean wire is always coming up as the rollers revolve and are stripped by the clearers. Again, unlike flats, the rollers do not require perpetual stripping by hand, and they are capable of doing more work than can be got through hand-stripped flats. So far so good, and this card appears on the surface as if it would hold its own triumphantly against innovation, especially for low numbers.

After giving this plan of card full credit for its good qualities, in fairness its defects must be exposed.

Firstly, touching labour, it is found in practice that the saving is more imaginary than real, inasmuch as the rollers and clearers require to be frequently stripped out by hand; likewise, to be kept in good working order, must be often ground up and brushed out. For this purpose a card has to be stopped and have the rollers taken out and carried away to the grinding room, requiring two persons to lift them in and out.

Secondly, in carrying them about for this object, they very soon get damaged by the wire being crushed down at the ends, which is productive of great mischief, as the card then turns out a ragged and neppy selvage.

Thirdly, they require lumbering covers to box them up (over the top and at the ends) which want lifting up every time the cylinder is stripped out or ground, and much waste is made, after all, by cotton gathering about and lapping round the roller ends.

Fourthly, although clean wire is always presenting itself to the cylinder as the rollers slowly revolve, yet this wire is not in the best position for carding and stretching out the fibres of the cotton, neither are there many points to operate upon the cotton passing through.

Now as the periphery of the cylinder forms a circular line and that of the carding roller another, two circles can only touch at one minute point, and as the wire teeth of a carding roller stand in an almost vertical position to the cylinder, the cotton fibres have a tendency to curl up from such action, hence the work from roller cards is much more suitable for weft than warp, for low numbers rather than high, or even medium counts.

Fifthly, the quality of the work as regards cleanliness and smoothness is necessarily inferior to flat carding, as the latter takes out more dirt and much of the little white nep, so difficult to remove.

Notwithstanding these defects, this is a popular card, and many spinners will not look at anything else. It is rough and ready, therefore will always find advocates, especially as the majority of carders have been trained to it. If some simple plan of roller card could be devised, by which the rollers could be kept clean and ground in their places, so as to save the labour and rough usage incident to their frequent removal for this purpose, it would not only be very desirable, but would give a finish to this form of card which would greatly increase its popularity.

Birch's Patent.—Another form of Roller Card was brought out about the year 1837, by Thomas Birch, of Manchester, who patented some improvements, in which

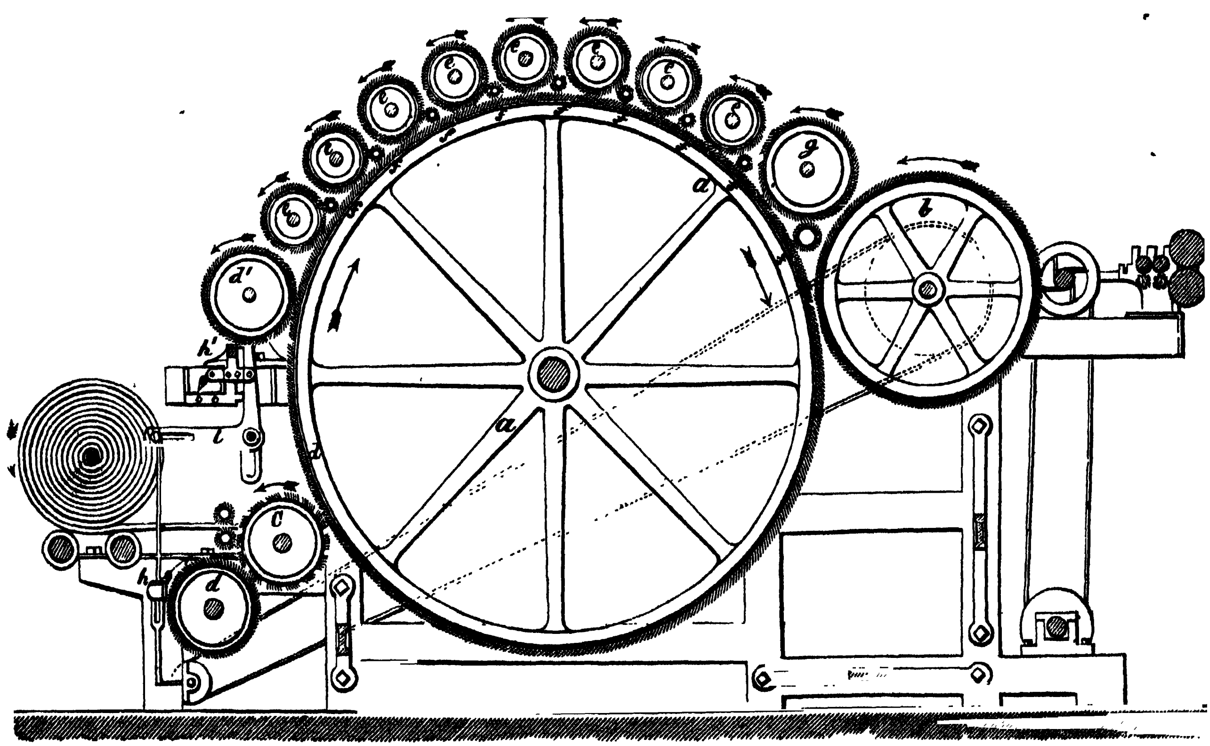


Fig. 72.—Birch's Roller Engine (⅝ of inch=1 foot.)

he stripped two dirt rollers by combs. One of these rollers was placed under the licker-in, and the other over it. In this engine the clearers were placed behind the carding rollers, instead of in front of them, which arrangement saved considerable space on the upper surface of the cylinder, and passed the cotton forward without being turned over and over again. The space saved allowed of one or two more carding rollers, as both rollers and clearers could be placed close together, which cannot be done in the general way when the clearers are in front of the rollers, on account of the space required for clearance. It will be seen that *a* is the main cylinder, *b* the doffer, *c* the licker-in, *d* is the first dirt roller, which is set up to the licker-in, and stripped by the comb *h*. The second dirt roller *d* is placed some distance above the licker-in, and is stripped by the comb *h*1, through the bellcrank lever *l*. There are eight carding rollers *e e*, which have eight small clearers behind them *f f*, besides a fancy roller *g* and clearer *f*1, for stripping the cylinder. It was generally made without the fancy roller.

There are some very good points about this engine which have been known to work well; and had it been made when first brought out in the style in which it could be constructed now, it would have maintained a lasting position. The principle of setting a dirt roller up to the licker-in is not bad, as by taking much of the heavy motes and dirt away at first the cylinder cards are saved and cleaner work produced; but it also takes out some good cotton which may be thought objectionable, and is so to a certain extent; but it is not all lost, as the waste can either be used up again, or will fetch its full value for coarse spinning. The dirt roller above the licker-in is a very common thing in roller engines, sometimes being stripped by a comb and sometimes by a hand card. The plan of having the clearers behind the rollers works decidedly well, and is believed to make smoother carding; the cotton being passed straight on from roller to roller without being turned over, as it is when the clearer is in front. More carding rollers, also, can be got on an engine so constructed. The clearers are of solid wrought iron, about $1\frac{1}{4}$-inch diameter without cards, and when clothed should be about $1\frac{7}{8}$ inches only, being clothed with very fine fillet (about 140's) of short cut wire, and more "keened" in the bend than usual. If ordinary

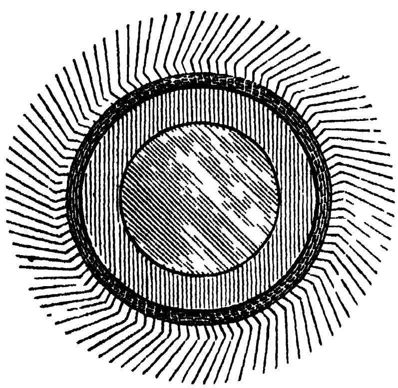


Fig. 73.

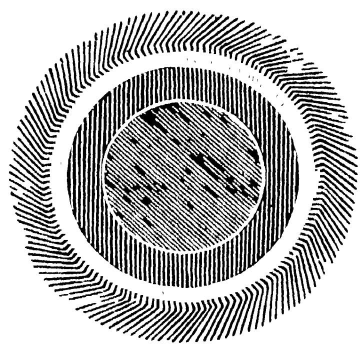


Fig. 74.

fillet (say No. 90's), with wire of 1-inch cut, was wrapped round a clearer of that diameter, and had its wire bent or "keened" (as it is technically termed) in the usual way, the wire teeth would stand nearly vertical, and be quite open. Thus *Fig.* 73, the clearer, when clothed being 2⅛ inches diameter, and appearing much coarser than the same fineness of card would indicate if put on a cylinder of larger diameter; but when the cut of the wire is shorter or more "keened" it then assumes its proper angle, as will be seen in *Fig.* 74, in which the wire is ⅛-inch less cut with considerably more keen; hence it assumes the natural angle for its work, and although so much finer, it remains sufficiently rigid. Finer wires and numbers of card have another important advantage, viz., the points are sharper as well as more numerous; therefore do their work better, and require less grinding; they also maintain a proper elasticity if, at the same time, the wire be of shorter cut.

Speed of Rollers and Clearers.—It will be noticed that in the last-named carding engine the clearers are very small in diameter, and it will naturally be supposed that they ought to go very fast. This is a mistake. True, they would have to go very fast indeed if worked at a surface speed of 400 feet per minute, which is commonly, but very erroneously, put down by most machine makers as the proper speed of a clearer, whilst the speed of a carding roller which the clearer has to strip is only moving at the surface speed of 20 feet.

Now all that the clearer has got to do is simply to take the cotton from the roller and put it on the cylinder again, which can be accomplished quite as well if the clearer has a surface speed of only 25 feet per minute, as if it runs 400 feet in that time; therefore all the power required to turn the clearers twenty times faster than necessary is entirely lost, together with the extra oil, wear and tear, &c. Prejudiced old carders have of course a reason for running the clearers so fast, which it will not be difficult to show is founded on error. It has been asserted that if the clearers go fast they will strike the motes down into the wire of the main cylinder.

This is plainly an error, because to do that they would require to run at the same surface speed as the cylinder itself, which would be utterly impracticable, and, were it possible, the cylinder would not then strip the clearers. If all the clearers in a roller carding mill were slowered to about one-twentieth their present speed, a visible saving of fuel would at once be effected, with less hurry and greater cleanliness about the engine, without any deterioration whatever to the quality of the work, but rather the contrary. The clearers would then go about 16 revolutions per minute instead of 320 revolutions as at present, which would be equal to a saving of about one-half the entire power which a roller carding engine takes. Respecting the surface speed of 20 feet per minute, which is put down as proper for rollers to run, it may be observed that the speed of a carding roller or worker is not absolute. It may be varied 50 per cent or more either way without making any perceptible difference in the carding. This arises from the circumstance that a roller does not fill with cotton to an injurious extent in a moment, and as the point of contact with the cylinder is so very fine, very little speed is really necessary to bring up clean wire sufficient for beneficial action. Some spinners, on the plausible theory that the more clean wire brought into action by the carding rollers the better, have increased the speed of their rollers to 40 or 50 feet of surface speed per minute, without the slightest beneficial result, indeed if any difference can be observed the work looks rather rougher, which may arise from the fact that a roller at so quick a speed has not time to fill; therefore it only brings up a very thin film of cotton for the clearer to strip and convey back to the cylinder, so thin that it can scarcely take hold of it, and the straggling cotton fibres being no support to each other, get curled up in different directions; therefore the extra power required to drive the rollers faster is not only lost, but the work is less smoothly done.

In some cases two rollers are stripped by one clearer, the latter being placed between them. This is not a good plan; there is no particular objection to the clearer stripping the two, but because it involves the two rollers being set up to the clearer, and if this be not done accurately the rollers get out of parallel with the cylinder, which is a great evil.

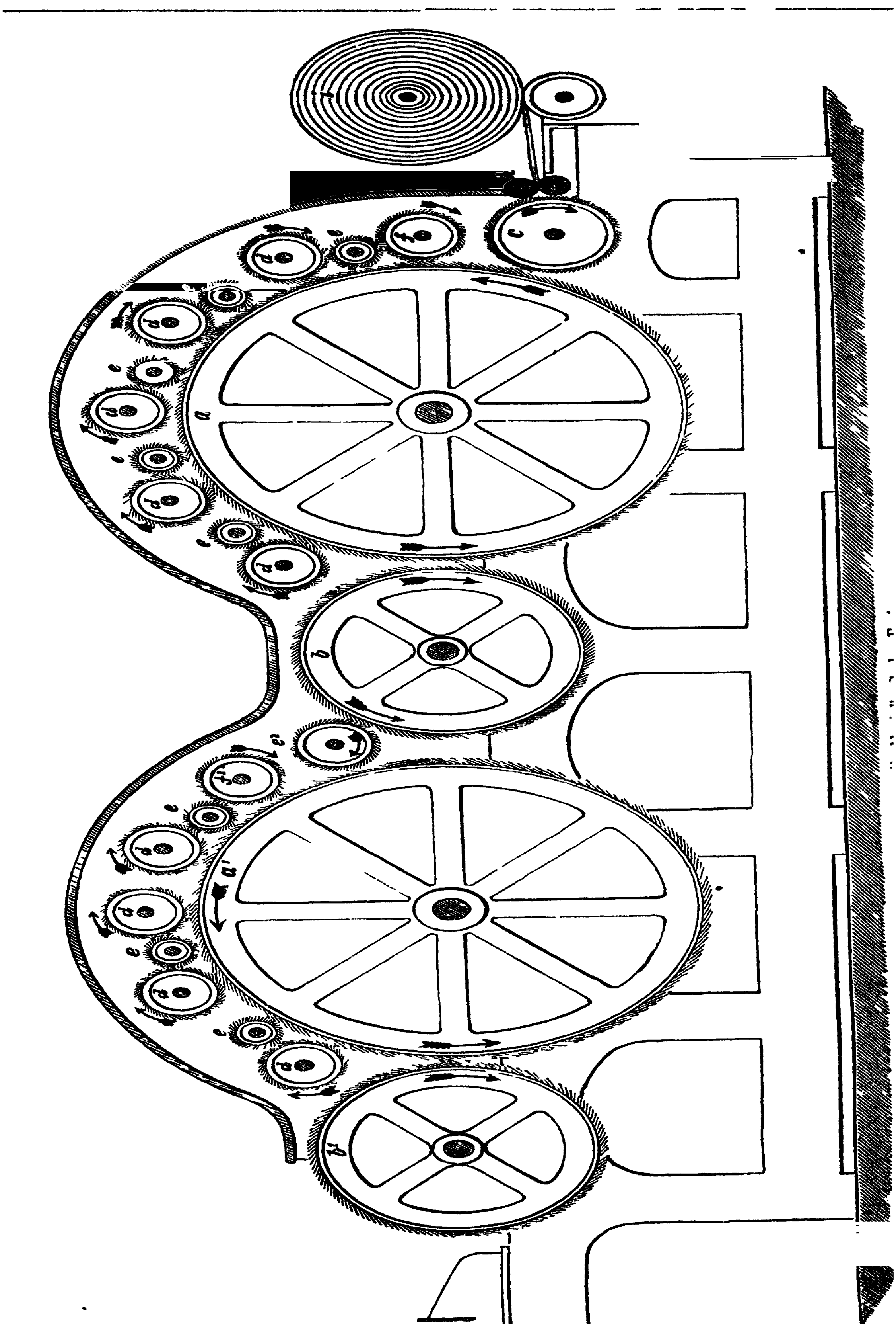
Roller Engine Bends.—Machinists have generally their own crotchets about engine bends and the mode of setting rollers and clearers. If illustrations were given of all the different methods that have been devised for this object, they would extend over many pages, and distract the student's judgment without answering any good purpose; therefore it is thought better to lay down an absolute rule, which must be attended to in the manufacture of all engine bends, whether for rollers or flats, otherwise bad carding will result. Whatever form of bend be adopted, it is of the utmost importance that the carding rollers or flats be set *exactly* parallel with the cylinder, and that the movement downward as the wire wears be in a *direct line*, converging to the centre of the cylinder on both sides of the engine. This is a point which is sometimes neglected by machinists, even where they have proper tools to do the work, and the result is unsatisfactory carding, arising from a cause which is not suspected, and which might just as well have been made right as otherwise.

This accurate movement of the rollers so as to converge to the centre of the main cylinder being assured, the simpler and neater the pedestals and other fixings are made the better, it being quite unnecessary to resort to complications and unsightly mechanism to effect this object with precision.

THE DOUBLE CARDING ENGINE.

This card has four cylinders besides the licker-in. The two larger cylinders have carding rollers and clearers mounted over them in the same manner as the single roller engine already described. The middle cylinder *b*, which is about the same diameter as the doffer *b*1, is technically termed the "tummer;" it acts as a doffer to the first main cylinder, as will be seen in the section *Fig.* 75, and in its turn is stripped by the clearer *e*1. That transfers the cotton to the second main cylinder *a*1, which with its rollers and clearers repeats the same process of carding as the cotton passed through on the first main cylinder; after this the doffer *b*1 takes the cotton off in the same manner as a single carding engine. The rollers *f* and *f*1 can be used either as carding rollers or as "fancy" rollers for stripping the cylinders *a* and *a*1; as shown in the drawing they are clothed as used for fancy rollers. When used for carding rollers, the fillets are reversed, and they are run at the same speed as the other rollers marked *d*; but when used for stripping the cylinders, the surface speed must exceed that of the cylinders. From the large quantity of wire in action, this engine possesses great carding power. It is used almost exclusively in Oldham and its neighbourhood for carding waste and low qualities of cotton to spin coarse counts. Sometimes spinners in that locality will use it for finer yarns made from American cotton without waste, which probably arises from prejudice and their having been trained up to its use, as no sound argument can be advanced in its favour, except as a powerful waste carding engine for low numbers, where neither quality or colour are an object. Critically examined in comparison with the single card, it is very doubtful if any real advantage could be shown in its favour for any numbers, or the roughest work. It costs nearly double the money, takes twice the floor space and power of the single card, yet it will not do double the work of the latter and come up to the same quality. There is no saving of labour from its use, and the *colour* of the yarn from the same mixing is never so good as from the single card, which arises from the great surface of wire which the cotton passes over and the fine particles of iron that lodge in the rollers and cylinders after grinding being gradually taken up and incorporated with the cotton, giving the yarn a bluish tinge and sullied appearance.

A striking instance of this once came under observation. Thus, a spinner of common 40's export yarn, in establishing a new concern put in a preparation of six double cards, all the rest being single engines, the drawing, slubbing, and roving frames were alike throughout the mill; all the cards worked from the same mixing of cotton and same laps. To his surprise the yarn was always striped, however careful he was in mixing the cotton, the stripes being of a bluish tinge. For some



time he could not find out the cause. At length, however, he traced it clearly to the rovings which came from the preparation of double engines being mixed with the other bobbins. This being ascertained, those bobbins were carefully kept separate and spun by themselves; but after being reeled, the hanks would not mix with the other, as every one could be picked out of a bundle from its bluish colour and sullied appearance, as if waste had been mixed with the cotton. He had worked on for some months before finding out the real cause of his striped yarn, during which he incurred considerable loss in making money allowances to the purchaser for spoiled yarn, which he thought arose from careless mixing. His reputation as a good spinner suffered at the same time with his old connexions, which was most vexatious.

After discovering the cause of all the trouble, he removed the six double engines to another room, and used them as a separate preparation to work up his waste and inferior bales of cotton. It required two "hands" to manage them, and they just took up the whole width of the room (sixteen yards), the engines being 40 inches on the wire. Before they had worked twelve months two narrow escapes of fire occurred through the excessive speed of the cranks (on the old plan of doffer comb) heating and taking fire. A part of the room they occupied being at length urgently wanted for other purposes, and a part of the power also, it was determined to sell these cards out, and put in seven single ones, with cylinders 45 inches diameter, which it was found would stand in the same width of room that the six double cards required, and leave half the room at the back. Trade being good at the time and machinery in demand, the six double engines sold, clothed as they were, for £600; and the seven single ones to replace them cost, clothed and set to work, £490, including all the expenses of removal. The results of the change were: (1) £110 of capital was saved, over and above the loss incurred in changing; (2) One hand was saved, at fifteen shillings per week; (3) The same quantity of work was done without hurry or danger; (4) One-half the power was saved, and one-half the room; (5) The yarn was of better colour and would fetch a better price.

It is no argument to say that certain individuals, who have used the double carding engine, have flourished, and so also has a certain district where its use prevails. If properly investigated, it will be found that the true cause of their prosperity lies rather in the indomitable industry of those individuals or community, and other favourable circumstances, than in the use of this card.

Faulkner's Roller Card.—In the year 1835, Mr. Samuel Faulkner, of Manchester, a very ingenious and persevering spinner of fine yarns, took out a patent for a roller carding engine of a very peculiar construction, in which he made an attempt to dispense with hand-stripped flats, by applying rollers in a novel form for fine cottons; and in the year 1843 he took out a second patent for further improvements in the same. *Fig.* 76 shows this engine in section, according to latter patent, which is thus described in the specification :—

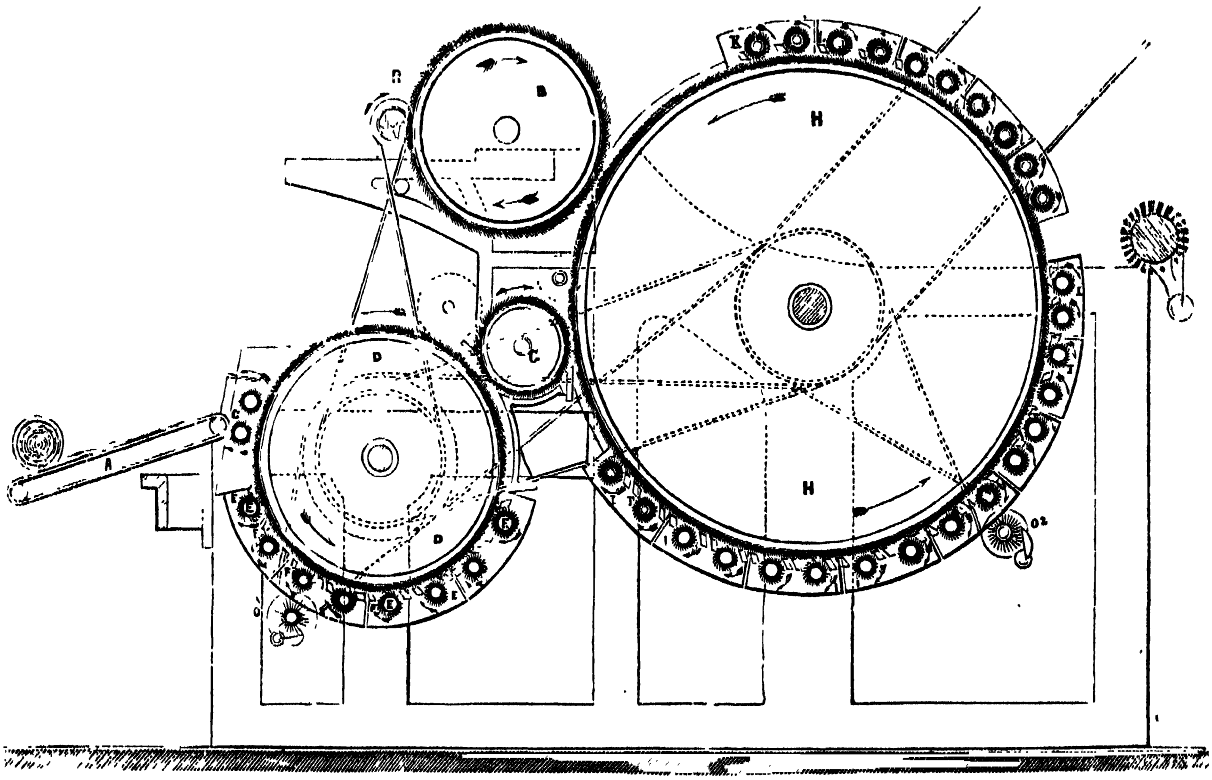


Fig. 76.—Faulkner's Patent Carding Engine (Scale ⅝-inch = 1 foot.

"A is the feeding cloth, placed below the doffing cylinder B in front of the card. From the feeding cloth A the cotton is uniformly delivered to the feeding rollers C. The cotton is then passed under the operation of a breaker roller D covered with cards, and a series of carding rollers E E, with their accompanying straight edges or blades F F, arranged below or around the lower portion of the roller D; the first series of blades F act to each carding roller E as a stripper, and the second series of blades F 1 are placed at such a distance behind the first as is considered sufficient to allow the dirt, motes and other extraneous matter to escape as it is disengaged by the action of the cards. This straight edge is also intended to knock off any dirt that may be upon the face of the breaker or carding cylinder D; but for that purpose I do not consider it new. I have ascertained by practice that 1-8th to 1-4th of an inch is sufficient space or opening to allow between the two blades F F 1. The cotton now having passed the first breaking or carding process, and beyond the action of the series of rollers and blades, a very considerable portion of all the extraneous matter is separated from it, and will have fallen upon the floor below the cylinder D. The cotton is now taken off the cylinder D by means of the intermediate card cylinder G, which conveys it to the main carding cylinder H, and is then submitted to the action of that and the lower series of carding rollers I I, and their assistant clearers, blades, or straight-edges J J on the lower part of the periphery of the main cylinder in a similar manner as just described, and thereby receives an increased carding to disengage that portion of motes and other extraneous matter which may still remain from this part of the process. The cotton continues to pass with the main cylinder until it is submitted to the action of the top series of carding rollers K K and their clearers, blades, or straight edges, I I, which are more particularly intended to take out the small white 'neps' or knots which frequently still remain, and are mostly found in fine or Sea Island cotton; and it is chiefly for this purpose that I consider them useful, and that they may be dispensed with in carding coarser cotton. The cotton now being completely carded, is taken off the main cylinder H by the doffing cylinder B, and is removed therefrom either by the ordinary doffing comb, or by my improved mode of doffing hereafter described."

Mr. Faulkner also included in his patent a novel method of making card cylinders, which will be noticed hereafter.

There is no disputing the great ingenuity displayed in this machine; and had Mr. Faulkner made his engine less complicated and more in the ordinary form, it is probable he might have been more successful. As it was, however, none of the fine spinners followed him, but some of his cards were tried in Glasgow for coarse numbers, and it was alleged that they got through an extraordinary quantity of work. Mr. Faulkner has recently taken out another patent for carding on this principle with cylinders so large that a pit is required for each card to stand in. Whatever may be thought by spinners in general about this new application of his principle, he succeeds in working it himself with apparent success, in lieu of the small breaker and finisher cards, for fine numbers, making one large engine do the work of about five pairs of the ordinary breaker and finisher engines.

Pooley's Card.—In the year 1845, Mr. Charles Pooley, of Manchester, took out a patent for carding. A section of his engine is given below *(Fig. 77)*, from which it will be seen that there is no taker-in, the cotton being fed to the cylinder *a* direct; the feed rollers are placed under the doffer *b*, and the lap unrolled by the action of a

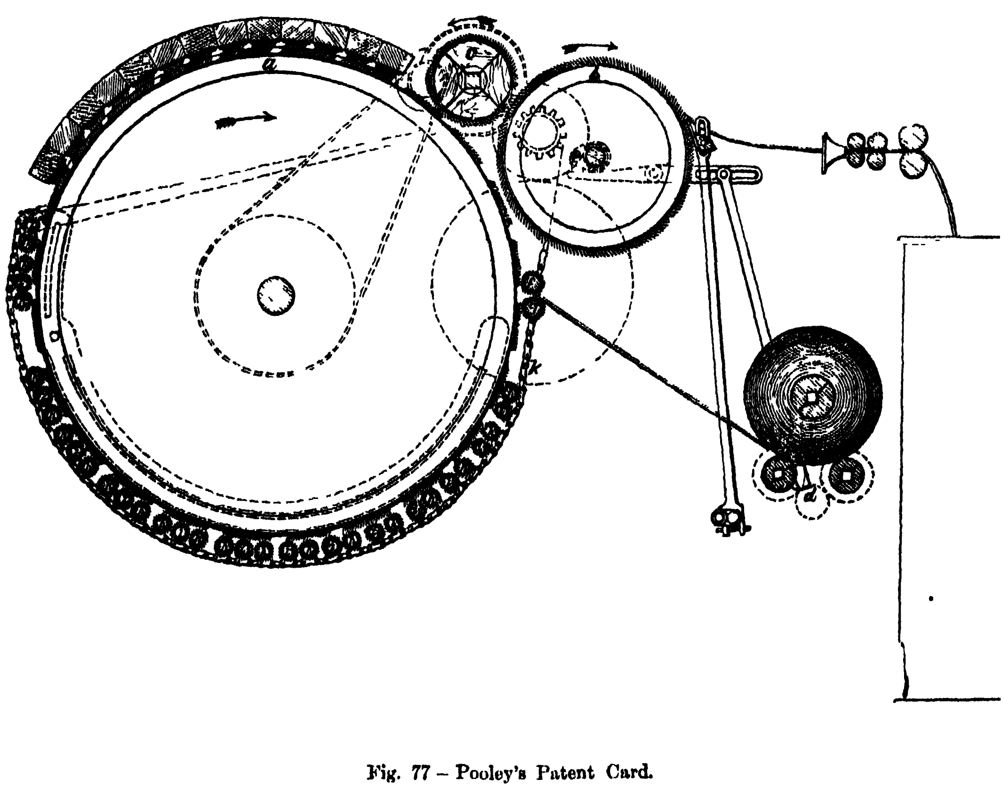


Fig. 77 – Pooley's Patent Card.

lever and connecting rod upon a ratchet wheel *d*, put in motion by a cam *e* on the doffer. A series of small rollers *h* and *i* commence at a short distance from the feed rollers, and pass under the main cylinder, terminating on the opposite side near to the first of the top cards. Part of the rollers forming the series are what are commonly called workers, and part of them are what are commonly called clearers. The workers are marked *h*, and the clearers are all marked *i*. It will be seen, on examining the drawing, that the workers and clearers are placed alternately at the early part of the series; in the next portion of the series two workers are placed for one clearer. The workers and clearers, *h* and *i*, are made to revolve slowly by means of two endless chains *k*, parts of one of which are only shown in the drawing. After passing the workers and clearers, the cotton comes in contact with thirteen ordinary hand-stripped flats, when it is taken off the main cylinder by the roller *c*, the periphery of which is made to run faster than that of the cylinder *a*; and it deposits the cotton on the doffer *b*, which revolves in the opposite direction from what is usual; therefore the cotton web comes off on the top side, and the doffing comb strikes upwards.

Mr. Pooley changed a number of his old cards to this principle, and worked them a considerable time with apparent success, but when he put in new machinery he abandoned it. There is something strikingly novel in taking the cotton off the cylinder entirely by the fancy roller or stripper *c*, and depositing it on the doffer, the latter not being in contact with the cylinder at all. If this principle could be carried out with neatness and certainty, it would have many important advantages. With a bare cylinder the top cards would carry no cotton or next to none; and the cylinder itself, when bare, possesses twice the carding power.

It is worth reflecting upon, whether it would not be worth while to try an engine on this plan, with the cylinder running only at half the present speed, with the rollers of larger size and more conveniently placed, or with self-stripping flats and a licker-in. The stripping roller *c* would do its work with ease and certainty if the main cylinder only ran at a surface speed of about 800 feet per minute; there would also be considerably less fly and strips, as the flats would scarcely carry anything but motes, and the small centrifugal action of the cylinder would throw off but little fly. Less power would also be required, as all would go only half speed, except the feed rollers and doffer. Probably 1,000 feet per minute of cylinder speed might be attained with comfort and certainty upon this plan of carding; but, beyond that, it is doubtful whether increase of speed would be attended with any advantage.

