Induction Coils. *Contents.*—Constructing a Shocking Coil. Regulator Medical Induction Coils. How to Make a 6-in. Spark Coil. Mercury and Electrolytic Interrupters. Tesla High-Frequency Coil. Repair of Induction Coils. Simple Commutators. Index.

Knotting and Splicing Ropes and Cordage. *Contents.*—Introduction: Rope Formation. Simple and Useful Knots. Eye Knots, Hitches, and Bends. Ring Knots and Rope Shortenings. Ties and Lashings, etc. 208 Illustrations.

Magneto Repair and Adjustment. *Contents.*—The Principle of the High-Tension Magneto. The "Inductor" Magneto. Dismantling. Adjustment and Repair. Fitting and Timing. Flywheel Magnetos. Ford Magneto-Dynamo. Typical Magnetos. Magneto Construction. Index. Fully Illustrated.

Miniature Electric Light. Chapters include: Lamps and Fittings, the Coupling-up of Cells and Lamps. Erecting Miniature Lighting Systems. Lighting a Room from Accumulators, Making Pushes and Switches, Accumulators—Making, Charging and Managing, etc. etc.

Model Aeroplanes. *Contents.*—Why an Aeroplane Flies. Types of Model Aeroplanes. Fuselages. Carving Air-Screws. Bending Air-Screws. Planes. Simple Twin-Screw Monoplane. Simple Twin-Screw Biplane. Winders for Elastic Motors. Collapsible Monoplanes. Tractor Monoplane. Hydro-monoplane. Compressed Air Engine for Model Aeroplane. Biplane Driven by Compressed Air Engine. General Notes on Model Designing. Tail-less Kites. Building Model Airship. Index.

Motor-Car Overhaul and Adjustment: Fully Illustrated. Contents include: Introduction. How the Petrol Engine Works. The Engine: Preliminary Tests, Dismantling and Decarbonising the Engine, Fitting, Adjusting, and Re-metalling Bearings, Engine Piston, Cylinders and Valves, Assembling the Engine, Overhauling the Carburettor, Overhauling the Magneto, Timing the Valves and Ignition, Overhauling the Transmission, the Radiator, Water Jackets and Tanks, The Rear Axle, Brakes and Springs, The Front Axle and Steering Mechanism, Overhauling the Electric Heating and Starting System, Tyres, Painting and Varnishing.

Motor Cycles and Side Cars: Construction, Management and Repairs. *Contents.*—Choice of Machine. Two-Stroke and Four-Stroke Engines. Carburation. Ignition. Transmission and Gears. Locating Faults Overhaul. Tyres. Driving. Index.

Mounting and Framing Pictures. *Contents.*—Making Picture Frames. Notes on Art Frames. Picture Frame Cramps. Making Oxford Frames. Gilding Picture Frames. Methods of Mounting Pictures. Making Photograph Frames. Frames covered with Plush and Cork. Hanging and Packing Pictures. 240 Illustrations.

Oxy-Acetylene Welding. Contents include: The Oxy-Acetylene Flame. The Oxy-Acetylene Blowpipe Described. Acetylene Generation. Purification. Valves, Gauges and Regulators. High-pressure System of Oxy-Acetylene Welding. Welding Sheet Iron, Wrought Iron and Mild Steel Plates. Welding Iron and Steel Castings. Index, etc.

Patents, Designs and Trademarks. By A. Milward Flack, F.C.P.A. A Concise Guide to the Patenting of Inventions, and the Registration of Designs and Trademarks.

Photography Simplified. Contents include: Lenses, the Dark Room and its Fittings, Developing the Negative, Improving Faulty Negatives, Toning Bromide and Gaslight Prints, Landscape Photography, Retouching Portrait Negatives, Lantern Slides, Printing-in Clouds, etc. etc.

Pianos: Their Construction, Tuning, and Repair. *Contents.*—Piano Construction. The Action. The Purchase and Choice of a Piano. Care. Maintenance and Cleaning. Tuning. Repairers' Tools. Repairing Piano Actions. Restringing and other Repairs. Polishing and Renovating Piano Cases and Keyboards. Index.

Poultry Houses and Appliances.—Chapters include: The Building of Poultry Houses, Nesting Boxes and Trap Nests, Coops, some Special Pens, Scratching Sheds, etc., Intensive System Poultry Houses described in detail; Cold Chicken Rearers, etc.

Practical Leather Work: Fully Illustrated. Contents include: Leather-working, Tools and Their Uses, The Leather: Its Varieties and Treatment, Simple Stitched Work, Purses, Wallets and Pocket Books, Ladies' Handbags, Suit and Attaché Cases, Photographic Frames and Clock Cases, Blotters, Mats, Covers and Thonged Work, Modelling, Incising, Punching and Stamping, Pyrography and Stencilling, Encrusted, Mosaic and Other Decorations, Gilding and Lacquering, Staining, Book Covers.

PIANOS

CASSELL'S
"WORK" HANDBOOKS

1s. 6d. net each.

For the Handyman, the Expert and the Amateur. Practical manuals with many helpful illustrations dealing with almost every subject of interest to the man who does things himself.

Basket Making.
Beehives and Beekeepers' Appliances.
Bent Iron Work.
Bookbinding.
Boot Making and Mending.
Building Model Boats.
Camera Making.
Clay Modelling and Plaster Casting.
Clock Cleaning and Repairing.
Conjuring Apparatus and How To Make It.
Cycle Repairing and Adjusting.
Domestic Jobbing.
Dynamo and Electric-Motor Building.
Dynamo and Motor Erection and Management.
Electric Accumulators.
Electric Bells and Telephones.
Electric Clocks.
Electric Lighting.
Electric Primary Batteries.
Electro-Plating.
Fishing Rods and Tackle, Making and Mending.
Furniture Repairing.
Gilding, Silvering and Bronzing.
Glass Writing, Embossing and Fascia Work.
Gramophones and Phonographs.
Handyman's 1,000 Practical Receipts, The.
House Painting and Decorating.
Household Repairs.
Incubators and Chicken Rearers.
Induction Coils.
Knotting and Splicing Ropes and Cordage.
Magneto Repair and Adjustment.
Metal Turning Made Easy.
Miniature Electric Light.
Model Aeroplanes.
Motor Cycles and Side-Cars: Construction, Repair and Management.
Mounting and Framing Pictures.
Oxy-Acetylene Welding.
Patents, Designs & Trade Marks.
Photography Simplified.
Pianos.
Poultry Houses and Appliances.
Pumps and Hydraulic Rams.
Rustic Carpentry
Sewing Machines.
Simple Lathe and Its Accessories, The
Small Dynamos and How to Make Them (including Electric Motors).
Small Electric Apparatus.
Small Lathes: Making & Using.
Small Workshop Appliances.
Soldering, Brazing and Welding.
Stage Illusions & Entertainments
Tailoring.
Taxidermy.
Ticket Writing and Sign-Painting.
Tinplate Work.
Toy Making.
Violin Making and Repairing.
Watch Cleaning and Repairing.
Wireless Telegraphy and Telephony.
Wood Finishing.
Workshop Arithmetic.
Workshop Hints for Metal Workers.

Send P.C. for Illustrated List of Technical Books.

Cassell's

Publishers, London

PIANOS

THEIR CONSTRUCTION, TUNING AND REPAIR

WITH NUMEROUS ENGRAVINGS AND DIAGRAMS

EDITED BY

PAUL N. HASLUCK

CASSELL AND COMPANY, Ltd.

LONDON, NEW YORK, TORONTO AND MELBOURNE

First published *August* 1905.
Reprinted 1907, 1911, 1915, 1917, 1918, 1919, 1921, 1923.

Printed in Great Britain.

PUBLISHERS' NOTE

THIS treatise on the Construction, Tuning and Repair of Pianos is issued in the confident belief that it is not only thoroughly practical and reliable, but is so simply worded that even inexperienced readers can understand it. Should anyone, however, encounter unexpected difficulty, he has only to address a question to the Editor of WORK, La Belle Sauvage, London, E.C.4 and his query will be answered in the columns of that journal.

CONTENTS

LIST OF ILLUSTRATIONS

PIANOS :

THEIR CONSTRUCTION, TUNING, AND REPAIR

CHAPTER I.

PIANO CONSTRUCTION.

PIANOS are now found in so many households, and there is such a dearth of published information on their construction, tuning, repair, and renovation, that it is thought that reliable instruction on these matters presented in the pages of a WORK handbook would be welcomed by a great number of persons. This handbook will treat the subject in a practical manner, and will discuss in the order here mentioned the construction and manufacture of a piano ; choice, care, maintenance, and cleaning ; tuning, repairs of all kinds, the finishing and renovation of piano cases, and the improvement of discoloured keys.

The construction of a piano will not be attempted by many persons outside the recognised factories ; but it is by no means an impossible task for the home-worker, be he amateur or professional, provided that he has mastered the use of woodworking tools, of which he must possess a goodly assortment. He will need a workshop of some kind, a bench, and a pair of trestles. At a late stage in the work special implements become necessary (see pp. 91 to 94, and pp. 104 to 111).

The piano, whose manufacture is about to be described, has a wooden frame, so that it is wholly within the capacity of the woodworker. However, as the majority of readers may wish to have an iron-frame

instrument, information as to the purchase and fitting up of the necessary parts for this is given at the end of the next chapter. Some idea of the instrument to be described may be gained from Fig. 1, which is a vertical cross section of the case. Its design may not compare favourably with that of an expensive factory-made model, but it is well adapted as a piece of work for a person of limited facilities. In Fig. 1, A indicates the end of a back; B, end of case to cheek C; D, truss; E, truss toe; F, end of key bottom; G, lock front; H, key block; I, name board; J, back flat and fall; K, top; L, end of bottom board; M, end of pilaster.

The glue is a very important item in piano making. Only the best should be used. To prepare it, break it in pieces, and cover it with cold water, leaving it to soak all night; then put a portion in the glue-pot and boil thoroughly, stirring from the bottom occasionally.

Begin the actual construction of the piano by making the back. Cut nine lengths of 4 in. by 3 in. bracing 3 ft. 6 in. long, also two lengths 4 ft. 3 in. Plane one side of each straight and out of winding, testing often with the straight-edge. Then square the edge or 3 in. side of each, and make the usual mark on them. Take the rough off the other sides, and stand them by to dry, as they dry quicker when planed over.

Now prepare the wrest plank and bent side by planing over, so that they will lie level and square across. Obtain two sheets of sycamore veneer, and cut the veneer the width of the wrest plank until there is sufficient to cover its entire length; joint it edge to edge on a board by tacking it temporarily, then glue strips of paper over to keep it together. When this is dry, tooth or scratch it with the edge of a saw.

The strain, or tension, on a piano is very great, and varies with the size and method of stringing. The tension from top to bottom of a wood-frame cottage piano is from seven to eight tons, while a wood-frame grand piano has a tension of about sixteen tons. The back, or foundation, of the piano must be strong enough

to bear this great strain. If the back is not strong enough, then the piano will not stand in tune, for the two extremities will be gradually drawing together,

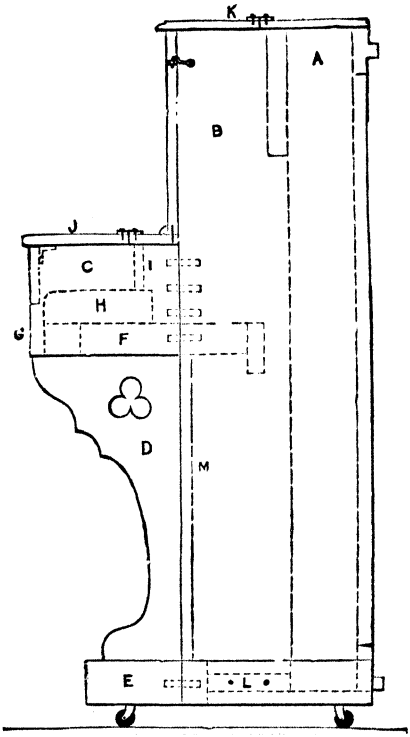

Fig. 1.—Vertical Cross Section of Piano Case.

the strings slackening accordingly. The tension in an iron-frame piano may be as great as thirty tons.

The parts of the back (see Fig. 2) are named bracings D, linings E, wrest plank A, and bent side B. The back of the piano will be composed of nine bracings or

uprights, and will be 4 ft. 2 in. wide by 3 ft. 6 in. high. The bracings are made of spruce, as free from knots and as dry as it can be got. It will take about 50 ft. of stuff, 4 in. by 3 in. The wrest plank A is the upper portion

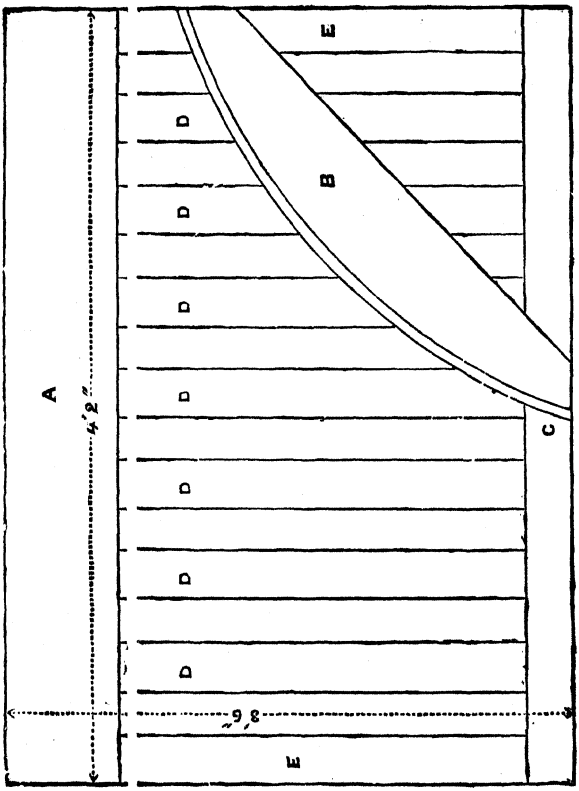

Fig. 2.—Front View of Piano Back

of the back, where are placed the wrest pins, or tuning pins, to which the strings are attached. This is made from beech, 1½ in. in thickness, and 8 in. wide, and 4 ft. 3 in. long. The bent side is also made from beech; into

this pins are driven to attach the other end of the strings. This beech is cut on the quarter specially for the trade, that is, the tree is cut in four parts, and the boards cut off the faces, so that they are not so

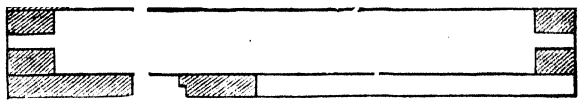

Fig. 4.

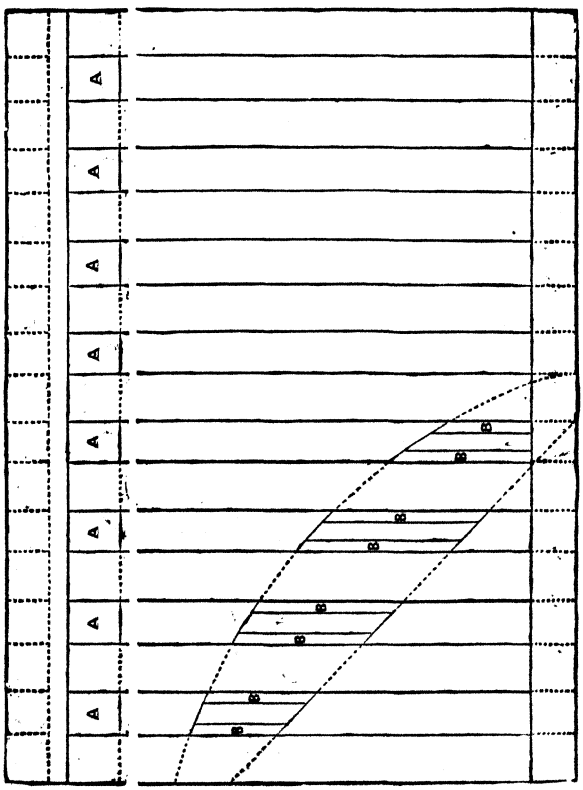

Fig. 3.

Figs. 3 and 4.—Back View and Section of Piano Back.

liable to split. Fig. 2 is a front view and Fig. 3 a back view of the back; c shows the bottom. A vertical section is shown by Fig. 4. Glue the wrest plank and the side of the veneer that is not papered, and place over it a hot board, rub the work with soap to prevent sticking, and cramp with hand-screws. After leaving this an hour or two, take off the hand-screws and board, and plane over the veneer with a smoothing plane set fine, and then scratch the surface of the veneer. Now apply the second sheet of veneer in the same way, but with its grain crossing that of the first.

The frame of the back is to be 4 ft. 2 in. by 3 ft. 6 in. finished. The two lengths of bracing cut 4 ft. 3 in. are for the top and bottom of the frame,

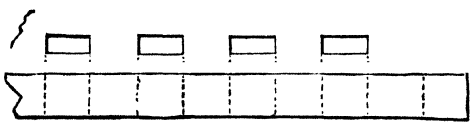

Fig. 5.—Mortise Holes in Bracing.

their exact length being 4 ft. 2 in., ½ in. being allowed at each end to work with, for cutting square, etc.

The outside bracings are called linings; they are dovetailed into the top and bottom, and the bracings tenoned into the top and bottom. The bracings must be spaced apart about equally, if anything, a little closer together in the centre, as the strain is greatest at this part. By subtracting the thickness of the bottom and top from the height of the piano, the measurement between the tenons will be obtained; for instance, say the bottom and top are 2½ in. thick, that would make 5 in.; take that from 3 ft. 6 in., so getting 3 ft. 1 in. between the tenons. The mortises can be bored out with a 1 in. centrebit, leaving the tenons 1 in. to fit (see Figs. 5 and 6). In putting the back together, before gluing see that it all fits together square; try this by placing a rod diagonally from corner to

corner; if the diagonals do not measure the same a good push at one corner may make it right. Attend to this also when gluing together. When ready to glue together, get some assistance. Just place the ends of the tenons in their respective places, so that the whole holds together, then warm both ends well, and brush on glue as quickly as possible to the parts of the tenons that are visible.

Now knock together with a heavy hammer, and see that the back is square, and lies flat on the floor. When the glue is dry, plane over both sides clean. Make a pencil line 8 in. from the top, and fill up the interstices to this line with blocks 6 in. long; this is to make a good bed on which to glue the wrest plank. When these are dry and levelled, tooth the work well, and warm it and

Fig. 6.—Lining with Dovetail End.

the wrest plank. After it has been fitted insert two nails at each end of the line, and glue and put on hand-screws. Gauge a line ¾ in. from the bottom of the bent side, on the round edge, and ¾ in. on the top; put the work in the bench screw, and with a hand saw cut down the line on the edge, and then chop out with the chisel from the line on the top; this will form a rebate for the sound-board to lie in. When the back is facing the workman, with the plank at the top, the treble will be to his right hand. On the treble lining under the wrest plank mark 5½ in. From the bottom corner at the bass end mark 2 ft. Knock two nails in temporarily, and lay the bent side on and mark round with pencil; then fill up the interstices with short pieces of bracing, as was done for the plank. When dry level and tooth, and glue the bent side up to the nails. After this is dry, get out two pieces of spruce

3 in. wide, ¾ in. thick, and 4 ft. 3 in. long. After planing, glue one at the top and one at the bottom of the back outside This will complete the making of the back.

It is a natural step from the back to the sound-board. The back is firm and rigid, but the sound-board is vibrating and sensitive, so that these form two extremes. The sound-board lies immediately behind the strings, and covers the back within the wrest plank and bent side. It is technically named the belly. The parts of a piano may have been named with the parts of the human frame in mind, for the piano has a back, belly, cheeks, legs, feet, and toes. The sound-board has an important function, and without it there would only be the tone of the wire, which would be poor and weak in itself, as can easily be proved by stretching the string over any rigid surface. When a piano string is struck by the hammer, the sound is transmitted from the bridge on which the string rests to the sound-board, which takes up the sound waves, and increases the power of the vibrations; so that when a person is playing the piano, the sound-board is in one continual vibration. If a tuning fork is struck and the end placed on a solid block, very little sound is emitted; but if struck and placed on the panel of a door, its tone is intensified. To show how wood is a conductor of sound, let a tuning fork be struck and held on one end of a plank, no matter what length, and it will be heard at the other end.

The sound-board is usually made from Swiss pine, but can also be made of American pine, or spruce, about ¼ in. thick, free from knots and shakes, and thoroughly dry. Most timber merchants keep suitable dry material. Having selected the wood, lay the back on the trestles with the plank and bent side uppermost. The boards will probably be found unsound at the extreme ends; if so, cut the ends off, as it is better to sacrifice material at this stage than to have trouble afterwards. Lay the boards on the prepared back and cut off the first length;

let it run parallel with the wrest plank, and overlap each side of the back ½ in., the first board put under the bottom edge of the wrest plank. Now take the remaining boards in rotation, and put together edge to edge; of course, they will decrease in length as the worker gets to the bottom; let them first overlap the rebate of the bent side, so that there will be a little on which to work. Having done this, make two lines across the whole of the boards in the shape of the letter V, so that their correct positions will be known.