WILKINSON'S ROLLER CARD.—This method of carding was brought out at Stalybridge, in 1856, by Robert Wilkinson, a mechanic in the employ of Messrs. George Cheetham and Sons. The principle in this engine will be seen in reference to *Fig.* 78, and consists in substituting rollers of small diameter in place of top flats. These rollers were alike in diameter, all carding rollers, and neatly arranged for setting to the cylinder. They had each a small pinion upon one end, which took into a chain that passed on the under side of them, being held up to them by projections from the steps

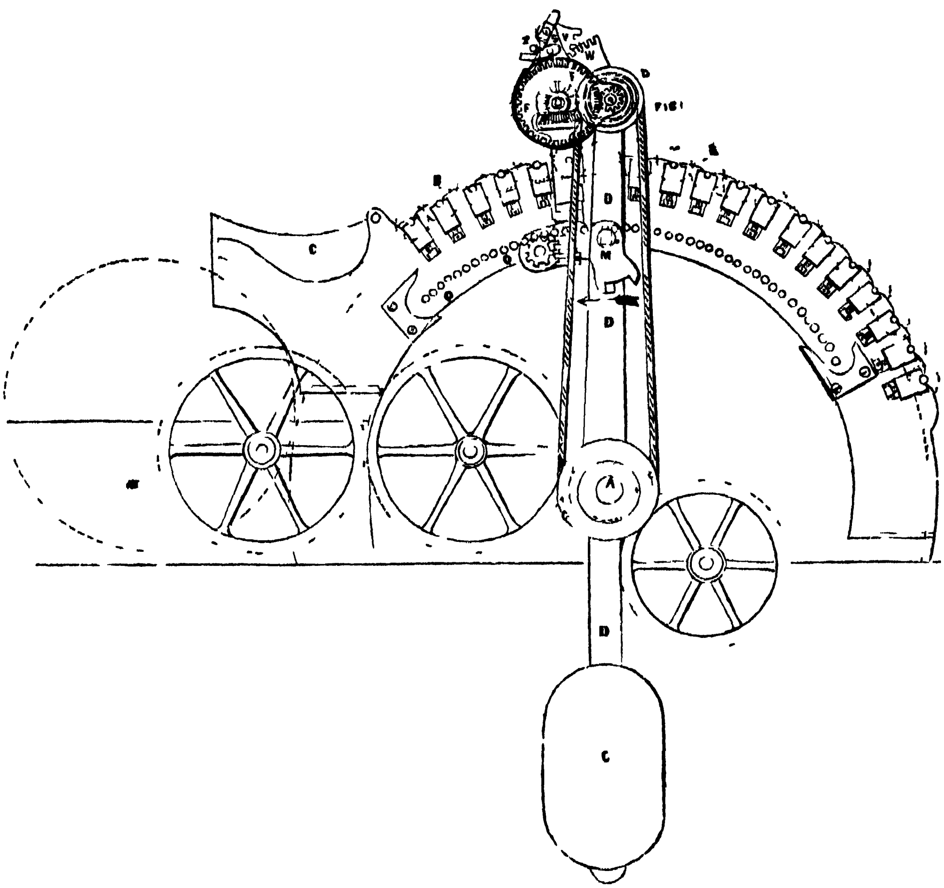


Fig 78 —Robert Wilkinson's Patent (Scale ⅜ inch = 1 foot).

of the rollers. A very slow motion was given to the rollers, all in one direction, and they were cleared of motes and dirt by a circular brush mounted on the lever B, which, after passing over them in the direction of the doffer, deposited the strips, by aid of a comb and other mechanism, into the box C. This lever was worked to and fro by a mangle motion, formed by studs cast on the bend, upon which a pinion worked top and bottom alternately, the brush being lifted off the rollers on the return motion, when the pinion rose to the top side.

The performance of this card was sufficiently satisfactory to induce Messrs. Cheetham to alter a whole cardroom to the principle, and a few other spinners followed their example; but after a lengthened trial, it was either abandoned altogether or not proceeded with further.

ADSHEAD AND HOLDEN'S ROLLER CARD.—This form of carding was patented by Mr. James Sidebottom Adshead and Abraham Holden, of Stalybridge, in 1857. It will be understood from the following description:—

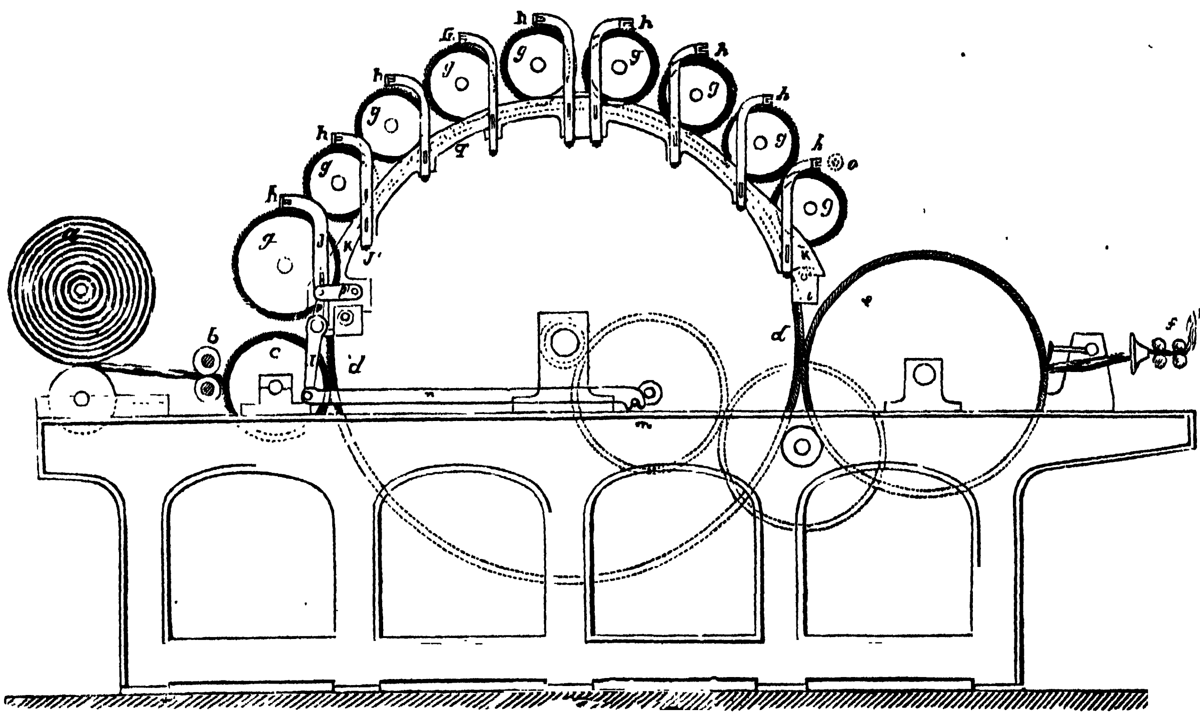


Fig. 79.—Adshead & Holden's Patent Roller Carding Engine (Scale ¾ inch=1 foot).

a (Fig. 79) is the cotton lap; *b* the feed rollers; *c* the licker-in; *ggg* are all carding rollers, which cover the main cylinder *d*, being set to the latter, and about ¼ inch apart from each other. They are all made to move in the same direction, with a very slow motion, acting as dirt and carding rollers combined. There are plates of iron placed between each roller, close to the cylinder, to prevent fly and dust blowing out between the rollers. As the latter slowly revolved, they brought up motes and cotton which were stripped from them on the top side by the combs *h*, which were mounted on the vertical legs of the frame *k*. This frame being caused to slide to and fro by a cam or crank motion, gave a horizontal movement to all the combs at once, causing the strips to curl up on the top of each roller, in such a manner that they could be pulled off by hand when the roll of strips on the top of each roller became sufficiently large.

This engine excited a considerable amount of attention after its introduction, principally from the fact of its being taken up and recommended by an eminent and well-known machine-making firm, who, no doubt, thought highly of it at the time, but finding, after a considerable number had been made, that it did not answer the expectations formed of it, ceased to advocate it; and it is believed that none are now made entirely on that principle.

The great drawback to the success of this engine, as a self-stripper, is the large amount of waste made by the rollers being all stripped by combs as they revolve slowly round, and the small amount of clean wire presented to the action of the cylinder. This invention, however, has not been without its use, for it is still applied to the stripping of one or two dirt rollers on ordinary roller carding engines, which are generally the two first rollers over the licker-in, being run at a very slow speed, and stripped on Adshead and Holden's principle, with two combs acting on the top side of the rollers with a longitudinal motion, the waste curling in a roll on the top, which is more convenient than being caught in a box, as shown by Birch in 1837.

THE UNION CARDING ENGINE.—When rollers and flats are used in combination on the same engine it is called a "Union Card."

These cards have been extensively employed for single carding; also as breakers, where breaker and finisher are used. Sometimes they are made with one roller and one clearer only the rest being flats; sometimes with two, three, or even four rollers, and clearers to correspond. The example selected (*Fig.* 80) has three rollers and two

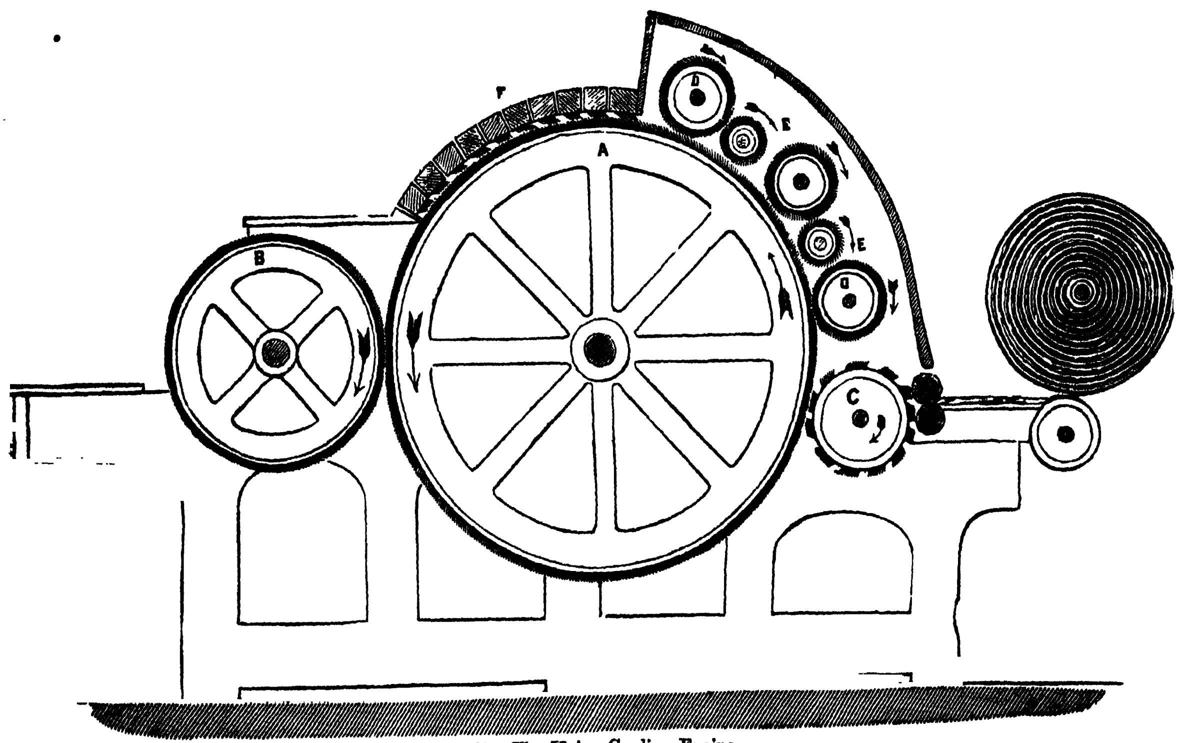


Fig. 80.—The Union Carding Engine.

clearers, one of which strips two rollers and the other only one roller. The first roller *d*, which is placed immediately over the taker-in *c*, can be used for stripping the cylinder, as a "fancy," if the wire be put on the opposite way (as shown in previous examples), and if the speed be increased so as to over-run the cylinder *a;* but it is more generally employed for carding, as above, being set up to the clearer. Some spinners prefer to have the flats placed over the taker-in, with the rollers and clearers next to the doffer, but the former is the most common method of construction.

The idea, in this card, is founded on good common sense, being simply to break up the cotton with the licker-in and rollers first, and then finish it off more smoothly with the flats before it gets to the doffer; also, it was imagined, it would save one-half the top strippers' wages.

It has, on the whole, worked well, but the saving in top strippers' wages disappears when account is taken of the hands required for cleaning, oiling, brushing out, and grinding up the rollers and clearers which require to be carried about the room for that purpose. Then, again, the same arrangement of bands, straps, and pulleys, for driving the rollers and clearers, has to be made as if the card was all rollers and strippers. This complicates the machine, and adds to the expense of construction, which is a drawback, but nevertheless it is a good practical card, in extensive use.

The Union Card is shown above with hand-stripped flats, but it is generally made now with self-stripped flats, of which one or two examples will be given further on.

Mason's Concentric Bend.—*Fig.* 81, below, shows a drawing of a carding engine bend, brought out many years ago by Mr. J. Mason, Rochdale. It is so arranged that two bends can be screwed together at the feet and turned in a lathe. The parts turned are the flanges A, A1, A2. In this bend the clearer pedestals B B

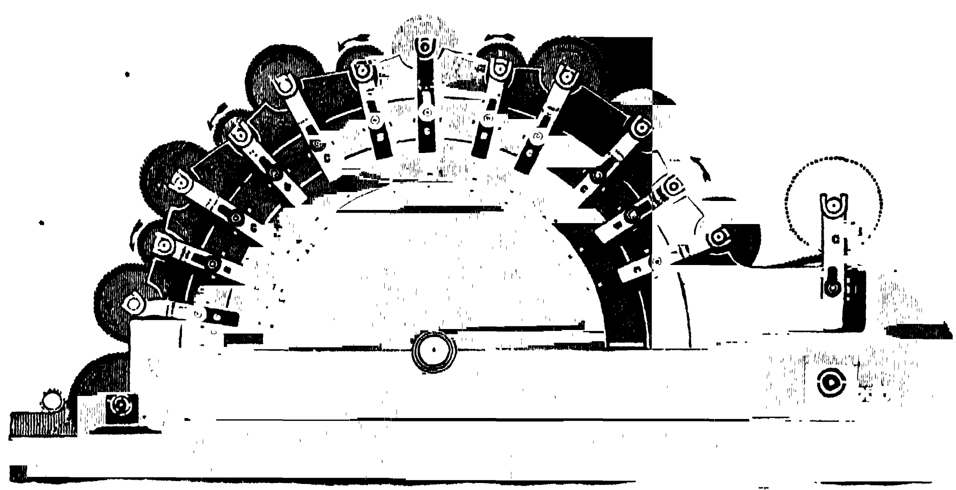


Fig. 81.—Mason's Bend (Scale ⅜ inch=1 foot).

have only one movement, up or down, converging to the centre of the cylinder; and the roller pedestals C C have a lateral as well as a vertical movement. Both the roller and clearer pedestals are each mounted on a shoe, to which they are fitted so as to slide freely up or down. These shoes fit in between the flanges A and A 1; and those shoes which carry the clearer pedestals B are, after being fixed accurately in their places, pinned fast to the bend, so that the clearers can only move up or down with precision, but the roller shoes will move laterally, thereby allowing the rollers to be set up to the clearers by the screws D and lock nuts D 1. By reason of the flanges A and A 1 being turned from the same centre as the cylinder, the shoes which fit in them can be moved to any part of the bend and still be in exact radial line with the cylinder centre, which is the object sought. The bottom flange A 2 has been added to this bend as a better means of raising or lowering the rollers and clearers, which may be done to a great nicety by the two nuts EE, which fit on the screws FF that pass through the flange A 2. The flange A 2 is made to project further out from the body of the bend than the other two flanges A and A 1, in order to allow the screws F and F 1 to pass through them; the flanges being slotted a little where the screws F 1 pass through, so as to let the roller pedestals C move laterally. The pedestal G, which carries the grinding roller over the doffer, is set up or down by the screw being placed on one side as shown, which is more convenient to get to than in the ordinary way. It will be noticed also that all the nuts are of the same size, so that one key fits everywhere.

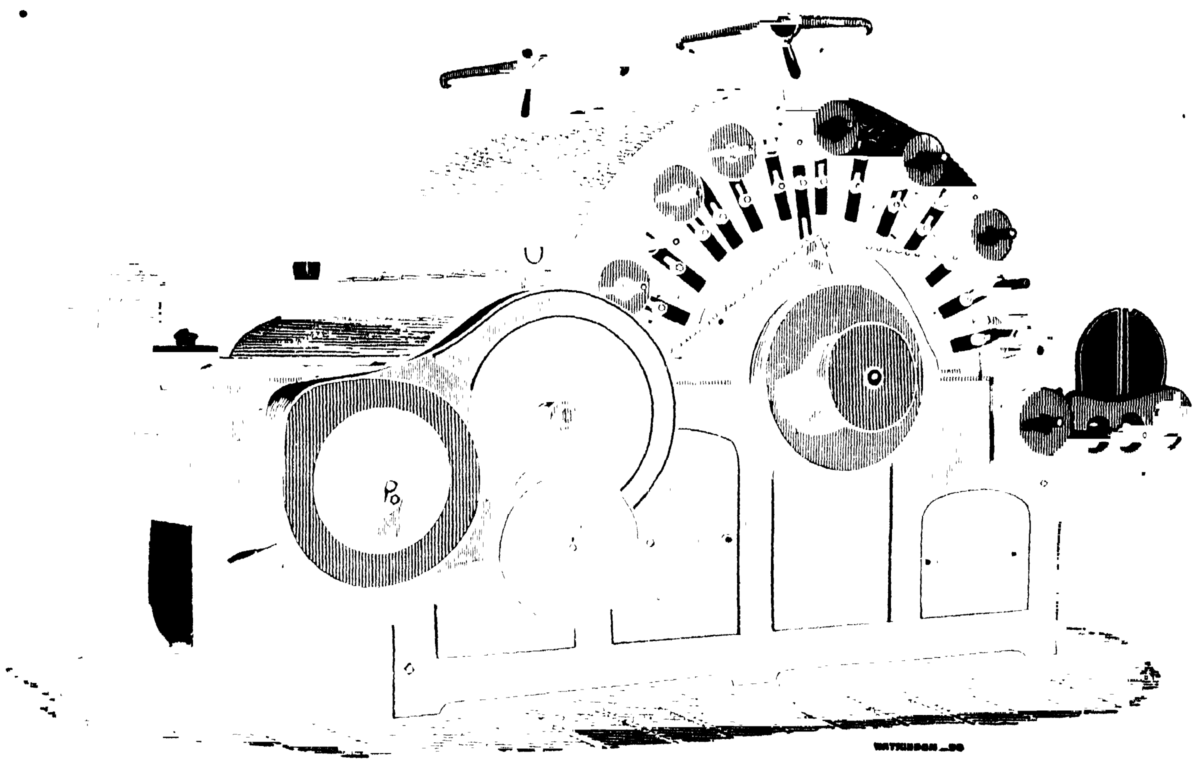


Fig. 82.—Carding Engine with the Mason Bend.

The external appearance of the Mason bend is not neat: the bent screws, by which the rollers are set up to the clearers, look clumsy and unmechanical, but the principle of maintaining exact converging lines to the cylinder centre is sound, and it also admits of two rollers being stripped by one clearer, if required, without danger of their being set out of parallel with the cylinder.

Fig. 82 shows perspective views of an engine built upon this principle, with latest improvements.

BREAKER AND FINISHER CARDS.

After Arkwright had fairly established the principle of carding, all the spinners of fine and medium counts of yarn settled to one uniform system of carding their long-stapled cottons by breaker and finisher cards. These engines were exceedingly simple in construction, small in dimensions, and cost little to make them. At first the framing was of wood, then of iron, in form as under, *Fig.* 83, representing the breaker in section, in which A represents the main cylinder, 36 inches in diameter,

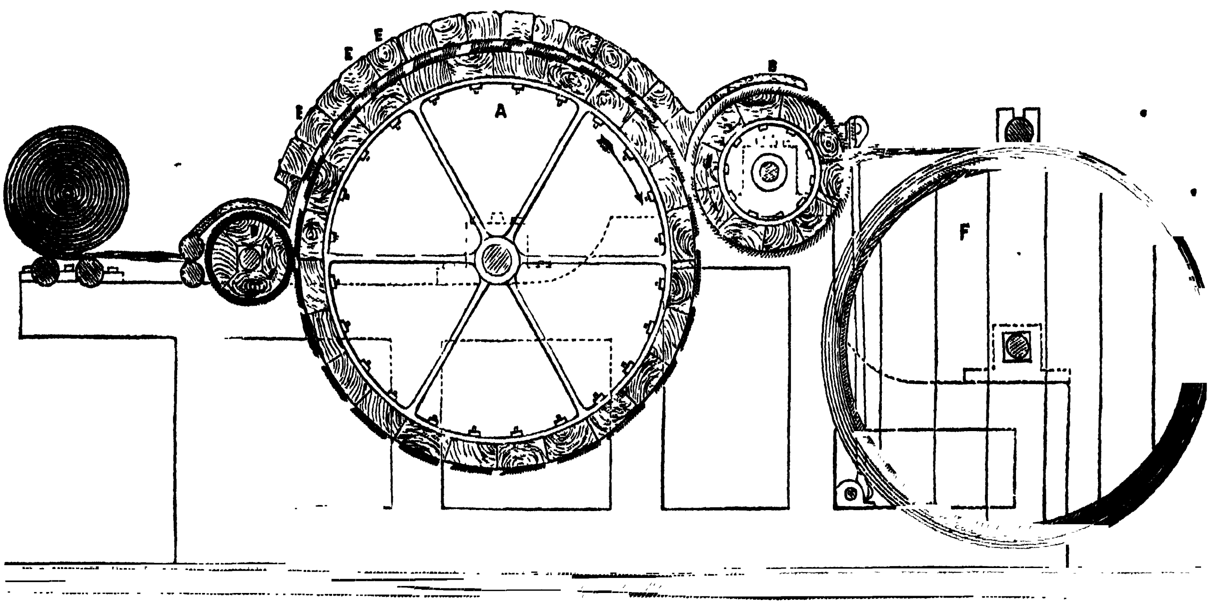


Fig. 83.—Breaker Carding Engine.

B the doffer, 14 inches diameter, and C the taker-in, 7 inches diameter; the licker-in not being used generally, only partially after some time had elapsed from the establishment of the system. Until Crighton invented the Lap Machine the cotton was spread upon a cloth or lattice feeder by hand, the cloth being marked transversely about two feet apart. A given weight of cotton was batted with a stick and fed upon it, being drawn in by the feed rollers D, was passed to the cylinder by the licker-in, and under the flats E, which were adjusted to the cylinder by screws, as shown in *Fig.* 84. When the cotton was stripped from the doffer B, it was rolled in layers upon the lap drum F, until it got a certain thickness of lap, when it was broken off by hand, doubled in folds, and weighed; if found too heavy a strip was broken off it longitudinally to adjust the weight, after which it was taken to the finisher card, *Fig.* 85, placed in a box F, and drawn through the feed rollers to the cylinder.

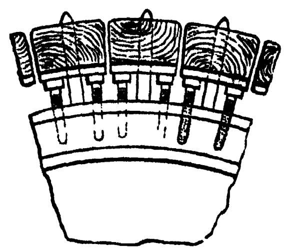


Fig. 84.

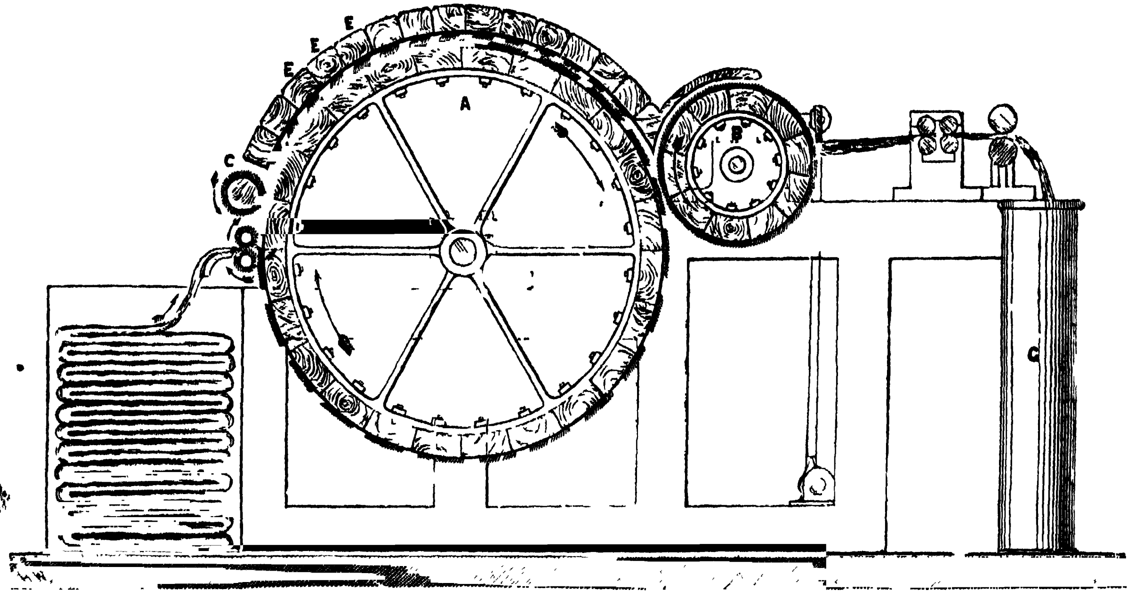


Fig. 85—Finisher Carding Engine.

The finisher card differed but slightly from the breaker. It had no taker-in, but a small roller, C, next to the feed rollers, termed "jack roller;" then followed the flats E. Instead of the lap drum, the end or sliver from the doffer was passed through a draw box and pair of callenders before being received into the can G.

For more than forty years this system of carding was used by the fine and medium count spinners of Manchester, Ashton, Stalybridge, Dukinfield, Hyde, Glossop, Mosley, Bolton, and Preston, likewise in Glasgow; and wherever it was in vogue a superior quality of work was produced. The width of the cards on the wire was only 18 inches for the finest yarns, and 36 inches for the medium counts.

The quantity produced, per pair of cards, was small, and the waste made in top strips and fly considerable, but the carding was well done; and the extra expense of the system, compared with single carding, was amply compensated for, by the superior working of all the frames and spinning machines in the subsequent operations, which not only produced more per spindle, but made less waste where a saving in the latter was of greater importance than in carding. The fly and strips were not lost, because waste of that description could be sold to waste spinners, but the waste made in spinning from breakage was almost entirely lost; therefore it could not be tolerated, as in that department it was then, as it is now, most ruinous.

It might be said, "Show me the spinning, and I will tell you what the manager is."

Although the little breaker and finisher have almost disappeared, having been succeeded by engines of a larger and more expensive type, the comparison between single and double carding still holds good, but not quite to the same extent, the scutching now being much more perfect.

It is also certain that the same quality cannot be produced from breakers and finishers of large dimensions doing proportionately more work, as was done upon the little breaker and finisher. In the former, the cotton has to pass over more wire in thicker layers, by which it is apt to get rolled and nepped. There is also such a thing as *over carding.* Machinists have been driven to make engines larger and more expensive by the constant clamour and pressure put upon them for more work from each card. For single carding and low numbers, where quantity rather than quality is the object, this may do very well, but not in breaker and finisher.

Notwithstanding that the small and simply constructed breaker and finisher cards held their ground so long, it must not be supposed that the system was faultless. On the contrary, there were many annoyances connected with it, which became more conspicuous as mills were established on a larger scale. So long as a master had only one or two top strippers in his mill, who were generally old hands that did their work honestly, all went well; but when the necessity arose of employing a large number of workmen in an occupation which from its nature was irksome, because dusty and unhealthy, it became more difficult to get all the men of a right class to do the work honestly. It was found that if the men were paid by weekly wages, the regularity of the obnoxious and dusty work was neglected; and if paid by the weight of strips obtained cheating was, in various ways, resorted to, such as mixing fly with their strips, or mischievously setting the doffers away from the cylinders, so that the latter might carry more cotton, and consequently the flats also, for the purpose of increasing their earnings, at a tenfold expense to the proprietor, through his cotton being partially rolled into neps instead of being properly carded.

Such vexatious things caused several determined efforts to be made to solve the difficult problem of mechanical stripping. An enterprising Scotch spinner took the lead in this important improvement in carding machinery; and it is believed that Mr.

Archibald Buchanan, partner of Messrs. Finlay and Co., of the Catrine Mills, in Ayrshire, was the first who practically succeeded in this desirable object.' A sketch of Mr. Buchanan's engine is given in *Figs.* 86 and 87, and his patent is dated December 4th, 1823, No. 4,875.

Referring to the two views of Mr. Buchanan's self-stripping card that are copied from his specification as enrolled, which is too long and elaborate to introduce here, A (*Fig.* 86) represents the main cylinder, B the doffer, and C the feed rollers placed

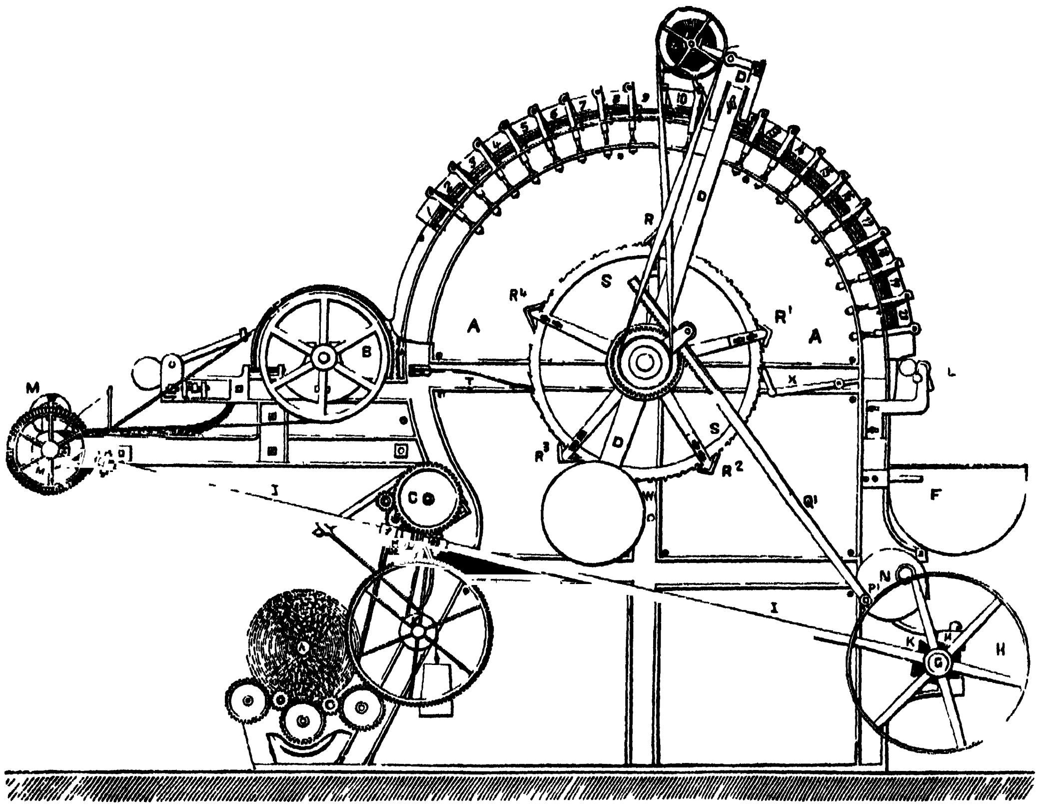


Fig. 86.—Buchanan's Self-stripping Card

under the doffer, and feeding the cotton direct to the cylinder. The flats are marked with figures numbering from 1 to 20. It will be seen that these flats are supported at one top corner by a hinge which is raised or lowered by two nuts acting against the bottom flange of the bend; the other corner of each flat rests on a set screw fixed in the bend; by these means the flats are set to the cylinder, and any desired bevel given to the cards upon them. There is a projecting stud fixed at one end of each flat, at the opposite corner to the hinge, by means of which the flat is raised and turned on its back; and while in this position the circular brush Z, which is mounted on the lever or radius arm D, passes over it, and strips off the motes, after which it is turned back again to its work by the return of the radius arm, but not until the latter has stripped another flat in its forward movement, and also cleansed the brush of the strips from the two flats. This is done by the radius bar passing on to the end of its stroke, when it comes in contact with a needle frame or comb E, when the brush cleans itself by revolving between the needles, which, in their turn, are stripped by a sliding copper plate, and the strips fall into the box F.

The mechanism in effecting these movements will be easily understood by referring first to the back shaft G, shown in *Figs.* 86 and 87. The end of this shaft (*Fig.* 86) has a pair of fast and loose pulleys H, being driven by a strap from the main driving shaft in the room. This back shaft gives motion to a diagonal side shaft I, by means of a pair of bevel wheels K K, which drive the feed rollers by a worm I in the middle (the cotton being fed direct to the main cylinder), and the callender rollers, MM, by a pair of bevel wheels. The doffer is driven by a cross strap working on a pulley keyed on the bottom callender shaft, and the lap rollers by a train of wheels from the feed rollers.

On the other side (*Fig.* 87), the back shaft G drives the main cylinder by a pulley and cross strap, likewise the crank or disc shaft N, through a pair of bevels, short shaft O, and worm. The shaft N has two studs, P P[1], one fixed in the worm wheel,

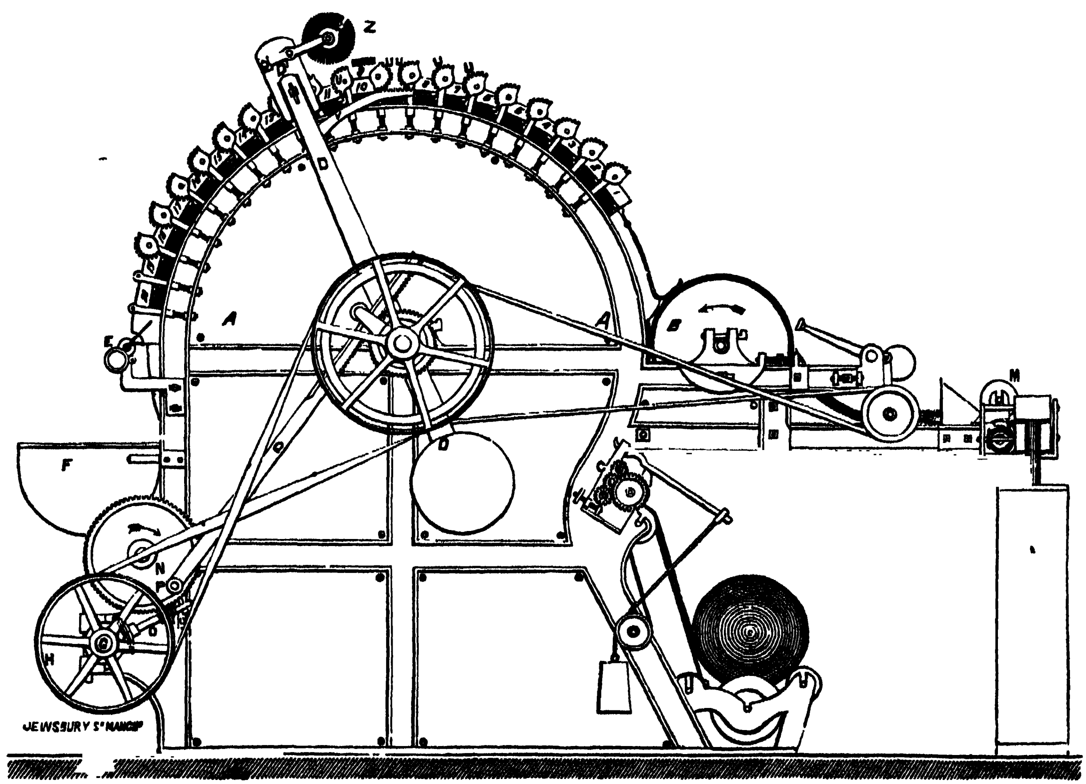


Fig. 87.—Buchanan's Self-stripping Carding Engine (2).

and the other in the disc at the other end. Attached to these studs are two connecting rods QQ^1, which work the oscillating arms by rack and pinion to and fro.

The radius arm D (*Fig.* 86) has a sliding bar fixed to the inner side with a bowl on the bottom of it. This bowl comes in contact with the triangles $R R^1 R^2 R^3 R^4$, screwed to the arms of a ratchet wheel S, that rests loose on the bush of the main cylinder, but is held in its place by the spring T, which catches in notches every time it is turned a tooth. In passing these triangles this inner bar (best seen in *Fig.* 88) is raised up when it acts upon the flat immediately above the triangle, which it raises and places the stud or handle of the flat in a curved recess formed in a head-plate D, fixed on the top of the radius arm, when the forward motion of the arm turns the flat over. On the return of the arm this stud takes into the curved recesses of the plate again by means of a sector wheel U and projecting arm rack V (*Fig.* 87) at the other side, and is put down again to the cylinder. Now, in making an oscillation to and fro, the arm passes two of the triangles, R and R^1; and if those be in the position shown, the flats 9 and 20 will be raised and stripped; after which, the ratchet wheel being moved

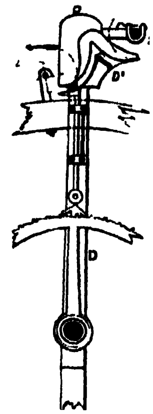


Fig. 88.

Fig. 89.—Portrait of Archibald Buchanan.

a tooth, the flats 8 and 19 will be next stripped, and so on all the way round. The ratchet wheel S is moved a tooth forward by a stud W, fixed in the balance weight at the bottom of the radius bar, coming in contact with the jointed lever X. A greater number of flats may be stripped at each oscillation of the arm by increasing the number of triangles on the circular ratchet wheel. The disc or crank shaft which gives motion to the radius arms, receives its motion through a friction brake Y, attached to the bevels on the little worm shaft; so that if anything gets fast, or goes wrong in the working of the radius arms, it gives way and stops without breaking anything.

It is hoped that the above description of the *first* self-stripping carding engine will be sufficiently lucid to enable the reader to understand its principles of action thoroughly, not only because the radius arm is at the present time the main feature in the Wellman and other self-stripping cards, but because it is an example of wonderful ingenuity, displayed, too, at a very early period in the history of the carding engine.

It is not known to what extent Mr. Buchanan's engines were used in Scotland, or whether any effort was made to introduce them into Lancashire, but they were never used to any practical extent in England; and it would appear that they could not have been sufficiently perfected to be quite satisfactory to the Scotch spinners, for the mechanical world was electrified by another "northern light" about ten years later, when the celebrated Mr. Smith, of Deanston, in Scotland, brought out at the same time a new self-stripping carding engine and a self-acting mule. These machines were introduced into Manchester simultaneously about the year 1834, and attracted great attention. Mr. Smith was an able mechanician, and a gentleman of pleasing manners; he was the managing partner of the Deanston Cotton Works, in Scotland, whence he emerged, and was recognised by the light he threw upon engineering, manufacturing, and agricultural science. His fame had preceded him when he came to Manchester to exhibit his new self-stripping carding engine and self-acting mule, and he was received with all the homage and courtesy usually awarded to men of genius. The author had the pleasure of his acquaintance, and took particular interest in him, because he was himself mentally labouring in the same field, viz., seeking the best method of making a self-stripping carding engine; but finding himself anticipated by Mr. Smith in regard to travelling flats, he dropped his plans until Mr. Smith's patent was run out.

Mr. Smith's engine was somewhat curiously constructed, feeding at both sides, with the main cylinder considerably elevated, over which traversed an endless chain of flats. These latter were made of tin, and covered on the face side with cement next to the cards. The ends of the flats had pieces of cast iron soldered to them, each of which carried a set screw with a lock-nut; one edge of the iron ends forming the convex and the other the concave hinge to couple to the next flat with pins. These flats were stripped as they came round by a very ingenious contrivance, consisting of a circular brush, which made a revolution as each flat came up, took off the waste, deposited it upon a long spiked comb which, in its turn, was stripped by a sliding copper plate, and the strips deposited in a box. The points of the set screws, placed in the cast-iron ends of each flat to adjust them to the cylinder, rested upon narrow pulleys of about the same diameter as the cylinder, which fitted loose on the ends of the cylinder shaft, and revolved slowly with the flats.

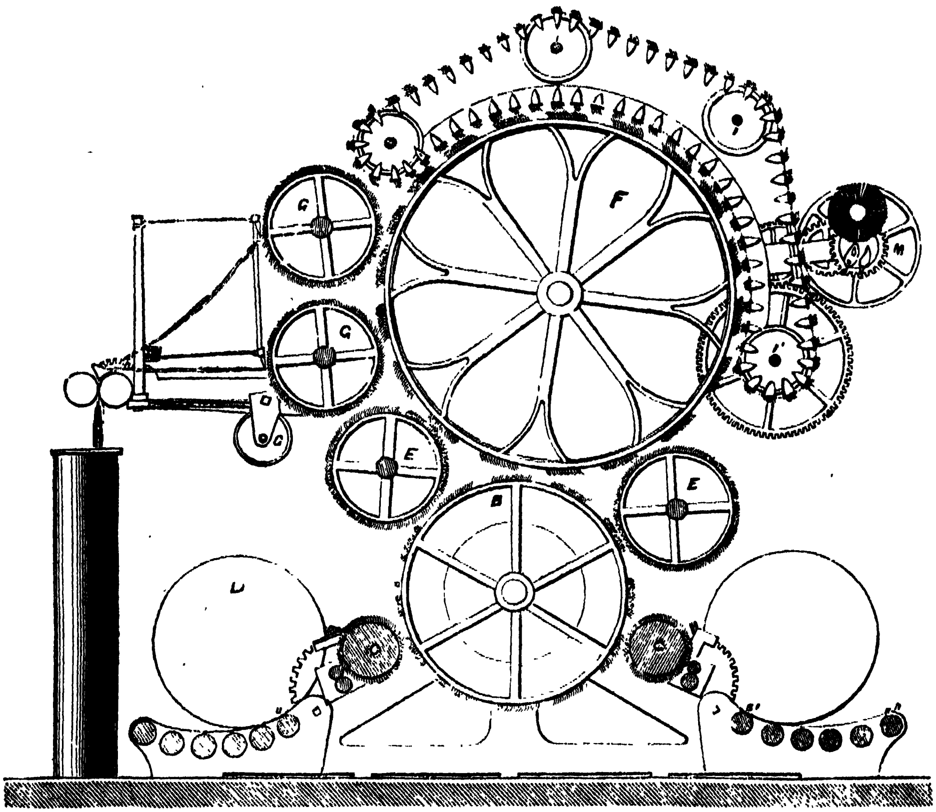


Fig. 90.—Smith's Self-stripping Carding Engine.

Referring to the section of this card, *Fig.* 90 (copied from enrolled specification, with writing abridged), it will be seen that D D represent the cotton laps, C C two takers-in, B a carding cylinder, E E are large rollers or doffing cylinders which strip the carding cylinder B, and give the cotton to the larger cylinder F, which is 36 inches diameter. The cotton then passes under the top cards or flats, of which about twenty-six are in action at once; it is then taken off by two doffers G G1, which are only 12 inches in diameter. These doffers are each stripped by a separate comb; and the carded cotton comes away in a double fleece to the callender rollers *g*, where the two fleeces are joined together. The stripping mechanism is shown at M.

Mr. Smith accomplished his object in making a carding engine strip its own tops; but finding he had to resort to considerable complication and expense in order to gain his point, he endeavoured to neutralise this by the addition of other cylinders and double feed, so as to produce twice as much work as could be turned off an ordinary card. This, however, only added to the general complication of the machine, and therefore its adoption in this locality was very partial, and after a fair trial proved unsuccessful; but his mule has answered very well, especially for low numbers.

Although a man may fail in carrying out what seems to him a good idea, and his invention may come to nought, nevertheless he leaves his mark on the age in which he lived—his footprint on the sands of time,—to show that he has trodden where man never trod before, in the pursuit of science for the benefit of his species. Therefore his labours are not in vain; he leaves his beacon in the desert to guide future travellers that way, or his buoy on the ocean to show where his ship foundered, as a

Fig 91.—Portrait of James Smith.

warning to others. Such a man was James Smith, the inventor of the subsoil plough and other useful things, for his genius was not confined to one particular pursuit, but partook of the universal, and his name will long be honourably remembered.

From the time of Smith's patent, in 1834, nothing particularly novel in carding came out, except Pooley's and Faulkner's roller engines, until the year 1850, when Evan Leigh took out a patent for a self-stripping carding engine, which was constructed as under (*Fig.* 92), in which A is the main cylinder, B the doffer, C C¹ two

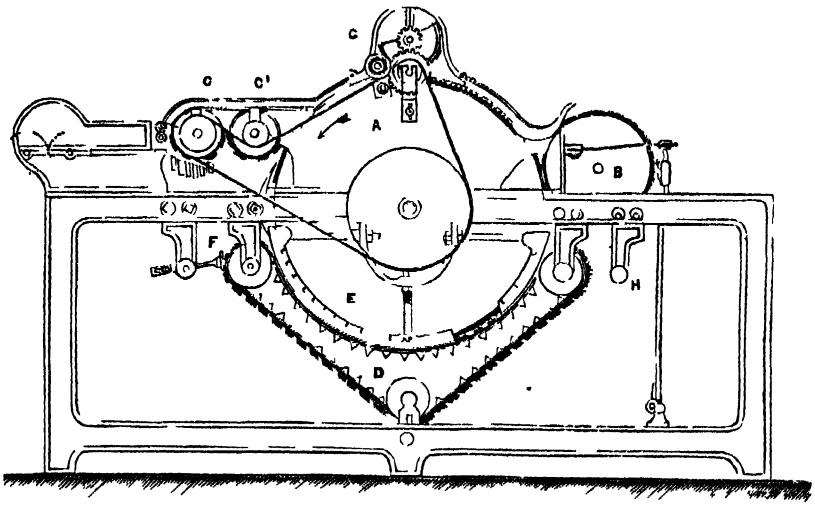


Fig. 92. Leigh's Self-stripping Card. (Scale ½ inch = 1 foot.)

takers-in, D an endless belt or sheet of cards, in spaces to represent flats, having the latter made of flat iron plates, two inches wide and 1-16th of an inch thick (*Fig.* 93), with V backs of tin soldered to them. These were fixed to the cloth with rivets under the wire, the indiarubber cloth forming the hinges, and were guided to the cylinder by a flexible bend E, so that they might act underneath the cylinder instead of on the top side, as usual. As they slowly revolved in the same direction as the cylinder, each flat, when it came up full of motes and dirt, was stripped by the oscillating comb F, when clean wire was supplied to the cylinder again. On the top of the card was placed a "fancy" roller and clearer (as shown at G) for stripping the main cylinder. This roller (*Fig.* 94) was not clothed with cards in the usual way, but had a narrow strip of card wound round it in a spiral direction, so that it might not throw all the cotton off the cylinder at once and put it on again by the clearer, but take a diagonal strip out here and there, by which it was thought that the carding would be smoother. It was feared, by the Inventor, that unless the flats were made very light they would

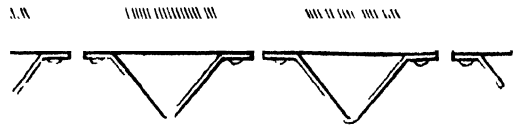


Fig. 93

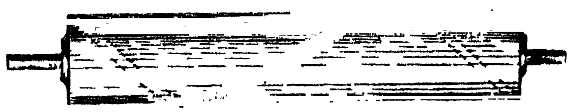


Fig. 94

not work well; consequently they were made so light that, when put to work, the sprung, and could not be set properly to the cylinder. Besides this, a great difficul was experienced in riveting them on to the cloth with lead rivets, which could not b properly done without special machinery; therefore, although the engine itself wa well built by the machinist who undertook it, nevertheless it was rejected at on from the above-named causes,—it might be said without a fair trial.

The appearance of this card was novel and striking, and its crude theo plausible. Cotton was fed to the first taker-in C, which ran at a surface speed about 500 feet per minute, taking the cotton downwards, until it came in contact wit the taker-in C^1, which ran at a surface speed of about 800 feet per minute in th opposite direction, thus stripping the first taker-in C, and conveying the cotton to th main cylinder A, which also took the cotton downwards, to the belt of flats acting o the underside of the cylinder. The web was doffed from the top side of the doffe as in Pooley's card, the comb striking upwards. The flats were intended to be groun in their places, when required, by placing a grinding roller at H, under the doffer. drawer was placed under the taker-in for receiving the motes.

This patent being taken out under the old expensive law, a number of othe things were combined with it, more in fact than could be carried out at once, ther fore the card was not then persevered with. One of the new machines specified i this patent was a Finisher Lap Machine, or Improved Derby Doubler (*Fig.* 95) whic

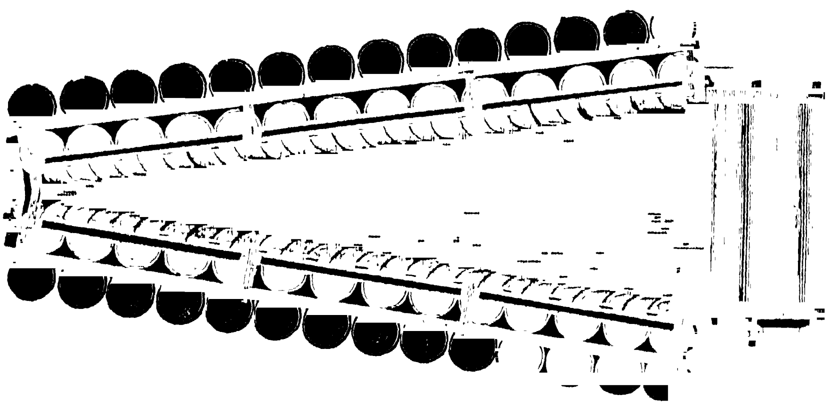


Fig. 95.—Finisher Lap Machine

consisted in adding a taper table to an ordinary lap machine. This table had a pai of callender rollers down each side. These rollers drew the ends from a number o

behind the callender rollers, deposited the ends neatly side by side, as they passed along the table and through the lap machine at the broad end.

This machine has come into almost general use, and the old lap drums have disappeared, but it is now generally made only half the width of the finisher card, and it has been much improved, first, by Messrs. Platt Brothers & Co., who added stop motions for each sliver, and afterwards by Mr. Knowles, of Bolton, who made a great improvement in the lap, by consolidating it and placing revolving discs at the ends of the lap roller.

In 1852 Evan Leigh took out a second patent for a self-stripping card, of which *Fig.* 96 shows side elevation of a carding engine built in accordance with this patent,

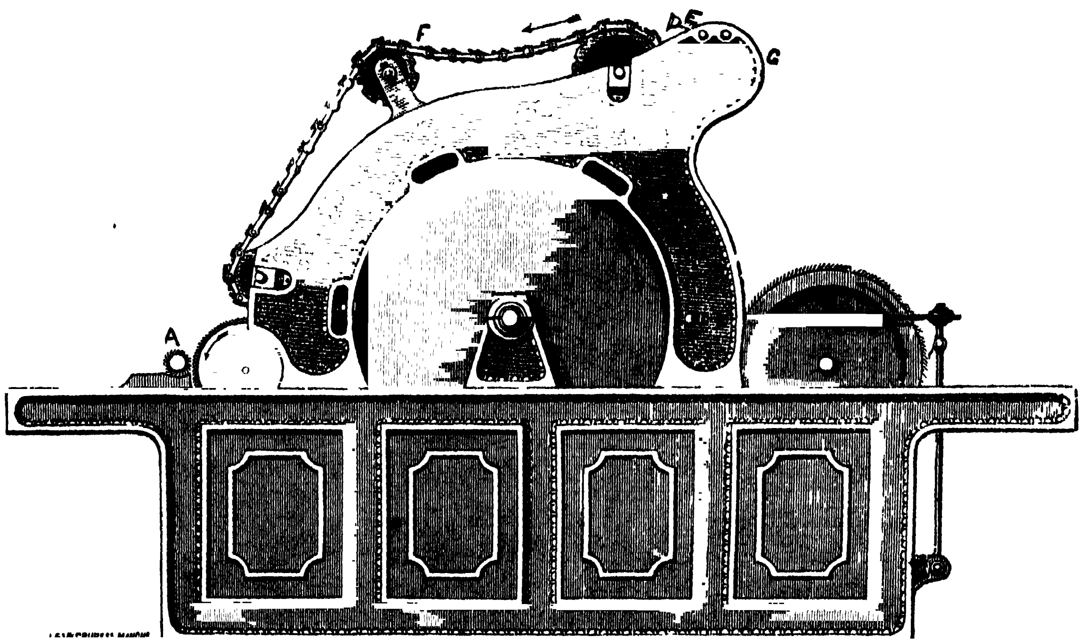


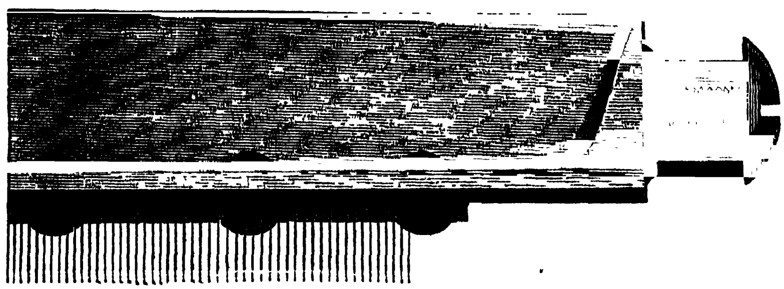
Fig. 96.

in which A is the feed roller, B the licker-in, C the main cylinder, D the doffer, E the stripping comb, F the chain of flats, G the stripping box, H the flexible bend, I the screws for setting the flexible bend and flats to the cylinder. In this card it will be seen that a flexible bend was used, as before, made somewhat differently, however; and the flats were placed on the top side of the engine, and coupled together from their centres like a Venetian blind, so that they would swivel round, and thus allow of being set bevel to their work. They were made this time of cast iron, and cut at each end to a bevel curve, so as to set bevel or on their heel to the cylinder, and slide steadily over the flexible bend, all being ground to one height of wire. To effect the coupling together of the flats, and still to allow them to swivel on their centres, a gudgeon was cast upon the ends, from which, after being turned up, they were coupled by wrought-iron links, as shown in *Figs.* 97 and 98. Though full of promise, from its apparent simplicity, a short experience proved it to have some important defects.

During the first two years from the date of this patent about one hundred carding engines were made or altered to this principle, and the Inventor, who was anxious to bring it out at a very cheap rate, lost heavily by making so many new sets of patterns to fit different makes of engines, to accommodate spinners who wished to try it, but who would only order a *single card*, generally, with a promise to go on if it succeeded; so the patterns for adapting the new self-stripping principle to old cards had, of course, to be made first in wood and then in iron, on account of the contractions, and frequently cost more than double the money charged for its application. They were in most cases never wanted again, and had to be broken up.

The coupling of the flats from their centres, as above described, was an important point, but the manner in which it was done at first, enabled anyone who was

Fig. 97.



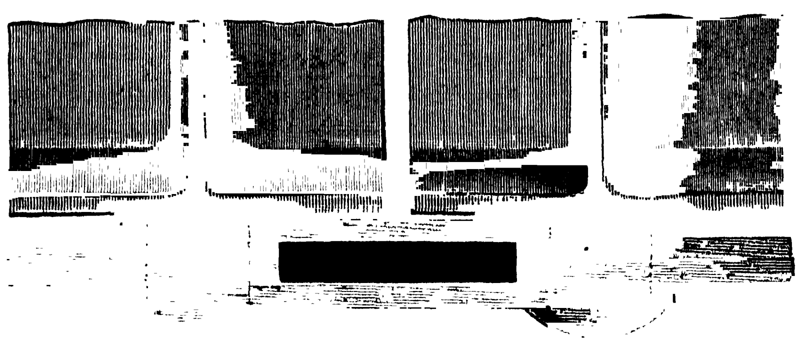


Fig. 98.

mischievously inclined to turn them over when at work and thereby cause a smash as soon as they came round to the carding cylinder. It was scarcely possible for them to get wrong themselves, but, whether done by accident or design, the breakages became so frequent about this time that spinners were deterred from adopting it, and it was in great danger of proving a failure altogether. As nearly all the breakages were made good at the Inventor's expense, the cost of sending men and material up and down the country to repair them was very heavy and mos discouraging. Each smash, invariably caused by a flat going in wrong side up, di great damage, the cards being ripped off the cylinder and many flats broken. Th suspicion was strong that these flats were turned over mischievously, for breakage did not occur until the engines had worked nearly two years, when they commence almost simultaneously, as if it had only just been found out that the flats might b turned over whilst the engine was at work. From their slow movement this might b done ten or fifteen minutes before the flat which had been turned wrong side up wen in to the cylinder, and the person who had done it might be far enough away wher the smash came. The cause of breakage, however, having been carefully noted, a very effective remedy was found, by applying a bushed chain for connecting the flats and at the same time shifting the chain so as to work over the back of the flats, as shown at A in *Fig.* 99, which represents the new mode. From this it wil

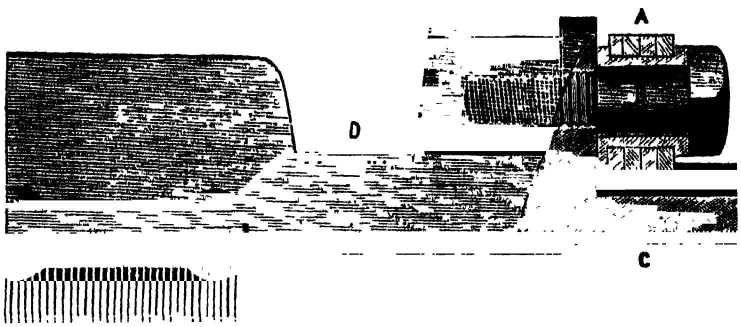


Fig 99.

be seen that the bushed chain allows the flats to swivel freely, sufficient to set them bevel, but they cannot turn over. In the old plan the pull of the links put a great pressure on the gudgeons at the ends of the flats, which in the new mode was sustained by the bushes in the chain, thus allowing the flats to swivel freely, and at the same time it admitted of any individual flat being taken out by unscrewing the set screw B, which screwed tight against a shoulder, without disconnecting the series, which could not be done before. The flat was cut for a carding surface at C, where it slided on a flexible bend, and it was surfaced for grinding at D.

After this decided improvement the breakages ceased entirely, but confidence having been once lost it was difficult to attract attention again.

As soon, however, as the clouds of prejudice began to disperse, a demand arose, which steadily increased, until rival schemes were started, one of which was Wellman's Self-stripping Card, which made its appearance about this time, the Specification of which runs thus:—

"This Invention consists in constructing a card engine with such apparatus attached as shall effect the elevation of each and every one of its top cards in succession from their beds or frame on which they are supported, the cleansing of such top cards and their return to their respective beds after being so cleansed, each and every of which operations shall be the effect of the same power that is used in giving motion to the other parts of the same carding engine, thus producing by mechanism what is now generally accomplished by hand labor. And in order that my said Invention may be more fully understood and readily carried into effect, I will proceed to describe the construction and operation of its several parts, as shown and illustrated in the annexed Drawings.

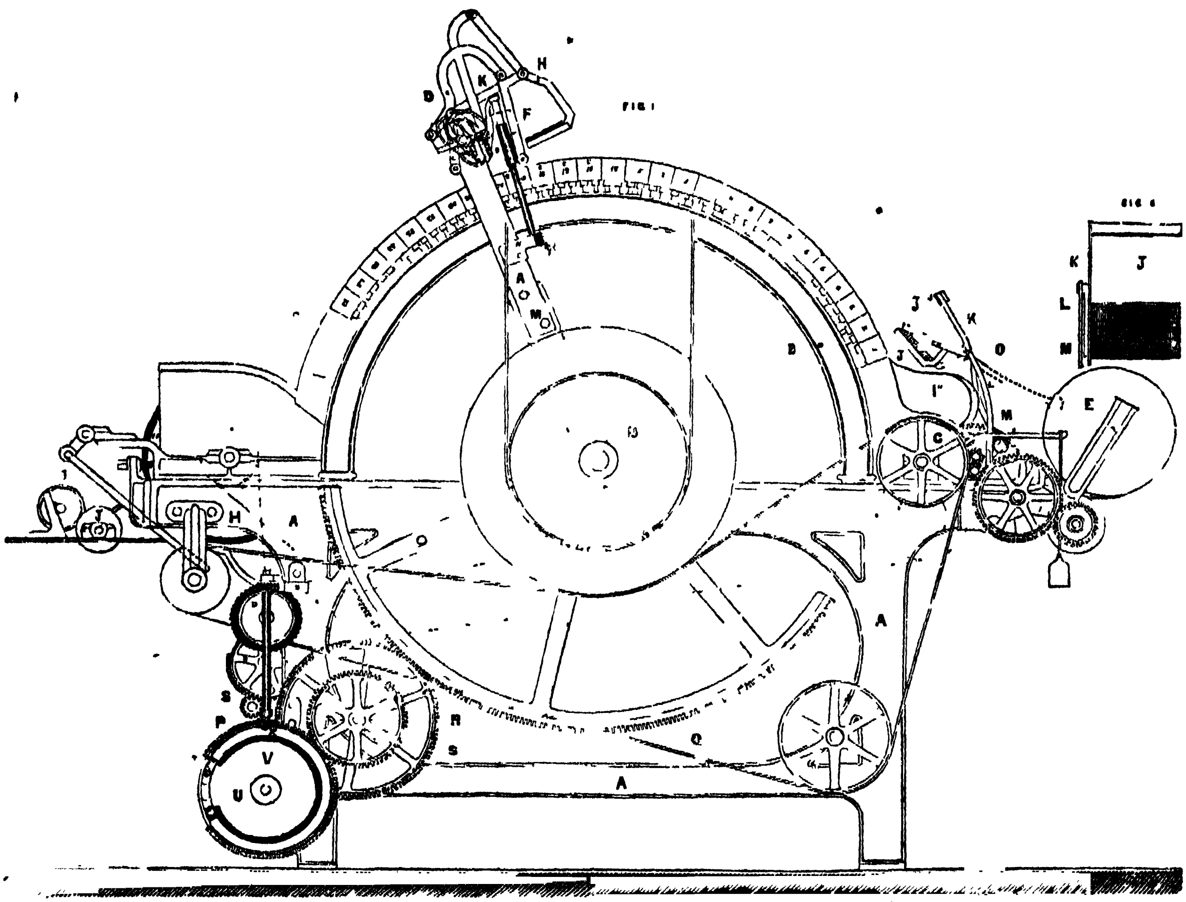


Fig. 100.—Wellman's Self-stripping Card. (Scale ? inch = 1 foot.)