Now turn the back over with the wrest plank on the trestles. In a factory the belly or sound-board is jointed on a large board, but in this case the back already made is utilised for the same purpose. The back has two strips of wood across the top and the bottom, and these will be found useful in jointing the sound-board. Shoot one edge of the first board, and after laying a sheet of paper to keep the back clean, place the board up to the slip of wood mentioned above; put a handscrew on each end to keep it in position; shoot the edges of the remaining boards, making as good joints as possible. Having jointed them all, get a piece of wood about a ¼ in. wider than the intervening space between the bottom edge of the sound-board and the bottom slip, and having ready some glue hot and thin, warm the edges of the wood, and glue edge to edge on the back, rubbing each joint till it is found to bite. Insert the slip of wood; being a quarter of an inch wider than the space the belly will bulge in the centre. Put a board with weights on the top to make the joints go up close.

While this is drying get out the bars; these are made of ¾-in. spruce ½ in. wide and are placed across the sound-board in a vertical direction, one between each bracing; thus eight of them will be required. Plane over the sides after they have been cut out, straighten one edge, and make the other edge a ¼ in. round in the centre, graduating to the points; on this edge use the toothing plane, or scratch it with the saw, as this edge has to be glued and it makes it hold better.

When the sound-board is dry take it up and with a chisel remove any superfluous glue. Then proceed to plane it over; the handscrews will have

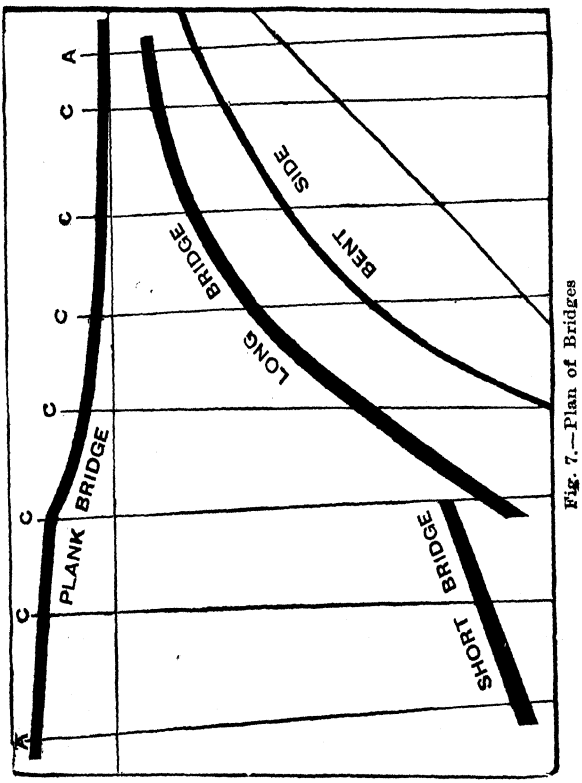

Fig. 7.—Plan of Bridges

to be moved about during this operation, after planing one side fairly level gauge it round from that side about ¼ in. in thickness all round, leaving it a trifle thicker at the treble end, also at the bass bottom edge.

Rub some chalk round the edge of the bent side, and lay the sound-board in its place, which will be ¼ in. below the wrest plank; two pieces of wood ½ in. long can be put on the bottom edge temporarily. Press the sound-board on the chalk line, and that will give the mark by which to cut it out, so that it fits in. Having fitted it, stand the back on its bottom; make a mark with pencil each side of the bracings, and between these marks will be the place for each bar before mentioned. The method of putting these on is by springing a bar a little longer than the distance between the bar and a board or ceiling above, which consequently gives a downward pressure; but it can also be done by gluing one bar in its place at the back, and using another at the front, which must not be glued; for giving pressure, put a handscrew at each end of the bars, the round edges to the sound-board.

Before gluing, see that it brings it to a joint; have the glue rather thin and the bars hot. Serve the remainder in the same way. When the bars have been got on, make a line across the top and bottom of them 4 in. from each end; from this point they must be bevelled down to ⅛ in. from the sound-board, except the base ones that do not touch the bent side; leave these ¾ in. thick at the bottom ends. Now put fillets on three edges of the belly; these will be of pine 1 in. wide and ¾ in. thick for the top and treble one, and 1 in. square for the bass one, graduating it from 1 in. in the centre to ⅜ in. each end; the top fillet is cut out to fit over the bars at the edge, and these are then glued on; of course the treble one will just fit the space between the wrest plank and bent side. The sound-board rests on these slips and on the rebate of the bent side.

A plan of the bridges is shown by Fig. 7, and the back of the sound-board by Fig. 8, both to a scale of 1 in. to the foot.

By reference to Fig. 7 the length and shape of the

bridges can be ascertained. They are made from beech 1¼ in. wide, except the top bridge, which is 1 in. wide and ½ in. thick. When purchasing the bent side and the wrest plank, an extra plank can be

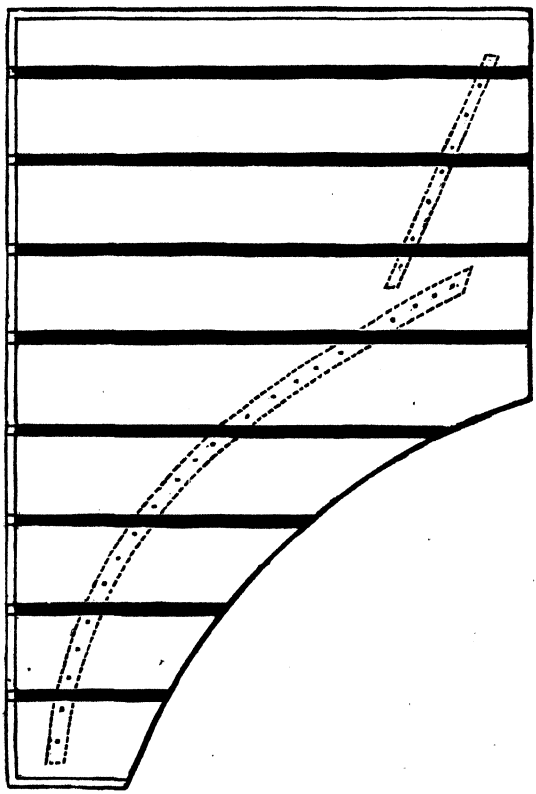

Fig. 8.—Back of Sound-board.

obtained with which to make the bridges. Cut one edge out to the shape of the long bridge, then gauge it 1¼ in. wide from the edge; with care all the bridges can be cut from one plank; cutting up the

straight part with a hand saw, and the curves with a frame saw. For the top bridges be careful to keep the flowery side of the wood uppermost.

Having planed the bridges, and prepared them for gluing, clean off any superfluous glue from the back of the sound-board, and then rub it with coarse glasspaper. Obtain a pint of white hard varnish and apply two coats to the back, except the fillets and bent side edge, as the glue will not stick to the varnish. Put the sound-board in temporarily, and mark for the long and short bridges, and $\frac{5}{8}$ in. below this line prick through the belly about every 2 in. with a small bradawl; this will help in putting on the belly bridges. Now get ready some $\frac{3}{4}$-in. screws, and some glue hot and not too thick, so that it will run nicely from the brush; warm the long bridge and glue it; put a handscrew on at the treble end, and where it is possible put others on from the hollow edge; then drive the screws in the holes that have been made, as quickly as possible from behind; serve the short bridge in the same way.

A bottom plate will be necessary; one made in cast iron for 47 notes will suit best, and be the easiest fitted. It generally has three projections containing screw holes, and the bottom of the plate has holes for bolts; the treble end rests on the end of the bent side, and the first bass note will be $4\frac{1}{2}$ in. from the outside of the back; this plate must be fitted level. Bore the holes for the screws through the projections, so that the plate will go in the same place, as it will have to be removed when putting in the belly. To put the screws in after the belly is in, bore centrebit holes through the belly above those previously made.

It may be mentioned that all the ironmongery required for the piano may be easily obtained from any pianoforte ironmonger.

The sound-board is now ready to be put in its place. Round the edges bore holes for 1-in. screws for the top

and treble and round the hollow edge, and for 1½-in. screws at the bass edge. It would be better to have assistance at this stage in gluing in the sound-board. Have the glue ready and the screws through the sound-board half way. Warm the edges of the sound-board, and glue all edges except the bottom. Now, as quickly as possible, turn all the screws in their place.

To ascertain the shape of the bridges and their position on the sound-board, it will be found on reference to the diagram that the bottom edge of the wrest plank is used as a basis for calculating the length of the strings; for this reason it is called the strike line, as the hammers strike the strings at this point. The first note is A, which is 2½ in. from the treble end on the strike line. The first C will be 7⅞ in.; make a mark at these points. Second C, 13¾ in.; third C, 20⅛ in.; fourth C, 26½ in.; fifth C, 33 in.; sixth C, 39⅜ in. The last note, which is A, is 47½ in. Take particular care with these measurements, which are all on the strike line, measured from the treble or right-hand side of your back. From the same side at the bottom mark one point 1 in.; second one, 5½ in.; third, 12¼ in.; fourth, 18⅝ in.; fifth, 25⅝ in.; sixth, 31⅞ in.; seventh, 38⅜ in.; and the last, 45¼ in.

It would perhaps be easier for a beginner if he were to have a sheet of white paper the size of the back, and measure the width of the wrest plank and make a line for strike line. Having made these points, get a straight-edge, and make lines from top to bottom intersecting these points.

The distances above the strike line to give the shape of the top bridge will now be mentioned. The first note, A, runs level with the bottom edge of plank. First C, $\frac{3}{16}$ in.; second C, ⅛ in.; third C, 1 in.; fourth C, 2¼ in.; fifth C, 3⅞ in.; sixth C, 4¾ in.; last note, A, 5½ in. Now for the distances below the strike line for the shape and position of the belly or sound-board bridge. First note, A, 2¼ in. First C, 3⅛ in.; second C, 5½ in.; third C, 10¼ in.; fourth C, 19¼ in.; fifth C,

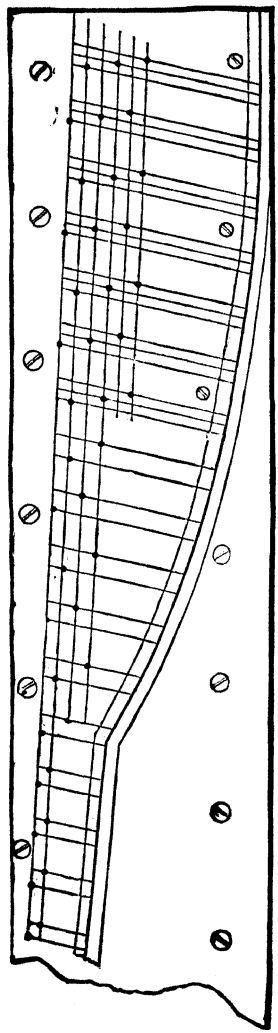

Fig. 9.—Wrest Plank marked out for Wrest Pins.

28½ in.—this is the last note on the long bridge. The first note on the short bridge is B, which is 25½ in.; then A, the last, 30½ in.; this bridge is straight and 15½ in. long. On the wrest plank the bridge is placed above the line, while on the sound-board the bridges are placed below the line. Fig. 7 shows the method of obtaining the shape and position of bridges. Fig. 8, as has been said, shows the back of the sound-board, the dark lines being the bars and the light double lines slips on the edge.

Directions will now be given on preparing the bridges to receive the strings, or what is technically termed marking off (see Fig. 9).

In a pianoforte factory the business of the marker-off is to take the back, with the sound-board in position, and to plane the bridges to their proper height, mark the scale, drill and pin the bridges, clean and varnish the sound-board, adjust the bottom and bent side plates, bore the wrest plank, and put in screws and bolts. How all this is done will now be shown. See that the bass bars do not touch the bottom of the back; if they do so, chisel the wood of the back away until they are quite free. To test this, strike the long bridge in the centre with the clenched hand, and it ought to sound like a drum.

Now prepare a slip of pine ¾ in. wide and ½ in. thick; this is to be placed round the edge of the bent side on the sound-board, the ½ in. edge being glued on the sound-board, and close up to the bent side. To bend this, make a number of saw-kerfs in it, bend, and hold in position with pins until the glue dries. Plane the top or wrest-plank bridges down to ⅞ in. at the treble, and $\frac{1}{16}$ in. lower at the bass end. Now make it straight in its length, and plane the bent side slip to ⅝ in. at the treble, diminishing to ½ in. at the bottom of the bent side. Put on the bottom plate temporarily, securing it with a handscrew; see that the bottom of the sound-board does not touch it. Take a straight-edge and hold it on the plank and long bridges at the treble

end, and it will be found that the long bridge requires reducing in height; plane it down about 12 in. of its length until the straight-edge is within ⅛ in. from the bent side slip; then move the straight-edge 12 in. nearer the bass, and plane down until it is ¼ in. from the slip; move another 6 in. and make the distance ⅜ in. from the slip. From this point graduate the slip to the bottom plate. Place the straight-edge across the bottom end of the long bridge, and make it, and also the beginning of the short bridge, ⅜ in. above the plate, diminishing to ¼ in. above the plate at the extreme bass end. The reason for planing the bridges is to give the strings a proper down-bearing, just as in a violin

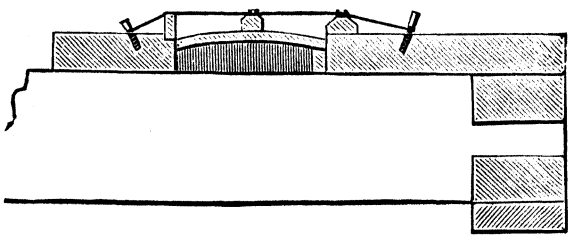

Fig. 10.—Section of Treble End of Back, showing Sound-board and Bridges.

(see Fig. 10) the bridge supports the strings. If the sound-board sinks or the strings lose this bearing, the piano loses its beauty of tone, and the tone becomes very thin.

For the scales for marking the bridges prepare two slips of wood about ¼ in. thick, ⅜ in. wide, and 4 ft. 2 in. long; clean one side of each, and mark one slip top and the other bottom. Gauge a line in the centre of each, mark a line across the top slip with a square and marking point 2½ in. from the end, and mark this treble. Now set some compasses to $\frac{8}{16}$ in.; start from the mark made, and proceed to divide the length of the slip until there are eighty-five marks upon it, each $\frac{9}{16}$ in. from the next; square the marks across. Now deal with the

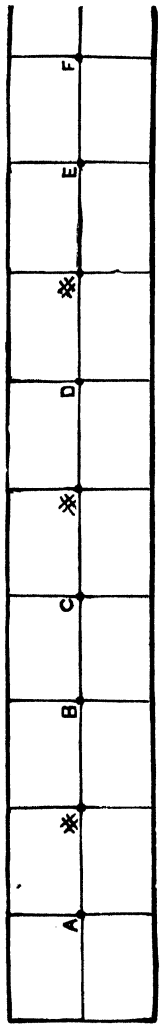

Fig. 11.—Scale for Marking Bridges.

bottom slip. Make a mark $1\frac{1}{2}$ in. from the end, and mark it treble. Divide the rest as before, except the last twenty-seven divisions at the bass end; these must be so contracted that the total space they occupy is 1 in. less than that of the corresponding twenty-seven marks on the top slip. This can easily be done by closing the compasses slightly and then making trial. Having marked the slip, bore a $\frac{1}{16}$ in. hole in the gauge line crossing each mark. For convenience it would be as well

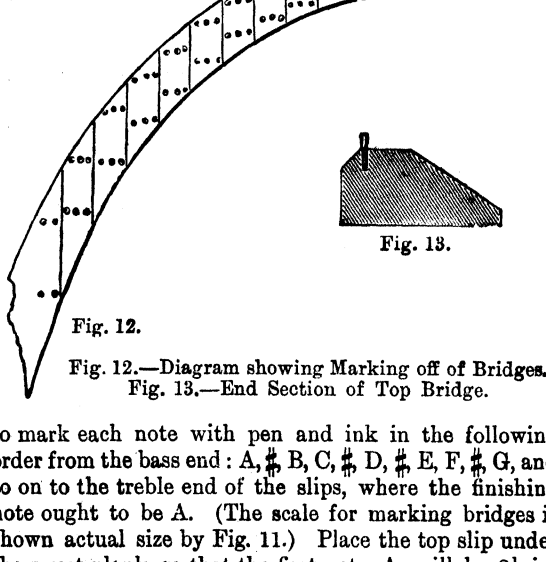

Fig. 13.

Fig. 12.

Fig. 12.—Diagram showing Marking off of Bridges.
Fig. 13.—End Section of Top Bridge.

to mark each note with pen and ink in the following order from the bass end: A, ♯, B, C, ♯, D, ♯, E, F, ♯, G, and so on to the treble end of the slips, where the finishing note ought to be A. (The scale for marking bridges is shown actual size by Fig. 11.) Place the top slip under the wrest plank, so that the first note, A, will be $2\frac{1}{2}$ in. from the treble, or right-hand side of the back. Put the bottom slip at the bottom of back crossing the bent side; fix these temporarily so that they will not move about. The bottom slip will be $1\frac{1}{2}$ in. from the treble end to the

first note. Place a piece of wire in each of the two first holes, and having a stick of black-lead pencil, flattened one side, so that it rests close to the straight-edge, put the straight-edge up to the pins at top and bottom, and mark across the bent side and both bridges; continue this until the bent side is passed, and then, of course, take these lines across the bridges. Set the compasses to $\frac{1}{4}$ in. wide, and use them as a gauge; run round both sides of the long bridge, making a mark on the top; also run them round top bridge from bottom side. Refer to Figs. 12 to 15, Fig. 12 being a diagram showing the marking off of the bridges; Fig. 13 an end section of the top bridge; Fig. 14 an end section of the long bridge; and Fig. 15 a plan of the bridge pins looking across the

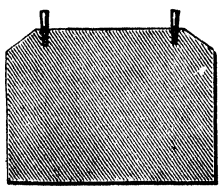

Fig. 14.—End Section of Long Bridge.

Fig. 15.—Plan of Bridge Pins.

top of the long bridge. Open the compasses to $\frac{5}{16}$ in and mark both sides of the short bridge.

The tools shown by Figs. 16 and 17 are now required, the former being for marking trichord pins and the latter for the bichord pins. The tools are known as trichord and bichord forks or punches. They can be made easily out of a piece of round steel; flatten one end, and make the prongs with a saw file. Take the trichord punch, and place one prong on the first treble line of the top or wrest-plank bridge the two other prongs being to the left of the line. Punch each one in this way until twenty-two trichord notes have been marked. Punch the remainder with the other tool, excepting the last seven at the bass end, those are single notes, so only require one punch mark. Now mark the long bridges.

Take the trichord punch and begin with the first note at the treble; place the right prong on the line which crosses the bridge, and the left on the line made with the compasses, holding the punch in a line parallel with the wrest plank. Mark twenty-two with the trichord punch.

Fig. 16.—Trichord Fork or Punch.

In the top bridge there is one line of pins; in the long and short bridges there are two lines of pins. To mark the bottom edge of the bridge, place the right prong on the line made with the compasses and the left prong parallel with the wrest plank. Of course, mark with the bichord punch to correspond with the top bridge. Mark the short bridge with the bichord punch in the line made with the compasses, except the last seven, which are single notes; serve these the same as the top bridges.

In the trichord use small bridge pins, bichord middle size, while for the short bridge use a shade larger. The pins ought to be obtained before boring the holes; the boring is done with a drill stock and bow, or an Archimedean drill will answer the purpose. Drills can be made from steel umbrella ribs; if they are round file them so that they have three sides to cut with, so as to prevent splitting.

Begin boring the top bridge, using soap on the bit; start at the treble; the worker can sit on the wrest plank while boring this, and hold his drill in a slanting

Fig. 17.—Bichord Fork or Punch.

direction, so that the pins will lean towards the bass. Now bore the long bridge, the top row bore leaning towards the bass, and the bottom row leaning towards the treble; serve the short bridge in the same way.

Having bored all the holes in the bridges scrape the

bridges clean and glasspaper them. Now mix some blacklead into a paste with water, and rub with a piece of flannel over the surfaces of the bridges; burnish the surfaces by rubbing with a piece of round steel. Set the compasses to $\frac{9}{16}$ in., and run them round the top bridge, using them as a gauge that will give a line to work to. With a small plane bevel the bottom edge of the bridge up to the pin holes. Bevel the top side of the bridge up to the line previously made with the compasses, smooth it well, and then varnish. Now bevel the bottom edge of the long bridge up to the first hole; also bevel the top treble edge, where the holes run straight. To kerf the bridges take a small saw, such as a dovetail saw, sit on the sound-board, looking towards the wrest plank, and begin the saw-kerfing at the treble end at the thirteenth hole. The strings will lie across the bridges $\frac{1}{8}$ in. the bass side of the hole, down to the hole of the note below. The kerfs will be about $\frac{1}{4}$ in. deep, and will lengthen as the worker gets down the bridge. Having cut them all, take a sharp $\frac{3}{4}$-in. chisel, and hold it half way across the holes and cut the pieces out, starting at the treble and going to the end; this is called carving the bridges, and if done carefully looks very neat; with the chisel clean the side that was cut with the saw. The short bridge is merely bevelled up to the pin holes at the top and bottom edge.

A bevel is now to be made in the following manner: take two pieces of $\frac{1}{4}$-in. pine, one piece $1\frac{1}{2}$ in. wide, and the other 1 in. wide, and both 9 in. long. Screw the 1-in. piece across the centre of the other $\frac{1}{8}$ in. out of square. Now start at the first treble hole on the top bridge, holding the bevel to the holes in rotation, and marking with a fine pencil across the wrest plank. This is done to mark for the wrest or tuning pins. Where it is trichord, mark a straight line 2 in. from the top of wrest plank, and 5 more lines below it, with a space of $\frac{5}{8}$ in. between each line. Where it is bichord, make only four lines; see that the bottom row of

pins is 4¼ in. at this point from the top bridge to make room for the action. Take a centre punch, and start at the treble, and punch the first, third, and fifth lines from the bottom; this will be the first note. Punch the second note on the second, fourth, and sixth lines. As the grain of the wood in the wrest plank runs straight, this is done to distribute the pins over as large an area as possible. When the bichord portion is reached punch the first and third line for one note, and the second and fourth for the following, and so on alternately. Clean off the pencil lines with a scraper and glasspaper, and give three coats of white hard varnish, allowing each coat to dry before the other is applied. Then clean up the sound-board, and give three coats of varnish.

The bent side now demands attention. Run a pencil line round the bent side 2 in. from the sound-board edge. From this line, mark towards the treble in short lines parallel with the wrest plank across the straight lines previously made, every four until thirty-eight lines have been marked across. Now punch a mark where the lines cross. There being twenty-two notes trichord in the treble, count this number, and 1 in. behind them make another line, and punch. Now clean off the pencil lines. Take a sheet of brown paper, and cut it to fit round the inside of the slip of the bent side, making it extend an inch over the holes already punched. Mark where it crosses each bracing for bolts; rub a piece of shoemaker's heel-ball over the brown paper so as to mark all the holes. This produces a pattern for an iron plate to cover the bent side to prevent splitting. Send this to a pianoforte ironmonger and order the bridge pins, Nos. 14, 15, and 16, one set and twenty-five over of wrest pins, nine wrest-plank screws and washers, and four 6-in. bolts with nuts and square heads, and sixty hitch pins for the bent sides. The screws required are not of a special character.

When the pins come to hand, the size to bore the

holes will be known. Let the bridge pins fit the holes, but not tight enough to split.. It is better to bore in a piece of waste beech till the right size of bit is found. The wrest pins must fit tight, or the piano will not stand in tune. Having bored the holes in the bridges, proceed to insert the pins, using a small hammer for the purpose; let the pins stand above the bridges about ¼ in., and run a file over them to level them. In boring the wrest plank, use a stock and (probably) a $\frac{3}{16}$ in. spoon bit. The worker should stand at the top of the wrest plank when the piano back is on the trestles, and let the bit lean towards him, so that the wrest pin is ¼ in. out of the upright in its length; this prevents a tendency to fall down, as when the piano is on its bottom, the pins point upward a trifle. Having bored the holes, countersink slightly to remove burr from the top. Mark above the holes the scale marked on the rods, beginning at the bass end, starting and ending with A.

The bent side plate must be put on so that the holes cover the punch marks; screw on, and put bolts through so that they are level at the back; bore in the bracing with a centre-bit to make a clearance for the nut; bore holes for the pins with a small bit, and drive in the bent side. Fix on the bottom plate, put in position by looping a piece of string on the last pin, and see that it comes in a direct line with the bridge. Hold it in position with a hand screw, and put 2-in. screws in the projections, and 6-in. bolts in the bottom into the bracings. To find the place for the nut, turn it on the bolt half an inch, then hold it on the bracing in its proper position and strike the nut with a hammer. Make a shallow hole with a 1-in. centre-bit and bore through the hole in the plate to meet it; drop the nut in the hole, and turn the bolt in. Put some 4-in. screws through the wrest plank under the top bridge in the bass and over in the treble into the bracings; this will secure the wrest plank at the bottom edge.

The theory of stringing requires that each octave,

starting from the treble, should double its length, but if that were carried out in the piano under consideration there would have to be a 16-ft. string for the lowest C, which course is impossible. The difficulty is surmounted by increasing the thickness of the wire to obtain lower notes. A string struck with the hammer in the piano vibrates a given number of times according to its length and tension; the higher the note, the greater number of times it vibrates. It is said by writers on acoustics that sonorous vibrations lie between 16 and 38,000 per second of time. This seems a large number of vibrations in so short a space of time, but it can be proved by many different methods. In a 7-octave pianoforte, the extreme bass A corresponds to about 27 vibrations, and the extreme treble A to 3,480 vibrations per second. The theoretical pitch, as it is termed, is the pitch accepted by acousticians as the natural one, being 512 vibrations per second for pitch C, each octave lower decreasing by half: thus 512, 256, 128, 64, 32, and each octave higher increasing by double the number in a second. The fork by which pianos are usually tuned is of a higher pitch than this, giving 519 vibrations per second, and called the philharmonic. Some use a higher pitch still, called the diapason normal, giving 522 vibrations per second.

Before beginning to string the instrument, take a strip of cloth listing (such as tailors cut off the edges of cloth) and glue it on the top of the slip that goes round the bent side, and also glue a strip on the top edge of the bottom plate; on this lie the strings, and jarring is prevented. With pen and ink mark the gamut over each note, beginning with A at the bass end, and marking it the same as the marking off slip. The treble and tenor notes of the piano are strung with steel wire, and the bass notes are steel with copper wire wound round them. Now mark under the notes the sizes of the wire, count 6 notes from the treble and mark 13, and then mark again in the following order:—10 notes of 14 wire, 6 notes of 15, 6 notes of 16, 21 notes of 17, 3 notes

of 18, 2 notes of 19, 2 notes of 20, 1 note of 21. A ¼ lb. each of all these sizes will be required with the exception of 17, of which ¾ lb. must be obtained. It will now be necessary to take a scale from the back for the covered bass strings; this is done by laying a sheet of newspaper on the back so that it covers the short bridge in its width from the bass end, and is over the top bridge and the bottom plate; rub heelball over the pins gently on the top bridge, short bridge, and bottom plate; this will give the size for the string maker. When ordering the strings say that they are to be about 4 lbs. weight.

When the strings come to hand, take the back in hand first; see that the back is laid evenly on the trestles, one under the wrest plank, and the other under the bottom. A tuning hammer (see p. 91) will be required for tuning the pins, also a pair of pliers to cut the steel wire. The pins are driven in with a hammer. As will have been learnt from marking the wrest plank, the start is made at the treble end with No. 13 wire, the first 22 notes being trichord. The centre string will need a loop on the end; this is looped on the front row of pins. To form this loop, put a piece of wire of the thickness of the hitch pin in the bench vice, hold the end of it with pliers, and give it (the end) a couple of turns round the wire; then slip it off the wire, and while holding the loop thus made, finish it off by turning the short end round it. Now put the loop on the first pin in the front row on the bent side, pull it tight with pliers, carry it over the bridges, and 3 in. past the hole where the pin is to go. Having cut the wire, put its end in the hole in the wrest pin and turn the pin round to the right until the wire is coiled round it two or three times; then drive the pin into the wrest plank with the hammer until the coil is ¼ in. from the plank, and tighten it by turning to the right; now put the end of the wire in a wrest pin and repeat the operation of coiling. Drive this pin into the first hole in the wrest plank, and take the wire round the first pin in the

second row in the bent side and over the bridges; cut off and put round a wrest pin, and drive it in the third hole of the wrest plank; this will complete one note. (For a more modern method of stringing see pp. 127 to 130.) The remainder of the stringing is done in the same way until the bichord part is reached; here, of course, the middle string is left out. Take care that the sizes put on agree with those marked on the plank; the sizes will be marked on the paper in which the wire is wrapped.

When all the steel wire is on, put on the covered bass strings; these are supplied threaded on a wire, with loops on the ends. Take off one note of two strings from the end where they are the thinnest; put the two loops together, and the one that is farthest away from the copper put on the bottom pin on the plate; carry them over the bridges, and pin the same as before. Take care to take them off the wire in rotation, as they are not all the same size; of course, the last seven are single; these are thicker than the others, being double-covered with copper. Now run a piece of listing in and out of the strings below the bridges, and a piece of red cloth or braid over the top bridge. This is done to damp the sound in all parts except between the bridges. The back can now be stood on its bottom, leaning against the wall, and see that the coils are all nice and even round the pins; if not to the worker's satisfaction, they can be drawn close by slacking a little with the tuning-hammer, and drawing up with a button-hook. The maker, no doubt, would wish to hear the tone of his instrument at this stage, and for this purpose the strings must be "chipped up" or rough-tuned, but of course he can only do this in a small measure until the hammers are in.

A C tuning-fork will give the note for pitch C, the third C from the treble end. Put the tuning-hammer on the pin of this note, strike the prongs of the fork, and place the end on the piano. When it gives the note. pull up the string until it sounds the

same as the fork; when the two sound together as one note, the string is in unison with the fork; but if it is not right, the tuner will hear what are called beats. The string must be tuned until the beats cease, and sound like one note. Now chip the other string of the note with a small piece of brass until it is in unison with the string pulled up to the fork. Now pull up the C below the pitch C; this is an octave below; when this is in tune and both C's are chipped, it will sound like one note, and very agreeable to the ear. Now pull up the G below, called a fourth, and also the D above, called a fifth, chipping the two notes together; then from D to A below, then A to E above, then E to B below, then B to F♯; then get the octave F♯ below; then from F♯ to C♯ above, C♯ to G♯ below, G♯ to D♯ above, D♯ to A♯ below, then C to F below. Try the following chords: G C E when the E has been tuned; G B D after tuning B; A D F♯ after tuning F♯; and F A C after tuning F. If the reader has a musical ear and some perseverance, no doubt he will be able to master it. This is called the scale, being the basis from which the piano is tuned. There is a small instrument sold at music shops called the chromatic pitch-pipe; by moving a slide it gives all the notes in the chromatic scale. This would be found a great help to beginners in tuning. When the scale has been chipped up, proceed with the octaves above; the first note to pull up will be F below pitch C, to be pulled up an octave higher than the F below it, and so each succeeding note is taken until the treble is done; then tune the octaves below the scale, the first note to tune being E, going down to the bass. It need scarcely be said that an octave would be from doh to doh, running up the scale or down. This having been done, take a piece of hard wood with a slight groove in the end, and press all the steel strings singly, and pull out the copper strings. This is done to stretch the strings so that they stand in tune better. Now chip it up again, repeating this

operation several times at convenient opportunities, remembering that this does the instrument good (provided that the pins are not turned backwards so as to make them loose) and improves the ear. If a note is pulled a shade too sharp, it is better to press it down. Keep the back in a dry place after it is strung to prevent rust. This completes the operation of stringing.

The worker has now arrived at the construction of the case or exterior, or, as it is technically termed, fitting up; it is so called because the parts of the case are fitted on the back after it has been strung and chipped up. The parts of the case are made for the fitter-up by a part-maker; in most factories part-making is a distinct branch of the trade. There is a variety of designs of exteriors, and the choice must be left to the individual worker. The names of the parts of the case as they are known in the trade are as follow: ends, cheeks, top door, bottom door, top, back hollow, fall, lock front, plinth, trusses or brackets, truss toes, pilasters, and key bottom.

The inexperienced is advised to make what is known as a solid case, that is, one that is not veneered. The reason for this is that the difficult process of veneering is avoided. In a piano factory the flat parts are veneered by means of sheets of zinc ⅛ in. thick, made hot, and placed between each layer of veneer after being glued to the wood and pressed down with iron cramps; these press out the glue and leave the veneer perfectly flat and free from blisters. The back hollow and fall of a veneered case are usually shaped, being jointed up in ribs of pine, and worked to shape with planes. In veneering, wooden cauls are used; one is shaped to fit outside the fall and the other inside; they are lined with zinc, and the fall, with the veneer glued on inside and out, is pressed between the cauls with iron cramps.

The simplest style of case from a mechanic's point of view is shown in section by Fig. 1 (p. 11), but when complete it is very effective, and leaves room for the

display of artistic taste in more than one direction. If a black case is desired, it should be made of American white wood and then ebonised, relieved with gold lines incised on it. The case here recommended is intended to be made of English walnut, as it matches overmantles and the prevailing style of light and artistic furniture; but, as already suggested, it is a matter for the maker's discretion.

Procure some dry English walnut and, for the key bottom, a 10-ft. length of 2-in. square pine, and 4 ft. 3 in. of pine, 1 in. by 3 in. The key bottom is 4 ft. 2 in. long and 14 in. wide. Plane one side of the 2-in. pine, square the edges, and cut off five muntings or cross rails 11 in. long. Cut the front rail 4 ft. 2½ in.; also a back rail the same length from the 1 in. by 3 in. stuff. Dowel these together with round pegs of beech-wood of about ½ in. diameter. Glue in the dowels, and when dry, plane the top square and straight in its length. This key bottom is the portion of the case on which the key-board rests, and an underneath view of it is shown by Fig. 18, in which A is the front rail, B back rail, C muntings or cross rails, E lock front, and F cheek.

Now take the back of the piano, and plane each end of it straight and square. Lay it on the trestles, strings uppermost, and cover it over with a sheet to keep the shavings and dust from it.

For the ends of the case obtain two lengths of ¾-in. walnut, 3 ft. 7 in. long by 12 in. wide: these are the finished measurements, so allow a trifle for working. Plane the sides, shoot the front edges straight, and square the top ends. Reference to Fig. 1 (p. 11) will show that from the front edge of the end to the wrest plank measures 6 in.; select the best sides of the ends for the outsides, and put a small nail in 6 in. from the front at the top of each end, and one at the bottom of the treble end 7⅜ in. from the front. These nails are driven in only temporarily, and allowed to stand out a little way for the ends to rest on the back; rest the treble end on the back, then take the bass end and rest

the nail on the wrest plank. Stoop down and look across the top of the two edges of the ends, and either raise or lower the bottom end until it is level with the

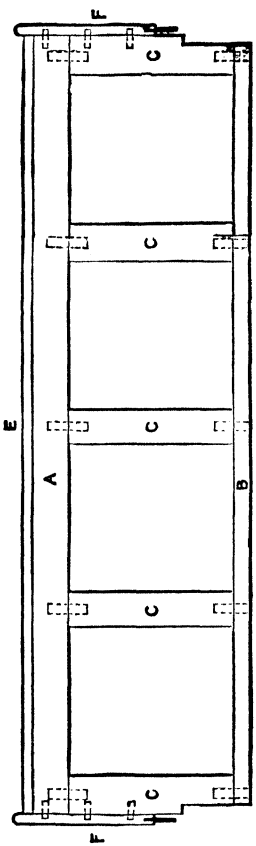

Fig. 18.—Underneath Plan of Key Bottom.

edges of the treble one; then make a mark and drive a nail in temporarily. Put on some handscrews, and see that they fit close to the back; if they do so, with a

toothing plane go over the parts to be glued. Warm the ends and have some glue hot, so that it runs nicely from the brush, but not too thin; glue one side and put on the handscrews as quickly as possible, then glue the other side in the same manner, keeping the square tops of the ends level with the top of the piano back.

Having done this prepare the cheeks from two pieces of walnut 10 in. long by 7 in. wide, and the same thickness as the ends; these are dowelled on the edges of the ends, at a distance of 1 ft. 9 in. from the top of the end to the bottom edge of the cheek. Put in four dowels ⅜ in. diameter and 5 in. long; glue them halfway in the cheeks; mark for holes by making a template of a piece of thin wood the width of the cheek; pierce four small holes, and mark through on the ends of the cheeks and also on the edge of the ends to correspond, so that the dowels in the cheeks will enter the holes in the ends. The cheeks are dowelled on the ends of the key bottom in the same way. Having glued the dowels in the cheeks and holes in the end, put them in their places temporarily; see that they are square with the ends; now take the key bottom and place the top side of it to the bottom edges of the cheeks, with the back rail resting on the ends. Having got the cheeks upright, make a mark inside the cheeks near the ends of the key bottom at each end, square a line across from these marks, and plane the ends of the key bottom to these lines, so that it fits between the cheeks; keep the bottom level with the bottom edge of the cheeks, and 1 in. from the top end of the cheeks; put a handscrew on each side temporarily, and then mark across with a small square and pencil over the bottom edge of cheeks and key bottom the position for the dowels, three in each; by taking it out and gauging a line 1 in. from the bottom edges of the key bottom and the cheeks, and squaring across from the lines previously made, the exact position for holes will be obtained. Glue the dowels in the key bottom, leaving them to stand out ½ in; try on the cheeks and see that everything fits;

cut a piece out of each end of the key bottom ¾ in. wide from the bottom of cheeks to the back (shown in Fig. 18): this is to give room for the pedals to work. Make the ends of the key bottom warm and glue on the cheeks; put on a couple of handscrews; glue the ends of the cheeks and the holes in the ends, and put the dowels in their respective places, and drive down with a mallet, interposing a piece of hard wood so as not to bruise the cheeks; thus the cheeks and key bottom are put together at one operation.

The bottom board, made of 1¼ in. pine, 4 ft. 2 in. long by 6 in. wide, is fitted in between the ends, and level with the bottom of the piano back, a piece being cut out to allow of it fitting over the end of bent side and plate. The bottom board is glued on the bottom of the back and at the ends, and dowels are put through the ends into it.

The plinth now to be made runs along the edge of the bottom board, and runs through to the outside of the ends, a piece being cut out of the ends to allow it to do so. The plinth is 4 ft. 3½ in. long, 3 in. wide, and 1¼ in. in thickness. The thickness can be made up by gluing a piece of ¼-in. walnut on 1-in. pine. Now make the two pilasters of walnut 2½ in. wide; these are fitted one end under the cheeks at each side of the case, the other end resting on the plinth, and the edge glued inside the end. Now, for the present, take the case off the trestles.

To make the back flat and fall, get two pieces of walnut ¾ in. thick, and 4 ft. 4½ in. long; the back flat is to be 3 in. wide, and the fall 8 in. wide; the edges are to be planed straight, and to fit on the top of the cheeks; the ends are to stand over the cheeks at each end ½ in. and to be rounded.

A name board of ¾-in. walnut is 2½ in. wide, and is glued on the under side of the back flat, at the front edge: it lies behind the keyboard. Now make a front flap to fall: this is 3½ in. wide, and fits between the cheeks under the front edge of the fall, and is secured to it with small butt hinges.

The lock front is 3½ in. wide, and also fits between the cheeks, and is glued to the front edge of the key bottom after being cleaned up with glasspaper.

The top is now made: it is what is known as a half-top; the back half is 7 in. wide, and is glued to the top of the back; the front half is also 7 in. wide; allow it to stand over ½ in. at the ends and front, and bevel the edges. The two halves are joined together with fancy hinges to match hinges on the fall; in fitting these, it is only necessary to screw them on temporarily, as they will need to be taken apart to polish.

The top and bottom doors are made in frames to fit the openings: the top door from the back flat to fit under the top, while the bottom door fits from the plinth to the key bottom, and between the two pilasters. The frames are to be made of ¾-in. walnut 1½ in. wide. Plane the edges square and cut off to the length required to fill the openings, the long rails to go between the short ones, and a couple of dowels put through each rail. When these are glued together and dry, plane the sides smooth, and then get some ¼-in. walnut with which to make the panels to cover the frames above mentioned. The panels are planed over smooth and cleaned up with glasspaper, and the openings are cut out; the trefoils can be bored out with a centre-bit; then these panels are glued on the frames, with pressure from small hand-screws along the edges. The edges of the openings are also to be cleaned up, either left square or bevelled. Behind these openings are fitted four smaller panels made square, to cover over the trefoils, and after being polished, a design can be incised and gilded, or painted on them; these smaller panels are screwed on from behind. The top door is screwed to the back flat from underneath, the latter being placed on short dowels in the cheeks, the top door being fastened with small hooks inside the ends to eyes in the back of the door. The bottom door has short dowels in the bottom edge, and these fit into a couple of holes in the plinth,

while the top part is held in position by two small buttons.

For making the trusses or brackets, glue two pieces of ¾-in. walnut together to make up the thickness, or obtain 1½-in. walnut; these pieces are 20 in. long. The truss toes are 6 in. long and 3 in. thick and are dowelled on to the plinth, and stand over the end ¼ in. Two end plinths, 3 in. wide and ¼ in. thick, can be made to butt up to the truss toe, and are glued to the bottom of the end.

To fit in the lock mark the centre of the lock front, or gauge from the top edge of the lock to the lock pin on which the key fits; make a slight mark on the lock front to cross the other, gauging from the top edges. Obtain an escutcheon of brass; bore with a small bit in the mark just made, and fit the escutcheon in with a ¼-in. chisel. Now fit the lock in from the top edge by boring it out, and marking it so that the pin comes to where the escutcheon is let in; glue this in, and clean off level with a file. Having fitted the lock, the link plate in the front flap of the fall must be fitted. Take the key, and turn the bolt up as though to lock the piano; on the top of the bolt put a little of the black oil from an oilstone; turn down the key, close the fall, turn the key again, as though to lock it, and it will make the mark on the fall where the link plate is to be fitted.

The whole case is now cleaned up preparatory to polishing. Have the smoothing plane set fine and sharp. Use also a steel scraper and various sizes of glasspaper, using the coarse first, then using the other sizes and finishing with No. 1. Any small holes may be filled up with shellac, using a hot iron or old file to melt it in the holes; minute holes may be filled by rubbing over a piece of beeswax, and then papering level. Exercise great care in cleaning up the case.

CHAPTER II.