"Sheet 1, Fig. 1, represents an end elevation of a carding engine, so constructed as to become self top-stripping by means of my Invention. Sheet 2, Fig. 2, represents a view of the doffer side of said engine. Other Figures will be explained as occasion requires: similar letters of reference indicate corresponding parts in each of the several Figures, A, represents the main frame or support to the working parts of a carding engine; B, is the arch frame or bed upon which rest all the top cards C, C, C, and *c*; D, is the driving pulley fixed to the end of the main shaft that carries the main carding cylinder; E, is the lap or roll of cotton or other material to be carded, which first passes between the feed rolls F, F; it is then taken by the licker-in or leader cylinder at G, which carries it to the main carding cylinder, and from this, after it has passed in contact with the card tops C, C, C, and *c*, it is taken by the doffer cylinder H; from the doffer cylinder it is taken by the vibrating comb I, and passes off through the draw rolls J, J, in the form of a sliver, in the usual manner. This part of the construction and operation of the engine is similar to those now in general use. On the end of the shaft of the doffer cylinder H, is a pulley K, Fig. 2, that by means of a belt drives the pulley L; on the same stud with this pulley L, is a geer M, that engages with and turns the geer N, on the end of the shaft O. This shaft O communicates motion alternately to the shaft P below and the shaft Q above. The shaft P below drives the apparatus for raising and stripping the tops, and the shaft Q above drives the gearing that moves the raising and stripping apparatus from one top to the next or to the next but one, &c. I will first describe the method of raising and stripping the tops. On the shaft O (which it will be borne in mind is in constant motion) is a quarter gear R, Figs. 2 and 4, which during a portion of each revolution of the shaft O, engages with and turns the pinion S on the shaft P, so that it (P) makes one revolution. This being done and the quarter geer R being disengaged from the pinion S, the semicircular rim T, on the side of the quarter geer R, immediately engages in the circular arc of the plate-wheel U. This arc is concentric with the semicircular rim T, so that when the rim T is engaged in it, it prevents the plate-wheel U from turning, and consequently as the plate-wheel U is fastened firmly to the shaft P, the shaft P cannot turn. But when the first tooth of the quarter gear comes round again so as to strike into the pinion S, the semicircular rim T disengages from the circular arc in the plate-wheel R, at the same moment, and allows the shaft P to make its revolution. On the end of the shaft P is a rag-wheel V, which by means of the endless chain W, turns the double pinion X. From this double pinion another endless chain Y, communicates motion to the rag-wheel Z, on the end of the cam shaft A^1. On each end of the cam shaft A^1 are two cams B^1, and C^1. The cams B^1, B^1, operate the rocker levers D^1, D^1, which are connected to the sliding jaws E^1, E^1, by the connecting links F^1, F^1, and thus the top card C^1 is raised from its bed and held up while the cams C^1, C^1, operate the rocker levers G^1, G^1, which through the connecting links H^1, H^1, cause the card arms I^1, I^1, that carry the stripper card, to move underneath the uplifted top card and against it, and then back again to its place, whereby the stripper card will be made to remove from the top card the surplus waste or matter to be taken from it; as soon as the stripper card resumes its position, the cams B^1, B^1, complete their revolution, and in so doing bring the top card down to its seat or bed again. The stripper card J^1 consists of a thin bar of wood or other material about five inches wide, and covered on its upper surface with card clothing or other material that will answer for a brush. The two ends of this are fastened one to each of the two levers or card arms I^1, I^1. These card arms are hung from the two bent posts K^1, K^1, that project upwards from and are fastened to the frame M^1, connected with the segment Q.

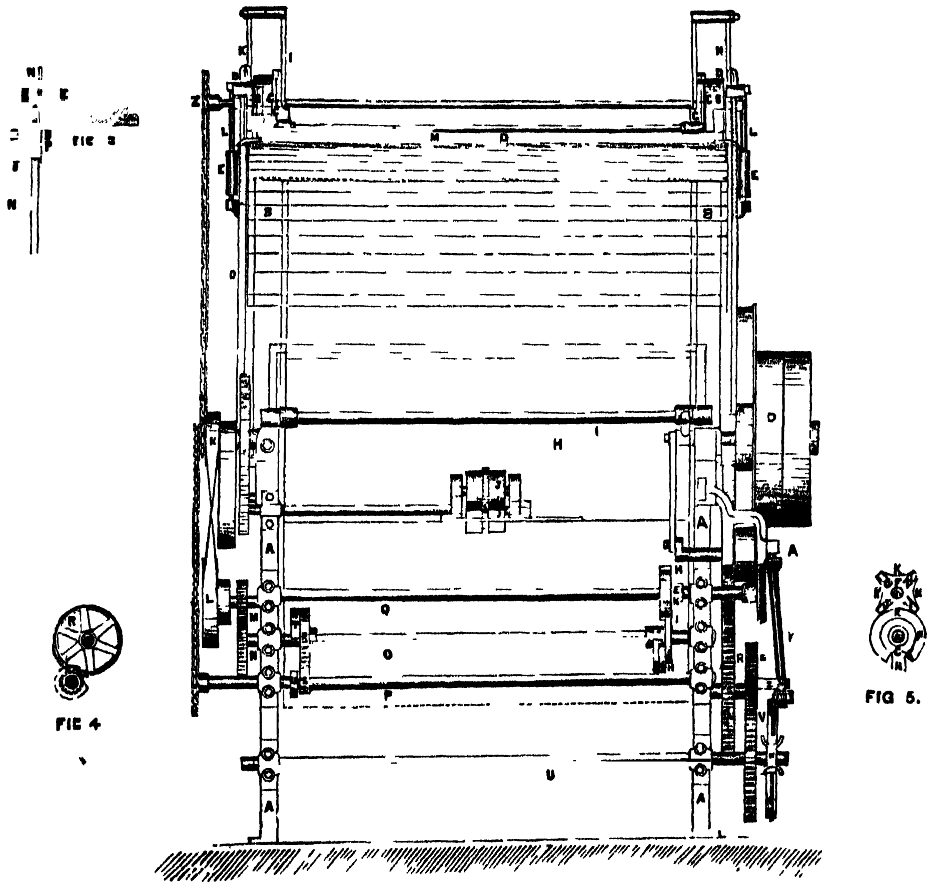


Fig. 101 —Wellman's Card (front elevation).

"In order that the method of holding the uplifted top may be more readily seen, I have drawn the Fig. 3, which is a longitudinal and vertical section through the top and through such parts as are immediately connected with it. G^1 is the top; E^1, are the sliding jaws which move up and down on the rod or slide bar L^1. Each end of the slide bar L^1, is fixed in the stands N^1, N^1, which are attached to the frame M^1. The upper stand N^1 also carries the rod or dagger O^1. This dagger penetrates a hole made for the purpose in that upper part of the jaw E^1, that projects over the top card, shewn in the Fig. 3, at *c*, and it is also intended to penetrate a hole made in the top card when such top card shall be lifted up from its bed, and thus it serves to pin the top card to the jaws so that it (the top card) shall be firmly fixed while the process of stripping it is going on. P^1, is the lower part of the jaw to which the connecting link F^1, is attached.

"When the lever D^1, is operated by the cam it raises P^1, and the top part of this projecting under the top card, strikes it, and raises it until its top bears against the upper part of the jaw, and thus being firmly gripped between the two parts of the jaws, is raised and held in its position as aforenamed. Having thus described the apparatus for raising and holding the top card, and for cleansing such top card after it is raised, and lowering it after it is cleansed, and which I call the "stripping apparatus," I will now proceed to describe the means by which the "stripping apparatus" is moved from one top card to another. And, first, I would remark that this moving apparatus is such, that by altering the size of the geering used I can cause the stripping apparatus to make its changes from the first top card to the second, thence to the third, and so on, each one successively, until it reaches the last, and then return in the opposite order; or I can so arrange it as to cause it to change from the first to the third, thence to the fifth, and so through with each of the odd numbers, and returning to take all the even numbers or those it did not take before, or to take them in any other order that may be desired. The geering, as shown in the Drawings, is arranged so as to change the "apparatus" from the first to the third, then to the fifth, and so on, which changes I deem to be most desirable. A rocker frame M^1, Figs. 1 and 2, composed of 2 bars *a*, Figs. 1 and 2, *b*, Fig. 2, (one on each side of the engine,) with a cross connection bar *d*, Fig. 2, is made to extend upwards from the main shaft. Each of the two bars *a*, *b*, have a bearing around one of the two boxes that carry the ends of the main shaft, so that the top part of the frame, with the stripping apparatus attached, may be easily moved from the feed-rolls over all the top cards to the doffer cylinder and back again, as may be required. An arc or sector Q^1, of teeth is made to extend downwards from the bar *a*, and to engage the geer R^1, fixed to another geer S^1, by its side, which has a bearing upon a stud fastened to the frame. The geer S^1, engages and is turned by a geer T^1, Fig. 2, fixed to the shaft U^1, on the end of which shaft is fixed the pin-wheel V^1 (sometimes called a "mangle-wheel"). The pins that extend from the periphery of the wheel V^1, are not set entirely around its circumference, there being a space or interval to which a metallic guide piece or block W^1, is fastened, the same being formed with two semicircular forked ends, as seen in the edge view of said wheel in Fig. 2. The termination of each end of the arc of periphery of the pin-wheel is formed semicircular, and concentric with its adjacent forked end of the block W^1, as seen at *c*, *f*, Fig. 2. The said pin-wheel V^1 is set in motion by the pinion X^1, which is fastened to the lower end of the upright shaft Y^1. This shaft is sustained at its lower end by a box Z^1, such as will allow it to move laterally so as to carry the bevelled pinion X^1, from one side of the pin-wheel to the other, and *vice versâ*. The upper end of the shaft has a journal supported in the upper part A^{11}, of a turning post B^{11}, that extends from the side of the frame. Another bevelled pinion C^{11}, is fixed to the shaft Y^1, and is engaged with and turned by a large bevelled geer D^{11}, which is fixed on the horizontal shaft Q. There is also on the shaft Q, a plate or block E^{11}, that has four grooves *g*, *h*, *i*, *j*, formed in it in radial directions, and at right angles to one another, as seen at Fig. 5, Sheet 2, which is an inner side view of such plate E^{11}. Between the outer ends of each two grooves the plate is cut or notched inwards in the form of a circular arc, as seen at *k*, *k*, *k*, *k*, which arc is of the same radius as the circular wheel F^{11}, that is arranged directly below it, and fixed on the horizontal shaft O. An arm G^{11}, projected from the shaft O, carries a pin or stud H^{11}, that during each revolution of the shaft O works into and out of one of the grooves *g*, *h*, *i*, *j*. A curved notch *i*, is made in the wheel F^{11}, so that as the pin H^{11} passes into and out of one of the grooves *g*, *h*, *i*, *j*, the extremity of such groove may be brought down into and carried out of the curved notch *l*, and thus at each revolution of the shaft O, the arm G^{11} causes one fourth of a revolution in the shaft Q. While the circular arc of the periphery of the wheel F^{11} is in any one of the notches *k*, *k*, *k*, *k*, the shaft Q is prevented from being revolved, but as soon as the pin or stud H^{11} enters into one of the grooves *g*, *h*, *i*, *j*, the shaft Q is made to turn as aforesaid. And I would observe here, as before, that the shafts O, P, and Q, are so arranged in relation to each other that while the shaft O is moving the shaft P, that sets in motion the stripping apparatus, the shaft Q is held by it stationary, and *vice versâ*; when the shaft Q, which sets in motion the geering for moving the stripping apparatus, is in motion, the shaft P is held still. Now when the shaft Q is revolved, the bevel geer D^{11} on its end will be rotated with it, and consequently cause the pinion C^{11}, the shaft Y^1, the pinion X^1, the pin-wheel V^1, the geers T^1, S^1, and R^1, and the arc Q to be put in motion, so as to turn the frame M^1 on its bearings. By the above-described machinery this frame is alternately moved from the first lag or top card to the third, thence to the fifth, and so on through the series, and then moved back again in the opposite direction, taking in course the even numbers, or those it did not take before.

"It is a common custom in cleaning the top cards to a carding engine to move or lift up every other one instead of every one in succession, leaving the intermediate top card down, and taking it up the next time going through the series.

"The next point to be considered is the manner of disposing of the strippings or waste that is collected by the strip card J¹ from the several top cards. This may be done by providing a receptacle made of wire cloth or other material which shall be fastened to the engine near the feed-rollers, as represented at I¹¹, and directly over this receptacle is hung a narrow strip, having upon its lower surface a comb or card clothing or other suitable material, that shall rake or comb from the strip card, when it comes in contact with it, all the strippings that shall have been collected upon it in going from the first top card to the last, and back again to the first. At J¹¹, Fig. 1, is the card or comb fastened to the end of the lever K¹¹, there being another lever of the same kind on the opposite side of the frame to support the opposite end of the comb J¹¹. This lever is hung on the post L¹¹, and has an arm M¹¹ extending downwards, with a weight N¹¹ upon the end of it, which is for the purpose of keeping the comb J¹¹ suspended in its position over I¹¹; it also has a fork or branch O¹¹, which when the stripping apparatus approaches it, is struck by it, and causes the comb J¹¹ to be borne down, so that the teeth of it (J¹¹) engage in the teeth of the strip card containing the strippings (this position is shown by the red lines in the drawings Fig. 1). This it dees while the stripping apparatus is being moved over that top card nearest to the receptacle. Now after this top card is raised to position, the strip card moves forward to clean it, and in moving forward the comb J¹¹ combs off all the strippings that have collected upon the strip card, drops them into the receptacle I¹¹, and then the weight N¹¹, upon the opposite end of the lever, causes that end to fall and brings the comb J¹¹ up into its former position. A front view of one end of the comb J¹¹, with the lever for holding it, and the receptacle beneath it, may be seen at Fig. 6.

"Carding engines, with such an improvement attached as I have just described, may be so constructed as to perform two or three times the amount of work which is done by the carding engines now in common use, because they will admit of having a very large carding cylinder with two or three times the number of card tops generally used, consequently they will cause a saving of room, of manual labour, and of expense. This invention is also applicable to some forms of the carding engines now in general use, with a slight alteration in a few of their parts.

"Having thus described my invention, and the mode of its operation, I do not claim the mechanism used for the mere purpose of carding the cotton or other similar fibrous material, but what I do claim as new, and desire to secure by Letters Patent, is as follows, that is to say:—I claim in combination with a series of top cards of a carding engine not only a mechanism for raising one or more of such top cards and holding the same upwards, and afterwards depressing the same back into a place, but a mechanism for acting on and cleansing such top card or cards when or while so elevated, not meaning in the above to claim either the mechanism for moving the top card or cards, or that for cleansing it or them in their separate combination with the series of top cards, but to lay claim to both in their joint combination together, and with the series of top cards.

"And in combination with the series of top cards and mechanism for raising and cleansing a top card and restoring it to its seat, I claim mechanism for moving the raising and cleansing mechanism in succession from one top card to another, and whether from one top card to the next one, and so throughout the series, or from one of them to the next but one, and so on, or in any other order, not intending by these claims to limit myself to the precise form of the parts herein described and represented, but to vary them as I may think proper while I attain the same ends by means substantially the same."

As this self-stripping carding engine, the invention of Mr. George Wellman, of Lowell, in the United States, not only possesses much ingenuity and merit, but has met with a considerable amount of success in America and in this country also, it has been deemed best, in fairness, to give the specification entire, although somewhat lengthy. Moreover, Mr. Wellman's invention has been the basis of many important modifications of that principle by other machinists, and it would be impossible to do him full justice in describing his machine without quoting his own words, and reproducing his own drawings from the "Patent Records."

Shortly after the Wellman card was introduced, two other self-strippers appeared at Stalybridge. Both of these were inventions brought out by influential parties, within a few days of each other, and were ready for work about the same time.

The first was a carding engine which purposed doing away with flats altogether, and substituting a series of small rollers on the top of the main cylinder, set close together, revolving with a very slow motion and stripped by a circular brush. This engine, the invention of Robert Wilkinson, has already been illustrated (*vide* page 99).

The next was Bayley and Quarmby's patent self-stripping card This patent bore date the 11th October, 1855, and was sealed the 8th April, 1856, just seven days later

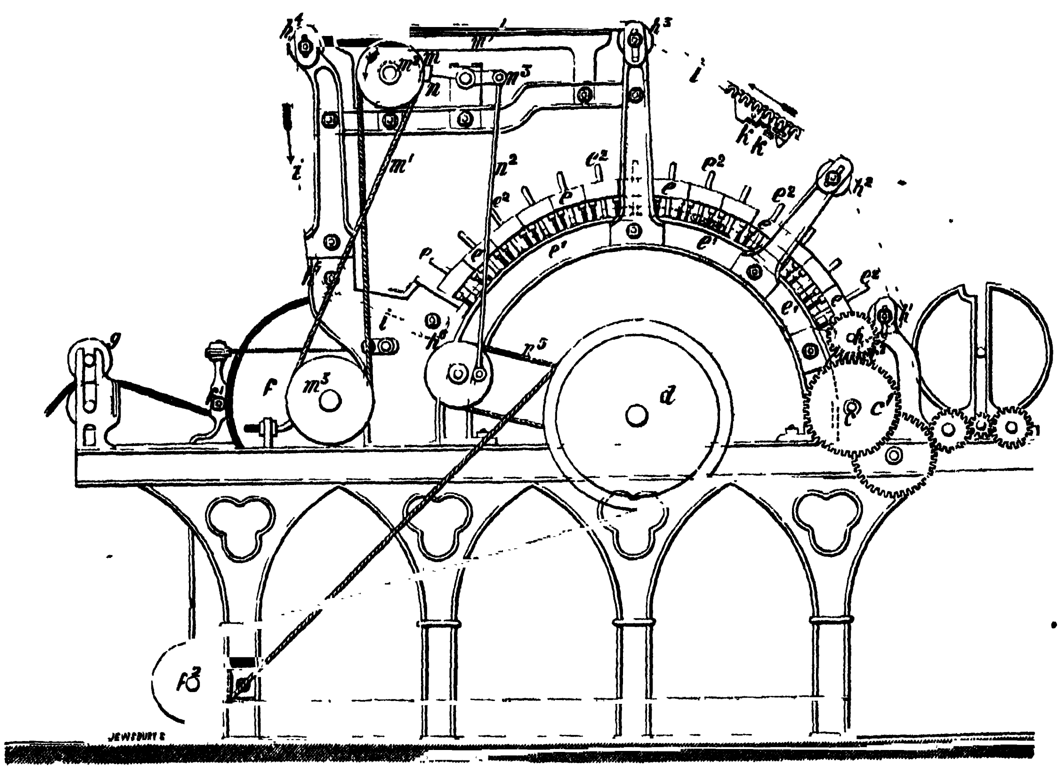


Fig. 102.--Bayley and Quarmby's Patent.

than Wilkinson's. It was a very ingenious contrivance, as will be seen from *Fig.* 102 above, and easily understood from their Specification given in abridged form :—

"Fig. 102 shows side elevation of an ordinary finisher card, in which a^1 are brackets secured to the side frame on each side of the engine, to carry the pulleys required to support the endless chains carrying the stripper card or cards and the mechanism for stripping it. These brackets are marked a^1, and the pulleys h to h^6 are those which support and guide the endless chains i. Motion is given to the endless chains by toothed wheels c^1 on the ends of one of the feed rollers (c) which gear with wheels (c^2) on the axis of the pulley h. The endless chains (i) are formed by jointed links of well-known construction ; those shown in the drawings are of the kind which form teeth on one side, which enter between teeth formed in supporting guide pulleys $(h$ to $h^6)$, and by this means motion is given to the chains so that the stripper card or cards (k) carried by them is kept square. Those portions of the endless chains passing under the flats, rest and slide upon the bends (e^1); this is best seen in Figs. 2 and 3, the first being a side sectional elevation showing part of the bend (e^1) and cylinder (d^1), chain (i) and stripper cards (k).

"It will be seen that the chain *(i)* (which is the same on each side of the engine) passes between the pins *(e^2)*, holding the flats *(e)* and the card cylinder *(d^1)* over the upper surface and near the edge of the bend *(e^1)*, being kept in its place by a number of guides screwed on the bends, one of which is shown (marked *e^3*) in Fig. 103 and Fig. 104.

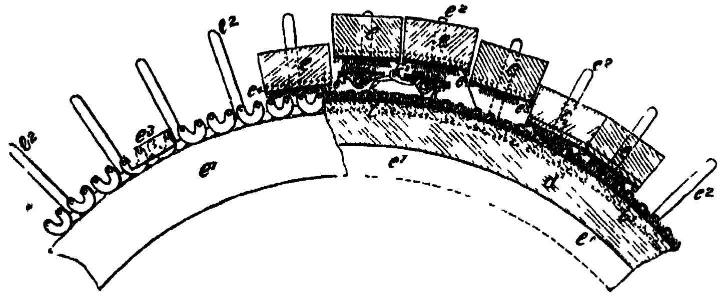


Fig. 103.

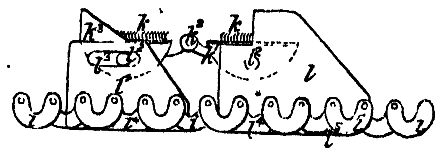


Fig. 104.

"The stripper card or cards *(k)* are secured to a metallic plate or plates *(k^1)*, and the ends of those plates are jointed to parts which each form one of the links in the endless chains *(i)*. In the drawings it will be seen that two stripper cards *(k)* are used, each of them secured to separate plates. . . . . The inclines which lift and slide the flats up their pins are formed on the parts *l*, to which the first stripper card plate *(k^1)* is jointed; these inclines keep the flat up until the stripper card has got a little under it, and then allow it to drop by its own weight on the stripper card, and when both the first and second stripper cards have acted on the flat small inclines *(k^2)*, formed on the second plate *(k^1)*, again slightly lift the flat till the stripper card is out of the way, and then allow it to slide down its pins *(e^2)* into its carding position. . . . . In Fig. 103 it will be seen that the stripper cards are shown as acting upon two flats, and that the inclines are sliding a third flat up its pins. . . . . The card roller *(m)*, for doffing or stripping the stripper card or cards *(k)* is fixed in bearings supported from the brackets *(a^1)*, carrying the pulleys *(h^3 and h^4)*; and it has revolving motion imparted to it in the direction pointed by the arrow by an endless band *(m^1)* which passes round a pulley *(m^2)* on its own axis, and one *(m^3)* on the axis of the doffer cylinder *(f)*. . . . . The card roller is doffed by a doffer comb *n*, fixed to arms from a shaft *(n^1)* supported in bearings secured to the frame which carries the card roller, and this shaft *(n^1)* has oscillating movements given to it by a connecting rod *(n^2)* jointed with an arm *(n^3)* on its end, and a crank pulley made to revolve on a stud fixed in the bend. . . . . It will now be seen that when motion is given to the endless chains *(i^1)* in the direction pointed by the arrows, the stripper card or cards will pass from the front of the engine, and the inclines attached to the chains will slide the flats up their pins in succession and allow the stripper card to act on the underside of the flats and strip them, and then as the chains progress will allow the flats to drop in their places by their own weight in succession, till the whole of them are stripped."

This engine appeared at first sight to be just the thing required for altering old cards, at a small expense, to self-stripping; and, besides this, it was alleged to have many other advantages.

After a fair and spirited contest conducted by the patrons of the Wilkinson card, in two separate mills, it was eventually abandoned in favour of the Leigh. The card produced at Messrs. Bayleys' mill did not work well in practice; and Mr. Bayley, who was an intelligent and extensive manufacturer, had too much good sense to push it into public use after he became convinced of its defects.

After this another impulse was given to the Leigh card; the Wellman card also maintaining its ground, some spinners preferring the one, some the other, but both were extensively adopted with satisfactory results.*

* The manager of a new mill in Bolton, in reply to special inquiries as to the advantages, saving of wages, &c., of the Leigh cards, stated that "for the manipulation of 208 carding engines in that mill, only £8 was paid weekly in

The little carding engine, *Fig.* 105, has worked very satisfactorily. About nineteen years ago 80 cards in a fine-spinning mill were altered in this simple manner to self-stripping, and have run so long without breakage or mishap of any kind. The wire on some of the flats seems very little worse for the nineteen years' wear, and they are very handy to strip out. The front portion of the flats, together with the strip box, comb, and circular brush, are carried by one end of the compound lever A, a similar lever

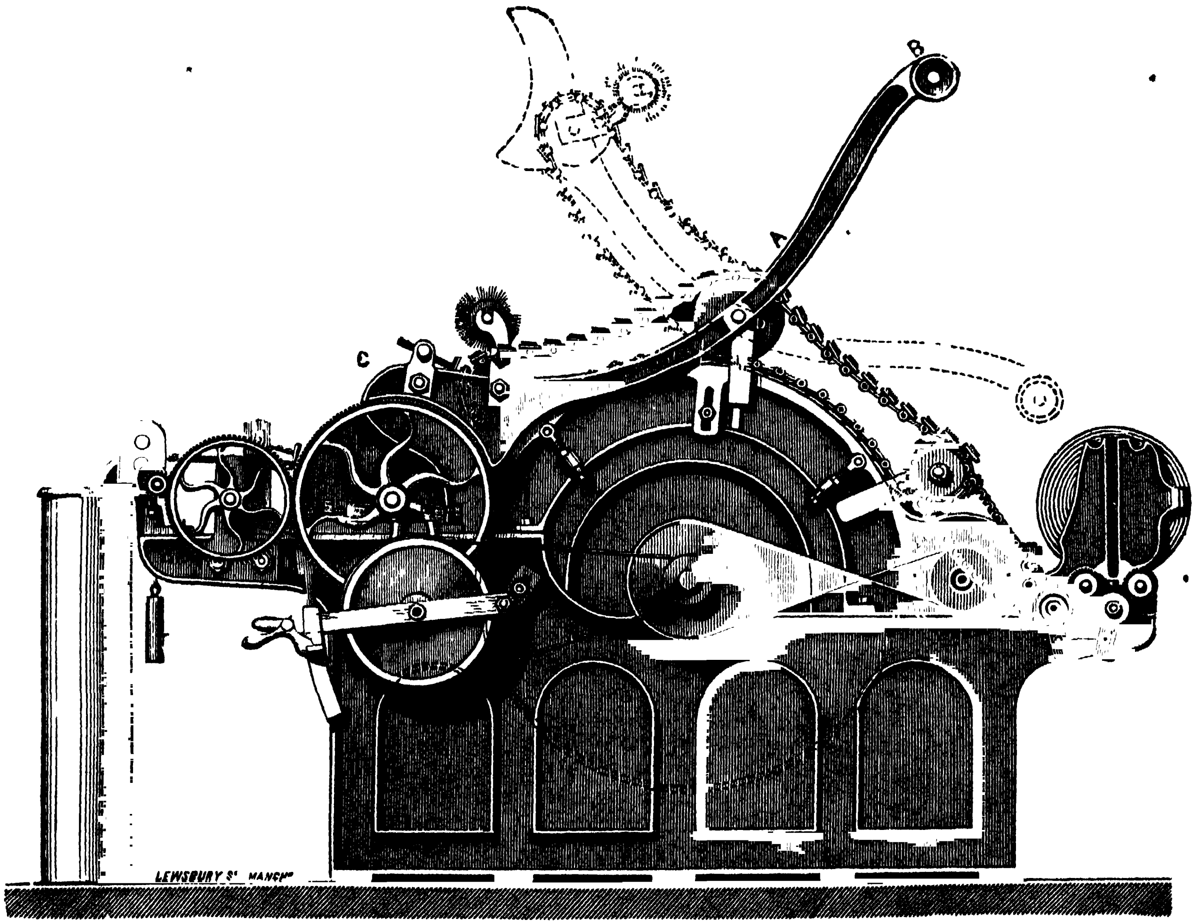


Fig. 105.—Finisher Card altered to Leigh's Self-stripper.

being placed on the other side of the card. These levers are keyed to the middle shaft D, which stretches across the engine, and are also connected together at B by

wages, all hands told, appertaining to the cards. In another mill, belonging to the same firm were 120 carding engines doing exactly the same kind of work, and of the same size, but *not self-stripping*, though as good cards as any of the ordinary make; for these latter 120 cards £18 was paid in weekly wages. Besides this the self-stripping cards did seven per cent more work per card, and the quality was so much superior that a better price could always be obtained for the yarn made from them than could be got for that made by the other." As this statement showed a saving of about £1,200 per annum, in one room, in wages alone, the proprietor of the mill was some time afterwards questioned as to its truth, and he confirmed it, adding that it was not only the strippers' wages which were saved, but, to a large extent, those of the grinders and card-setters also.

a solid cast-iron shaft about three inches diameter, which acts as a balance weight to the flats. When raised for stripping out the main cylinder, the lever is placed in the position shown by the dotted lines; the weight B, having then the preponderance, holds them up till pulled down again.

THE NEWHALL FACTORY.

This factory, the establishment of Messrs. John Robertson and Co. (shown in Part V.), is situate at Bridgeton, Glasgow, and the following description of it is abridged from the *Mining Journal*:—

"The Newhall Factory, as it now stands, covers about 10 acres. It contains 150,000 spindles and 3,200 power looms. Not less than 3,000 hands are employed, the great majority being women. Motive-power is supplied to the machinery by four pairs of engines, the largest being 800 indicated horse-power, 48 inches diameter of cylinder, and 6 feet stroke. These engines work up to a pressure of 40lbs. They were built about 12 years ago by the well-known firm of Messrs. Musgrave and Son, of Bolton. The monster fly-wheel weighs 40 tons, and the other parts are in the same proportion. There are two other pairs of engines, the one horizontal and the other beam, driving off the same shaft, and of 400 indicated horse-power. They are fitted with Corlis valves, an American invention, which is coming into pretty general use in Scotland, and with the action of which many of our readers will be familiar. In regulating the speed of the engine with the throatle-valve, a difficulty has long been felt in obtaining the fullest expansion of the steam, the valve being placed so far from the cylinder; but the Corlis valve, which resembles a large stop-cock, is shut by means of strong springs, and effectually prevents the wire drawing of the steam. It is now some six months since the Corlis valve was attached to these engines. The third pair of engines are of 800 horse-power indicated, and constructed on M'Naught's principle. They have a 40-inch and 32-inch cylinder each, 6ft. stroke, and work at 40 strokes per minute, with a pressure of 50lbs. To supply the engines with steam there are no less than 20 large boilers on the works. Five of them are Galloway, and the rest are Cornish two-flued boilers, and they consume, when in full work, about 60 tons of coal per day.