THE ACTION : COMPLETION OF PIANO.

THE case having been completed as described in the previous chapter, it is now ready to receive the internal mechanism, or action. This branch of the trade is known as the finishing. The finisher prepares the keys and action for the case, and adjusts the different parts so as to bring the whole into working order. Formerly, the pianoforte manufacturers made their own small work, or action and keyboards ; but as the demand for pianos became greater, it was found necessary to make more divisions in the labour to facilitate production. Now key making and action making are two distinct trades, although there are a few firms who still make every part of the instrument. There is a variety of actions in the market, each having its particular claims to merit, but the maker exercises his discretion as to the one he adopts. The action selected for this piano is what is known as the tape action, from the fact of it having a tape or bridle attached to the hammer butt. This action was patented in England as far back as 1842 by Robert Wornum, who spent a large amount of time and money in perfecting the pianoforte, but it did not find the favour in this country that it deserved. But the French makers soon discovered the merits of this action, which was so much used in France that it acquired the name of the French action. Latterly, however, it has found more favour in the land of its birth.

The action forms a very important part in the construction of the piano, as without it the piano would merely be a large dulcimer. The action and keyboard form the link between the performer's

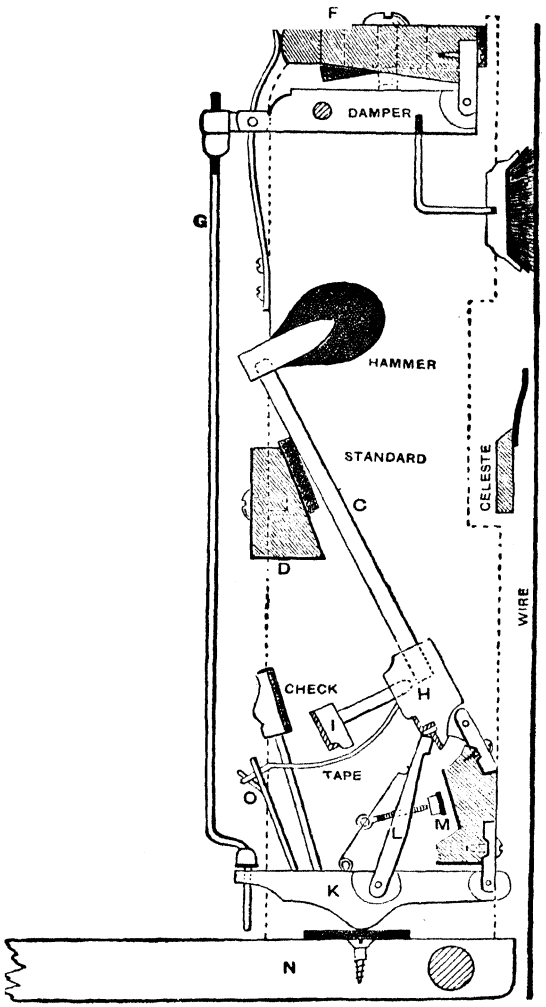

Fig. 19.—Tape Check Action.

hands and the strings. There exists much difference of opinion as to the weight or balance of a key or note. When a pianoforte key is pressed down and the finger taken off, it is returned to its former position by a weight at the extreme end of the key. Some prefer a light touch or fingering of the keys, while others are in favour of a heavy touch; it would be as well to accept the happy medium. For if a touch is too heavy, it renders playing for an hour or two more the nature of work, as it makes the fingers and wrists ache; while, if too light, the player cannot feel enough weight under his fingers.

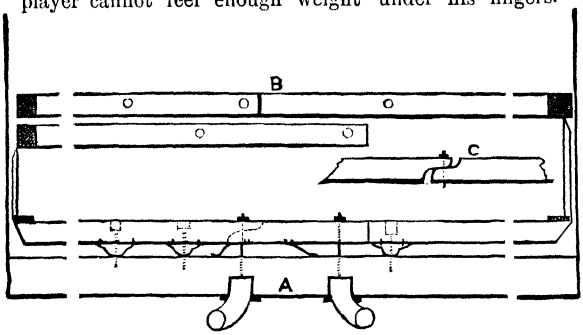

Fig. 20.—Arrangement of Pedals and Rockers.

The reader will find that in very old pianos the touch is very light, while in modern pianos it has a decided tendency to be heavy. The action selected for this piano will require a weight of 2½ oz. to press down the key of each note sufficient for the hammer to strike the string. It will readily be understood that if the touch is heavy, a person playing for some hours will get very fatigued.

The different parts of the keys and action as they are known in the trade will now be enumerated. Beginning with the keys, there is the key frame on which the keys work, comprising front rail, balance or middle rail, and back rail; in the front and balance

rail are key pins, those in the balance rail penetrating the keys, while those in the front rail partly do so. On these pins cloth is placed to prevent noise, the back rail also having cloth to form a cushion on which the back of the key rests. The keys in a seven-octave piano number eighty-five, and they comprise fifty white or natural keys, and thirty-five black or sharp keys. Some parts of the tape action are named in Fig. 19; others are: damper rail (F), hammer rest, set off or slide rail (M), lever or crank (K), hopper or fly (L), hammer butt (H), check arm (I), bridle or tape (O), escapement button, bridle stay, and damper wire (G). Fig. 19 is a sectional diagram of a tape check action, and the letter references not yet explained are: C,

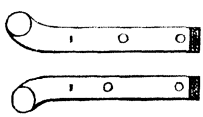

Fig. 21.—Plan of Pedals.

hammer shank; D, hammer rest; and N, part of key showing regulating screw.

In ordering the keys, ask for one set of keys (ordinary scale), ivory or celluloid according to means, 14 in., 7½ in. balance. In ordering the action, ask for one tape check action (ordinary scale) 10 in. strike, with hammers complete. The principles on which this action and others perform their duties will be explained later, and the arrangement of the pedals, dampers, and other parts will now be described.

The arrangement of pedals, rockers, dampers, etc., is illustrated by Figs. 20 to 22. In Fig. 20, A indicates the pedals in position and the arrangement of rockers; B shows the rockers in plan; and C shows the overlapping of the celeste rockers. Fig. 21 is a plan of the pedals. In Fig. 22, E shows a plan of the celeste and section of the sticks; F a plan of the pedal sticks to support the celeste; G. the crank and the method of

working it; H, the bass end of the damper rail; I, treble end of damper rail; J, method of fixing standard and standard block; L, the wooden button for securing the action; M, key; and N, section of balance board.

The first business will be to set up the action in the cases; take the two screws out of each end of the damper rail F (Fig. 19) and put it aside for the present; now take the extreme bass and treble hammers out of their packet, and file the ends of the shanks until they fit the holes in the hammer butts H (Fig. 19) at each end of the action. In the bottom of each standard put a dowel (see J, Fig. 22) and make two blocks to fit them; on these the action rests, and they are glued on the key bottom when it is in position. Stand the action on the blocks, put the hammers in the bass and treble holes, and when the point of the hammer touches the string, see that the shank of the hammer is $\frac{1}{4}$ in. out of the upright and leaning back, both ends the same. Keep the front edges of the standards upright or square, and mark the front of the standard blocks, and keep all in this position temporarily. Leave this for the present.

Put the keyboard on the bench, and take the extreme treble and bass keys off the frame. Holding the treble one $\frac{1}{16}$ in. from the front of the lock board, rub it under the treble note—its bottom having been black-leaded a line will be made on the top of the key; serve the bass end in the same way, and so make a line on each key. Put them in their places on the frame, and with a straight-edge make a pencil line across the whole of the keys at the two marks. Then take a centre-punch, and mark the centre of each key on the line; in these punch marks holes are bored for $\frac{5}{8}$-in. No. 10 screws, and counter-sunk so that the head is level with the key: these are called pilot screws or regulating screws; put these in. Now make a pencil line across the keys $\frac{3}{4}$ in. behind the screws. The keys are now removed from the frame and loaded. There are two methods of loading them; either bore the holes in the keys, and melt the lead in a ladle and pour into the hole

while holding the key on a flat-iron gripped in the bench screw; or buy the leads moulded ready to put in the holes and insert them by hammering, the leads being ½ in. in diameter and numbering one or two for each key, according to the balancing.

A balance board has now to be made; this is a

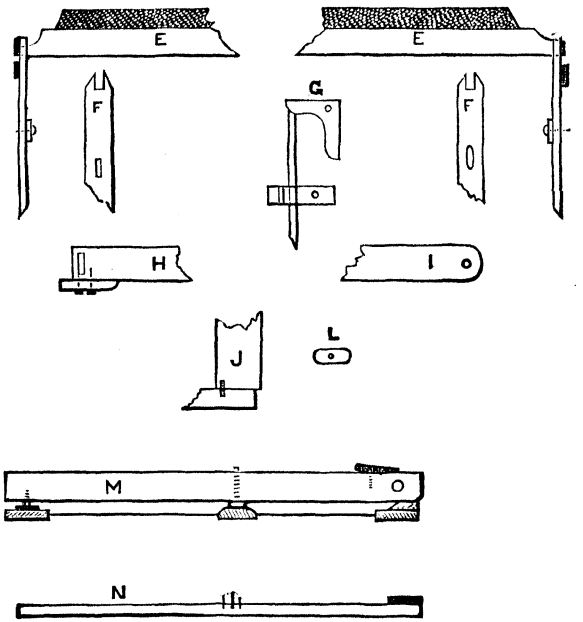

Fig. 22.—Parts of Damper, Celeste, etc.

piece of wood 3 in. wide, and the length of the key; mark one end for the back, then cut a saw-kerf in the centre of the wood, and put a piece of thin brass or veneer in the kerf, allowing it to project above by about ¼ in. For the reception of headless wire nails, bore holes ⅛ in. and ¼ in. in front of the kerf. Have a moulded lead ready; put the wire in the ⅛-in. hole, so

that it stands 1 in. above the level of the veneer. Beginning at the bass end put in the keys by their central holes, and slide the lead towards the back of each key until it weighs it down. Mark the position of the lead on the key, taking care that it does not come on the regulating screws. Serve as many keys as there are dampers in this way, then change the nail into the ¼-in. hole and treat the remainder of the keys. In the treble the keys are a little heavier, to compensate for the weight of the dampers in the bass; bore centre-bit holes in the keys right through the sides at the marks made in balancing, and fill them up with lead; see that the lead does not move in the holes and so cause rattling noises.

A strip of cloth 1¼ in. wide, and the length of the set of keys, is glued on to the keys at the line behind the pilot screws, so that the cloth covers the screws. Let the cloth be of firm texture, such as box cloth or black cloth. Glue behind the screw only, leaving the front of the cloth over the screws loose, as these may have to be regulated. After gluing, cut the keys apart with a knife. Some baize or felt has now to be put on the key frame; felt such as that used for putting under carpets will answer the purpose. Put the two extreme end keys on the frame, and mark with a pencil the frame where it extends outside the keys; also see that the frame is level with the back of the keys; if it is not, plane it down. Cut the ends off the frame at the marks previously made. Cut two strips of baize or felt, one piece 1 in. wide, and the other 1½ in wide, and the length of the key frame; these strips of baize are to form a cushion for the back of the key to rest on, and are placed on the back rail of the key frame directly under the regulating screw; gauge a line and make a groove with a rebate plane about ¼ in. wide, holding the rebate plane at an angle so that it makes the groove deep enough for a 1½-in. piece of baize to lie in; the 1-in. piece is simply glued at its front edge and laid on the frame, and the 1½-in. is glued in the groove and lies

over it. On the centre pins of the key frame are placed small pieces of cloth of the same kind as that used for the top of the keys. In the trade, it is usual to punch these out; they can be purchased already punched out, or a strip of cloth can be cut to the width and length of the balance rail, and stretched across the top of the pins; rub a file over it and it will make a hole for each pin; then press the cloth down level on the rail. For the front rail get two strips of felt: cut these the width of the rail, and make holes in the same way. The keys are now ready to be eased on the frame, and for this two small files, one round and the other square, will be necessary. Use the round file first, easing the round hole so that the key drops easy on the pins, but do not make it loose. With the square file ease the top hole so that it fits; serve the front holes in the same way: of course, ease every key on the frame. Now put the set of keys as it is on the frame into the case; the extreme bass and treble hammers are put in the butt at each end of the action, and while the lever is resting on the key, plane down the blocks that are under the standards until the point of the hammer is 2 in. from the string at each end: this distance is technically termed the blow, as it is the distance the hammer has to strike or give the blow to the string. When the blow has been made the right distance, move one of the hammers, placing it in several butts, to see that the hammers will strike each note squarely, and that the shanks will be upright; move the action either to the right or left until it is correct. Mark the place where the blocks or standard feet are to come, and glue these blocks down on the key bottom; put a screw through when the glue is dry, take out the keys, and unhook the tapes or bridles off the stays with a pair of pliers; notice how they come off, as they will have to be hooked on later.

Lay the hammers out on a clean board; it will be found that each is numbered on the side. Taking the extreme treble hammer, cut a piece off the end of the

shank until the point of the hammer strikes the string close under the bridge pin; this gives the length to which to cut the hammer shanks. A block will be needed to cut these, so that from the top of the wood of the hammer to the end of the shank they are all the same length; this block can be made by rebating the edge of a piece of wood 8 in. long, and making a saw-kerf across at the right length for cutting the hammer shanks. Having cut the hammers to the length required, file the ends of the shanks so that they fit the butts; do not make them loose; begin at the treble, and take each one in rotation according to the numbers. While doing this lean the case back, as the hammers will have a tendency to fall forward.

After fitting them all in, take two small straight-edges about 8 in. long; begin at the treble, and place one on the top of the hammers and the other under the check arms, and see that the tops of the hammers and check arms are straight; if they are not so, file a little off the end of the shanks until they are. Now proceed to glue in the hammers; have the glue hot and of medium thickness, and apply it with a small stick. Put a small portion on the shank, place in the first butt at the treble and turn the hammer round two or three times while it is in the butt; this forces the air out, and assists in setting the glue. Place the hammer up to the strings, and see that it strikes the note square; glue about a dozen in this way, then press one straight-edge under the check arms and the other on the top of the hammers, and see that they are straight; then draw the hammers back, and let them lean on the straight-edge about 2 in. from the strings; this is the length of the blow. While they are in this position regulate the spaces so that they look even to the eye; serve the hammers right through the set in this way; screw on the hammer rest with two screws. To find the place for this, lean the treble and bass hammer back, holding the hammer rest under them until the point of the hammer is 2 in. from the string; this will be

the place for it to be fixed. When the hammers are all lying back on the rest, overhaul them and see that they are satisfactory; when the hammers are dry, place all the tapes or bridles as before; put the keys in the case, and take out the keys where the frame passes over the cross rails of the key bottom; then move the key frame to the right or left, until each key is under the lever of each note. Now mark the front, middle, and back rails of the frame for holes to be bored for screws to go into the rails of the key bottom. Having bored these holes, put the key frame in position, leaving a space of $\frac{1}{16}$ in. between the front of the keys and the lock front; screw down to the key bottom. At each side of the standards, hard-wood blocks are fitted to fill up the space between them and the ends of the case; these are 1 in. thick, and the bass one has a piece cut out for a pedal stick to work through, the hole being lined with cloth; the pedal stick is tapered from 1 in. at the bottom to $\frac{1}{2}$ in. square at the top. In a line with the front of the standard a $\frac{3}{16}$-in. slot is cut out of the blocks for a button to fit in which secures the action in its place. The position of these blocks on the ends of the case is 1 in. above the top of the hammer rest; put a screw through these into the ends, also glue them; scratch a line under them on each standard and insert a small dowel, allowing it to stand out $\frac{1}{2}$ in.; these press under the blocks and prevent the action from moving upwards. Screw one button L (Fig. 22) on each standard to fit in the slots before mentioned; the buttons can be made of beechwood $\frac{3}{16}$ in. thick, 2 in. long, and $\frac{3}{4}$ in. wide; both of the ends are rounded, a hole is bored in the centre for a $\frac{1}{8}$-in. screw.

Having secured the action, it may be found that the hammers do not lie evenly on the rest; some may be a shade high, while others may be low; by taking hold of the rest in the centre and pulling it forward, some of the hammers will be found to follow the rest: these are low. Take out the key and turn up the regulating screw a little until they remain stationary; if any stand

a little above the rest, take the key out, put it on the bench, and give the cloth over the pilot screw a sharp blow with a hammer. The hammers being in line on the rest, the next operation will be to make the touch; that is, the depth the key presses down. Take two pieces of wood $\frac{5}{16}$ in. thick, 2 in. long, and $\frac{7}{8}$ in. wide; on the back of these is screwed a piece of lead—the touch weight—sufficient to press the key down; one weight is placed on the front of a treble key, and the other is placed on a bass key, then a light straight-edge is placed from one touch weight to the other; if the keys are too high, and the straight-edge does not touch the weights, then the touch is too deep, and must be altered by placing a piece of cardboard under the front rail of the key frame; if the straight-edge rests on the touch weights and the keys do not touch it, then the touch is shallow; this can be altered by putting a piece of cardboard or thick paper under the middle rail of the key frame at the places where it is screwed; get it as nearly right as possible to the straight-edge in this manner, and then take a shaving off the bottom of the high keys, while a piece of paper must be put on the centre pins to raise the low ones; the keys that are out of square may be made square by tapping the centre pin either right or left, as required; the spaces of the fronts of the keys are now made equal by a key spacer, this being a forked piece of steel which moves the key pin to one side or the other (see Fig. 53, p. 107); it can be done with pliers, but care should be taken not to scratch the pins.

Having spaced the fronts, now space the sharps, and by tapping the centre pin of the sharp, space it between the two naturals on the balance rail; the backs of the keys are spaced by striking the key on the side with a hammer, using a flat iron as a support.

The damper rail must be fitted when the dampers are on the strings; the largest damper is for the extreme bass note. Let the rail hang over the standards $\frac{1}{2}$ in. each end; at the treble end a hole is bored through for a screw to go in the top of the standard, while at the

bass end a slot is bored out for a round-headed screw to go through freely so that it does not touch the sides. On the front of the damper rail at the bass end a piece of wood 4 in. long is screwed and glued, and extends beyond the damper rail to within $\frac{1}{8}$ in. of the end of the case; behind this projection works a crank which is screwed on the end of the case. The crank presses the damper rail forward, while a spring screwed on the front of the standard presses it back, the screw at the treble end acting as centre, and the bass one keeping it in position. The bottoms of the dampers should be $\frac{1}{2}$ in. above the hammers when they touch the string, and if they are too high, cut a piece off the tops of the standards until they are right, screw the damper rail on, and screw a stop on the back of the standard to prevent the damper rail going back too far, placing a piece of felt between to act as a buffer. There must be a space of $\frac{3}{8}$ in. between the top of the damper and rail.

With a pair of long-nosed pliers put the damper heads on the string, bending the wire to right or left as needed, and keeping the tops of the dampers and heads in a straight line; then put the damper wires in, screw the top button down until there is $\frac{1}{8}$ in. space or play between the damper and lever when the wire is in, put them in, and then with pliers cut off the tops level with the damper.

An opportunity will now be taken, before describing the pedal arrangement of the piano, to explain the principle on which piano actions work. Actions are of two chief types, sticker and check. Fig. 23 shows a common form of sticker or hopper action, and Fig. 24 a check action with over-damper arrangement. By common is not meant the cheapest class, but those forms in general or common use There are many different kinds of actions in general use, but they vary in details only, the same general principle underlying them all. Most of them appear to be modifications of a tape or "French" action (see p. 44) and of a Molyneaux action that was deservedly popular a few years ago, as it was

an action that filled the part of a go-between. When complete iron frames, full trichord, and panel fronts were adopted, the sticker action became too common,

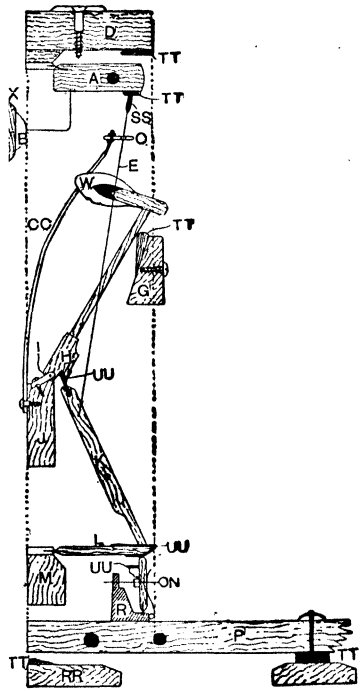

Fig. 23.—Sticker or Hopper Action.

and the check too expensive. The Molyneaux met the requirements of the case, as it combined the principle of a sticker with the advantage of a check; and, the patent rights running out, this action became the

standard pattern for English and Continental makers, with slight variations for an action suitable for medium-priced instruments. The higher-priced instruments are now for the most part being fitted with actions known as "under-dampers," in which the celeste pedal felt

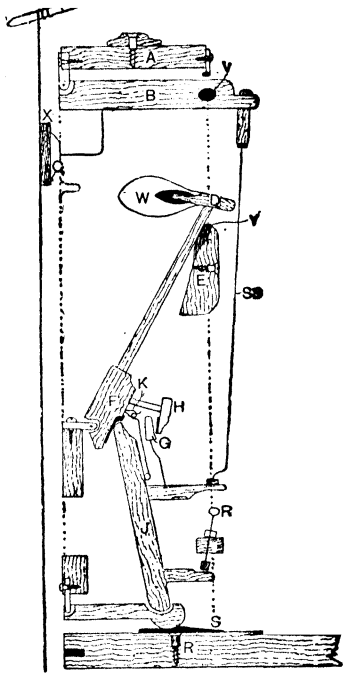

Fig. 24.

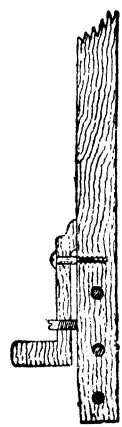

Fig. 25.

Fig. 24.—Check Action with Over-damper Arrangement.
Fig. 25.—Part of Action showing Key with Raised End.

arrangement (see Fig. 19, p. 45) is dispensed with. The striking and damping are self-contained, the check of vibrations being effected *below* the point where the hammer strikes instead of above, so rendering it possible to adjust the set off and toning without

taking off the damper rail, as necessary with actions having over-dampers.

The principle on which most actions work is as follows :—A key receives the blow from the fingers, a hammer strikes the wires, a sticker-rod rocker or lever transmits the blow from one to the other. The hammer is worked from a centre ; the rod or sticker receives the impact at one end from the key ; the other end, being fixed on to or against the hammer butt, transmits the force of the blow thereto, and causes the hammer-head to strike the wire with more or less force, but, without some further assistance, the rebound of the hammer would not be sufficient to cause it to fall back against its rest in readiness to receive the next blow. In the sticker this is effected by gluing the top of the sticker to the hammer butt, leather answering the purpose of a hinge ; in the check a loop of silk (K, Fig. 24), attached to a spring, serves this purpose.

If the head of the hammer remained against the wires, even for an instant, vibration would be prevented, thus causing what is technically termed "blocking." The arrangement for pulling the hammer away immediately is termed the "escapement," and in a hopper action is effected as follows :—When the key is pressed down, the back end raises the hopper, and with the lever and sticker, these propel the hammer towards the string or wire. When within about one-sixteenth of an inch, the hopper escapes or hops from under the lever, which then falls, bringing with it the sticker and hammer, the lead imbedded in the sticker assisting ; the block on the back of the hopper prevents the lever falling too low. On releasing the key it rises to its level and the whole arrangement settles into its place ready to receive the next blow. By turning the regulating screw the hopper will go farther under the lever, or withdraw from it ; if too far, it would not escape, thus causing the "block ;" if not far enough, loss of touch or weak blow is the result. With the check actions, the silk loop and spring exert a somewhat similar influence by acting in

two ways—first, when the hammer has completed its journey, the loop pulls the hammer away from the string; secondly, it pulls the sticker into its place again under the butt.

Up-to-date actions are more self-contained than older ones, that is, the loud and soft pedal arrangements form part of a whole, instead of being separate attachments. In order to make the same actions adaptable to instruments of any height, the keys may be used as in Fig. 24, or with a raised end, as in Fig. 25, and these may be made still higher by putting strips under these regulating blocks. In others the difficulty is overcome by means of thin, slender round rods, one of which drops into a hole bored in the key to receive it.

The following are the reference letters in Fig. 23: A, damper; B, damper head; C, wooden socket rail with holes bushed with cloth; C C, socket rail support (iron); D, damper rail; E, damper wire; G, hammer rest with strip of baize; H, hammer butt, with leather hinge securing sticker; I, hammer centre; J, hammer rail, showing iron support for socket rail; K, sticker—the round dot represents lead weight; L, lever; M, lever rail; N, regulating screw; P, key, showing two lead weights; R, hopper, with regulating screw and spring; R R, key frame—dotted lines indicate action standards; S S, wood cap to damper wire; T T, baize; U U, leather; W, hammer-head of felt, with cloth lining; and X, soft felt. In Fig. 24, A shows the damper rail; B, damper; C, damper head; E, hammer rest; F, hammer butt; G, check; H, counter check; J, jack; K, silk loop and spring; R, regulating screws; S, box cloth; S S, damper wire; V, lead weights; W, hammer-head of felt, with cloth lining; X, soft felt; and Y, baize.

A tape check action agreeing in general principles with those already described, but with certain of its details modified, is illustrated by Fig. 26, in which A represents the back part of key. When the finger depresses the front of the key it raises B, which carries

forward C, having a small button which rides along a bevelled rail, pushing hammer, D, to the string H, closely followed by E, which is the check. Projecting from the hammer butt is the check arm, under which is the tape which pulls back the hammer. The button in C is so regulated that when the

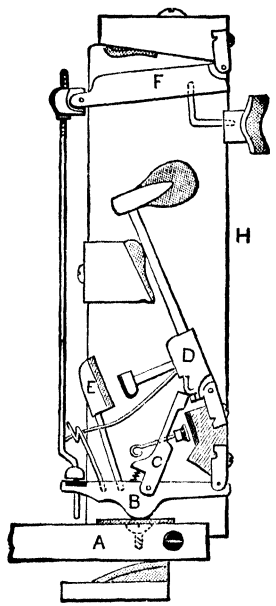

Fig. 26.—Tape Check Action.

hammer strikes the string, C moves forward, allowing the check arm to fall on to check, E, which has the effect of holding the hammer rigid, so that it does not rebound on the string. F indicates the damper. When the hammer moves forward to strike the string, the damper moves away from the string, so that the string is left free to vibrate; when the finger releases

the key the damper falls on the string and stops the vibration, except when the loud pedal is operated, this pedal keeping the dampers off the strings.

A type of check action known as the acme is shown by Fig. 27. In this figure, A indicates the key, which, when depressed raises B, which carries up C, this having a peg slotted through B. As B rises C

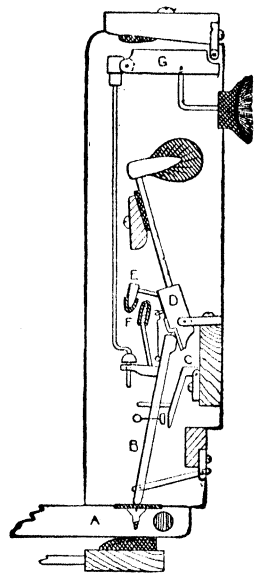

Fig. 27.—Acme Check Action.

comes in contact with the escapement button in B, which causes B to come forward from under the notch of hammer, D, which is connected by a spring and loop to B. This brings into play the check arm E, which falls upon the check F, and holds the hammer firm to prevent rebounding on the string; G is the damper raised from the string when the key is depressed.

The fitting up of the pedal and celeste action of the piano in course of construction will now be described.

The piano must be placed on its back on two trestles, so that the worker can get at the bottom of it. Make two pedals of beechwood 16 in. long and ¾ in. thick, as shown in Figs. 20 and 21 (pp. 46 and 47). Mark 4 in. from the front, and put two pins in temporarily; this is the distance they stand out in front of the plinth. Bore a hole in the right or loud pedal 2¼ in. behind the temporary pin and in the left or soft pedal, 3⅝ in., for the pedal bolt to pass through. Pedal bolts are made of stout wire with a nut to screw on the top. Bore a hole in each pedal 1½ in. from the back for a stout screw to go through. Glue a piece of felt on the bottom of each to prevent noise.

Mark the centre of the plinth, and 2¼ in. each side of this centre place the pedals, so that there is a space of 4½ in. between them. Cut pieces out of the plinth so that the pedals can work freely; cut up to the bottom board of the case, leaving space for a piece of felt to go round the hole; this felt is glued in the holes and tacked under the plinth.

Let the pedals rest on the pins, and put them in their respective holes, and mark through the holes made for the bolts; at these marks bore two ¾-in. holes through the bottom board. Now put the pedals in their place and put a stout screw in the bottom of each.

The rockers can be made of deal 1¼ in. square, and one piece will be 2 ft. long, and two pieces 2 ft. 6 in. long. On the 2 ft. 6 in. rockers a small block is glued at the bottom 10 in. from the end, while the 2 ft. rocker has a block 8 in. from the end. Take one of the 2 ft. 6 in. rockers and put it on the bottom board, extending 1 in. over the hole of the right pedal, the block being 10 in. from the pedal, then mark through the hole, and bore a hole at this

mark for the pedal bolt to go through, the other end of the rocker being cut so that it is ¼ in. from the base end of the case. The rocker is bored with a ½-in. centre-bit half-way through over the block, the remainder being bored with a spoon bit for a 2-in. screw. Round the block over from the hole at the bottom and insert a pedal spring so that its point comes near the bolt hole; clean this nicely with glasspaper, rub some soap on the block and spring, put the bolt through the pedal from the bottom and through the rocker, put the screw in through the block, and then pull the pedal and see that it works free, without noise. Do the same with the back rockers, except that they overlap each other, and the pedal bolt penetrates both. The short rocker is at the bass end and the long rocker at the treble. Rub plenty of soap where there is friction. Figs. 20 and 22 (pp. 46 and 49) show how the parts are arranged.

The soft pedal in this piano works what is known as the celeste; a strip of felt or flannel on a slip of wood rises when the pedal is depressed and the felt is interposed between the hammers and strings, and so softens the tone. Fig. 19 illustrates the celeste, but not the mechanism for working it. It is also shown by E (Fig. 22). The loud pedal moves the crank G (Fig. 22), which gives the damper rail a forward movement, taking the dampers away from the strings and allowing free vibration, so making the tone louder. By referring to F (Fig. 22) it will be seen that the two sticks which hold the celeste have slots in them, and that a piece is cut out of the top for the celeste slip to ride in; screws pass through the slots into each end of the case to keep the celeste in position, so that it is near but does not jar on the strings; fit it so that the top edge of the flannel is ½ in. below the strike line when the pedal is at rest. The crank is made of beech ½ in. thick, and is screwed on the end of the case above the damper rail at the bass end, the front of the

crank being over the pedal stick, whilst the back is behind the projection of the damper rail.

It is usual in the pianoforte trade to polish cases with a solution of shellac in methylated spirits. The operation will be described most briefly here, the whole subject of finishing piano cases being dealt with in Chapter IX. The work is begun by rubbing a piece of fine glasspaper over the part to be polished. This is to remove any spots of glue or foreign substance that may have adhered to it since it was cleaned up. Mix some plaster-of-Paris into a paste with methylated spirits, add a little brown umber, to make it the colour of walnut, and rub this well over the work so that it fills up the grain of the wood, employing plenty of friction, and then wiping off clean with a piece of rag. Put some raw linseed oil on a piece of wadding, and rub over the surface; do not flood it with the oil, because if too much is used it has a tendency to sweat or ooze out on the surface of the polish. Make a polishing rubber with a piece of wadding formed into the shape of a ball, with one flat side; put about a teaspoonful of polish on the rubber, and see that it penetrates the wadding; by pressing with the thumb it will enter the wadding better. Put over the wadding a nice piece of soft linen rag free from holes, and twist it round, the twist occupying the hollow of the hand when using. Again rub the wood with fine glasspaper, and then go over it with the rubber in all directions, up and down, then across, then forming the letter O, then the figure 8, and every way, so that the rubber is not worked too much in one direction, as this tends to make minute spots on the surface, which should be level; work on until the rubber is dry, and then replenish with more polish. Put a drop of oil on the face of the rubber, applying it with the finger so that it works free; keep the rubber well supplied with polish until the grain of the wood is quite filled up, and a smooth surface is on the work. Up to this point, the work is called bodying up; and a day or two should elapse before

finishing or spiriting off. For this purpose, use half polish and half spirits on the rubber, and work with this until the smears left from the bodying are removed. After using half and half, make a rubber of methylated spirits only, and use it very lightly until it gets dry; then apply more pressure, until the smear is finally removed.

The fly finisher now receives the parts of the case from the polisher to put together, and he has to see that all the different parts of the case are complete. The finisher must take a pair of bellows and blow out all particles of dust or shavings which may have lodged behind the strings or in any part of the piano. Also stand the case on its top on a clean board, and tap the bottom gently with a hammer so as to make the dust fall from under the bottom plate.

Put the trusses or brackets in their place between the key bottom and the truss toes, and secure them with screws through the bottom of the latter and top of the former. Then put on four castors with screws, two being on the truss toes and two on the bottom of the back.

At each end of the keyboard there is a vacant space, which is to be filled with blocks 7 in. long and the width of the spaces, to stand $\frac{1}{8}$ in. above the key: these are called key-blocks.

Hinge the fall and back flap together and see that the fall fits in its place nicely, and try whether it locks. When that is satisfactory, screw the name-board to the back flap from its bottom edge. The name-board now in position will not go down into its place because the sharps or black keys are too long; therefore cut the ends off these after marking, so that they are $\frac{1}{8}$ in. clear of the front of the name-board. It may be necessary to plane a little off the bottom edge of the name-board so that it rests on the top of the key-blocks, and the back flap on the cheeks. Glue a strip of red cloth or flannel along the bottom, allowing it to stand over so that it shows behind the keys. Hinge the top together, fit the panels, and fasten them in. On each of the pedals put a boss, this

being a round piece of brass to prevent the wood being worn by the feet.

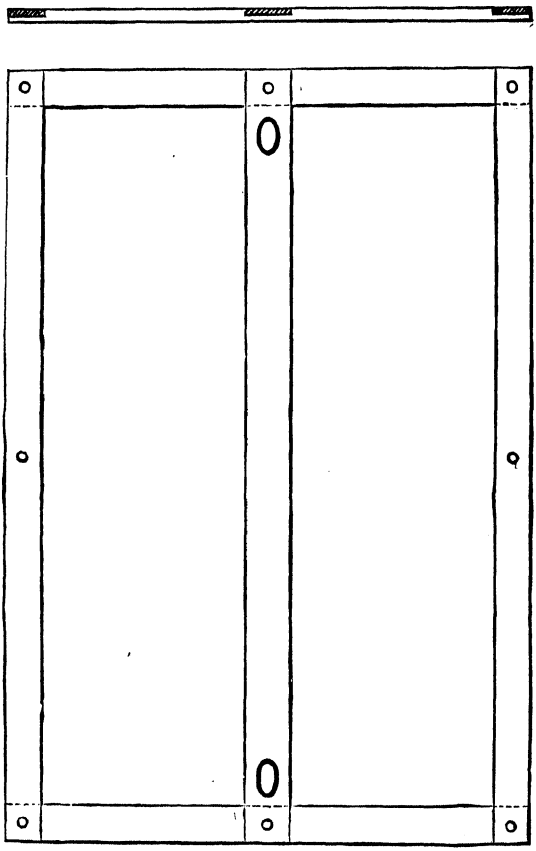

Fig. 2

Fig. 28.

Figs. 28 and 29.—Elevation and Section of Back Frame.

In the back of the piano is a back frame covered with lining or other suitable material; the back frame is merely a square frame made of $\frac{3}{4}$ in. pine, with a rail

crossing its centre (see elevation and section, Figs. 28 and 29), and it is used in lifting the piano about. Level the ends down to the frame, and clean up with glasspaper and colour it with brown umber and polish. Screw the back frame in, and insert two round knobs just under the top at the back, to prevent it touching the wall.

A music desk for the piano may be of the over-

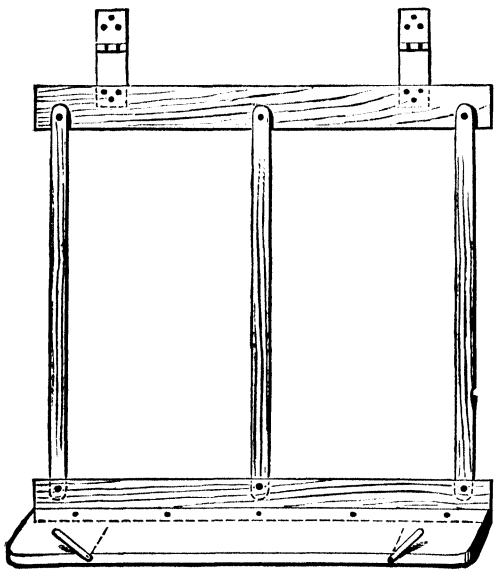

Fig. 30.—Music Desk for Piano.

hanging kind (Fig. 30). This is comprised of six pieces of walnut, ⅜ in. thick, there being two pieces ¼ in. wide, one piece 1½ in. wide, and three pieces ½ in. wide. When complete, it closes up, and turns under the top door out of sight. Six desk rivets and washers, a pair of overhanging hinges, and a pair of book-holders must be obtained. The two 1½-in. pieces have three rivet

holes bored in each, and are 14½ in. long; the 1½-in. piece is the same length, and is screwed by its edge to one of the 1¼-in. pieces, while in the other edge the book-holders are screwed; the three ½-in. pieces are 12 in. long, and have a rivet hole at each end; these three are riveted, one end to the top of the desk and the other to the bottom. One flap of each overhanging hinge is screwed on the top edge of the top door and let in the wood so as to be flush; the other flap is screwed to the back of the top piece of the desk. Sconces or candle holders, if required, can be obtained, and a great number of ornamental designs is available.

The finishing will not be complete until all the following have been attended to. Take out the keys and place them on the bench. Take a thin piece of wood about 1 in. wide, and wrap round it a piece of fine glasspaper, and rub over the wood of the keys behind the ivory or sharp, cleaning one at a time. Brush off the dust, and remove any dust from the key bottoms. Between the balance and front rails fit a piece of thin wood to prevent the light being seen through the spaces of the keys. Where the ends of the sharps were cut off, black with ink about 1 in. wide; also black the lower part of the sharp from this line. While the keys are out, take off the damper rail carefully, and by moving each hammer to the string, see that each hammer strikes it fair; if the shank has cast to one side or the other, as shanks do sometimes, it can be altered by warming an old file, or flat piece of steel, and holding it to shank at the side to which it is desired to bend it. (A special tool for this purpose is illustrated by Fig. 55, p. 108.) Now see that the bridles or tapes of the action are properly adjusted; put one finger under the lever and raise lightly, and there ought to be $\frac{1}{16}$ in. play between the top of the fly and the hammer butt; if there is not, make it so by bending the bridle stay either backwards or forwards. Take out the action and put the keys back in their place. Take each key separately and see that

it works free; if it does not, ease it with a file, but do not make it loose; if it is a trifle loose, tap it gently with a hammer over the hole and this will tighten it. Having done this, put the action in its place and see if there are any regulating screws which need turning up, as in the finishing. Look over the keys and see that they are straight when tested with a straight-edge; tap on the keys with the straight-edge, and the high ones will move; take a shaving off these, and make the low ones level with tissue paper. The spaces of the keys must now be adjusted.

The action is now regulated or set off. In this action it will be found that there is, through the fly of the hopper, a wire with a button on the end; as the key is depressed, this button rests on the slide rail, this being on the bevel; as it rises, the fly is pushed forward from under the hammer, allowing the hammer to fall into check. This is accomplished in the following manner. As the hammer moves towards the string, the check follows it, and when the hammer falls the check is there to receive it, holding it firmly by the check arm. Make a hook for turning the wire that has the escapement button (for a special tool see Fig. 57, p. 109). Beginning with the first note in the treble, press the key gently down and watch the hammer; by turning the escapement button to the left, the hammer will bump against the string; therefore it damps the tone, or causes blocking, as it is called. On turning the escapement to the right, the hammer escapes from the string; the check allows the hammer to fall the requisite distance from the string. Allow the hammer to go up to the string within $\frac{1}{16}$ in., and allow it to fall, after it has struck the string, about $\frac{3}{8}$ in. Regulate the check, to catch the hammer at this distance, by bending it forward or backward. When the key has taken the hammer to the string, it ought to rest on the front baize; if it does not the touch is a little deep, and that means loss of power; remedy this by placing a piece of brown paper under the baize.

If the touch is too shallow, and the key does not carry the hammer far enough, strike the baize with a hammer to compress it, so that the key carries the hammer further. Regulate every note in this way.

The damper rail should now be put in its place and made to work without noise. Put the foot on the right or loud pedal and press it down, so that it removes the dampers clear off the strings; put a small block under the front of the rocker to prevent it going down further than is necessary; glue a piece of cloth on the top, and glue the bottom to the bottom board of the case. Serve the celeste, or left pedal, in the same way, so that when the foot is pressed on the pedal, the hammer strikes the felt or flannel; stop this also with a block.

The tuning of the piano is the next operation, and it is one of such importance that a special chapter will be devoted to it (see pp. 91 to 103). The piano will be ready for use when one other matter has been attended to; this is the toning, by which the inequalities of the tone are made more equal. One note, if the felt on the hammer is too hard, may sound like a tin kettle, while another may seem much softer; to remedy this, prick the felt at the point of the hammer with a sharp needle, or with two or three needles held in a piece of wood (see p. 111); this softens the tone. The extreme treble should sound bright, or brilliant as it is termed, and this can be accomplished by passing a warm flat iron over the points of the hammers, first trying the heat of the iron on a piece of paper, so as not to burn the felt.

This concludes the description of the construction of a wood-frame piano.

The above instructions may be modified to a slight extent to enable an iron frame to be inserted, especially if T. H. Hutchinson's or one of Grassélt & Rhauss' complete iron frames, sound-board and back, ready strung up, be used. Hutchinson's iron frame extends from the bottom (floor) side to the top of the wrest plank instead of the bottom, and has no upright bars

or divisions to form an awkward break in the scale which would necessitate an action adaptable to each separate make of iron frame. But apart from these considerations, the more satisfactory plan to adopt would be to buy the parts already built up; thus the iron frame might be bought fixed into the back already strung up, together with a suitable set of keys and action. This would mean that a case only would have to be built in which to fix them.