"Although the Newhall Factory is altogether on a colossal scale, its most distinguishing feature is the weaving sheds, three in number, the largest of which covers 54,450 square feet of ground, or nearly an acre and a half. In this single department there are between 800 and 900 operatives, and from 1,400 to 1,500 looms. It is constructed with the most punctilious regard to due ventilation and light. The roof is in six spacious bays, running from east to west, and the light, which is reflected through the southern half of the bay, is so arranged that the sun can never affect the optics of the workers. Each division of the roof is supported on a series of light, graceful, iron pillars, and the *tout ensemble* of the place is strikingly effective and interesting. No girls are admitted under the age of 13, and all new applicants for work must produce a medical certificate of physical competency. The more experienced workers are allowed the control of two looms, but the younger operatives can only manage one. Hoary-headed matrons ply their vocation side by side with children of the tenderest admissable age; and all alike are thoroughly intent on business, the character of their labour, not less than the conditions of their remuneration, entailing constant and undivided attention. It is worthy of remark that the belting and other gearing connected with this shed is all below ground, so that there is no obstacle in the way of the eye while ranging over the vast expanse of looms and human faces; and the whole scene, with its varied and picturesque accessories, is one which those who have witnessed it will not readily banish from their memory. Seen by gas-light the view is still more impressive.

"There are upwards of 800 jets of gas in the apartment, making an average of one jet for every two power-looms. The looms are erected in pairs, with convenient passages intersecting each row. Of the other two weaving-sheds, we may remark that one, 240ft. in length, by about 200ft. in breadth, is quite a recent erection, and has not yet been quite fitted up; the other, which contains 800 looms, was acquired along with the other premises connected with Mr. Scott's factory, and was honoured with a visit from the Prince of Wales some few years ago. All the weaving-sheds are built on the same principle, but in the two latter the gearing is above the looms, and this presents a striking contrast to the arrangement of the first shed. Spacious store-rooms adjoin each of the weaving-sheds, where the products of manufacture are prepared, either for further manipulation or for the market.

"There are two large spinning-mills, each four storeys in height, connected with the Newhall Factory. They are situated at opposite corners of the establishment, and, although they are within easy access of one another, there is a different public entrance for each, the one which formerly belonged to Mr. Scott being approached from John-street, while the original mill of the Messrs. Robertson is entered from Greenhead-street. In addition to 150,000 spindles which run off thread at the rate of 300 miles per minute, the mills contain a great variety of "scutching" and other machinery.

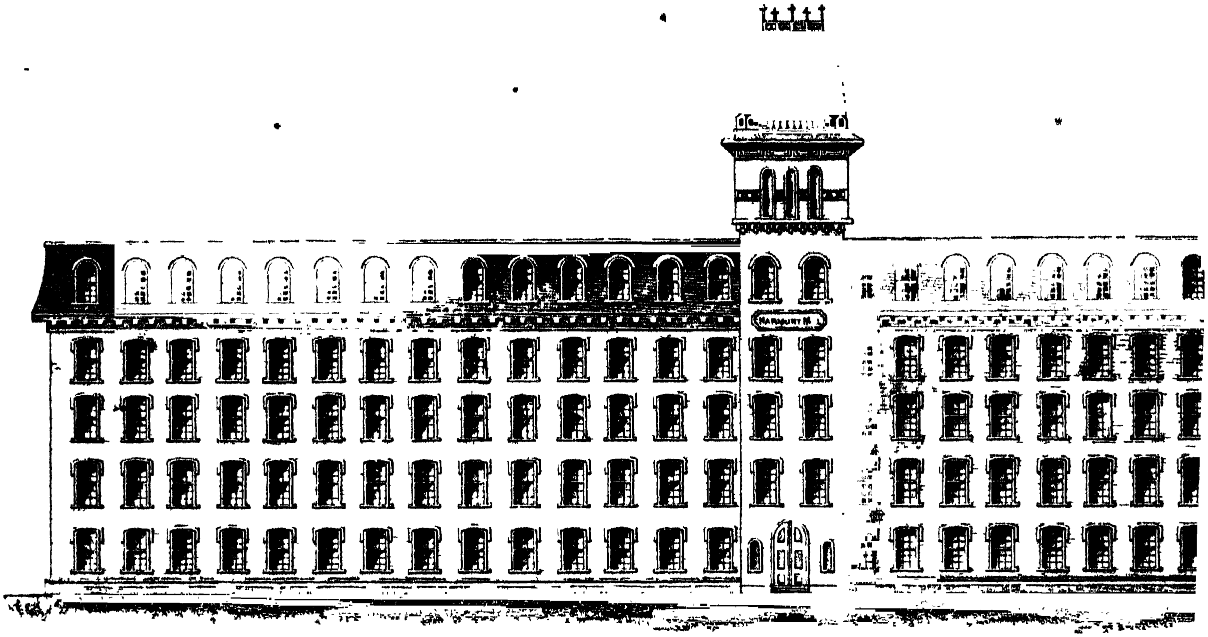
"Of the other accessories of Newhall Factory we need say but little. Its situation at the east end of the green is admirably open and airy, and all the rooms are so lofty and ventilated that they present a most agreeable contrast to some other establishments of a similar kind. A cooking depôt has been fitted up on the premises, where those operatives who may happen to reside at some distance from their work can be supplied with their meals; and there is likewise a meeting-house, or chapel, which is sometimes used for devotional and sometimes for recreative purposes. Telegraph wires connect the different parts of the factory with each other, and a wire communicates directly with the General Post Office in George Square. Steam pipes run throughout the whole establishment, which is thus abundantly heated during the winter. Large stores and ample mechanics' shops, where joiners, tinsmiths, and other operatives, are regularly employed, are also included in the premises."

CONNECTING CARDING ENGINES TOGETHER.

It is believed that the plan of connecting carding engines together in a series, so as to double the slivers and convey them to a drawing head, or lap machine, had its origin in Switzerland; at any rate it was first mentioned in 1835, by the late Mr. Albert Escher, of Zurich, on the occasion of his visiting the author in Macclesfield, where the latter was then filling a mill.

Mr. Escher gave no particulars, except that the doffers were all connected together, and worked independently of the cylinders, and the slivers from each card were deposited on a broad belt, which conveyed them to a lap head.

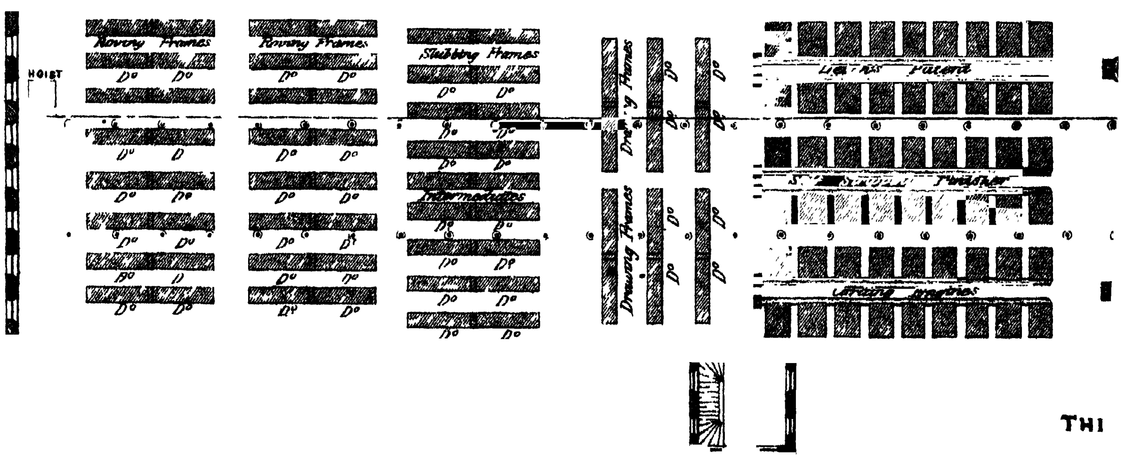
Struck with the novelty and simplicity of this arrangement, the author immediately ordered nine new carding engines, then being built, to be sent in without any gearing except the usual spur wheel on the doffer and side shaft. An allowance of £9 per engine was made in lieu of the rest of the ordinary gearing, which was more than amply sufficient to make a draw box, and connect them together. After working these engines a short time, the travelling belt and trough were dispensed with, the ends being kept tight by each pair of callenders from the drawing box head being slightly diminished in diameter all along the row. The front roller of the drawing head gave much trouble from lapping, and every time it was stopped along with the doffers, to pick these laps off, the whole row of cards were stopped (leaving only the cylinders running). As these nine cards produced about 4,000lbs. per week, with a draft of 4.50 in the drawing box, the front roller was obliged to go at an excessive speed, which caused heating, and the leather covering soon got cut up by the sand and motes passing through so rapidly. A remedy was found for the heating by having steel bottom rollers, the front being as large in diameter as possible, and the lapping was effectually got over by placing an additional top roller in front of the other, which was made to run rather quicker. This latter roller always kept smooth,



HARMONY MILL,

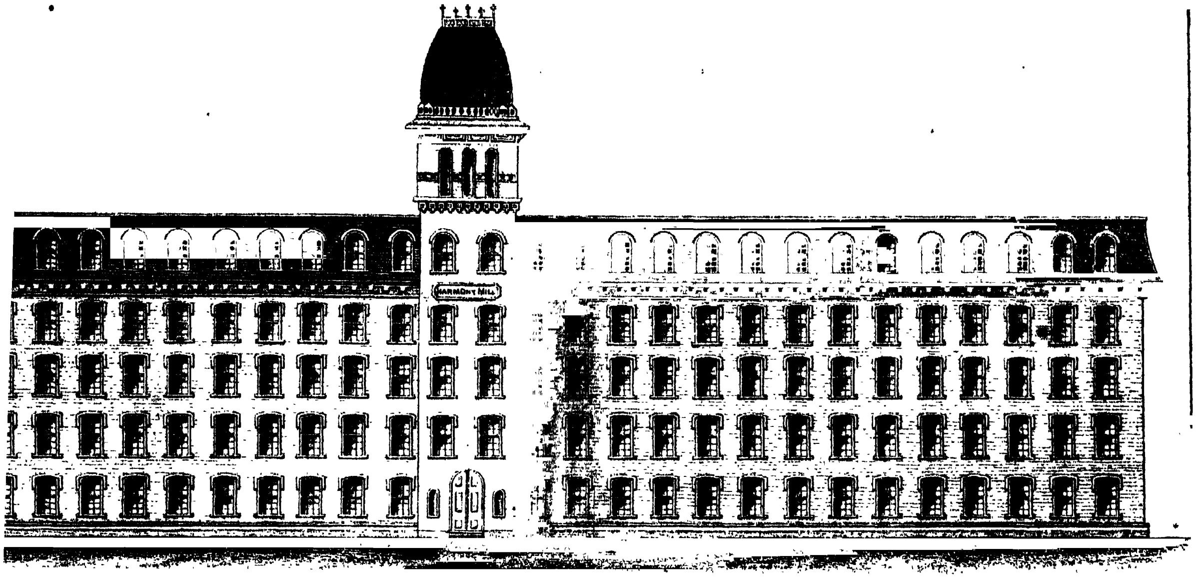
No 3, COHOES, N.Y.

SCALE OF FEET

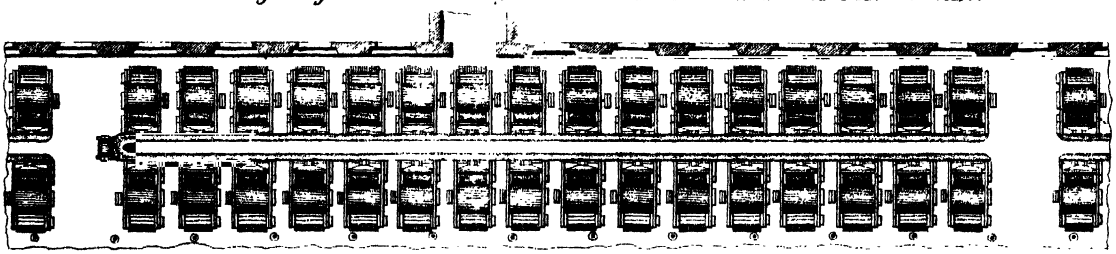


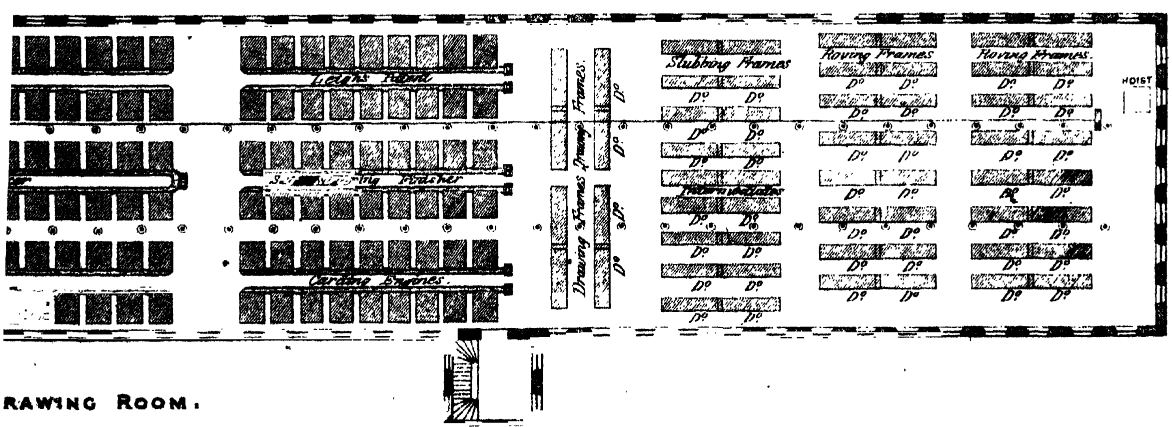
THI

PLATE XX.



Breaker Carding Engines with Railway Head Deliveries. *Scale 20 Feet = 1 Inch.*





RAWING ROOM.

J. GALLOWAY, LITH.

and proved an admirable remedy for preventing the lapping. Nothing more could be desired, all now worked satisfactorily, and the rest of the cards were altered to this principle at once, which saved a large number of cotton cans, and the labour of carrying them about, &c., showing on the whole a decided advantage. This having been accomplished thirty-six years ago, wonder will naturally be excited why it has not been generally adopted? The reason is believed to be this, viz., as the invention was never patented, for some time it was worked quietly, until a machine maker of the name of Hulme, from Stockport (whose men were putting up two throstle frames to fill a spare corner), came over, and seeing these cards working together he took a sketch of them, and applied the same principle to drawing frames as well as connecting cards, upon which he put his own name, and it acquired the designation of "Hulme's Railway." This had a great success for some time, and helped Mr. Hulme in getting orders for other machinery (as he subsequently told the author). Unfortunately, however, when Mr. Hulme took his sketch he did not notice either the large steel rollers or the extra top roller in front, and although in his application so many engines were not connected together as in the Macclesfield mill, neither had any single box in his drawing frames to go through as much as 4,000 lbs. of cotton per week, still they had not worked very long before they began to get out of favour through occasional heating and lapping, which at length raised a prejudice against the whole system, and it was rejected. Through this unfortunate introduction of the connection of cards, as above described, and the invention of the coiler, a good thing has been lost sight of in this country, but not so in America, where it is almost in general use.

A practical example of this is shown on the Cardroom Plan of one of the "Harmony Mills," situate at Cohoes, New York.—*Vide* Plate XX.

AMERICAN COTTON FACTORY.

The example given in Plate XX. of an American Cotton Factory, is one of three mills belonging to Messrs. Garner and Co., all about the same size in machinery capacity; but built in different styles of architecture, one of them being only two stories high. They each contain abont 70,000 spindles, with about 1,500 looms, and are driven by turbines and belting as shown.

Harmony Mill, No. 3, has the singular designation of the "Mastodon Mill," from a very interesting circumstance, viz.: whilst digging the foundations a bed of soft peat was encountered at one end which had to be excavated to a considerable depth before a solid foundation could be obtained. In doing this a complete skeleton of the huge extinct animal the Mastodon was found, which had, in all probability, lain there for thousands of years, being preserved by the pyroligneous acid of the peat.

The above mill contains, besides the usual opening and scutching machines, 204 carding engines, viz., 96 breakers and 108 finishers.

Breakers.—There are 16 breaker cards in each row. Two rows come together at the breaker lap head, making a lap about 19 inches wide, with 32 ends. Two of these being put behind each finisher card make laps of the proper width (64 ends), which come off alternately.

Finishers.—There are 12 rows of finishers, 9 in each row. Every row has its drawing head where the nine slivers come together, and pass through rollers having a suitable draft with an "evener" to regulate the thickness, if a card happens to be stopped for grinding or stripping out. The evener is an admirable contrivance, which varies the speed of the front roller on the drawing box, according to the thickness or weight of the cotton going through; thus, if an end happens to be down or the work be coming up too light, the front drawing roller is slowered in proportion, and if heavier it is accelerated accordingly by suitable mechanism.

Drawing Frames.—There are four drawing frames in each row across the mill, two heads to each frame, six deliveries each head, making 48 deliveries each row; on warp three operations of drawing, weft two operations.

The rest of the machinery is as usual, there being 32 pairs of self-acting mules containing 38,912 spindles, and 190 ring spinning frames containing 30,780 spindles, or 69,692 spindles altogether; also 1,540 power looms, with the usual accompaniments of winding, warping, dressing, &c. The turbine wheels driving this machinery are three in number, 98 inches diameter and 10 inches deep, under 25 feet waterfall, giving a power of 350 horses to each wheel, or 1,050 horse power in the aggregate.

The Harmony Mills have been erected and set to work under the intelligent management of Mr. Robert Johnston and his son, Mr. D. J. Johnston, of the firm of Messrs. Garner and Co., who run altogether about 300,000 spindles and about 6,000 power looms, in Cohoes and elsewhere.

In reply to the author's inquiry as to the duration of the large belts and the power they drive in the Mastodon Mill, Mr. D. J. Johnston writes—"Our new mill is "driven by bands, or as we say belts. The power is taken from the jack shaft from "pulleys 12ft. diameter, 2ft. 6in. face, and communicated direct to main lines in each "room by belts 24in. wide, double leather. These run 3,780 feet per minute, and are "six in number, driving from highest to lowest power 175 horse each; required "tightening three or four times in the first three months, and never since. With "proper care will last 20 years; with your English leather would last much longer. "The Boyden Turbine, described in the work sent you, is the best wheel made when "constructed with proper care, and has given effective power of upwards of 90 per cent; "the general and safe estimate for them is 75 per cent. They are building a wheel "near Lowell, Massachusetts, that has given good results and promises well; it is a "combination of the Fourneyron and Jonval Turbines."

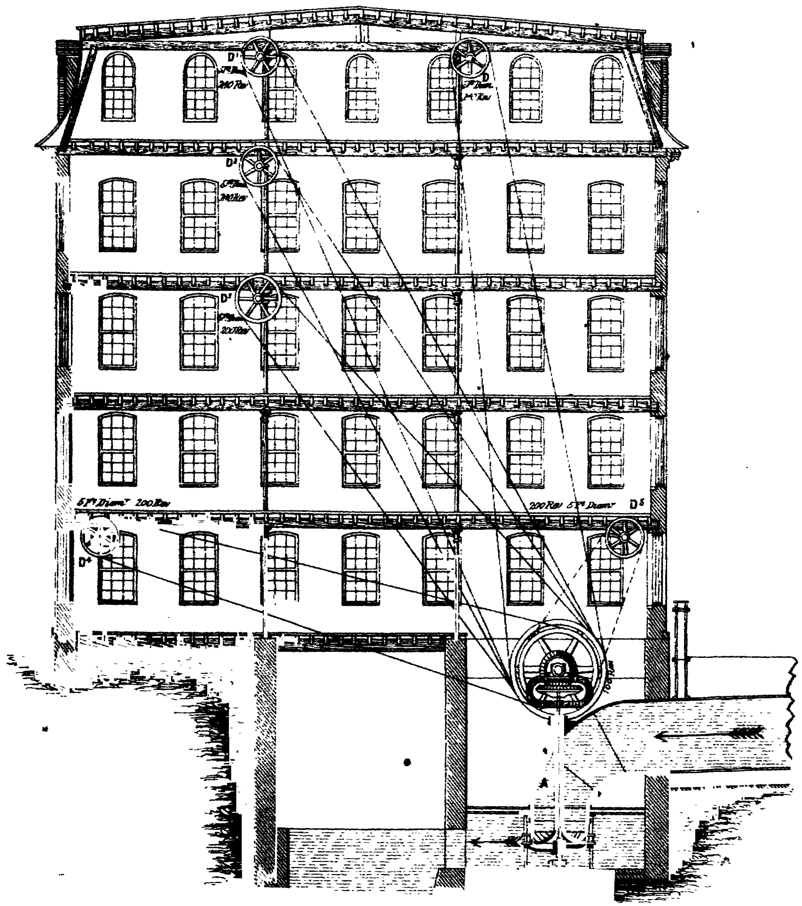
PLATE, XXI.

HARMONY MILL, No. 3, COHOES, N.Y.

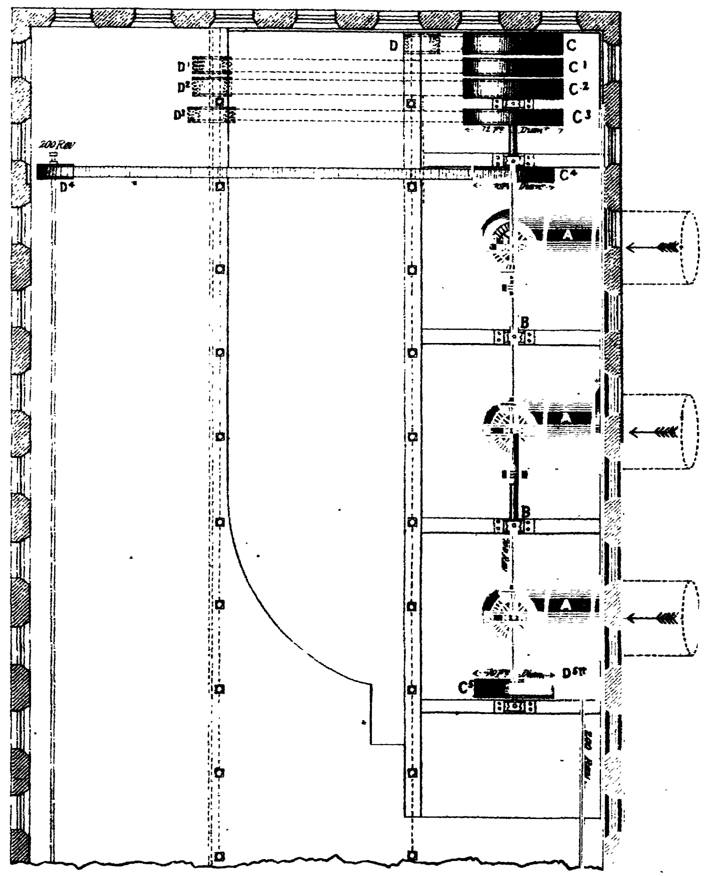
SCALE OF FEET.

50 Feet 40 30 20 10 5 0

SECTION OF MILL SHOWING TURBINES AND BELTING.



PART PLAN OF MILL AND TURBINES.



The travelling flat card, originated by Smith, and altered by Leigh, may be said have remained stationary for thirteen years; the last improvement recorded being patent obtained by Leigh in 1857, which was merely an improvement in the shape and arrangement of the flats and other details, and will be understood as follows:—

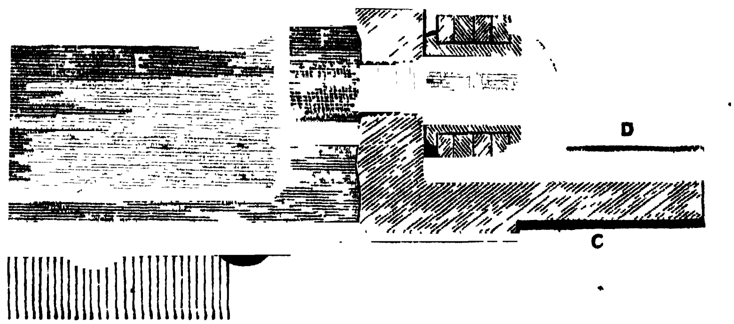


Fig. 106.

Fig. 99 (page 117) represents a flat of the old construction; and *Fig.* 106 represents a flat of the new construction.

In *Fig.* 99 the surface from which the flats are ground will be seen at D, in the hollow between the back rib and the notch into which the set screw B takes.. When the flats are passing over the top side of the card in an inverted position, the surface D slides over a plate fixed immediately under the grinding roller pedestals, and the flats are supported by this plate when the grinding roller comes down upon them.

It is evident that unless the surface D be perfectly clean when the grinding roller is applied, those flats which had dust and dirt caked upon the surface would be raised up a little by it, and they would be more ground than the others, and thus rendered irregular. In practice this was found to be the case; for the grinding surface being thrown so far back from the end of the flat, it was exposed to dust and fluke, which in time got caked hard upon it and produced the mischief described.

In the new flat, *Fig* 106, the rib E is joined up to the notch F, which greatly strengthens the flat, and prevents its springing when the grinding roller comes upon it; and the surface D is moved to the end of the flat opposite the carding surface C, which slides on the flexible bend. In this position it has two important advantages: the first of which is that it can be adjusted with greater nicety to the carding surface; and the next, that it is outside the engine, where it can be seen and wiped down every time the engine is cleaned, whereas before it could scarcely be seen, and was so difficult to get at as to make it practically impossible to keep it clean, even by those who understood the importance of so doing; therefore in a room full of cards it was sure to get neglected.

Fig. 107 shows the plan of coupling the flats together according to the latest improvements, with the grinding surfaces D D outside the chain at the ends of the

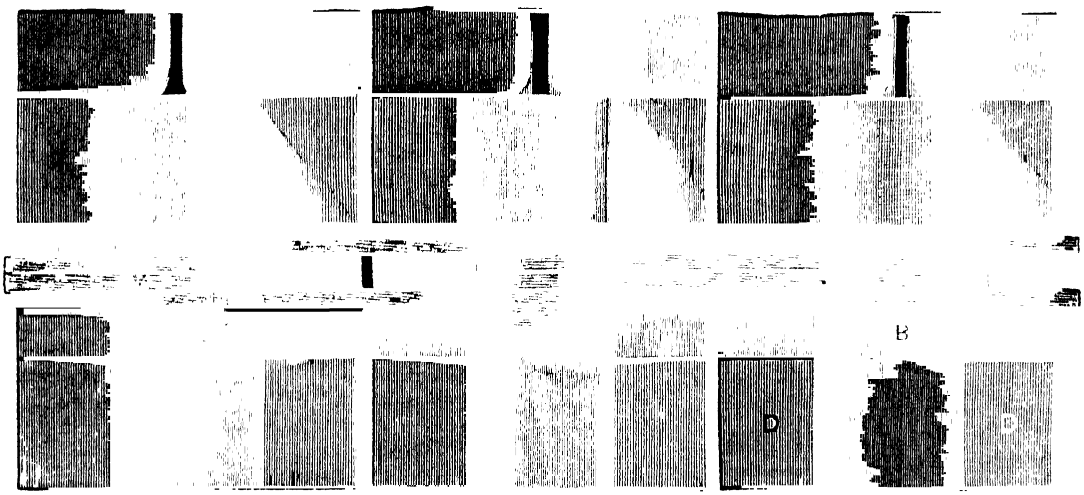


Fig. 107.

flats; and *Fig.* 108 shows an end view and part section as they appear when at work, in which A is the bushed connecting chain, B the set screw which takes into the flats; D D the surfaces from which they are ground, and C the carding surfaces which rest on and slide over the flexible bend which sets them and holds them bevel to their work. The segment of main cylinder and flats are shown full size in these figures.

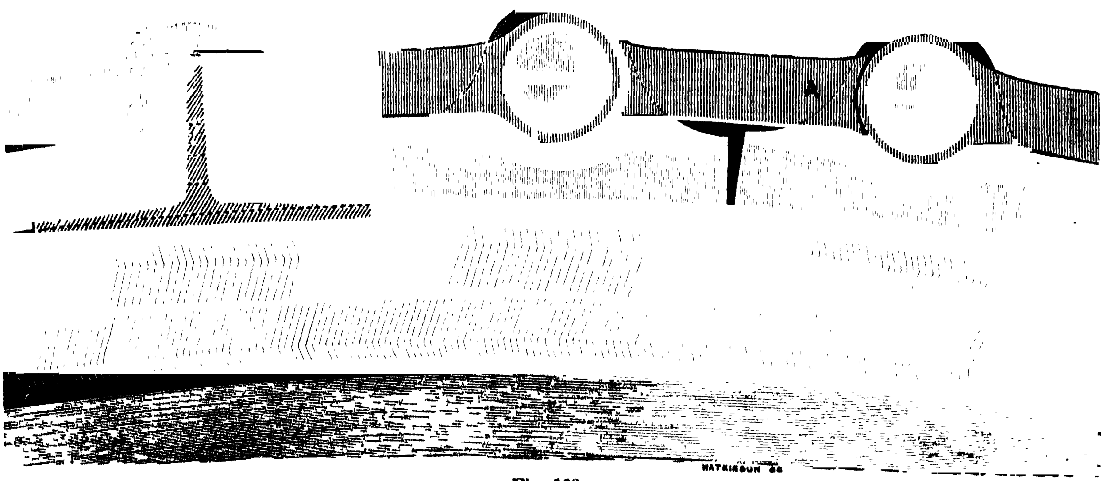


Fig. 108.

Fig. 109 shows perspective view of a carding engine made with the old kind of flat (after the bushed chain was introduced), in which *f* is the plate that supports the flats for grinding.

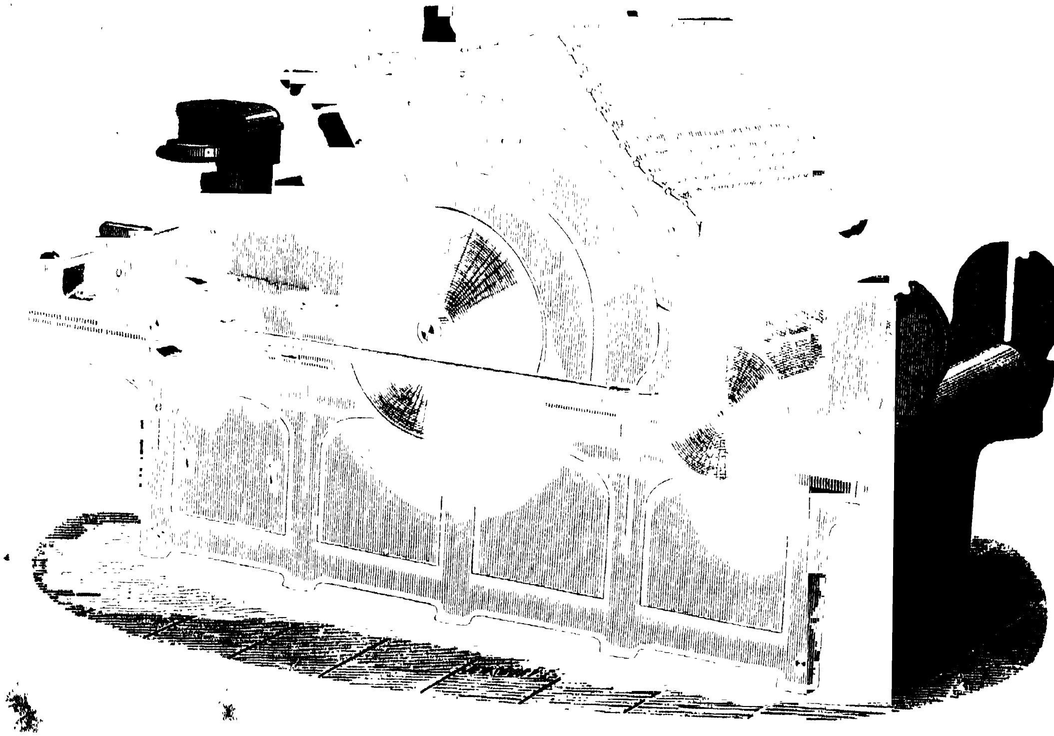


Fig. 109.—Leigh's Self-Stripping Card (Third Patent).