With regard to converting an ordinary wooden frame piano into an up-to-date overstrung iron frame instrument, great difficulty will be experienced in obtaining an iron frame, the setting of the pins of which will accord with the wrest or tuning pins. The frame would most probably have to be specially made, or, as an alternative, a new wrest plank would have to be inserted. The majority of iron frames are furnished with at least two tension bars which cause an awkward break in the setting of the pins, and are also set out for full trichord, whereas most old-style instruments have only about twelve notes trichord. This will render it necessary also to obtain an action and another set of keys so arranged as to accord with the break caused by the tension bars. Overstrung instruments have the wire arranged from corner to corner, that is, the bass or covered wires at the top or tuning end are at the extreme left, whilst at the bottom they are at the extreme right, thus giving greater length. The steel wires are arranged in the reverse position underneath the covered strings, an arrangement that necessitates the employment of a most expensive and intricate action, the hammers of which are arranged on the bias to accord with the crossing of the strings. The use of Grasselt & Rhauss' complete iron frames, soundboard and back, ready strung up, does away with any difficulty about the scale, setting out, stress and strain, position of and setting out of bridges, and many other complications. As already suggested, such a back could be readily fixed in any style of case.

If, however, a frame other than the Grasselt & Rhauss or the T. H. Hutchinson is obtained, the following information with regard to the construction of a modern iron frame full trichord piano will be of service.

In setting out the scale and position of the bridges, due regard must be taken of the class of frame that is being used. Some complete iron frames have the top bridge cast on, the bridge pins being done away with; the wires are kept in position by pressure bars. Other frames have a pressure bar for steel wires only, the covered ones being passed through holes or projecting studs. There may also be one or two tension bars, which necessitate a troublesome break in the scale and the use of an action and keyboard splayed out to clear these bars. In the case of three-quarter iron frames on which the wrest plank merely takes a bearing, the setting out follows the routine of wood frame instruments, the bottom edge of the wrest plank being taken as the strike line and the plank divided into spaces. Taking an instrument set out from A to A, seven octaves, the first note (A) is $2\frac{1}{2}$ in. from the treble end on the strike line, the first C is $7\frac{3}{8}$ in., the second C $13\frac{3}{4}$ in., the third C $20\frac{1}{8}$ in., the fourth C $26\frac{1}{2}$ in., the fifth C 33 in., the sixth C $39\frac{3}{8}$ in., and the last note (A) is $47\frac{1}{2}$ in.

To determine the shape of the top bridge, the spaces indicated above should be clearly defined by marking down to the bottom of the plank, still taking the strike line as the basis. The bottom edge of the bridge at the first note (A) runs level with the bottom edge of the plank; at the first C it rises $\frac{3}{16}$ in.; at second C, $\frac{3}{8}$ in.; third C, 1 in.; fourth C, $2\frac{1}{4}$ in.; fifth C, $3\frac{7}{8}$ in.; sixth C, $4\frac{3}{4}$ in.; and the last A, $5\frac{1}{2}$ in.

The distances that determine the shape of the sound-board bridges are also taken from the strike line, with the difference that whereas the plank bridges are given as at the bottom edge, the sound-board bridges must be placed below the line. For the long bridge at A the

distance is 2¼ in.; first C, 3⅛ in.; second C, 5⅛ in.; third C, 10½ in.; fourth C, 19¼ in.; fifth C, 28½ in. The next note (B) will be on the short bridge; this should be 25½ in., then A 30½ in. The short bridge about 15½ in. long is perfectly straight in its length.

The music wire gauges for an instrument set out as just described are as follows: ten notes of No. 14, six notes of No. 15, six notes of No. 16, twenty-one notes of No. 17, three notes of No. 18, two notes of No. 19, two notes of No. 20, and one note of No. 21. The weight of the covered strings would be about 4 lb. It will thus be seen that the instrument is strung partly trichord only. In the event of full trichord a variation in the sizes will be necessary; it is assumed that a Molyneaux action will be used. The theory of stringing may be recapitulated:—Starting from the treble, so far as the steel wires are concerned, each octave should double its length, but though the principle was more workable in practice with old-fashioned grands, in modern cottage pianos it is quite out of the question, and the object in view must be gained by using wire of various thicknesses. It will thus be seen that the greater the variation of the contour of the whole frame and the setting of the pins in the wrest plank, the greater must be the graduation of the sizes of wires—sometimes to such an extent that half sizes must be used. Application should be made to the ironfounder or music smith supplying the frames to furnish a copy of the scale and sizes most suitable to withstand the strain to which the frames will be subject.

High-grade finished iron frames are got up by japanning, for which purpose a japanner's stove or oven is required. The necessary groundwork materials and varnishes are seldom made by the user, but are procured through a varnish maker. The iron frames are primed with a mixture of copal varnish and zinc or flake white, each coat being smoothed down, the first and second coats with glasspaper, and the succeeding coats by pumice powder and water. When the groundwork is perfectly

smooth, it is bronzed, then varnished. The varnished surface being subjected to heat for some hours at a temperature of from 250° to 300° F. causes the gums, resins, etc., of which the varnish is composed, to liquefy; the solvent evaporates, and the gummy residue adapts itself to all inequalities. If the body of varnish is sufficiently dense, the result will be a uniform and glossy surface. Six or more successive coatings may be necessary before a high-grade finish is obtained: the varnish used after bronzing must be perfectly clear. In the majority of cases, the surface gained by heat will suffice. In special cases, however, the portions most exposed to view—that is, around the wrest plank—are sometimes finished by rottenstone and chamois leathers. The requisite heat and length of exposure vary slightly with the quality of materials used, and must be ascertained by experience.

To bronze the cast iron frame of a piano it will be necessary to first fill up the minute holes that are frequently found in cast iron. To do this, mix whiting with patent size and give the frames a few coats, allowing it to dry after each coat, and rubbing level with glass-paper until there is a smooth surface. Now give a coat of japanners' gold size, and when nearly dry, but still tacky, take a piece of wadding, and dip well into some bronze powder, then dab it over the frame until it is covered. When all is dry, coat with parchment size. Gold bronze mixed with gold paint medium could be used if desired.

Gold name transfers are fixed to a pianoforte in a very simple manner. To ensure that the transfer shall be fixed in its proper position the paper should be held up in a strong light and tally marks made at its chief points and corresponding marks on the portion to be decorated. Lay the transfer on a sheet of newspaper and give the face of the design a thin even coat of spirit varnish; coat the whole of the paper with the varnish and do not cut in around the design. Allow it to lie a few seconds till the varnish becomes tacky or sticky, and

then place the design (face downwards) where desired and press it down well so that all parts adhere. A rubber roller (squeegee), as used by photographers, will be very useful for large names. After allowing an interval of at least five minutes, damp the back of the paper with a moist sponge, using warm clean water, and press down again. Then allow the paper to soak in water a few minutes, when it should glide off, leaving the design on the place desired. Take up all surplus moisture by gently dabbing with a clean moist washleather, and then set aside for several hours in a warm place. On walnut and rosewood goods the ordinary brown spirit varnish will suffice; on black goods, varnish made from bleached shellac, also white polish for finishing off, is advised. The white film left behind as the name is fixed is of no account; wiping over with raw linseed oil will restore the colour, and as the names are polished over, the film of varnish used as a fixative will gradually merge into the polish.

CHAPTER III.

THE PURCHASE AND CHOICE OF A PIANO.

In the selection of a piano the question of primary importance is undoubtedly its cost, because upon this largely depends its probable durability, and in a lesser degree its tone and touch. A really good instrument cannot be made to sell at prices ranging from £10 to £15, even though many thousands of showy foreign instruments are imported into England, and sold at these prices; but how often do these instruments prove to be worthless! Scarcely in any particular do they withstand the wear of even a few years; and from the nature of the wood employed in their manufacture, many evils arise which are invariably a cause of perpetual trouble.

To persons of limited means, the "three years' system" of purchase offers undoubted advantages, inasmuch as they are often enabled thereby to secure really good instruments. In some cases, also, advantageous terms may often be made with the manufacturer or his agent, where the buyer is agreeable to deposit half the value at the time of purchase. Either of the methods spoken of—though, perhaps, entailing slight extra expense—is infinitely preferable to buying one of the cheap and nasty instruments previously described.

Throughout the musical profession, pianos of English build are regarded as the most thoroughly reliable, both in strength and beauty of tone; tuners also, whose judgment may be rated as the best by reason of their wide experience in all varieties of manufacture, are unanimous in the opinion that in these qualities they remain unapproached. For sweetness and breadth of tone, combined with truly wonderful durability, a Brinsmead, Broadwood, or a Collard

may be said to be unrivalled. These, and a few other old-established firms, stand pre-eminently first among manufacturers. It cannot be denied, however, that they have serious competition to contend with in the cheap and highly polished pianos sent from Ger many. In some cases, these instruments are sold at prices which, doubtless owing to their apparent perfection, seem to command a ready sale. Albeit, when the question of durability is considered, the difference of a few pounds at the time of purchasing should never for a moment be allowed to weigh with the buyer; he may be sure of acquiring a thoroughly reliable, if not a showy, instrument in one of English manufacture. If a foreign piano must be bought, let it be of a firm having a sound reputation at stake, such as Rud, Ibach, Steinway, Erard, Bechstein, Neumeyer, Blüthner, R. Lipp & Sons, or Pleyel Woolf & Co., though it must be admitted that the prices charged by these makers are somewhat high. Generally considered, a good serviceable piano should be got from £30 or £35 to £70.

With regard to the choice of woods, either walnut or rosewood is preferable to black or ebonised wood, seeing that the latter is apt to become scratched, and is more easily disfigured than the former; though ebonised pianos, while unsoiled, are unquestionably handsome in appearance, especially when decorated with gold or pretty marqueterie. For concert purposes, nothing better could possibly be selected than the transposing pianos made by Messrs. Brinsmead and by G. Russell. With the aid of this clever device, the singer has a choice of three keys. In many of the modern pianos, *pianissimo* effects are obtained by what is known as "half blow" of the hammers; this is a decided improvement upon the old method, and should therefore be looked for. In the matter of touch, probably Messrs. Broadwood have no rivals.

A piano built by any of the makers mentioned, or by Chappell & Co., Hopkinson, Challen & Sons, Cramer, Moore & Moore, whose names form but a few

among the many manufacturers of repute, may be safely purchased, providing it can be ascertained beyond doubt that the wear it has undergone has been merely sufficient to destroy any stiffness in touch it may have once possessed; or that its original condition and purity of tone have not suffered from long or violent usage. Great caution must be exercised in purchasing so called second-hand instruments which, while ostensibly by an eminent maker, have in reality been put together as cheaply and showily as modern skill can suggest, in order to deceive the inexperienced. The persons who manufacture these pianos fraudulently attach some well-known name to them, and place them in the hands of a stationer, tobacconist, or some other tradesman, who, for an agreed sum, disposes of the instruments to unwary buyers. The manner of advertising forms not the least important branch of the system of fraud, and the advertisements can often be detected by the frequency with which they emanate from one address. Usually it is a "widow in difficulties," or "a gentleman going abroad," who is "reluctantly compelled to sell a magnificent seventy-guinea walnut trichord cottage piano, new this year, and in faultless condition."

Almost as much risk attends the buying of pianos at sales by auction. Pianofortes are as often as not placed in sale-rooms because of some defect, or are purposely manufactured for periodical sales at these places, and sold as unsoiled though second-hand instruments. They have invariably attached to them a label bearing some high-sounding German name so like one of the leading manufacturers that it is almost sure to be mistaken by a hasty buyer. Nevertheless, it would be wrong to suppose that good instruments are never sold at auction sales or by advertising from private houses; bargains are certainly obtainable in these ways, but before deciding upon an instrument which appears to be satisfactory in all respects, the purchaser should, if possible, engage the services of a

practical tuner or someone having a thorough knowledge of the construction of pianofortes. For a comparatively small consideration he will probably save the purchaser many pounds. If an "out-door" tuner employed by an established pianoforte dealer is engaged, he may be relied upon to judge accurately the value of any instrument he might be called upon to view. His experience will enable him to make thorough examination of the action, also to ascertain the rigidity of the keys, condition of the felt covering the hammers, condition of the ivory or celluloid surface of the keys, and many other matters of equal importance.

Regarding the practice of fraudulently attaching some prominent maker's name to pianos of an inferior order, it should be said that heavy penalties being now strictly imposed where discovery is made, the trick has given way in a great measure to one of far less danger to the buyer, and likely to mislead only the careless. The later method is that of placing the name of the maker in such small letters as to be scarcely perceptible, followed by the word "from," and then the name of some great firm in very large letters.

The chief characteristics of a good piano, besides standing well in tune and being in an attractive-looking case, are that the strings should vibrate freely or be checked as required, with no dull, tubby sound asserting itself anywhere. It should have a clear, ringing, sympathetic tone; the keys should respond to the slightest touch, yet with such firmness and elasticity that a heavy-handed player need not fear lest he should put the piano out of tune the first time he plays on it. An instrument kept always in this state is greatly appreciated by pianists.

The difference between English and German makes of pianos cannot well be gauged unless instruments of a similar class and price are compared, for the fact remains that in German- as in English-made goods, if a first-class instrument is desired, a high price must be paid for it. The Germans are ahead of the English in

the finish of their goods, both interior and exterior; however, in cheap German pianos a thin sound-board is used which gives out a clear tone at first, but afterwards loses it; also the keys turn a bad colour, and the polish, beautifully level and bright when new, soon vanishes. Therefore it is fair to say that in the cheaper and medium-priced goods—say up to £30 each—a reliable English maker's goods are the best.

Three steel wires to each note is the rule in all up-to-date instruments.

As the vibration of the strings is greatest on those of the greater length, the checking is only necessary on these. The short steel wires forming the extreme treble are required sharp and crisp, consequently the damping or checking arrangement should extend only over about five and a half octaves from the bottom or bass end. If reference is made to Figs. 23 and 24 (pp. 56 and 57), the difference between a sticker or common action and the check action will be the more readily understood. The latter engages with the hammer immediately a blow is struck, thus rendering it beautifully responsive to the touch; so that in a really first-class action, carefully regulated in all its details, one has a feeling that he could go on playing nearly all day without much effort, whereas with the sticker, or even a badly regulated check, the feeling may be just the reverse.

The brass pin-plate is a questionable advantage except for appearance' sake; the nickelled bolts may or may not serve a useful purpose. The pin-plate is apt to buckle up, work loose, and so cause a jarring noise; it may also hide a defective plank; in any case, it hides a split should the plank give way at any time. If the bolts are situated at the extreme top, they rarely have much bite; screws distributed about the plank are more effective, unless the bolts are used to secure a complete iron frame in position.

Cottage and upright iron grand pianos are practically the same. As a rule, the latter appellation is given to instruments of "up-to-date" manufacture—

that is, iron frame, check action, and full trichord. Beyond this the name signifies nothing.

Owing to the growing scarcity of ivory, celluloid is commonly used for keys; it makes a very good substitute, the best qualities wearing and keeping colour well. In a seven-octavo piano the difference in price is at least thirty shillings less for celluloid.

The French or tape action is a good quality of check action—a great improvement on sticker actions. Though in appearance very complicated, it wears well and has a good blow and fair repetition, and when well finished is very sensitive, the softest chords being given out as well as the loud ones.

Machine-covered hammers are generally more heavily felted. The pinning is merely a device to prevent the ends lifting up should the glue fail to hold. In addition to this, the felt is more tightly stretched than would be possible by hand.

In some pianos the soft effect is gained by means of a shifting hammer-rail, which moves to the right when the left-foot pedal is depressed; the hammer then only strikes two instead of three wires. Other pianos have an arrangement for bringing the whole of the hammers nearer the wires, thus giving the hammer a shorter blow; but in the majority of the cheaper class of modern pianos the celeste is used—that is, a strip of very soft felt is so arranged that, when required, it can be brought by means of the left foot within the striking line of the hammers. Thus the felt stands between the hammer and wires and muffles the tone.

The silencing stop is a contrivance, sometimes called the "sordine stop," by means of which the celeste may be operated by the aid of a knob working on the block at the extreme treble end; it has the advantage of keeping the celeste down till such time as the knob is drawn forward again. It is a cheap, simple contrivance by whose means the piano is at once rendered more quiet in tone without in any way interfering

with the touch ; and the cost of renewal of the felt is but a few pence. It embodies the principle of harp-foot pedals, which, on being pressed down, may be kept in position by giving a slight pressure sideways, when the pedal will lock itself in a notch. This arrangement in either form is not common on English-made pianos.

A piano is said to be overstrung when the wires are stretched from corner to corner instead of vertical, with the idea of getting a longer range of wires. This in all cases necessitates an iron frame. The steel wires cross in one direction, and the copper-covered ones cross in another. This transverse stringing renders necessary the use of an action in which the hammer heads are set on the bias, and in a few instances a small portion of the felt is skived away from one side of the hammer head in order that it may have sufficient clearance to pass its fellow. Such actions are complicated, and expensive to renovate when out of order ; but if of a good make there should be no difference as regards touch by comparison with those in instruments vertically strung.

CHAPTER IV.

CARE, MAINTENANCE, AND CLEANING.

To the fortunate possessor of a good instrument, the importance of knowing how to take care of it cannot be over-estimated. How often is a brilliant-toned and expensive piano placed thoughtlessly between a door and a window, or in some other direct line of draught, such as from fireplace to door or window! It is almost impossible to keep the piano in perfect tune under these conditions.

The first essential is a naturally dry room. For this reason ground floors are unsuitable, unless the foundation of the house be such as not to cause any trouble from dampness. A few sticky or weak-sounding notes are sometimes an indication of prevailing humidity of atmosphere, and not a few pianos have been rendered almost dumb through constant exposure to its effects. Endless indeed are the evils arising from dampness; therefore every effort should be made to avoid it. The most highly seasoned wood is scarcely impervious to damp atmosphere; in truth, it may be said to absorb moisture by reason of its extreme dryness.

A common mistake is to place the pianoforte close against a wall. The importance of keeping it in a fairly even temperature (60° Fahrenheit) is sufficiently demonstrated by the fact that in some instruments the enormous strain of thirty tons is reached when the strings are at full tension. When a piano is destined to remain upon a ground floor known to be slightly damp, matters may be improved by taking advantage of every dry and sunny day to open all convenient parts, especially after a continuance of wet weather.

Jarrings or noises are the result of so many little accidents, to say nothing of carelessness, that it may be well to point out a few possible causes. Frequently such substances as crumbs of cake, pins, and small particles of biscuits find their way on to the sounding-board of a grand piano, occasioning exceedingly unpleasant noises. Jarrings sometimes appear to defy all efforts to ascertain their origin, and are only discoverable by persons experienced in similar difficulties.

A disagreeable rattle in an upright piano has been known to be caused by two loose screws in the brass plates covering the hand holes at the back of the instrument. With the tightening of these screws the noise disappeared. Jarrings will sometimes arise in an upright pianoforte from the fact of the fall, or lid which covers the keys, vibrating against the front. In order to avoid this, it is necessary sometimes to place between the two a soft thin pad, made of a silky piece of cloth, to prevent injury to the polish. Loose candle brackets, and china ornaments placed upon the top of the instrument, are also frequently contributive to trouble from noises. The former cause is occasionally obviated by the use of a little piece of indiarubber.

The placing of ornaments on the top of a piano is not only productive of jarring, but causes a deadened tone; heavy weights of any kind, such as books, have the same tendency. Another cause of deadened tone is the placing of the piano upon a thickly carpeted floor, or upon carpet having a layer of felt beneath it. Great disappointment and astonishment are, from this cause, often experienced by the purchaser of an expensive instrument; having, perhaps, heard it in the maker's showroom and considered the tone to be highly satisfactory, he finds that, when tried in his own drawing-room, its beauty of tone has disappeared. In some instances brilliancy seems to have entirely departed, leaving in its stead a dulness of

sound truly depressing to the sensitive musical ear. The primary reason may be sought for in the carpeted floor, or in the fact that the room is too heavily curtained. Again, some drawing-rooms are built in such a manner that the most perfect acoustical properties are not secured. This is an important point, and, in justice to the pianoforte manufacturer, should be borne in mind.

Not infrequently an irritating sound is heard in one particular part of the room whenever certain notes are struck on the piano. Glass vases and metal ornaments, often on the mantelpiece, are commonly the cause of such sympathetic vibrations; so also are gas-globes, fire-brasses, and the like. If any of the articles mentioned are struck, corresponding sounds can be faintly heard in the pianoforte, though its keys remain untouched, thus affording a further proof of the great existing sympathy. It may happen that when certain notes are struck the vibrations may run down to one of the castors, thence along the floor board, and may act on a table, a leg of which may be resting on that particular board. Should there be a lamp on the table, the glass globes of which do not fit tightly, there is set up communication between those loose articles and the wires that are being struck; similarly the vibrations may act on a vase on the mantel, a loose gas globe, or even a chattering door knob. When the trouble recurs, note any strange article or ornament not in its accustomed place; or moving the instrument only a few inches will ofttimes suffice.

The tone of a piano is not improved by supporting the instrument on a wooden platform, although this will prevent the damp striking up. However, damp can be avoided by tacking a piece of felt or floorcloth on the bottom of the instrument in such a manner as will let the pedals have free play; then stand the instrument on insulators, thus allowing a current of air to pass underneath.