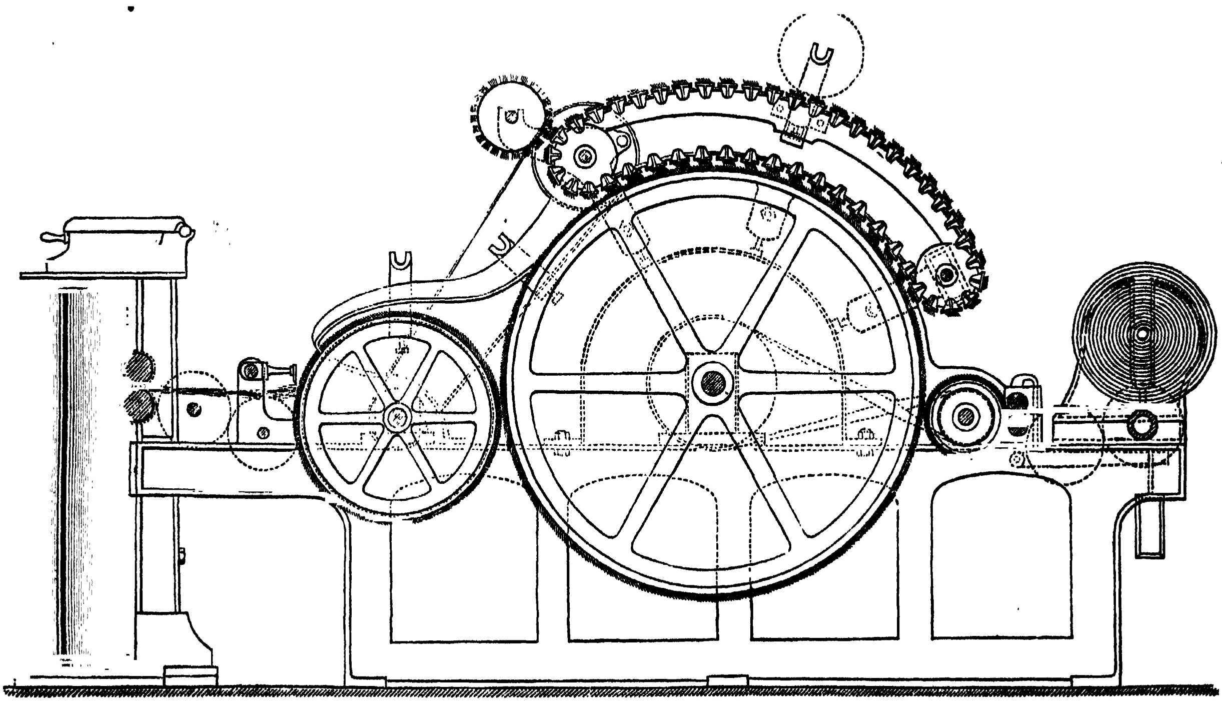


Fig. 110.—Section of Finisher Carding Engine (Leigh's Third Patent).

Scale ¾ inch = 1 foot.

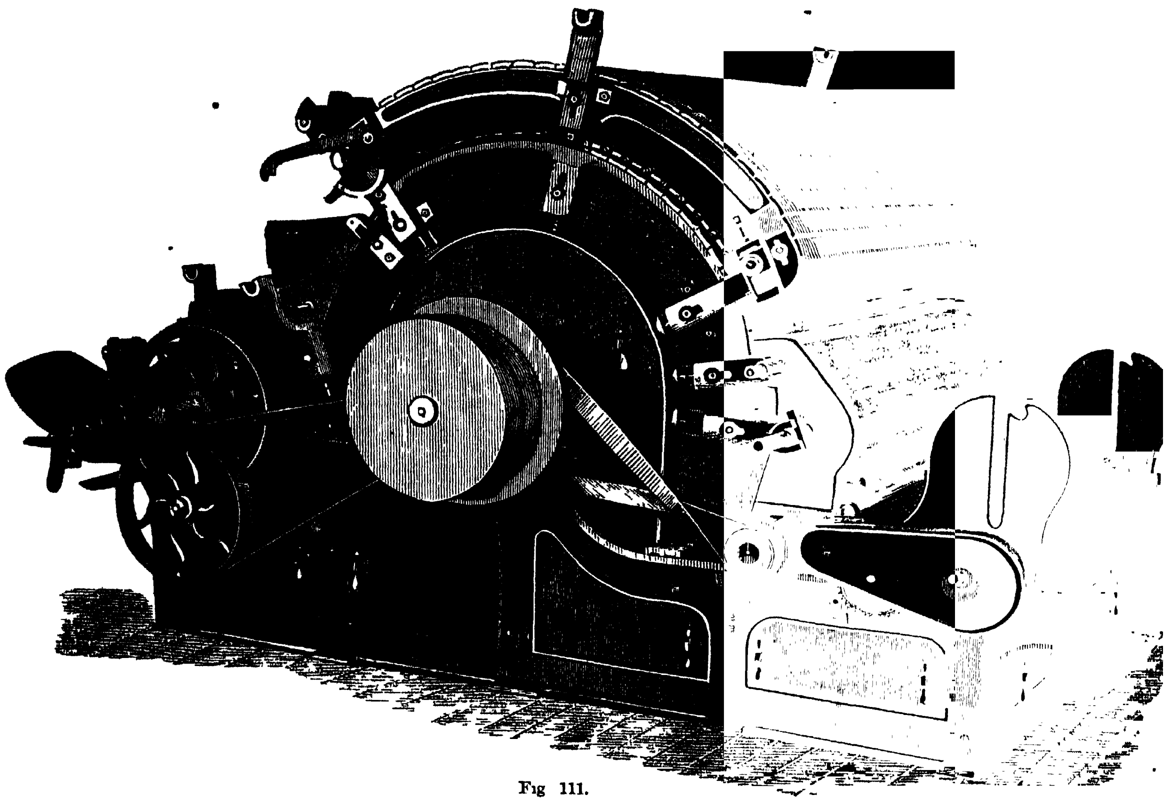


Fig 111.

LEIGH'S SELF-STRIPPING CARDING ENGINE

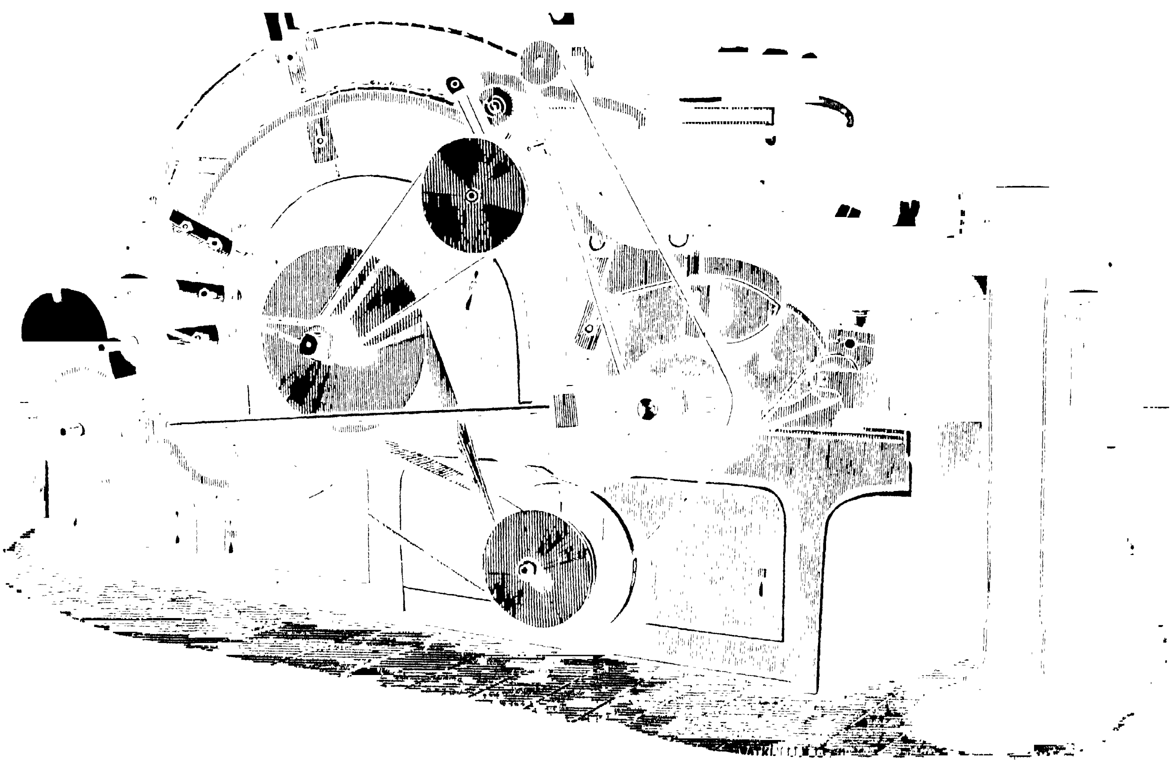


Fig. 110 shows a section of a finisher card with all flats; and *Figs.* 111 and 112 exhibit right and left hand view of a card according to the patent of 1857, above mentioned, in which the flats slide over an arched plate in returning to their work, after being stripped by the comb *g*.

The brush *h* may either be worked constantly or only put on occasionally. When worked constantly it has not only a tendency to keep the flats sharp, but in time wears the wire to a needle point, so that very little grinding is necessary.

It should also be remembered that in this principle of carding, there are nearly three times as many flats as those in action; therefore they do not in any case want grinding oftener than once in six months, and then only very lightly. Where circular brushes are used to each card, revolving slowly, at a speed of about 20 or 30 revolutions a minute, and set about one-sixteenth of an inch in the wire, the tops have been run two years without grinding.

The Wellman card, before alluded to, has been much improved since its first introduction into this country from America. The makers who first took it up, Messrs. Dobson & Barlow, of Bolton, made considerable improvements in it, particularly in

Fig. 113.– Portrait of George Wellman.

adapting it to a plan of setting flats with one screw at each end that had been recently patented by Mr. Thomas Arrowsmith, of Bolton, and which they materially improved upon before using it for the Wellman self-stripper, to which it was admirably adapted. Since then the same firm have brought out some further patented improvements upon Wellman's self-stripping flat card, called treble stripping, by which, they say, "the flats, through a simple and effective arrangement, are stripped at various speeds, proportionately to the requirements of the cotton." *Fig.* 114, opposite, shows a breaker or union card made as above described, with latest improvements; and *Fig.* 115 shows a finisher card with all flats, by the same makers.

Several other patents have been taken out in this country for improvements, or alleged improvements, upon the Wellman principle of carding, the main features of which have been to enable the flats to be ground or sharpened on the engine whilst at work. Although the Leigh card had, like almost every other machine, its objectionable points, still it could be worked with less labour than the Wellman from the fact of the travelling flats being ground in their places, and there being greater facility for stripping out the cylinder, which could be done by turning up a cover without removing anything from the engine. As this was not so convenient in the Wellman card, the improvements above alluded to removed one of those defects by enabling the flats to be ground in their places,* as will be seen on referring to *Figs.* 1 and 2, Plate XVIII., which show a right and left-hand elevation of a carding engine just brought out by Messrs. Curtis, Parr, & Madeley, which is of the "Union class," and described by them as follows:—

"*Two oscillating arms* (one upon each side of the carding engine) are swung on the bosses of the main cylinder pedestals, and are connected by a cross shaft, on each end of which is keyed a chain wheel, over which are carried the *lifting chains*, into which they gear. Upon the cross shaft is keyed a spur wheel, driven by pinion, pulley, and strap, from the cylinder shaft. In each oscillating arm is fixed a *main slide*, with a traverse of about six inches, which has in it a *second slide*, with a traverse of about five inches and a half; and also carries a *revolving box*, turning freely in a boss thereon. This box has on its inside face two guides, between which the *flat end* can slide; and has its top in the form of a rim or arc of a circle, the chord of which forms the same angle with the two guides as the wire on the flat with the flat end. Against the side of the oscillating arm, and parallel with the main slide, is fixed a *planed bracket*, having at its lower end a small bowl; and so that when the box shall have made about one-fourth of a revolution or thereabouts (according to the bevel required in the flat), the aforesaid chord and the planed surface of the bracket shall form a right line. On the inside of the second slide is a stud with oscillating lever, to the upper end of which is fixed a second stud, upon which turns the *lifter*, the said stud passing between the legs of the revolving box, and carrying on its other extremity a bowl, capable of sliding between a pair of flanges on the inside of the main slide. This lifter is made so as to enclose the flat end on the bottom, end, and top, to which latter is attached a *spring*, which presses the flat on to the bend, and also steadies it during stripping, &c. The *traversing motion* is effected in the following manner: Through a boss upon each arm passes a shaft, having on its outer end a *toothed chain wheel* of twelve teeth, which occupy about four-fifths of its periphery, the remaining one-fifth presenting a flat surface to the edges of the lifting chain, which a bracket keeps in close contact therewith. On the inside of this shaft is keyed a spur wheel, into which gears a second spur wheel on a *pinion shaft*, turning in a boss at the end of an oscillating link which pierces and works through the aforesaid boss on the arm. The *pinion* works in a *mangle rack* attached to the bend. The *stripper* is carried across the engine; turns in two sliding brackets, one on each arm, adjusted by regulating

* It is believed that the first Wellman card on this plan was brought out by Messrs. W. Higgins & Co.

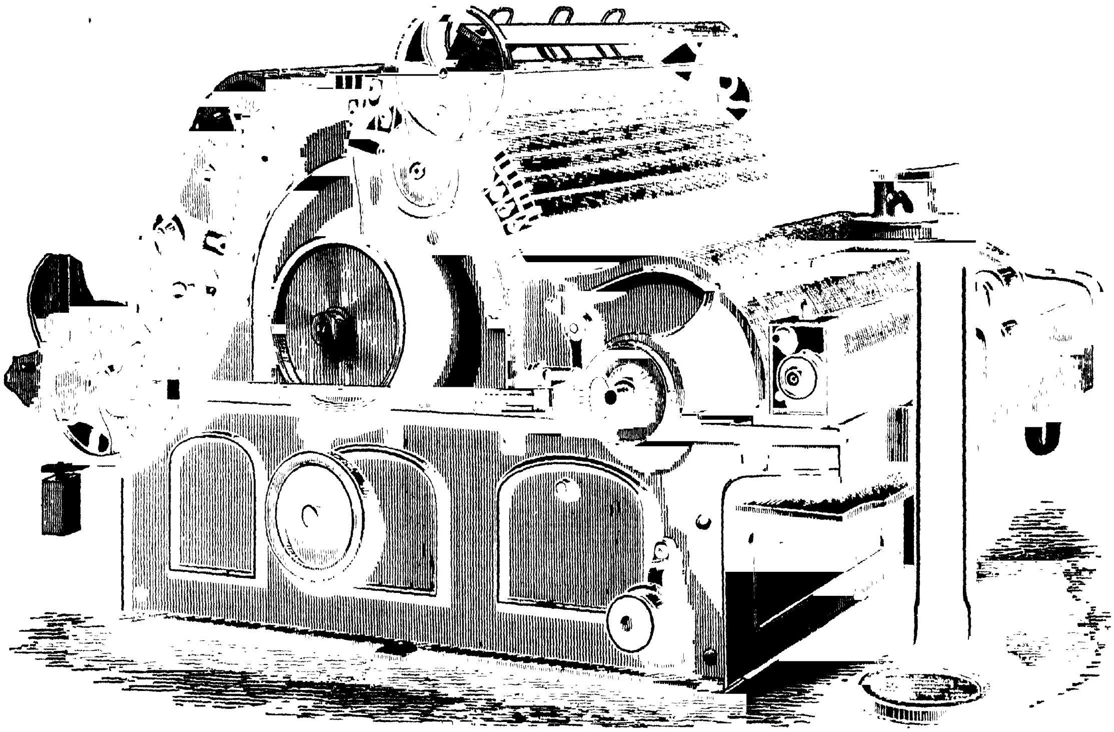


Fig. 114.—Wellman Breaker Card, by Dobson and Barlow.

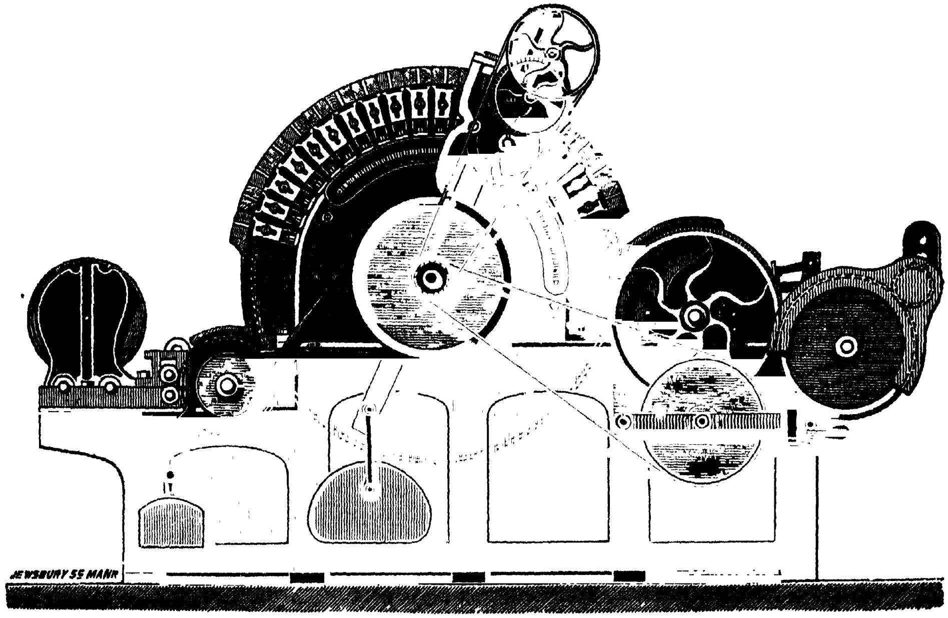


Fig. 115.—Wellman Card by Dobson and Barlow. (Scale ⅜ inch = 1 foot)

AS MADE BY PARR, CURTIS & C°. MANCHESTER.

Scale of Feet

FIG: 1.

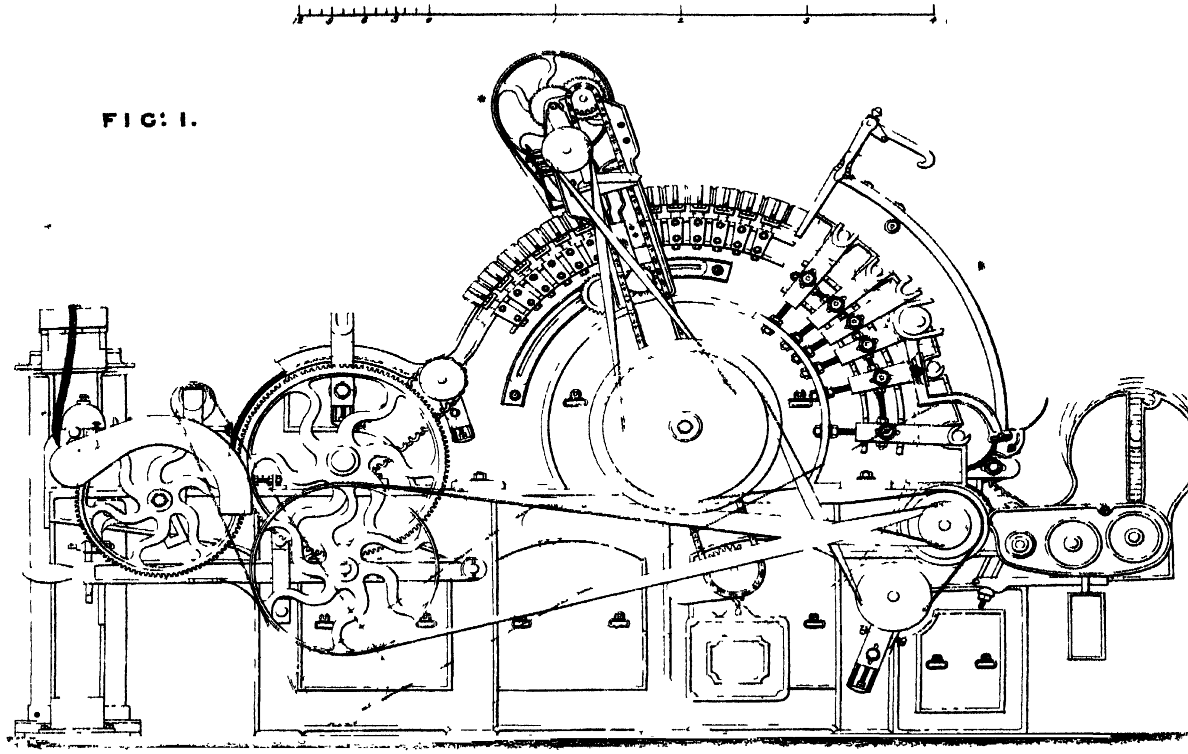
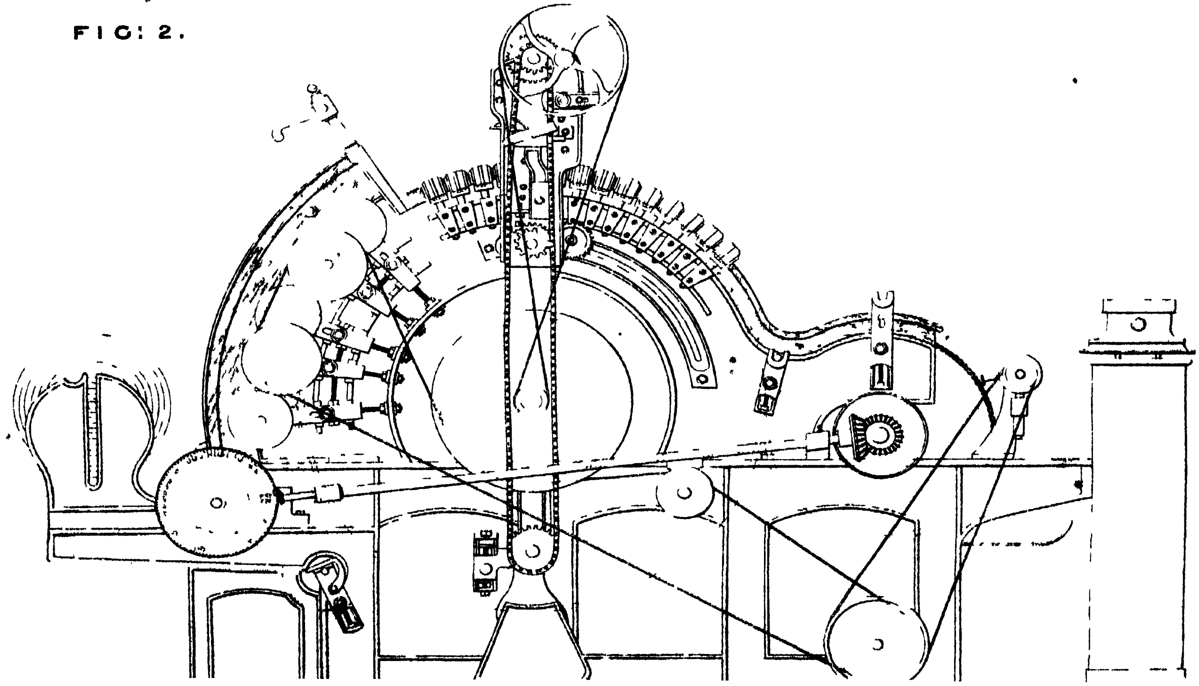


FIG: 2.



PLATE, XV

SELF STRIPPING CARDING ENGINE
WITH 16 IRON FLATS,
AS MADE BY JOHN HETHERINGTON & SONS

Feet

FIG: 1.

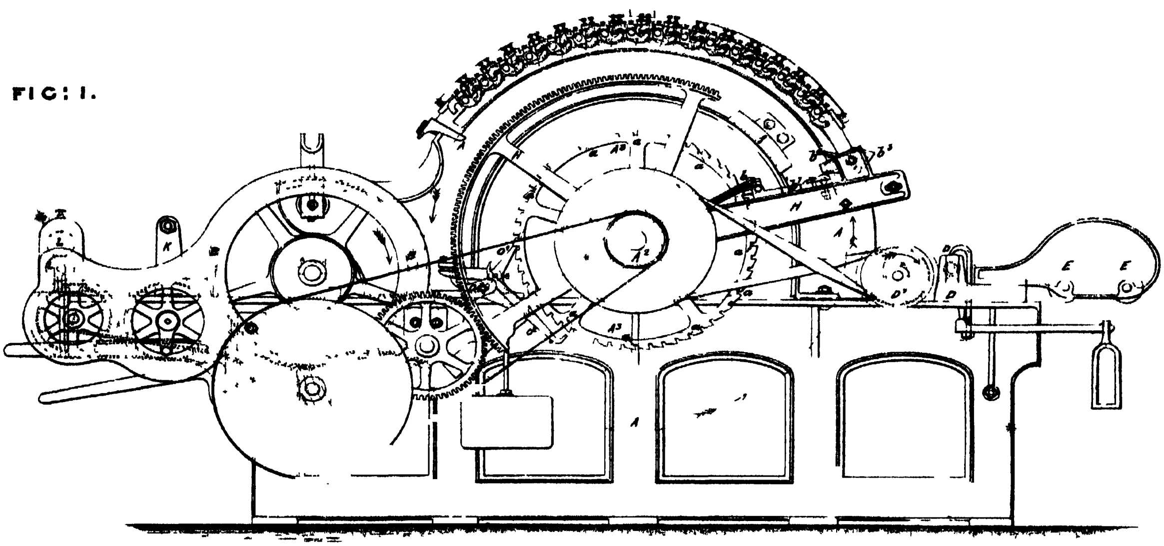


FIG: 3.

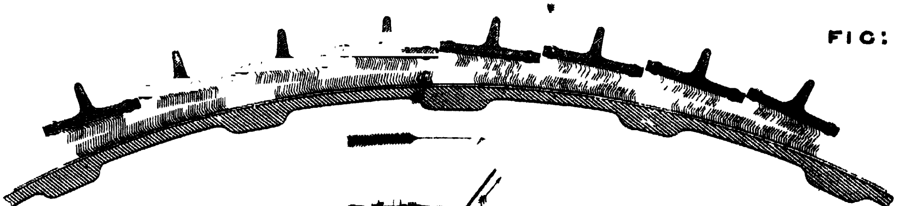
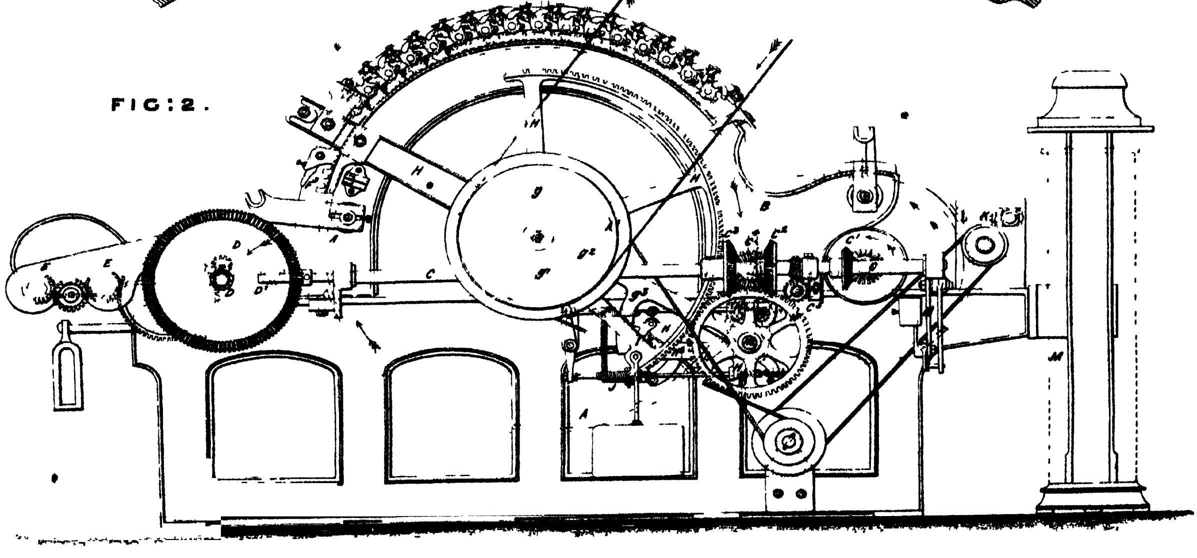


FIG: 2.



screws; and is made to describe an arc of about one-third of a circle by a pinion on the cross shaft gearing into a spur wheel working as an eccentric, a connecting rod oscillating on a tappet upon the stripper shaft. Beneath the stripper, and bolted to the two oscillating arms, is fixed the *stripping board*, and both are clothed with card wire,—the former with the points down, and the latter with the points back.

"The flats are stripped alternately, and the mechanism works in the following manner: The *lifting chains*, revolving together by the revolutions of the cross shaft, bring the bowls which they carry against the under sides of the T brackets, which move simultaneously; the *lifters* attached thereto raise the flat, the ends of which enter the guides upon the revolving boxes, and the bowls on the ends of the studs carrying the lifters traverse the straight portion of the guides on the main slides until they have attained a height of about two and a half inches, and the flat is raised clear of the others. The said bowls here arriving at the curves in the guides, and the springs on the lifters pressing against the projections on the faces of the revolving boxes, they commence to revolve, and continue so doing until the second slides arrive at the top of their slots in the main slides. During this operation the latter have been prevented from rising by their box rims being in contact with the small bowls on the planed brackets until the flat is in a stripping position, when the flange or rim suddenly ends; and all obstacles to the rise of the main slides being removed, the lifting chains carry all up together past the stripper (which is timed so as to meet the flat during its ascent), and the brush or grinding roller (whichever may be in use), and the chords on the boxes and the planed brackets on the arms are face to face, so as to prevent any vibration of the flat during ascent or descent. The *stripper* during the ascent of the flat has moved out of the way, and is delivering its strippings on to the stripping board, the front of which it clears a second time before the flat next in order is raised. The *grinding roller* is carried in two brackets above the stripper, and is driven from the cylinder shaft. The intermittent traversing motion is commenced by the action of the bowl on the chain, upon a finger on the toothed chain wheel, the corner of the flat surface thereon falling into a hollow in the chain immediately under the said bowl; and is continued by the action of the chain upon the teeth, when a corresponding hollow higher up the chain allows the revolution to be completed, the pinion having travelled over a space on the rack corresponding to two flats.

The important advantages secured in this carding engine may be stated as follows:—

"1. The flats are stripped by self-acting mechanism, and with the least possible amount of wear and tear to the wire, necessitating little more than half the grinding usual in carding engines having stationary flats, and ensuring a corresponding saving in card wire; in addition to which the flats are stripped so clean as to present the appearance of having been continually brushed out.

"2. The flats are ground without removal from the engine, and by self-acting mechanism, one grinding roller serving for about thirty carding engines. It can be placed in position or removed therefrom with the greatest facility, by screwing or unscrewing a single set screw, and may be transferred from one engine to another, without any readjusting to the surface of the flats (except such as is necessitated by a gradual wearing of the wire.) It will be evident that the labour of carrying the whole of the flats in a mill to and from the grinding room to be ground, say once every week or ten days, is saved, and the damage to which the flats and card wire are thereby subjected is wholly avoided; in addition to which no opportunity occurs for carelessness and neglect in the grinding of the flats.

"3. Each flat is turned up when being stripped, so that the spinner can see at a glance the state of the wire upon the flat, and the completeness of the stripping. When the carding engine is stripping at the rate of one flat per minute, the flat is absent from the bend about ten seconds, and when replaced is lowered gently, and pressed closely on to its resting place before it is left.

"4. Card wire of any width, and of varying degrees of fineness, may be used for the flats of this engine, and more working flats are obtained than upon any self-stripping card, under the same conditions at present in use.

"5. The various motions by which these results are obtained are slow and steady, the mechanism simple and so arranged as to render a break-down almost, if not quite, impossible."

Another self-stripping card, which partakes more of the Buchanan than the Wellman, is made by Messrs. John Hetherington & Sons. The latest improvements, shown in Plate XVII., are thus described by Messrs. Hetherington:—

"This self-stripping card differs from the other systems now in use, inasmuch as the flats are placed upon pivots, and the bearings in the bend, in which these pivots work, are fixed concentric with the main cylinder; and the adjustment takes place by the pivot being bolted to a slide on the ends of each flat, and regulated in position by a screw, as the wire wears down by grinding.

"The arrangement of the pivots and bearings—true with the main cylinder and equi-distant from it—necessitates that (as the wire on each individual flat has to be accurately set to the wire on the main cylinder, and as all the bearings are concentric) the points of the wire on each flat in the card will, when it is turned up, form as true a circle for the stripper to pass over and clean as these points did to the main cylinder when working; and no variation in the length of the wire on the flat will (as the adjustment takes place between the point and the point of the wire) affect the truth of this circle.

"A screw on the top of bend is arranged to set the flat to the desired heel, and after this is once set the ordinary adjustment of the flat to the wire on the cylinder will not affect this heel. A similar screw, when the flat is turned up, allows the point of the wire to be levelled for stripping or grinding. When either of these screws is once set it need not again be disturbed.

"The flats do not fall when they are turned back into their working position; a small projection from a tooth of the segment wheel, which turns the flat back into its place, is allowed to come into contact with an inclined plane as the lever passes. This incline places the flat quite down before it is out of contact, so that it cannot fall or come down too quickly.

"The stripping-card only passes over the wire in one direction, and the wire on the flat has not to clean the stripping-card. The wire on the flat is thus improved by the process of stripping.

"When the flat is turned over the carder is enabled to see at once if the stripping is properly performed, and to assure himself that the flats are truly set to the main cylinder, and perform their work in an efficient manner.

"The stripping motion can be arranged that the back flats may be be stripped in any desired proportion, say two, three, or four times, for the front flats' once, so that the stripping can be exactly regulated to what is required, or what would be done by hand stripping.

"Each flat can be lifted, turned over, stripped, and re-turned to its working position in about six seconds. The rapidity with which the stripping is performed does not allow time for the accumulation of fly in the empty space out of which the flat is lifted.

"The flats are made of cast-iron, which precludes a possibility of their being affected by the weather, and although so made are very light.

"The strippings are conveniently collected in a box placed over the doffer. A roller stripped by the licker-in or a roller and clearer can be applied to this card without reducing the number of flats, or these flats are combined in any proportion with rollers and clearers.

"Motion is given to the main cylinder A in the usual manner by a strap on the pulley A¹ (Fig. 2). All the other motions are then obtained from the cylinder shaft. On the opposite end of cylinder shaft to A^1 is the pulley A^2 (Fig. 1) which, through the strap and gearing shewn, drives the doffer B, and it, from its opposite end, through the side shaft C, gives motion to the feed-rollers, D, D, and lap-rollers, E, E. The side shaft, C, also gives the reciprocating motion to the quadrant H through the gearing, C^1, C^2, C^3, C^4, and H^1, C^2 is fast on the side shaft, and, whilst the quadrant moves forward, gears into the bevel wheel C^4, with pinion on its boss gearing into wheel H^1 on shaft H^2 which passes across the card, and has a corresponding wheel on the opposite end of it, gearing into a similar quadrant H, thus giving a uniform motion to the radial arms H H on each side of the card.

"The radial arm is changed from the backward to the forward movement, and *vice versâ*, by an exactly similar motion to that used in the slubbing, intermediate, and roving frames, and consists generally in changing the bevel wheel C^4 into gear with the bevels C^2 and C^3 alternately. The lever H^5 (Fig. 2) moves on the centre H^2, and has an upward arm carrying the bevel C^4 with spur pinion on its boss. Two plates G, G^1 are bolted on the quadrant H. The catch I rests on the projection on lever H^5. The plate G^1 lifts the lever G^2 which slackens the chain between h^1 and G^4, and (as the lever H^5 is firmly held by the catch I pressing on at h) causing the two springs J and J^1 to be held in tension until released by the arm G^3 lifting the catch I off h, and allowing the lever H^6 to swing on its centre H^2, thus changing the bevel C^4, on its upper arm, from C^3 to C^2, and thereby altering the direction of the carrier H^1 together with that of the quadrant H.

"The carding flats F, F, F, are stripped by the forward movement of the stripping-card which is carried between the radial arms on each side of the card.

"The carding flat is previously turned over wire outwards in the following manner. On the ratchet wheel A^3 (Fig. 1) are arranged the inclines a, a, a which raise the pall b and the incline b^2 on radial arm H. As the quadrant moves forward the incline b^2 comes in contact with the finger F^1 on the carding flat, which it causes to revolve on its axis and to pass up and down the double incline b^3, thereby turning the flat over, which, after being cleaned by the stripping-card F^2, is gently lowered into its place by the toothed segment F^3.

"The radial arm having traversed over the flats, from the back to the front, the reversing motion is not allowed to make its full change until the small worm wheel C^5 has made a revolution, so that by this means the stripping card may be prevented working continuously if desired.

"The flats nearest the feed end require cleaning oftenest, as in hand-stripping; this is accomplished by the fixing f changing the plane of the lifting pall b. The inclines a, a, a, on the ratchet A^3, are of different widths, and the pall b usually travels in the outside plane of the broad inclines. It will be seen that the fixing f acting against the pall b by the lever b^1 throws it into the plane of the narrow inclines, causing the lifting and stripping of the flats in the same radial limit as the fixing f to be twice (or more) as often as the others. The ratchet wheel A^2, and with it the inclines a, a, a, is moved one tooth forwards every time the quadrant H returns, by a stud O lifting the catch O^1, the lever O^2 preventing it slipping back.

"Provision is made for any accident that may happen to the gearing by the Patent Self-acting Stop-motion N, which, if the wheels get choked, throws the bevel wheel C^1 on the side shaft C out of gear with the wheel on the end of doffer, instantly stopping the whole of the stripping motion, the feed rollers D D, and the lap rollers E E.

"The general description of the working of the card is as follows :—The lap from the scutcher is placed on the lap rollers E E, which are driven from the feed rollers D D, through which the cotton passes. These feed rollers are driven from the doffer B by the side shaft C, thus proportioning the amount of feed to the amount of delivery. From the feed rollers the cotton is taken by the licker-in D^1, and carried forwards by the main cylinder A to the carding flats F, F, F, which thoroughly card the fibre, retaining the short cotton, seed, and dirt, and allowing the carded cotton to travel forwards to the doffer B, whence it is stripped by the eccentric comb K, and, passing through the callender rollers L L, is deposited in the usual way in the form of a sliver in the can M."

It must not be understood as a recommendation, where the Wellman or other cards are described in the makers' own language, or any particular example shown of this or that machinist's build; for many respectable houses build self-stripping cards of the Wellman or Buchanan character now the original patent is out, the whole of which it would be simply tiresome to illustrate and describe. It is hoped that full justice has been done both to the Buchanan and the Wellman principles of stripping in the examples given, including the improvements of Messrs. Dobson & Barlow, William Higgins & Sons, Hetherington, and others.

If no more be done than what at present exists, it is sufficient to show that the self-stripping of top cards or flats is already *un fait accompli*. Whether this or that mode of doing it is best is of little consequence: Time, which tries all things, will eventually settle the question; but as self-stripping is only yet in its infancy, it is probable that, for some time to come, several different kinds will continue to be made.

CARD CLOTHING.

Formerly cards were set by hand in a leather ground, by children and women, until a machine was invented to do the work. The first attempt on record to set cards by machinery was by Kay, of Bury; but the successful machine was of American origin, and when first introduced into this country the patent was purchased by Mr. Dyer, of Manchester, and subsequently materially improved by Mr. James Walton. There is an old saying that he showed his wit who first invented clocks; to which might be added, he also showed his wit who first invented the card making machine. This interesting machine is a beautiful and most ingenious contrivance, for which we are indebted to our Transatlantic cousins. Its importance and utility have proved quite equal to the admirable mechanism displayed in its construction. Prejudice, which is the constant companion of those persons to whom nature has not given quick perceptions, battled with it for a long time, but has been discomfited and finally vanquished, leaving triumphant, like truth, this small and elegant machine. In making this observation, it must not be understood as treating with any contempt people given to prejudice and unbelief. They have a salutary effect in our social system; checking undue enthusiasm, detecting *humbug*, and holding down the volatile and over-sanguine, they blend society in one harmonious whole, working together for good; developing sterling merit, they leave it standing out in bold relief, more clear and defined from the rasping it has undergone at their hands, of which this is a good example.

The card making machine has not only been very useful in saving a most monotonous kind of labour, but it has brought into extensive use various other materials for ground work to substitute leather, which together with the saving in labour, has lowered the price of cards very materially. One of the best of these substitutes was Walton's patent material, which was cloth and indiarubber combined, the latter being all on the top side. After that came William Horsfall's patent, which was a mixture of woollen and cotton cloth, then vulcanised indiarubber and cotton cloth.

Of all these materials, Walton's natural indiarubber has perhaps answered the best, and next to it Horsfall's material, and then Macintosh cloth cards. Leather is now almost entirely gone out of use for this purpose, except in some hot countries where there is still a lingering prejudice in its favour, for which it is believed no substantial reason can be shown. Both Walton's natural rubber and Horsfall's material are now used by all cardmakers, as the patents have long ago expired.

Although indiarubber cloth and other substitutes had a degree of flexibility and evenness, which made it evident at a glance that those materials would certainly supersede leather, yet it has taken more than a quarter of a century to bring them fairly into use, so strong is prejudice against innovation. The author recollects being much pleased with the first indiarubber cards he tried, about 35 years ago, and after working them a few years very satisfactorily, asked an old experienced spinner what he thought about the new substitutes for leather? He at once denounced them all in the most unqualified terms, adding that there was nothing like leather for cards. As he spoke so decidedly, the author asked him in what particular manner he had found them to fail, as it was so contrary to his own experience. The reply was—"Oh, I don't know, I have not tried any of them, nor will I ever try them, for I am sure they won't answer!" Verily, the old adage about leather will never die as long as that spinner lives.

HOW TO COUNT CARDS.

In ordering cards it is necessary to name the numbers or counts required; for instance, No. 100's sheets, 110's or 120's fillet, &c. Now what is meant by 100's is really 25 staples or teeth to the inch one way and 10 staples the other way, or 100 staples in four inches (the usual width of a sheet), being 250 teeth to each square inch. The American system of counting cards is different from the English, as they count by the wire gauge as well as by the numbers. Thus—

Nos. 60's, 70's, 80's, 90's, 100's, 110's, are, in American numbers,
„ 28's, 30's, 31's, 32's, 33's, 34's, wire.

The Cut means the length of wire which forms two points or teeth when stretched out, generally about 1in. maximum cut for No. 100's cards, from which they may go down to $\frac{15}{16}$, $\frac{7}{8}$, or less. For lapping rollers of very small diameter cards are sometimes used as short as $\frac{3}{4}$in. in the cut, and much more keened than is customary for large rollers or doffer fillet, it being clearly indicated that the smaller the diameter of the roller the shorter the cut, the finer the counts, and the more ought to be the keening or bend, to make the card look natural and work properly. (See *Fig.* 74, page 91.)

The Crown is the head of the staple between the points. It may be $\frac{3}{16}$in., $\frac{1}{4}$in., more or less, as indicated by the fineness or coarseness of the numbers; the object being to make all the points of an uniform distance on the face of the card, according to the counts.

The difference between a *ribbed* and *twilled* fillet is in the mode of setting the wire. *Fig.* 27 (Plate XXII.) shows the back of a ribbed fillet, and *Fig.* 24 shows the back of a twilled fillet, which is supposed by some spinners to be better set for work; but the twilled fillet always shows a spiral groove when wrapped round a cylinder, doffer, or roller where the laps join, whilst the ribbed fillet joins up so close that the surface of the card is uniform throughout. For main cylinders when clothed with sheets they are generally set plain, as in *Figs.* 1 and 2, Plate XXIII., and when clothed with fillets either twill or rib setting seems on the whole the best; but for doffers or rollers ribbed fillet is undoubtedly the best, and looks the neatest.

FEED ROLLERS.

Like other things appertaining to carding engines, there is much difference of opinion about Feed Rollers. Formerly only two kinds were used, viz., plain fluted rollers, or plain shafts covered with coarse narrow fillet of needle or diamond-pointed wire. The latter was infinitely the better in principle; but from want of judgment in the bend of the wire, proper support of the feed rollers, bad clothing or improper setting, the rollers were apt to lap and the wire get crushed down at the ends and spoiled. When the fluted rollers were made sufficiently small in diameter to admit of the licker-in taking hold of the staple of the cotton they were apt to spring, if a lump or thick place in the feed came through, and allowed the cotton to be snatched in lumps or flakes, which spoiled the carding, and if made large enough in diameter to prevent this, the nip of the feed rollers was so far from the bite of the licker-in that the staple could not be held for the latter to have a combing action upon it; therefore it was delivered in little lumps to the licker-in, and by the latter carried on in that state to the main cylinder, which is prejudicial to good carding.

It will thus be seen that the proper action of the feed rollers and licker-in is very important, and that neither of the above-named plans of feeding is exactly what is wanted even for long stapled cotton, and totally unsuited for the shorter kinds. Where fluted rollers are used it is better to have a coarse deep flute than a fine flute, which not only holds better, but by one roller working deep in gear with the other the effect as regards the nip is as though the rollers were smaller in diameter. (See *Figs.* 116 and 117.)

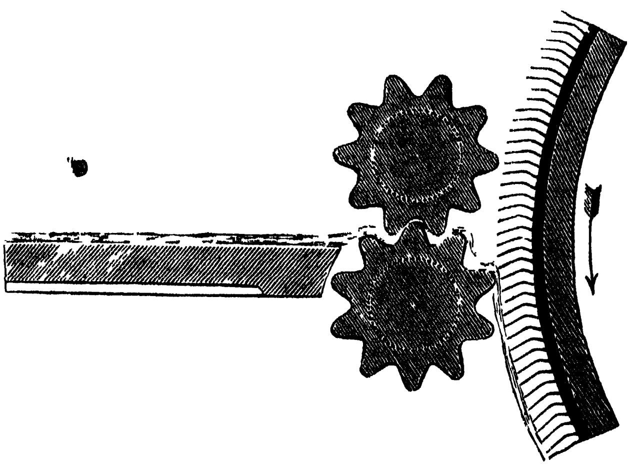


Fig. 116 (half size).

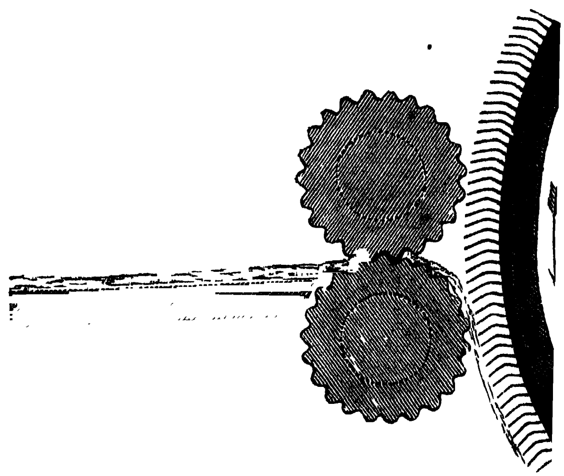


Fig. 117 (half size).

A new light was thrown upon this subject about thirty-three years ago by a simple invention, patented by Mr. Joseph Bennett, a spinner in Glossop, which will be seen in *Fig.* 118, represented in the next page.

By means of a dished plate one roller is dispensed with, and the bite of the licker-in can come as close as may be desired to the nip of the feed roller. An ordinary fluted feed roller is very often used (*Fig.* 118) in connection with this shell, which is not good, because if set too close the cotton is apt to get wedged betwixt the rigid iron plate and the cards on the taker-in, when it gets forced into the wire of the latter, so that the main cylinder does not clear it well, and, after working some

FIG. 1.

Licker In. Angle Wire set in leather Backs. No 14/17.

FIG. 3.

FIG. 2.

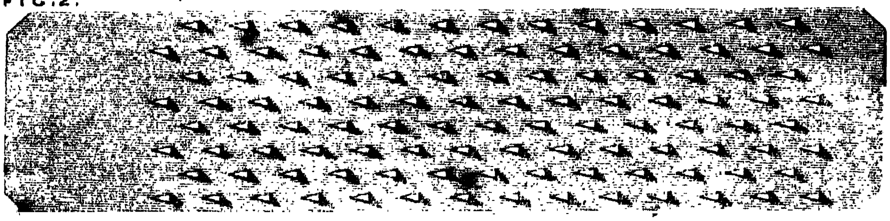


FIG. 15. FIG. 13.

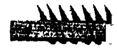


FIG. 14.

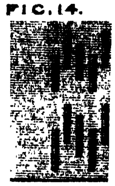


FIG. 4.

Licker In. Angle Wire set in leather Backs. No 16/19

FIG. 6.

FIG. 16.

FIG. 5.

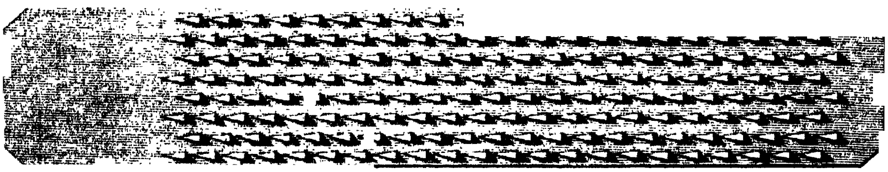


FIG. 17.

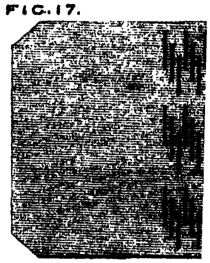
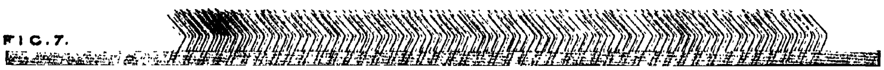


FIG. 7.



In. Angle Wire set in Leather Backs No 55. 22/26.

FIG. 9.

FIG. 8.

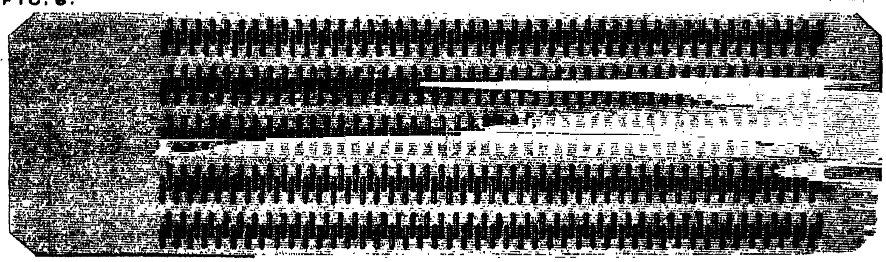


FIG. 19.

FIG. 20.

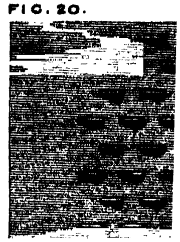


FIG. 10.

FIG. 3. Licker In. Needle Points set in leather Backs. No 18.

FIG. 12.

FIG. 11.

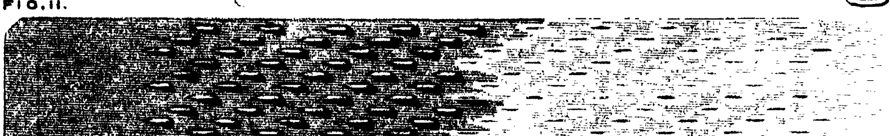


FIG. 21.

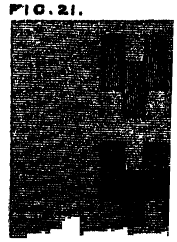


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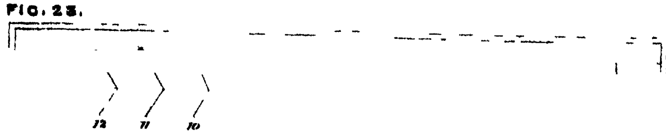
FIG. 23.



SCALE FOR BEND OR KEAN.

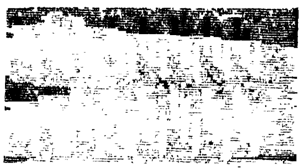
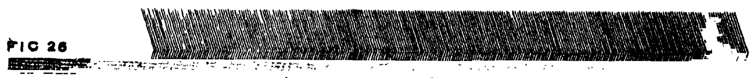


FIG. 24

FIG. 26



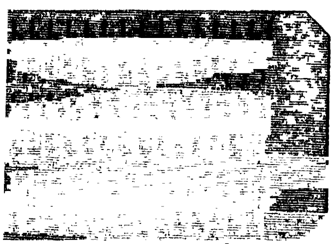
er Bucks Nº 50

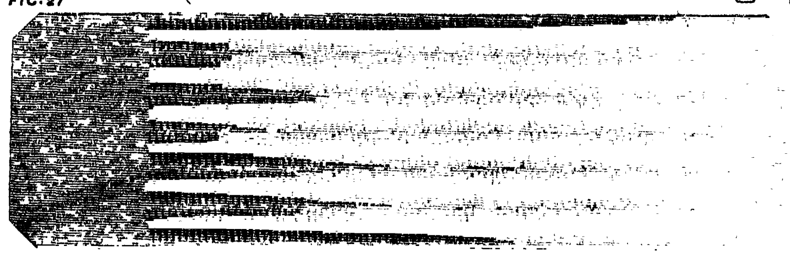
FIG 19.

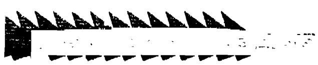
Natural India Rubber Nº 92^s 12^c–110^s 10^c

FIG. 28.

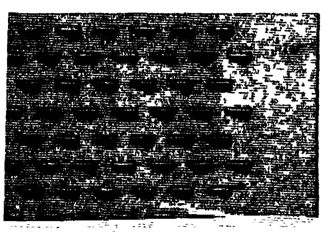
FIG. 27







ude, 30 Teeth to 4 inches



Pointed

FIG 30

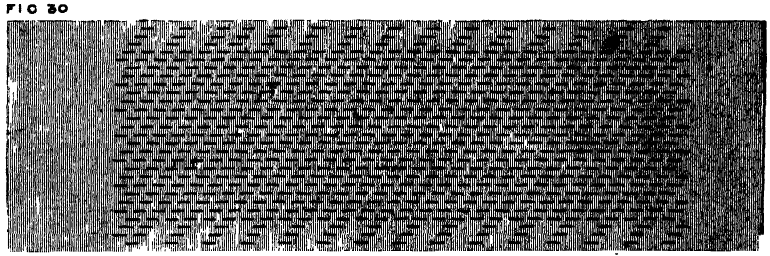
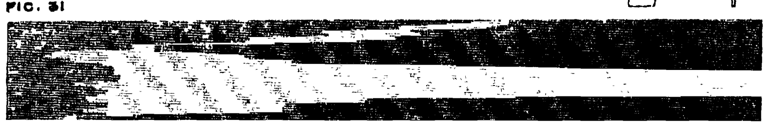
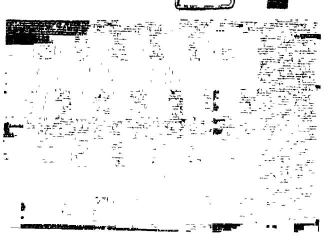


FIG. 32.

FIG. 22

FIG. 31





FOR CARDING ENGINES.

FULL SIZE.

FIG: 1.

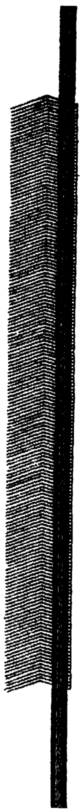


FIG: 2.

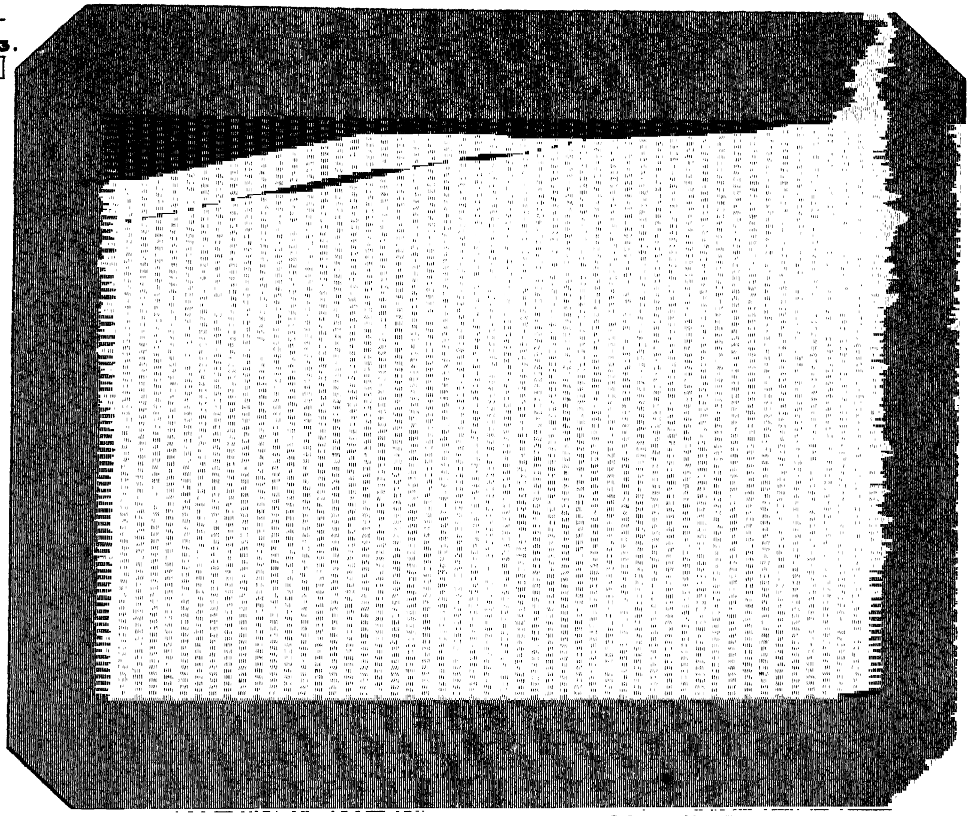


FIG: 3.

Woolen with Cotton Cloth Backs. Sheets No. 90 10 Crown.

FIG: 4.

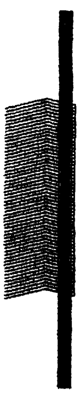


FIG: 5.

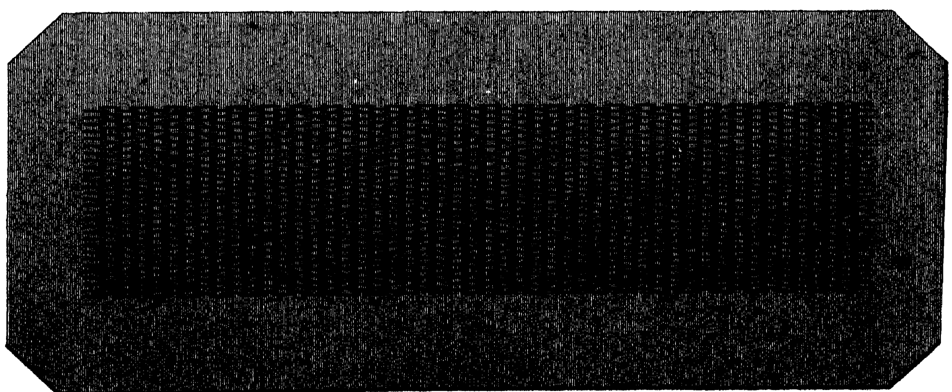


FIG: 6.

with Cotton Cloth Backs for Tops No. 90 10 Crown.

time, it gets choked to an extent which causes nepping. The choking of cards is, above all things, to be avoided; for no engine can work well if either the cylinder or licker-in carries too much cotton. In consequence of this fault many spinners have abandoned the shell feeder altogether after trying it only with a fluted roller, which they certainly would not have done had they tried it with a card covered roller of suitable bend and form of wire, or with a Calvert roller, because in either of these the cotton can be drawn gradually from between the teeth of the roller, whereby the lumps are separated instead of being pushed in all at once, and held with a firm grip up to the point of the shell, as is the case with the fluted feed roller.

An improvement has been made upon this kind of feed by Mr. John Tatham, of Rochdale, which is simple, and appears to be in the right direction. It consists in placing the shell on the top side of the feed roller instead of under it, thus, *Fig.* 119.

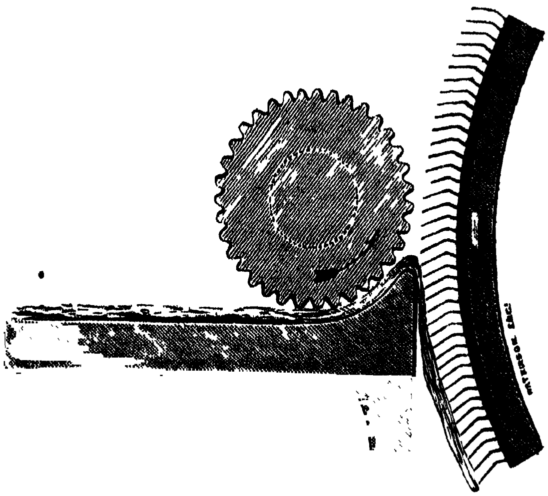


Fig 118.—Bennett's Feed Roller (half size).

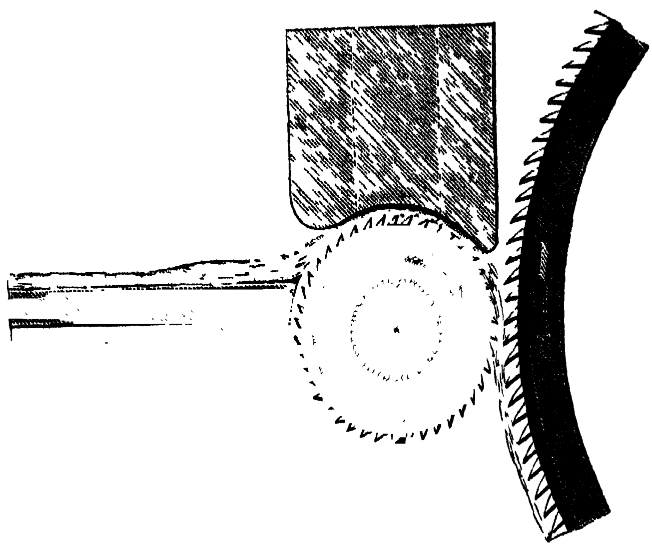


Fig 119.—Tatham's Improved Feed Roller

The dished plate or shell is narrowed at the ends to fit into the roller pedestals on which it rests, so that the hollow part just clears the wire fillet when no cotton is going through, acting as a weight to the roller. If the feed comes under too thick it can raise the dish a little vertically, when the cotton gets pressed down into the wire of the feed roller, and no snatching can take place, as there is a degree of elasticity where the licker-in takes hold of it, which is beneficial; the bend of the wire on the roller being in the direction of the motion, the licker-in keeps the roller clear from lapping. Both licker-in and feed roller are shown with the Calvert tooth, which is not indispensable, as they will work to the same advantage with other kinds of clothing.