In seeming contradiction to what has been already stated, a piano stood upon a hollow box will have its tone improved; in fact, this is the principle of Schreiber's Independent Patent Resonator—a shaped platform, made up in similar woods to the piano, the foot pedals being made readily accessible by means of a central portion about 9 in. wide, which slides out, and on which the feet may rest whilst playing. Good dry pine, about ⅛ in. thick, should be used, strips on edge inside forming supports and dividing the box into channels. At the end of each channel a soundhole should be bored, either round, or ornamental as in the front of violins. Some further hints of service in this connection are given in Chapter V.

The owner of an expensive and highly finished instrument is naturally anxious to preserve the brilliancy of its polish as long as possible; and more often than not, from want of timely advice, adopts very bad methods in his efforts to do so. It is not advisable for the inexperienced worker to attempt the restoration of polish which has been injured through liquid of any kind having been upset and allowed to remain upon it; instead, procure the services of an experienced polisher. Usually the polish of pianofortes, especially what is known as dull polish, merely requires to be rubbed vigorously with a soft dry cloth, to restore its beauty. Care should, however, be taken lest any grit or anything likely to scratch the surface finds its way beneath the polishing cloth. A little turpentine on linen may be used with good effect upon wax-polished instruments, providing it is followed by a good rubbing with a soft dry cloth. Do not use furniture polish; and do not place anything hot upon the surface of the piano, or the polish will become blistered as a consequence. To brighten gold incised work which has become tarnished after years of neglect, a soft brush and a little warm water are often all the necessary requirements.

One of the chief causes of discoloration of the keys

is the habit of leaving the lid or "fall" open constantly during wet weather, and so exposing the keys to damp. Another cause is cleaning them with rags steeped in milk, which is wrongly considered by many persons to be the correct method. Discoloration is also frequently the result of never exposing the keys to a strong light, and walnut falls are particularly apt to cause it if they are seldom opened.

All that is required, in order to clean the keys properly, is a soft white cloth slightly damped with water only; after the application of this the keys may be rubbed with the dry portion of the cloth. A little spirits of wine is recommended as an addition to the water where the keys have become sticky from contact with perspiring fingers. The use of soap or any kind of washing powder, in the process of cleaning the keys, cannot be too strongly deprecated; and under no circumstances should it be possible for either beer, wine, oil, wax, or ink to drop upon them. The last-named will almost instantly stain the ivory, and the stain invariably resists all efforts made to remove it.

A piano, like a watch or a piece of household furniture, may be improved in appearance, if not in quality, by an occasional cleaning, if only to free it from dust which will accumulate under the very best of conditions.

After taking the instrument apart (see the chapter on repairing actions, pp. 112 to 126), one of the first things to ascertain is the condition of the coils. These are those portions of the wires coiled around the wrest pins (tuning pins), which show so uniform and meet the eye directly the instrument is opened at the top. Should these show signs of rust it is an indication of damp at some period of the piano's life, and they may be cleaned as when new, after taking out the action, by rubbing briskly with a strip of leather and emery powder. But, in order to keep the leather in its place, some assistance will be required. In a general way the tuning hammer will suffice, this being placed on the pin as for tuning (see Fig. 31); it is kept in its place by pressing the chest

against it. The strip of leather, a piece of calf leather about 18 in. long and ⅜ in. wide, of a thickness and quality as used for workmen's bootlaces, is placed over the coils, an up-and-down motion being imparted by holding one end in each hand, the tuning hammer meanwhile preventing its slipping off.

Though a tuning hammer may be used, it is by no means the best, owing to the shortness of the shank compelling a tall person to stoop more than is pleasant, a fault which may be remedied to a great extent by

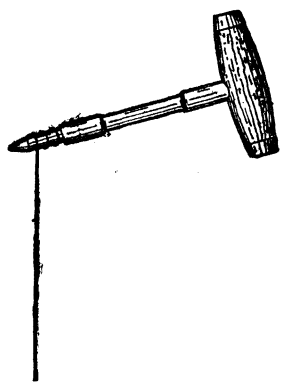

Fig. 31.—Holding Pin whilst Cleaning Coil.

utilising the shank of an old tuning hammer; by taking off the handle one shank may be fitted into the other, thus lengthening it by 4 in. or 6 in. A simple and more effective tool for the purpose is shown in Fig. 32; and it is made out of a piece of ¾-in. dowel rod, about 15 in. long, tapered at one end after a ⅜-in. hole has been bored up the centre about 1 in., and a ¾-in. No. 6 screw turned in at the bottom. This may be slacked out to suit the varying lengths of the pins as required; the other end of the rod may have a knob similar to those on a boring brace; a wood door knob has thus rendered good service.

Emery has been mentioned as the cleansing agent; a little flour emery and an equal bulk of a coarser grade are mixed together with paraffin oil. Other oils will do, but in the use of these care should be taken that they do not get near the wrest pin at the point where it enters the wood, thus rendering the pin liable to slip. For that reason only as much oil should be used as will bind the emery together. The strip of leather—the portion that passes over the coils—should be pressed on this mixture as occasion requires; it will take up sufficient at one time to clean several pins.

So far only the top side of the coils has been dealt

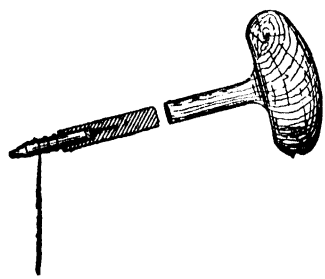

Fig. 32.—Holding Pin with Piece of Dowel Rod.

with, and, in the majority of cases, it is the only portion thus treated, but, in the best class of goods, the underside should be similarly treated; the subsequent tuning of the instrument, with its consequent stretching of the wires, would cause a rusty portion again to show on the top. To enable the underside to be cleaned it is necessary to remove the instrument away from the wall and lower it backwards, the top resting on a box about 18 in. high. Whilst in this position it is also a favourable opportunity for cleaning the steel wires; this is generally done by means of fine emery cloth or glass-paper, though the better plan is to use a piece of thick leather and the emery mixture. The dirt should be

brushed out of the copper covering of the other wires by means of a hard brush only.

In cleaning a piano action, first remove all dust from it. Then unscrew the hammer rail, take off a thin shaving, and finish off with glasspaper; also do the sight face of the standards. The damper rail should be similarly treated—that is, if it is not already polished; in that case cleaning with soap-powder water will suffice. If the action is of the check type, the damper wires may now be lifted from their sockets and cleaned up with fine emery cloth, or bath brick and turps. The felt of the hammers may be cleaned by rubbing with dry pipeclay and well brushing it out again; a common nail-brush will answer the purpose.

The action having been replaced in position, it only remains before blacking the pins to tune the instrument —a rather necessary proceeding, because the cleaning of the coils sometimes disturbs the "set" of the pins. After the tuning, remove the action and coat the pins, using a small camel-hair pencil. The black may be thin Brunswick, though a spirit black enamel is probably better. Cycle enamel can be recommended. Care should be taken to keep it off the coils just cleaned. Whilst the black is in hand, do not forget to touch up any boltheads or other ironwork that may require it.

This completes the work, unless the brasswork, pedal bosses, hinges, and sconces are to be renovated; but these are generally left to be dealt with when the polishing and renovation of the exterior is done. Defects may at the same time be dealt with by following out the directions given in the chapters on repairing pianos (see pp. 112 to 142).

CHAPTER V.

TUNING PIANOS.

THOSE who wish to become pianoforte tuners are advised either to gain a factory experience or to place themselves under the tuition of an outdoor tuner with a fair connection; they will thus have a wider range of instruments on which to practise. In the one case the beginner will have a number of instruments newly strung up, and in the second case he may meet with some that require several new wires or a complete set, and perhaps a few that are much below pitch and require "pulling up." For newly-strung instruments, or those much below pitch, the preliminary stage is "chipping up" (see p. 35)—that is, the action is dispensed with, the wires being plucked instead with a piece of bone or ivory, the wires meanwhile being tightened till they all sound fairly well in tune. The action may then be put in, and the scale or bearings laid. This means that in an instrument of full compass (seven octaves) the keyboard is divided into seven groups of twelve notes—seven white keys and five black ones. The middle group is taken as the model or foundation from which the others are tuned; the notes in this group are struck in chords of fourths and fifths, the middle C being pulled up into perfect accord with a tuning fork, and the rest of the group being put into harmony by the aid of chords. The other groups are then put into accord by means of octaves. To do this satisfactorily with the minimum of trouble needs good tools—that is, one or more tuning hammers and several wedges.

The tuning hammers are furnished with holes to correspond with various styles of wrest pins; thus to be fully equipped the tuner should be provided with

at least one hammer for square pins (mostly in German pianos) and another for oblong pins (mostly in English pianos). Some tuning hammers are furnished with

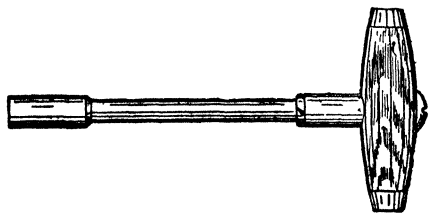

Fig. 33.—T-shaped Tuning Hammer.

holes of star shape, so that they can be used on both styles; but such a hammer should not be used constantly on one piano, as, not fitting the pins properly, it cuts the corners off.

The old-fashioned T-shaped hammers (Fig. 33) can be purchased cheap, but cannot be recommended. In the trade, those of English make bearing the imprint Reynolds on the barrel are looked upon as reliable; but the very best, furnished with detachable heads—adaptable for English and foreign pianos—are more costly. If T-hammers must be used, those with a stem about 7 in. long are advised; very stiff pins can then be easily moved. The short stem T-hammers are useful for turning the pins in square—commonly called table or grand—pianos.

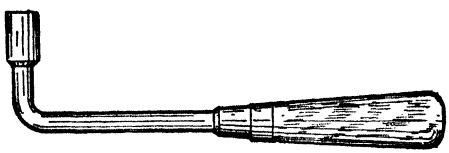

Fig. 34.—Crook Tuning Hammer.

Except for stringing and rough tuning the T-hammer is not much used, being supplanted by the crook hammer (Fig. 34), which often is furnished with a star-

shape hole. A combination tool (Fig. 35) with square- and oblong-shape holes is extremely useful, and is sometimes without the double head, the barrel and handle

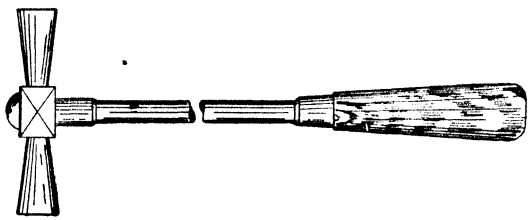

Fig. 35.—Double-headed Tuning Hammer.

being fixtures. The heads are either double- or single-screwed on to the stem, and can be further secured by a set-screw. These crooks may be used on cottage or grand pianos, and enable the tuner readily to turn the pins at the extreme ends of the wrest plank, which is often impossible with a short-stem T-hammer.

For the convenience of stowing in a tuner's kit, a good T-hammer may be procured with detachable handles, which allow a stem of either shape to be used; also, the handle may be used as a screwdriver, a suitable bit being included in most kits.

The wedges (Figs. 36 and 37) are tools used to stop the vibration of one string of the note whilst the other is tuned, the tool shown by Fig. 36 being used for upright pianos, and that shown by Fig. 37 for grand and square pianos. The latter tool is usually made from a piece of thick hammer felt, such as is used for covering the hammer-heads at the extreme left or

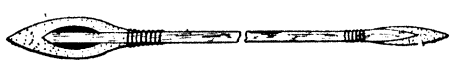

Fig. 36.—Wedge Used in Tuning Upright Pianos.

bass end. To make a wedge like Fig. 36, take a strip of rosewood, lancewood, or whalebone 7 in. long, $\frac{1}{8}$ in. thick, and $\frac{1}{4}$ in. wide, and taper the extreme ends

slightly; cover one end on both sides for about 1½ in. down with doeskin, securing it with good glue. Then taper off the bottom edges and bind them with strong thread or hemp to prevent them catching when pulling the wedge in and out of the action. The other end should be much thicker, consequently it requires a packing of cloth or felt and a stouter leather; for wearing qualities, calfskin from which leather boot-laces are cut is advised. In an upright piano the wedge is placed between the strings in a position in the action half-way between the hammers and first joints below. The whole thickness at the covered end of the wedge should not exceed ¼ in. A wedge for grand pianos may also be of this shape if specially desired, but it should not be more than 4 in. long and 1½ in. wide. In the case of upright pianos possessing

Fig. 37.—Wedge Used in Tuning Grand Pianos.

a celeste pedal, it is necessary before tuning to remove the action carefully, and then detach the wooden felt-lined rail, which is raised by pressure of the left pedal.

To use the wedge in a cottage piano furnished with over-dampers, if the operator wished to tune the note C he would put the wedge between the hammers that strike E and F at an angle so that it will reach C; as the tuning proceeds, keep moving the wedge always three or four notes in advance, to allow freedom to the hammer shank of the note being tuned. In further explanation, it may be said that when tuning the bichord parts, the wedge is pushed between two notes. This will damp two strings. Tune the two undamped, withdraw wedge, and tune in unison. The trichord is tuned by putting the thin end of the wedge between two strings. Tune the first one and withdraw the wedge; put it between two notes, tune the second, take out the

wedge and tune in unison. A little practice will enable the tuner to use the wedge rapidly. The method of using it is shown in Fig. 38, in which A denotes the hammer; B, thick end of wedge for tuning bichord; C, thin end of wedge for tuning trichord; D, strings of piano. A side view of the wedge is given in Fig. 38 to show how it can be made, but in use it is inserted the reverse way.

A tuning fork is another essential. With regard to pitch, it will be found that tuning forks vary;

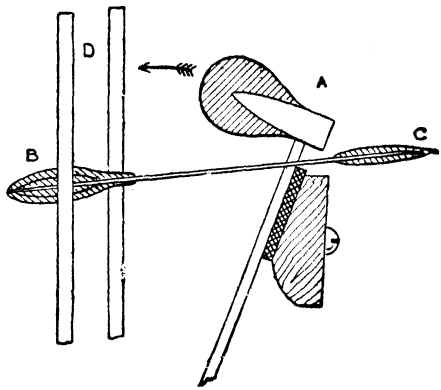

Fig. 38.—Use of Tuning Wedge.

the one now favoured by the prominent musical societies is called the "French Diapason Normal," and this will prove the most useful pitch for general use. In sounding the fork, it should never be struck upon hard substances, such as wood or iron, which have a damaging effect in course of time; the knee is considered to be a convenient object.

The workshop practice of tuning pianos allows them to pass through four stages: that is, chipping up, rough tuning, tuning, and fine tuning. By the first two stages juniors and apprentices get well grounded into the business. Some workmen tune by ear only, and

often they do it very well; others work according to a set principle that can be laid down in black and white. In either case there must be method; whilst laying the "scale," one note must follow another in sequence, though not in chromatic order. The tuner has to dodge about, octave to octave, a fourth below the note just tuned, or in a series of thirds, fourths, or fifths, as may be rendered necessary by the plan. The theory of the subject lies in the fact that, owing to the absence of notes to give out E♯ or B♯, there must of necessity be an unequal division of intervals.

A full compass piano contains eighty-five notes of steel and covered wires, divided into groups of seven octaves. In order to get these notes into tune with each other, the centre group is taken as a base, C natural being generally taken as a foundation note. In most cases this is tuned to accord with the sound given out by a tuning fork, and the C natural below is then brought into accord with this, the notes lying between being then brought into accord, and forming what is technically called the "scale" or "bearings," from which the rest of the notes on each side are tuned by octaves. By some methods of laying the scale, the base may extend a few notes beyond the space confined within these two C notes, and professional tuners may be eminently successful when working from a short scale, whilst another man may find it a decided advantage to work from a longer scale. It requires much practice and frequent testing, by means of trial chords, to enable the operator to get this base or scale truly laid; any error, however slight, will result in a running out as the extreme ends of the piano are approached.

The intervals that require special attention in tuning are the fourths, fifths, and octaves, whilst unisons also demand an accurate ear to determine their correctness. For two strings to be in perfect unison, there must be an absence of sound-waves, and so the strictest attention

must be given to them, absolute silence in every respect also being indispensable to their correct tuning. In training the ear to distinguish true unisons, first flatten one of the strings slightly by turning the hammer to the left. When the key is struck, this will instantly produce an exceedingly disagreeable effect, causing quick and irregular pulsations or beats. Now turn the hammer very slowly to the right and listen attentively to the gradually decreasing number of beats, until the steady striking of the key produces but one continuous tone, absolutely devoid of undulations or sound-waves, this constituting true unison or single sound.

Octaves are somewhat akin to unisons, in that when

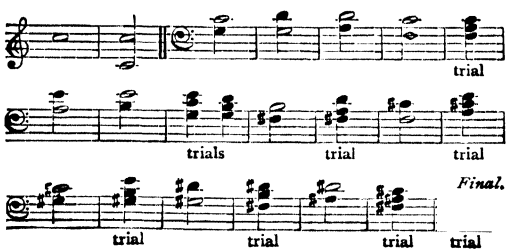

Fig. 39.—Scale of Tuning.

properly tuned there should be but one sound apparent to the listener. The true intonation of intervals of fourths and fifths, as required for pianoforte tuning, proves rather more difficult to distinguish. When struck simultaneously, two slow waves only should be heard, the keys being, of course, held down after striking. It should here be explained that if each successive fifth were tuned perfectly, starting from the octave below the middle C of the instrument, the E in the top space of the treble clef would be found too sharp to form a true major third from the C just below it—a fact which accounts for every note upon the instrument having to be tuned inaccurately. In a properly tuned pianoforte each fourth and fifth is equally im-

perfect; the imperfection must, however, be so slight that it is perceptible to no one but the tuner himself. Fourths and fifths have thus to be what is known as "tempered," in order to produce a good "scale" or

Fig. 40.- Striking Octaves.

"bearing," and all major thirds require to be just the least degree sharp. From the example given by Fig. 39, it will be seen that, in going down the keyboard towards the bass from the middle C, the fourths must be tuned a trifle flat, and the fifths sharp to an equal degree, the black notes having to be tuned one degree or wave flat, and the notes conveniently shaped thus: ◊ to be tuned one wave sharp.

The last trial chord will prove the crucial test, and when the lower note appears to be too flat, it will be an indication that the "tempering" has been unequal, necessitating a careful trial and correction of each chord throughout the bearing; then, if the octaves of every note above and below the given scale are tuned accurately, the work will be complete.

In tuning the octaves throughout the treble register, be careful to compare each note with its double octave

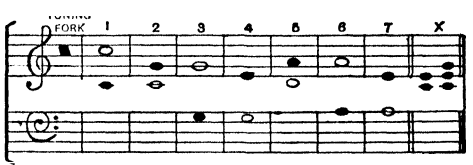

Fig. 41.—Test Notes or Trial Chords.

below. Similarly, compare all bass notes with their double octave above, the last mentioned being usually taken first and started from the F natural shown in the final trial chord. The best method of striking octaves

to ensure detection of any error is exemplified by Fig. 40. The same trial chords as those given on p. 97 may be used frequently during the process of octave tuning. In the operation of tuning the bass notes, no

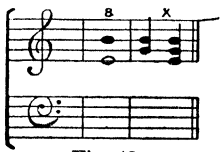

Fig. 42.

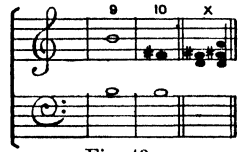

Fig. 43.

Figs. 42 and 43.—Test Notes or Trial Chords.

ttle difficulty will be experienced; indeed, many a rofessional tuner's work may be found faulty in this spect. One plan to render the task less trying onsists of first tuning every succeeding note in going own the scale up to the level of the next half tone bove it, unisons being easier to distinguish; the string then carefully lowered half a tone, and struck with s octave above, which together should sound as but ne. If the whole of the notes constituting the top ctave are tuned slightly sharp, it will effectually add to he brilliancy of the tuning. Strange as it may seem, top octave in perfect accordance with the rest of the nstrument has the peculiarity of sounding a trifle flat vhen played upon in the course of a piece employing

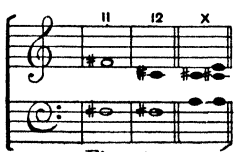

Fig. 44.

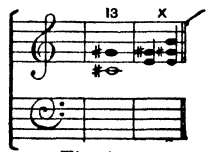

Fig. 45.

Figs. 44 and 45.—Test Notes or Trial Chords.

both ends of the keyboard. Avoid frequent turning of the pins, else the instrument will be less likely to remain in tune.

Many persons imagine that to play upon a pianoforte

immediately after it has been tuned is to upset some of the tuner's work. Ordinary playing can do no more harm then than at any other time. Certain atmospheric conditions are more likely to affect the work; therefore,

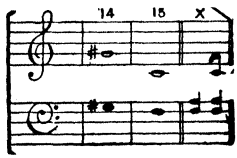

Fig. 46.—Test Notes or Trial Chords.

see that the piano is not exposed to a strong draught, or allowed to undergo extreme changes of temperature.