CLOTHING OF THE LICKER-IN.

After passing through the feed rollers, cotton first comes in contact with carding wire at the licker-in. It is then in a tangled and matted state, which naturally suggests a coarse, open wire on the first cylinder, just as a coarse comb would be taken first to open matted hair. It often happens also that bits of wood or other hard substances are found in the cotton which have escaped the scutcher, especially with the lower qualities; these impurities would spoil ordinary cards, therefore it is a matter of necessity to have a very coarse card on the licker-in, or a substitute for such. An excellent substitute for licker-in cards was invented by Mr. Calvert, an American, about 20 years ago, which consisted in chasing a groove about $\frac{1}{16}$in. deep and $\frac{1}{4}$in. or less apart, into which was wound and staked edgeways a narrow ribbon of steel serrated on the edge like a saw. This worked very well and kept clear, but had the disadvantage of being costly and difficult to repair. By a subsequent invention the steel ribbon was made in the form illustrated, with the top edge serrated (see *Figs.* 120 and 121), and

Fig. 120.

was held on by flattened wire wrapped between the points, as in *Figs.* 122, 123, 124.

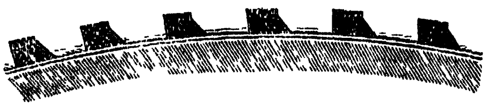


Fig. 121.

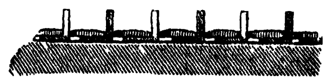


Fig. 122.

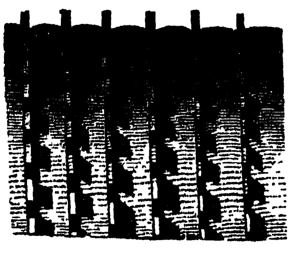


Fig. 123

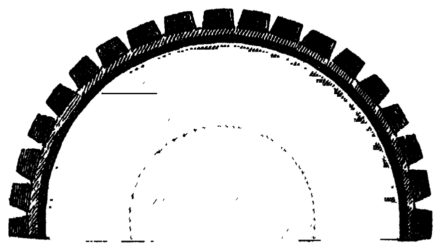


Fig. 124.

This plan has now given way to flattened wire of short cut, set as in *Figs.* 19, 20, 21 (Plate XXII.), which answers very well; or to short needle-pointed steel wire, as in *Figs.* 13, 14, 16, 17 (Plate XXII.), which also works remarkably well. In reference to the latter, Mr. Daniel Foxwell states "that he has made thousands of "them, and claims for them the following advantages, viz.:—1st, they never carry "any cotton or make waste, but are always clean; 2nd, they never want grinding; "3rd, they possess great durability, he never having known one to wear out. But "they cannot be used without a grid or under cover."

A similar kind of licker-in clothing is made of angle wire as in *Figs.* 1 and 2, 4 and 5 (Plate XXII.), which show two kinds, one being coarse and the other fine. It will be noticed that these have no keen or knee bend, being merely set in strong leather at an angle as shown. This kind of licker-in can hardly be affected by any bit of wood coming in with the cotton, as it would saw it to pieces; indeed they are almost proof against anything that is likely to appear in the cotton. *Figs.* 7 and 8, in same plate, is a finer angle wire card, with a longer tooth, bent to an angle or keen which is intended to give it elasticity. *Figs.* 10, 11 is a sample of needle-pointed wire of long cut with considerable knee bend, and *Figs.* 16, 17 is one of plain wire, which is ground up and sharpened in the regular way.

CLOTHING OF ROLLERS.

Fillets about one inch wide are generally used for rollers. Wire as fine as the doffer fillet, having a shorter cut and more keen, would be best for this purpose, but in consequence of the rollers having to be taken out frequently for stripping the cylinders, and for being ground and brushed out themselves, they are carried about the room, knocked about with rough usage, &c., therefore it becomes necessary to clothe them with coarser wire to stand such treatment, otherwise the ends would be crushed down after a few weeks wear. For covering rollers of about six inches diameter a suitable keen is No. 6, *Fig.* 23, Plate XXII.

CLOTHING CLEARERS.

Some spinners like to clothe their clearers with fine wire of a long cut and very little keen, to act, as they say, like a brush. About as much reason can be shown for this as for the clearers going at a surface speed of 400 feet per minute, which is none at all. The brush theory is altogether a mistake, for the clearer is not set into the roller to brush it out, but only near to it to take the cotton off, and put it on the cylinder again; therefore straggling wires, standing in an almost vertical position, are very ill adapted for that purpose, being more calculated to produce neps. It is recommended that clearers be covered with the same fillet as the rollers, and that whatever numbers of card be selected up to 100's, the cut should not exceed $\frac{7}{8}$, and if finer cards than 100's be put on, let the cut be only $\frac{13}{16}$.

It is frequently thought that by having a long cut card it will last longer, as there will be more wire to grind away before it is done. What appears to be, in this case, far-sighted policy, is really the reverse, for roller and clearer cards rarely, if ever, wear out, before they are rendered useless from the wire getting knocked down and abused.

If they could only be kept in their places, and cleaned by some gentle process without removing, much finer wire might be used than is now practicable, with a correspondingly beneficial result.

CLOTHING OF CYLINDERS.

In the olden time, when cards were set by hand in leather foundation, it was found most convenient to have main cylinders clothed with sheets four inches wide of wire, and about five inches wide altogether, leaving a margin of about half an inch of leather for the tacks on each side, besides a small welt on one margin, to take hold of by the stretching pliers, which was afterwards cut off. This width of sheet became so fixed that cards were counted by the number of teeth in four inches. Now that cards are made by machinery, the wire can be set in cloth and indiarubber, which are excellent substitutes for leather, being both better and cheaper; better, because india-rubber cloth, when properly made, is more uniform in texture, possesses greater elasticity, is free from soft places, blistering, or piecings.

Such being the case, indiarubber cloth fillet, about two inches wide, is now much used in place of sheet cards, whether of leather, plain cloth, or indiarubber-coated cloth. Some spinners prefer to have their main cylinder fillets spaced at intervals of four inches, whilst others prefer it without spaces at all, which is thought on the whole the better plan. When a cylinder is covered with spaced fillet, but more especially with sheets, a much greater current of air is created; the interstices causing the cylinder to act to that extent like a fan, blowing out dust, fluke, and fibres of cotton, which find their way out wherever there is the slightest aperture. Notwithstanding this, and the loss of about one-tenth of the cylinder carding surface by the spaces, as well as other disadvantages, many spinners are still to be found who have a deep-rooted prejudice in favour of sheets, alleging that they can be stripped out rather better, which is no doubt the case when cylinders are stripped out by hand card, but this is a very pernicious practice, as it damages the cards, and ought to be abandoned in favour of the circular brush with comb.

When fillets are put on it is better to tack them only at the ends, as the slack caused by stretching (which will take place by the time they have worked a month or two) will run all to one end, where it may be easily tightened, after which it will run for years, generally till the card is worn out, without giving further trouble, if the fillet be a good one to commence with. If tacking otherwise than at the end is preferred, it should not be done until the card has worked a month or two, otherwise the slack runs up to the tack. The numbers of cards suitable for clothing main cylinders are No. 90, for general purposes; No. 80, for coarse yarns; and No. 100, for fine long stapled cottons.

The bend or "keening" of the wire should vary according to the diameter of the cylinder, thus:—For a cylinder of 36 to 40 inches diameter a suitable bend is 7 (*vide Fig.* 23, Plate XXII.); for a cylinder 42 to 50 inches diameter 6 guage. The proper length of cut is for

No.	80	90	100
	$1\frac{1}{16}$in.	1in.	$\frac{15}{16}$in.

DOFFER CLOTHING.

Doffer fillets should always be at least 20 points finer than the main cylinder cards, thus—

If cylinders be	No.	80	90	100
Doffers ought to be	No.	100	110	120
Width of crown	inches	0·145	0·125	0·125
Bend or "keen"		7	6	5
Length of cut		$\frac{16}{16}$	$\frac{7}{8}$	$\frac{13}{16}$

The "keen" above named is calculated for a doffer of 18in. to 20in. diameter. If the doffer be only 16in. or less in diameter, the fillet should have a point more "keen," and if the doffer be 20in. to 24in. diameter, a point less. Some spinners prefer to make a greater difference than 20 points in fineness of card between the doffer and cylinder, which is sound in theory, because when the cotton reaches the doffer it has been thoroughly combed out and the fibres lie in fine parallel lines; therefore the more points there are in the doffer to take them off the better. When very fine doffer fillets are used, care must be taken to have them made of a correspondingly short cut and fine wire, also that the foundation (of whatever material made) be a suitable thickness, neither too hard nor too soft. *Fig.* 24 shows the back of a twilled doffer fillet, and *Fig.* 27 shows the back of a ribbed fillet, the side elevation of which is shown in *Fig* 26.

DIRT ROLLER FILLET.

Fig. 29 shows side elevation of a dirt roller fillet. *Fig.* 30 the face, and *Fig.* 31 the back of same. It will be noticed that this is an open set card having considerable keen or knee bend.

Attention is called to *Fig.* 23 on this Plate, which shows a scale of the bend or keen given to cards for different purposes. It ranges from 1, which is very slight, to 12 which is very acute.

Figs. 3, 6, 15, and 22 show the teeth from each sample of card having no knee bend, and *Figs.* 9, 12, 18, 25, 28, and 32 show the different bends from each sample; also the width of crown and length of tooth.

CLOTHING OF FLATS.

Top cards are now generally made from 1in. to 1¼in. wide; formerly, in the days of hand stripping, they were made from 1½in. to 2in. wide, set in the twilled fashion. In counts they vary from 60's to 100's, some spinners preferring them finer than others, or coarse set flats over the licker-in, and finer ones afterwards. Some like diagonally-spaced tops and others plain, as in *Figs*. 4 and 5 (Plate XXIII.) It is considered a good plan to have about every fifth top card clothed with wire of keener bend and opener set, similar to the dirt roller card (*Figs*. 29, 30, 31) on Plate XXII. In nailing on the cards great care should be taken to put them in a straight line both nose and heel of wire, and stretch them uniformly.

FANCY ROLLER.

For heavy carding a fancy roller, which is a roller that overruns the periphery of the cylinder, is sometimes used with advantage. Its object is to prevent the cylinder from choking, and thereby rolling and nepping the cotton. No engine can possibly card well unless the main cylinder is kept clear, therefore the fancy roller, by running about one-sixth faster on its periphery than the cylinder, lifts the cotton that would otherwise get wedged in the wire of the cylinder, and thereby admits of heavy carding. It may be applied to any part of the cylinder which is most convenient, but is generally put under or immediately over the licker-in; the former is its most natural, but the latter the most convenient position for setting. The *value* of a fancy roller depends upon circumstances. In situations where there is little room for the amount of carding required, and where quality is not so much an object, there is no doubt of its utility, when properly applied and carefully attended to; but under other conditions its expediency may fairly be doubted. Those spinners who put 30 per cent more cotton through their cards by the use of the fancy roller, would do well to remember that it is a kind of cheap carding which is not *all* gain, as it requires power in driving, great care in oiling and setting, adds to wear and tear, and the quality of the work from heavy carding can never be relied upon; besides the subsequent operations cost more, and the value of the yarn is less, therefore old and experienced spinners are seldom found hurrying cotton through their cards, as they find it more profitable, on the whole, to put down a few more engines, and card light. To those who card waste and spin shoddy the fancy roller is perhaps the most useful.

The action of the fancy roller appears on the whole beneficial *only* where very heavy carding is demanded, and where the engines cannot be depended upon to stand true; but from the fact that the surface of the "fancy" runs in the same direction as the cylinder, only a little faster, it has to overtake and run past it, which is a very different kind of stripping to that effected by slow motions when the surfaces move in opposite directions. With the "fancy roller" it is necessary to strip out the cylinder occasionally by hand, when much cotton is often found wedged in the wire, which is detrimental to its proper action. This is especially the case where the fancy is not properly set and carefully attended to.

There is comfort and safety in light carding; but when cotton is pushed through the cards at an undue speed, the least negligence on the part of a carder or his assistants, the smallest variation in the quality of the cotton, a change from dry to wet weather, and a number of other small matters, are productive of irregularities in a mill, and consequent loss, which more than counterbalances the apparent saving in hurrying cotton through the carding engines.

It has often been noticed by respectable and shrewd spinners, that "fast spinners," like "fast men," soonest run their course, and finish their work by coming to grief. There is such a thing as an abuse of machinery, as well as an abuse of Nature's laws; and the haste to get rich by immoderate speeds is often punished in the same manner as intemperate habits or cruelty to animals. The fact is that God's blessings are showered abundantly upon all those of His creatures who have the wisdom to use and not abuse them, who conform to Nature's laws, and so comport themselves that they sail pleasantly down the stream of Time, in harmony with all creation. But let a man start up in opposition to known principles, and he soon gets entangled in the meshes of the net he weaves about himself.

It has before been observed that where a fancy roller is used great care should be observed—first, that it is balanced to a nicety; secondly, that it should be so driven that its periphery runs, *with certainty*, a little faster than that of the cylinder (say about one-sixth); thirdly, that it should be clothed with wire having nearly a straight tooth; fourthly, that it should be set close to the cylinder, without touching, otherwise the cotton is driven down into the wire of the latter and gets wedged in.

Various expedients have been resorted to for accomplishing the desirable object of stripping the cylinder without stopping the card, not only to save labour; but every practical spinner knows well that whenever the cylinder begins to choke the carding becomes inferior and neppy. The late Mr. Bodmer, of Manchester, devised a very ingenious method of doing this, namely, by a plain iron roller having a slot in it nearly the whole length; beneath this slot, inside the roller, was a screw having a right and left hand thread chased upon it. This thread carried a nut to and fro. A finger, in which a few wire bristles were inserted, worked in this slot, and the screw was driven by spur wheels carried round with the roller or fancy, and acted upon by suitable mechanism, the whole being accurately balanced. This, like many of Mr. Bodmer's other schemes, was more ingenious than useful, being too tickle and complicated to be practical, and it was therefore short lived. The principle of stripping a small portion of the cylinder at once was sound, hence it is mentioned.

Mr. Rivett, of Prestolee, near Bolton, patented a plan of stripping the card cylinder by power, which appears to have considerable novelty and merit. This is accomplished by a knocking off motion which stops the card at any certain interval, turns the cylinder slowly backward, brings up a circular brush (with which every card is provided) under the engine, takes off the strips with a comb, and sets the engine on again. The only drawback to this is the necessary complication and expense added to the card in order to effect this desirable object, otherwise the work is efficiently done.

Another way of stripping cylinders in motion has recently been introduced by Messrs. John Elce and Co., machinists, of Manchester, which is simply to have a metallic licker-in (similar to Calvert's) which is run constantly over the speed of the cylinder on its periphery. A card roller or clearer is placed over it which strips it, and conveys the cotton to the main cylinder again. This is said to work well by several spinners who have tried it, and is very simple. It is thought that in this plan a difficulty may occur when the licker-in gets worn blunt and dull, as it cannot easily be sharpened.

The Gamble card, which was introduced into this country from America a few years ago, effected the stripping of the cylinder by having three takers-in, all set up to the cylinder, the third one being run alternately quicker and slower than the latter on its periphery. Although adopted to some extent, its working has not been altogether satisfactory.

Another way of stripping the cylinder is to have a fancy roller run fast and slow alternately, by simply putting the strap on and off the fast pulley at intervals.

All the preceding methods of stripping the cylinder while in motion have objections, and it is not thought that the precise way of doing it in a sufficiently simple, practical, and masterly manner has yet been discovered. What appears to be clearly indicated is to have something to *pick out*, or raise up at intervals, *a little at a time*, the cotton which gets wedged in the wire, without disturbing the general arrangements of the carding engine.

CYLINDERS.

It is curious to find that some spinners, men whose experience has been great, and whose judgment is generally considered sound, have still a prejudice in favour of *wood*, and most decidedly object to iron cylinders. When closely questioned about their objection, it is found that some have never even tried what they object to, and others have had those they have tried so badly made—being heavy, clumsy, and out of balance—that they have become disgusted with a good principle through bad workmanship.

Machinists cannot be too careful in balancing their cylinders, doffers, and lickers-in accurately—*most accurately*. This however is very often much neglected, and generally imperfectly done; the consequence is that the journals wear oval, and the shaking and tremor, which were bad from the first, get worse every day, until the spinner loses his patience, and sometimes throws them out in disgust, exclaiming that there is nothing like *wood*, as the cobbler said there was nothing like leather.

If judiciously constructed, iron cylinders need not exceed in weight those made with iron rings and baywood lags. The doffers, which are often considered perfect when true outside, also the lickers-in, should likewise be of iron, and as carefully balanced as the cylinders, else when they are run quick for grinding they jump and shake the whole card, rendering it impossible to grind them with perfect truth.

Rough and careless machine makers should never have anything to do with a carding engine. It is they who are to blame for getting many an excellent principle condemned by the honest and industrious spinner, who judges by results, and is not expected to have a profound knowledge of mechanics, or of the laws of gravitation and centrifugal force.

The necks or journals of carding engines should be of cast iron, and work in cast iron bearings, *well polished out*, with the sharp edges rounded off.

This rounding of the edges, singular as it may seem, prevents the oil from running off, especially if the journals be a little reduced at the ends. Cast iron is of a porous nature, and absorbs oil equally over the whole journal. This constant absorption has the property, after working some time, of glazing or casehardening the surface, which attains a high polish, runs light, requiring little oil, and becomes, the longer it works, more and more indestructible.

Great care should, however, be taken when they commence running to oil them well, otherwise, should they be bound in the steps, heat, and get dry, they will cut down rapidly; indeed any other metal journal will do the same. What is wished to be impressed upon the reader is that cast iron, as a journal, when properly treated, is superior to either wrought iron or steel, which is always softer on one side than the other (unless it be cast steel), and is apt to wear oval. Wrought iron contains a great deal of sand. If steel be used for a journal of any kind it ought to be cast steel.

WOOD CYLINDERS.

There are three methods of constructing what are termed wood cylinders; but, more properly speaking, wood and iron combined.

The first is with iron rings, to which are bolted dry deal lags, the rings being of course keyed upon the shaft. The next is precisely similar except that baywood lags are used (see *Fig.* 85). The other method is to build up the cylinder with baywood segments, the arms being made of wrought iron, and fixed in the segments as the work progresses. These segments are both glued and nailed together; and when completed form a very light cylinder, which stands, on the whole, if carefully made, pretty well, but cannot be entirely depended upon. Of the three it is thought those with the deal lags stand the best, and are, taken altogether, preferable to either of the others; but wood cylinders, however made, may now fairly be looked upon as things of the past. No one using wood cylinders, especially on a ground floor, can possibly have that *extreme* accuracy which is now imperatively demanded in modern carding.

SHEET IRON CYLINDERS.

Another ingenious method of making cylinders and doffers, the invention of Mr. Samuel Faulkner, cotton spinner, Manchester, is to key three or four iron rings on a cylinder shaft, turn them up, and cover them with sheet iron the breadth of the cylinder, which, after being painted, is covered with old card fillet cemented on or with a thin strap leather. This when set is ground up by applying an ordinary emery roller, when it is ready to be covered with card fillet, that may be spaced or full for the cylinders, and fastened at the ends by pegs in the rings, which makes a very light, true, and good cylinder when accurately balanced. Mr. Faulkner's invention possesses considerable merit, and deserves to be more appreciated by the trade than it has been.

HOW TO ENSURE GOOD CARDING.

Truth, which in a moral sense, may appropriately be termed the "life buoy" of commerce, as it supports a man in a most wonderful manner amidst the stormy billows and troubled waters which so often occur in the ocean of life, proving fatal to many a stately vessel;—Truth, that magic virtue, morally so potent and beautiful, is physically of the utmost importance in the carding engine. Everything must be true, well balanced, and steady, or it is vain to expect good carding. This secured, and the cards put on very tight, the next point demanding attention is careful—*very careful*—grinding. The method of grinding cards (cylinders, doffers, and lickers-in especially are meant) as at present in vogue, is erroneous in principle, as will be shown. Any body or object that moves rapidly has a tendency to damage the matter with which it comes in contact, although it may be itself of a softer nature than such matter; for instance, a soft tallow candle, shot from a gun, will go through an inch thick board, a lead bullet through an iron plate, &c. If two objects of equal strength and weight (two carriages for instance) come in contact when going in opposite directions, the one that was going slowest at the time will receive the most damage; therefore the surface of a grinding roller should go through more space than the cards operated upon,—but as practised now the reverse is the case. So the soft flexible wire of cylinders in rapid motion has an immediate tendency to blunt the cutting edge of the emery roller, receiving very little impression itself, thereby rendering it necessary to lay on harder with the grinding roller, which presses down and hooks the wire. Now, if one had microscopic eyes, he could perceive a certain wavy surface and hook on the wire, produced by the violence of such grinding, and the jumping vibration caused too often by an unbalanced doffer put in rapid motion. Theoretically the grinding roller should run very quickly, after being balanced to a hair, and the card surfaces slow—very slow—but this is not practical under present arrangements. The good offices of the inventor are here required, and anyone who would contrive a method of taking a motion from the loose pulley, when the strap is on it, that would turn the cylinder, doffer, and licker-in slowly round, and at the same time drive the grinding rollers rapidly, would perform a good and desirable service to the trade.

Assuming the cylinder, doffer, &c., to be carefully ground with the emery roller, the next thing is to apply a stiff circular brush in the place of each emery roller, and run it at a rapid speed, the wire still going very slowly. Those brushes should be set into the cards about one-sixteenth of an inch, and if run sufficiently fast whilst the wire is going slowly, will soon have a wonderful effect in polishing up the wire, and bringing the edge to a needle point, which is not so easily lost again.

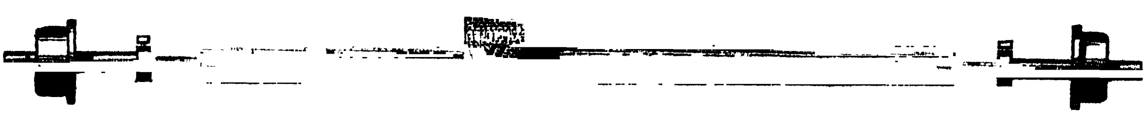
After this, set the card surfaces as close as possible for work; never mind if here and there they touch the cylinder a little, the effect will only be to rub off any possible inequality of surface, that will soon come right again by the application of the circular brush. Insist above all things in pushing up the surfaces, when little waste will be made, and the best quality of work obtained. Should there be the least tremor or vibration about the cards, arising from the causes above named, get rid of it immediately, as it is vain to think of obtaining first-rate work unless such defects are removed. Carding is a delicate process. If anything gives way or gets out of truth, such as the swelling of wood cylinders in wet weather, and if the cards are set close as they ought to be, off goes the edge of the wire, the cotton gathers round the cylinder, and neps innumerable appear. Practically it is not possible to set engines with wood cylinders so close as iron ones, simply because they cannot be depended upon. It is also not possible to set engines which are out of balance as close as they ought to be, because of the vibration. Spinners who prefer wood cylinders have been heard to say, when reminded of their unstable nature, "Well, if they do fly out of truth, it is seldom they go more than the sixteenth of an inch!" They have been known however to err more than that after standing on a ground floor from Saturday till Monday, when the weather has changed from fair to rain; but suppose a sixteenth, or half a sixteenth, what is the result? A fortune may be won or lost in a few years by attention to or neglect of *that particular point* in the carding engine. Even the one-hundredth of an inch cannot be allowed between the doffer and the cylinder, nor between the cylinder and the other carding points.

When this matter is carefully attended to the best results may be expected. Let the card setter keep setting up the doffer to the cylinder at suitable intervals in minute degrees, and at the same time bring down the flats or rollers to the cylinder until they *almost* rub; by this means the cylinder will *feel*, as it were, any irregularities or imperfections in the rollers, flats, licker-in, or doffer, and rub them off like a grindstone, without injury to itself, on account of the great speed of its surface. Of course this can only be done where the engines are constructed entirely of iron, and great care is employed.

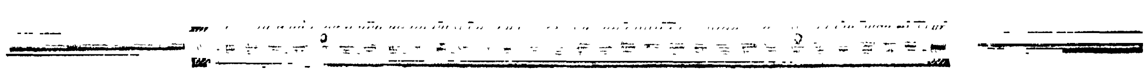
GRINDING.

The present plan of grinding cards is quite unmechanical, and it is somewhat singular that so great an error should have escaped notice so long. Yet so it is, notwithstanding that this is a subject of *the very utmost importance*, both as regards the expense it entails and the general welfare of a spinning concern. The reader is referred back to page 70, where it is shown why the object acted upon should turn slowly and the grinding roller quickly. Although it is easy to demonstrate this, the remedy is more difficult, and it must be confessed that at present the way to overcome this important evil is not easily seen, but by directing attention to it the talent of the country may perchance be brought to bear upon it, and the difficulties will disappear; if the theory now advanced is founded upon truth, a new system of grinding cards will be inaugurated.

At present a grinding roller, of about 8in. or 9in. diameter, covered with coarse emery, is mounted over the cylinder or doffer, and is made to revolve *slowly*, at the same time traversing a little endwise by suitable mechanism. Another contrivance, and much superior to the former, is a small drum or pulley, which is made to traverse to and fro across the cylinder or doffer, with a double threaded screw placed inside the hollow shaft on which it moves, as below (*Fig.* 125).



d 1 Fig. 125. *d*



126.

Referring to the above, *Fig.* 125 shows a Horsfall grinding roller complete; *Fig.* 126 is part section of the hollow shaft, showing the double-threaded screw which is attached to one end of the shaft, whilst the hollow part is fixed to the other. The pulley *a* slides freely to and fro on the hollow shaft, and makes the same number of revolutions, being driven by the pulley *d* to the right, whilst the screw is driven in the same direction by the pulley d^1 to the left. As one of these pulleys is a little larger than the other, a traversing motion is given to the roller *a* by the finger *b*, seen in *Figs.* 127 and 128. This finger passes through the slot in the hollow shaft, and

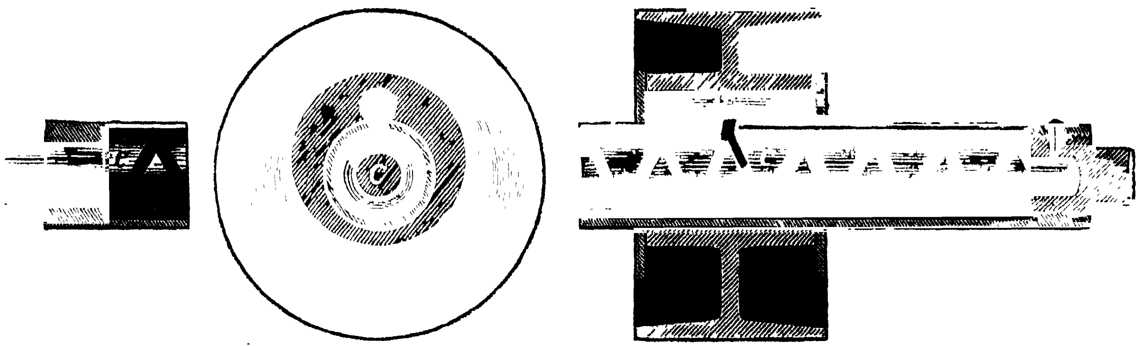


Fig. 127. Fig 128.—Horsfall's Patent Grinding Roller. Fig. 127.

works in the thread of the double screw *c*. When it gets to the end it takes into the other thread, and thus gives reciprocating motion. Care should be taken in the working of the roller that the difference in speed between the pulleys *d* and d^1 is not great, otherwise the traverse of the grinding drum *a* would be too rapid, and the shock in reversing too great, which would soon destroy the finger *b*. A little space is left inside the pulley or drum *a* to allow sufficient play to the finger in making the change from one thread to the other, during which time the grinding drum dwells, and allows the finger to get a fair hold of the thread before it moves the drum forward again. The maximum speed of the traverse across the cylinder of the drum *a* should not exceed once over and back again per minute; therefore the difference between the two driving pulleys should be regulated accordingly, bearing in mind that the faster the roller goes, the less difference in diameter between the pulleys is required. This is far better in principle than an ordinary grinding roller: it ensures the cylinder being ground true, as it passes off the ends of the cylinder every time it moves to and fro. Of course it is a longer time in grinding any object, on account of the small surface of emery acting at once.

Hand strickles are also extensively used, both made with curved and straight wood covered with emery, and they are likewise made from cloth. These latter are ready for touching up the cylinders and doffers very frequently, and are in almost general use. Much mischief is produced by these strickles in grinding the cylinders, etc., hollow, loosening the wire, and hooking it. It would be better to discard them altogether, and to adopt some plan whereby a brush moving rapidly could be made to act upon the almost stationary wire. Indeed the whole system of grinding cards at present is erroneous.

Perhaps the best way of inaugurating a new system of grinding cylinders and doffers would be to run a light shaft between two rows of engines, so placed that the engine straps would just be the proper length when taken off the card, about to be ground, and put upon the shaft. This shaft need revolve only about twenty revolutions per minute, and might be put in motion when required. A grinding strap should then be put upon the drum which gives motion to the engine, and drive the grinding roller from it. In this manner, without any complication, and at a small expense, the cylinders and doffers may be turned very slowly, and the grinding rollers very quickly, which is just what is wanted. Where there are not two rows of engines the slow shaft would be required the same for one row. It is believed that if the expense of this alteration were ten times as much as it only need be, it would pay the spinner to introduce it.

In cases where engines are connected together, as in the example previously shown (*Page* 126), the shaft which drives the doffers would suffice to turn the cylinders when grinding, by having a strap of the proper length for the purpose; this would serve for all the cards, by being moved from one engine to another as required.

A more efficient method of pointing cards is much wanted. The ordinary emery roller is both clumsy and ineffective, being difficult to keep true, and grinding the wire to a chisel edge. Several attempts have been made to supersede it, but hitherto apparently without practical result.

For grinding the rollers and clearers of carding engines a machine similar to *Fig.* 129 opposite has for a long time been used with a cylinder covered with emery. This cylinder had a traverse motion endwise, and the rollers intended to be ground were set up to it. If this cylinder was covered carelessly, or by any means got out of truth (which was often the case), the rollers were not ground correctly, as a matter of course. An improvement worthy of notice has been made in this machine, by putting a Horsfall traversing grinder in the place of the cylinder, which is a great improvement. If the emery drum is made to traverse *over the ends* of the carding rollers it is sure to grind them perfectly true, even if it be out of truth itself. *Fig.* 129 represents a grinding machine arranged in this manner with a Horsfall roller in place of the cylinder.

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