So as to present the system of tuning in a readily understood form to those conversant with Old Notation notes, the scheme of tuning by fifths and octaves is given here in music notes instead of letterpress. Figs. 41 to 49 present a series of test notes termed trial chords, indicated in particular by the letter x. Frequent use should be made of these chords till proficiency is acquired, when their use becomes natural and takes up very little time.

The principle of tuning is the same for both upright and grand pianos; for grands a T-hammer with a shorter

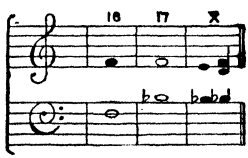

Fig. 47.—Test Notes or Trial Chords.

shank or a crook hammer is used, and the wedge is generally of a different shape, as already explained.

Possibly, when a piano has been carefully tuned, the tone will be found of very indifferent quality, and some means of improving it will be sought.

Many years ago the use of metal—iron or steel—was recommended as a means of improving the tone of a rather indifferent piano, and brass, German silver, and aluminium had been employed previously for a similar

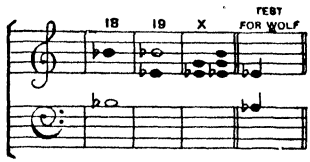

Fig. 48.—Test Notes or Trial Chords.

purpose on banjos. In the case of a piano with a weak treble, its owner was advised to fix a piece of sheet iron on the wrest plank underneath about four octaves of the wires forming the treble; this was to serve as a reflector or sound-wave collector and transmitter affixed in front of the sound-board (see Fig. 73, p. 141).

Messrs. S. and P. Erard's Resonator (Patent No. 20764—1894) consists of a sheet of thin steel pierced and stamped with a series of openings and depressions resembling table spoons, the bowl of each spoon having a small hole at or near the tip. This sheet is fixed to the back of the sound-board and to the bracings round the outer edge by means of a series of ears or lips left

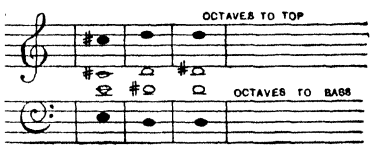

Fig. 49.—Test Notes or Trial Chords.

around the outer edge of the resonator and turned under, allowing round-headed screws to pass through a hole pierced in each lip and adjoining portion for the purpose.

It will be seen from this that only a very small

portion of the metal actually touches the woodwork of the piano, thus differing from the first method mentioned, where the metal was fixed firmly to the plank.

The bowls of the spoons referred to are so arranged that they come between the bracings and are pulled downwards towards the sound-board by means of catgut, one end passing through a screw-eye turned into the sound-board bars, the other end passing through the small hole in the tip of the spoon. These resonators are applicable both to grand and upright pianos, and in the case of the latter are hidden from view by means of the canvas backing. The average cost for fitting one to an upright piano is £5 5s. extra.

Ernst Kaps, Dresden, is the patentee of a "Reflectrophone" (Germany, D.R.P. No. 71243; England, Patent application No. 14326—1894) made of wood which differs from the Erard resonator, as it takes the form of an additional sound-board mounted in a framework of wood veneered with a choice wood to match the instrument to which it is affixed. The canvas backing being removed, the reflectrophone beds firmly against the back of the instrument. The framework supporting the extra sound-board fits flush with the sides and bottom, being carried about 6 in. higher at the top and finished off in an ornamental style forming a canopy and spindle gallery. The whole, when fixed, stands back from the piano about 3 in. Thus it will be seen the principle embodied in this invention is that of an instrument with two sound-boards standing from 6 in. to 7 in. apart. the sound waves passing out at the back through a strip of wire gauze skilfully hidden by the canopy and gallery. The average cost of this appliance for upright pianos is £7 extra.

The Schreiber Independent Patent Resonators vary from the others by taking the form of a hollow box or raised platform about 4 in. to 6 in. high, on which the piano is placed, the foot pedals being still readily accessible by means of a small sliding platform on which to rest the feet. The idea is apparently based on the principle

that most string instruments—violins, guitars, mandolines, and harps—owe their beauty and purity of tone to their strings being stretched across or affixed to a hollow chamber. The cost of this resonator is from two-and-a-half guineas to six guineas (see also p. 86).

To say that the Erard and Kaps resonators make the tone louder is hardly correct, for this is not what the makers aim at. They merely claim to add volume, and this they do in a very appreciable manner, especially when the instrument is at the mercy of a heavy-handed player, or when a skilful player is showing off his abilities in the concert room. The foregoing are given as what might justly be termed "mechanical aids"; but so far as the ordinary cottage piano—as found in the average artisan's home—is concerned, the gain to be derived from the use of such appliances is not considered to be worth the expenditure, though there is a wide field for experiment open to those possessed of an instrument indifferent in quality of tone.

When the tone of a piano proves disappointing, probably the best thing to do is to take the instrument apart, clean the rust off the wires, free it from dust, and keep books and ornaments off the top; try the instrument with the top door left out. Should the piano then sound louder and clearer, take the hint thus given and revert to the silk and fret instead of the pane. front, which, though "up to date" so far as appearances go, often gives a boxed-up or muffled tone.

CHAPTER VI.

PIANO-REPAIRERS' TOOLS.

A PIANOFORTE repairer, in addition to being a good tuner, should have some knowledge of mechanics and the use of ordinary bench tools as acquired in a cabinet-maker's workshop; he should also be a man of resource, so that if a difficulty crops up he may be able to overcome it in some way, for to tackle an instrument in a strange house with only such appliances as can be carried in a handbag is a very different matter from taking the same job in hand in a workshop fitted with a number of modern appliances.

In addition to the tools for tuning described in the preceding chapter, the workman should carry in his handbag for outdoor work a small iron thumb plane to take a shaving off keys, etc.; a pair of steel wire cutters; a pair of round-nose pliers, as eye twisters; a music wire gauge; a pocket-size lamp glue-pot, containing a small spirit-lamp (glue is useful for gluing-in hammer shanks or broken hinges); a key spacer; toning needles for pricking the hammer-head felts in order to soften the tone; a small screwdriver and a screwdriver bit of stout make, with a shank filed to fit into a tuning-hammer socket, useful for tightening up screws in wrest plank, etc.; a key file for easing guide-pin holes in keys; several coils of wire of various sizes; and an assortment of screws, panel pins, action buttons, and springs stowed away in a small wash-leather pouch, such as a cash bag, to prevent them getting frequently upset; a combination pad containing several sizes of bradawls, a gimlet, small chisel, and saw; a leather knife, with a sheath to protect the blade; a hammer shank bit to fit into the combination pad or tuning-hammer for replacing broken

hammer shanks; a few hammer shanks; and a piece of vellum for repairing a broken hinge. With these a start may be made, but other tools will suggest themselves as required, or with a knowledge of the prospective job some tools may be left at home.

A much wider range of tools will be required for workshop practice where constructive repairs are undertaken, such as making a new wrest plank; repairing sound-board; scraping and repolishing keys; re-stringing; re-covering hammer-heads with new felt; inserting new bottom plates and re-setting bent sides. The tools then necessary include a number of iron cramps with 14-in. or 16-in. jaws for wrest plank and bent-side work; planes, saws, and chisels for general woodwork repairs; and drill-stock and bow with various size bits for boring holes for wrest and bridge pins. For general bench use in regulating, etc., the following will be wanted:—Casting-tongs of iron or copper, which, when made hot in the gas flame, are used for straightening hammer-heads or shanks that may be twisted; punches for cloth and paper washers of various sizes; coil lifters; damper wire regulators; damper head setters; grand set off; hinge saws and hinge pusher; hopper turners; pin extractors for withdrawing broken wrest pins; set of letter punches with a "sharp" for marking a new wrest plank; stretching tool with brass wheel for running down the wires of a newly strung instrument; and a sticker hook.

The outdoor repairer should aim to avoid carrying a large number of tools by acquiring the faculty of putting a tool to many uses, and much space is ofttimes saved by having a variety of tools that will fit into one handle; a combination pad containing several sizes of bradawls, a small chisel, saw, and gimlet that can be stowed away in the handle, can be obtained from most tool dealers. Several other tools likely to be of service to the outdoor tuner, such as a damper head setter, hopper turner, and damper wire regulator, can be readily adapted to fit into such a handle.

For boring wrest-pin and hitch-pin holes, a carpenter's brace stock will be found very inconvenient in certain positions. A drill stock and drill bow (see Figs. 50 and 51) will be a much more convenient tool and less tiring to the worker; the whole series of holes numbers nearly one thousand. The holes for the wrest pins are made with a good quality quill bit; its size

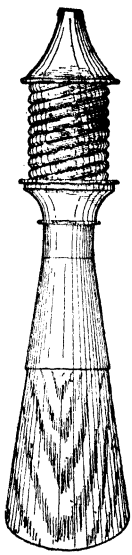

Fig. 50.—Drill Stock.

Fig. 51.—Bow.

must correspond with the pins that will be used. As the sizes of the pins vary, it is advisable to experiment on a spare bit of beech before boring the holes; all should be a true fit and fairly tight. The quill bit should fit direct into the stock, and, to ensure the holes being bored of a uniform depth, the bit should be run through a piece of 1-in. dowel rod endwise, one end to butt against the stock and the other end being cut so as to leave sufficient of the bit free for boring to

the required depth. To enable drills to be used in the same stock, it is furnished with extra iron pads or chucks; one end fits into the stock similarly to the quill bit, the other end being furnished with jaws to hold the bits; these are secured by a set-screw.

Fig. 52.—Coil Lifter.

The drill bow is of lancewood 2 ft. 9 in. long, $\frac{3}{4}$ in. wide at one end, $\frac{1}{2}$ in. at the tip, and $\frac{1}{4}$ in. thick; 6 in. of the wider end has an extra thickness planted on each side, and is then shaped into handle form. At $\frac{3}{4}$ in. from the handle and tip, holes are bored, through which to pass a length of gut as used on violoncellos; the ends of the gut are secured by tying into knots The gut should be sufficiently long to enable it to be passed round the grooved part of the stock once, and bend the bow sufficient to give clearance as it is worked to and fro. Drill bows can be bought made of iron, and are extremely useful for the smaller holes, but are apt to strain the wrist if used for the larger holes.

Holes for the insertion of screws or bolts in wrest planks are bored with a carpenter's ordinary long twist bit. For screws, two bits of different size should be used, the larger bit to bore the hole half the depth, the other bit not quite the depth of the screw; this will enable the screw to gain a firmer grip. The holes

Fig. 53.—Key Spacer.

should be countersunk to enable the screw heads to fit in level with the face of the planks, unless mush-room-head screws are used, with brass collars; in this case countersunk holes are not required. The screws are turned home with a screwdriver bit fitted

into a brace stock. If bolts are used, the holes are bored right through; in either case care should be taken that the screws or bolts are so placed that they pass through or grip into the bracings.

A hinge saw is used for cutting out old vellum

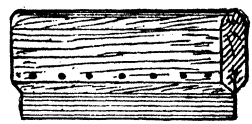

Fig. 54.—Hinge Pusher.

hinges that have broken off short and cannot be pulled out with square-nosed pliers; a metal-worker's saw, costing about ninepence, will do capitally.

Coil lifters (Fig. 52) are slipped behind the wire when stringing for the purpose of pulling the coils close together.

A key spacer (Fig. 53) may be either straight or bent; it closely resembles a screwdriver with a slot filed up about ½ in., and of such a width that it will just grip the key guide pins to enable them to be strained to the right or left, as may be required, in order to gain a uniform space between the keys. For pianos in which the key slip does not readily take out, the bent shape will be most serviceable. The straight ones are useful for harmoniums or pianos that are being dealt with in the workshop.

A hinge pusher (Fig. 54) is used for pressing the leather well home when re-hingeing "stickers"; it should

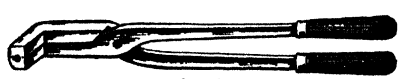

Fig. 55.—Casting Tongs.

be 3 in. or 4 in. long to enable half a dozen stickers to be hinged at the same time.

Casting tongs (Fig. 55) for straightening hammer shanks have been mentioned. The tip of the tongs should be heated in the flame of a gas or spirit stove, and, the

offending hammer shank being firmly gripped in the grooved jaws of the tongs, gentle pressure is exerted till the shank is slightly bent over, so that the hammer head strikes the two or the three wires as may be

Fig. 56.—Sticker Hooks.

required. Sometimes when the tongs cannot be conveniently heated, the hammer shank is made hot in the flame of a spirit lamp. Such lamps are generally small primitive makeshift affairs, such as a small bottle with a piece of round wick passed through a hole in the cork, wood naphtha or methylated spirit being used instead of oil.

The sticker hook (shown by Fig. 56) is used for pressing the hinge flap on to the hammer butt when re-inserting the stickers after re-hingeing.

Eye twisters are for twisting the eyes of the wire where they go on the hitch pins. Such eyes can readily be twisted around a headless round nail driven into the bench or held in a vice.

A desk rivet bit is useful when making new folding music or overhanging desks. The size should be in accord with the kind of rivets that are used. There is a difference in the sizes of German and English make.

Nippers for re-centering cut the wire close to the hammer butts, thus avoiding the necessity of filing off any surplus wire.

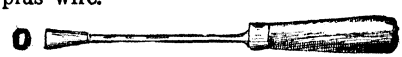

Fig. 57.—Regulating Tool.

Figs. 57 to 59 show further tools used for regulating pianos. The illustrations already given by no means represent all that are requisite for the various styles of actions, such as stickers, check, and grands, fitted with under- or over-dampers, which require tools of special

shape and size. In regulating pianos with different actions, no set system of working the tools can be laid down. The worker undertaking such repairs should understand all the important mechanical principles of the various types of actions, and endeavour to perceive their inherent defects and the readiest means of

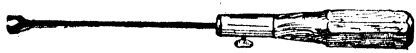

Fig. 58.—Regulating Tool.

rectifying them. He will find some actions with all working levers in good balance and working practically frictionless; in other actions he may find that some parts can only with difficulty be made to work smoothly; these parts may, by reason of undue friction, require frequent renewal. A ready grasp of details such as

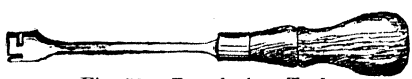

Fig. 59.—Regulating Tool.

these can only be obtained by practice and observation in this direction; a few lessons from a practical man would be of great assistance.

Fig. 58 shows a form of handle into which many useful tools will fit.

Burnishers will be necessary for burnishing the

Fig. 60. Fig. 61.

Figs. 60 and 61.—Burnishers.

blackleaded parts of actions. Blacklead of good quality, as sold in packets in powder form, not cakes, should be mixed rather stiffly with methylated spirit and applied with a chip of wood to the hoppers, levers, jacks, or other parts to be burnished; or if several movements are to be treated at once, the blacklead can

be rubbed on by means of washleather or soft felt, and afterwards burnished. In shape the burnisher (see Figs. 60 and 61) closely resembles a razor strop with its two or four sides covered with soft new chamois leather and secured by thin hot glue, which must be free from lumpiness. The burnishers improve by usage, but

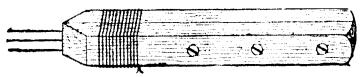

Fig. 62.—Toning Needle.

should be kept free from grit such as they would pick up by being carelessly flung on a workbench. A string through the handle whereby the burnishers can be hung up when not in use is advised.

Toning needles, sometimes called felt prickers, are used as described on p. 70, to soften the surface of felt that has become hard by usage. The points of a series of two, three, or four needles are simply stabbed into or pushed through the hardened felt, such as the tip of the hammer where it strikes the wire, or the damper felt. The aim should be to soften the felt by a series of holes rather than by careless pricking to yield a fluffy surface. A fairly good felt pricker can be made of two pieces of hard wood 4 in. or 6 in. long, $\frac{3}{8}$ in. thick, and $\frac{5}{8}$ in. wide. Between them place three No. 5 needles evenly spaced, glue the faces, and fix in a vice till the glue is set.

Fig. 63.—Toning Needle or Felt Pricker.

Then finish off the handle into any desired shape, and wind the needle end tightly with waxed thread or hemp (see Fig. 62). Toning needles with adjustable jaws, which enable broken needles to be readily replaced, can be obtained from any dealer in piano tools. Fig. 63 shows a form of needle in general use.

CHAPTER VII.

REPAIRING PIANO ACTIONS.

In the majority of English-made pianos the actions may be easily taken out by turning the two wood or brass buttons at the top of the standards; then take hold of the hammer or check rail near the standards with both hands and pull forward. Occasionally one may require to be lifted up a few inches at this stage to enable it to free itself. If the action is a sticker with a damper rail extending only two-thirds across, this rail must be removed before attempting to take out the action.

With some of the German-made pianos the operation is not so simple at first sight, as the action appears to be fixed by some invisible means. In reality, the action standards are built into the key frame; consequently one cannot be removed without the other. This may be done in a very simple manner; first remove the lock rail, by taking out three or four screws inserted underneath the key-board. Then take three screws out of the key frame; one at each end is plainly visible, and the position of the centre one is generally indicated by a star or imprint of a hot screw-head on the middle C or D key. Take out this key, remove the screw, unfasten the buttons that secure the action standards at each end, place each hand on the key-blocks at the extreme ends of the key-board, then pull gently forward.

The above style of German action is now being supplanted by others that take out like those of English make, except that they are kept in position by the aid of two powerful clip springs, and others with bronzed iron standards that are kept in position with thumb screws. An additional security is often gained in these actions by means of a slender support, one end being

screwed to the check rail, the other to the key rail at the point where the keys spray out to miss the bars of the iron frame ; the bottom screw should be removed.

From a German piano of the pianette class or small model, the action may be easily removed by first taking out the bent iron pins passing through the standards into blocks secured to the inner sides of the piano case, then pulling gently forward by grasping the damper rail at each end.

In an old Broadwood table piano the key-board and hammer action is self-contained, and is sometimes in two sections, the largest portions extending from the extreme bass end to a support for the sound-board. This forms a division extending from the sound-board to the base board or floor of the piano, and the smaller portion extends from this division to the extreme treble end. Dampers are attached to the larger portion only. The hammers and hammer levers are hinged on rails supported on standards fixed in the ends of the key frame. To withdraw these take out the maker's name-board by pulling upwards ; it slides in a channel at each end. Next remove a thin slip of wood that fits into a groove immediately in front of the keys. This is rarely screwed in, but fits tightly ; if necessary, prize it up with a chisel or the point of a screw driver. The larger portion of the key-board should now pull forward, and should be taken right out before withdrawing the small portion. The hammer stems are in two sections, the longer part to which the hammer head is attached, being vellum hinged to a short section which is glued to the hammer rail. A thin strip of mahogany is generally screwed over these short sections for greater security and to give a neater appearance. If the felt covering of the hammer heads is so badly worn as to need re-covering, it will be more satisfactory to re-cover the whole set ; for this purpose a cheap hammer felt will be quite suitable.

To remove the action from a grand piano, take out the fall or covering to the key-board. Next remove the

key blocks—that is, the oblong pieces of wood at each end of the keyboard—by turning the thumbscrews, which are inserted from underneath. Then with a turnscrew remove the key slip immediately in front of the keys. See that the hammers are all down on the hammer rest. Take hold of the key frame at the extreme ends, being careful at the same time that none of the keys are depressed, then pull steadily forward. In some instruments the slip in front of the key is secured on dovetail wedges and kept in position by wood buttons; turn these so that they stand clear, and gently force the front rail downwards. If the damper action is attached to the foot pedal action, remove the vertical pedal rod, first making on it a mark to ensure proper replacement. Then unscrew the rail at each end, but if only a few dampers are defective, unscrew the heads of the offending dampers only.

The remedying of faulty touch will now be discussed.

A heavy touch may be due to incorrect balance of the keys, the weight of the dampers, the buttons at the bottom of the damper wires being turned down too low, or the action bedding on the keys too firmly. Try the effect of raising the action by putting a thickness of cardboard underneath the standards. Slacken out the tension, if any, on the damper wires; also, after taking out the top door of the instrument, see that the damper wires do not drag on the back of the fall.

When keys require to be struck so powerfully that the hands soon tire, it will probably be found that the instrument is a check-action piano of cheap grade, in which the balance of the keys has not been very carefully adjusted. Test the instrument and see whether the key frame or hammer rail has twisted and so caused an uneven contact. If the balance of the keys is at fault, the remedy is as follows. Get ninety $\frac{1}{2}$-in. key leads; take out the top door and fall or key cover, thus enabling the whole of the mechanism to be seen. Place a lead on the front side of each balance pin of a few keys, say several chords, and move the leads towards the

worker until the touch seems light and elastic. The bass is a shade heavier, and may require the leads a trifle nearer the front. If one lead to each key does not suffice, two or even three may be used. The exact position may be best defined by placing the leads (if more than one is required) one on the other, where the finger touches the key, and so adjusting them that the key returns to rest at the back when the fingers are off. Having determined the place that will suit, make a pencil line along the keys, lift a few out, and with a brace and ½-in. centre bit bore a hole through the key at the mark; bore against a piece of wood to prevent fraying. Place a lead in each hole and gently hammer the ends of the lead on some hard substance—just sufficient to prevent the leads working loose again.

Should the heavy touch be more apparent in the centre, the fault is probably a slight twist of the hammer rail or key frame, thus bringing the keys and action mechanism into closer contact. If the keys are furnished with regulating screws under small pieces of cloth glued at the extreme end under the action, or are fitted with capstan regulating studs, try the effect of reducing the friction by turning down the screws or studs; remove the action and burnish the parts that come in contact, using black-lead and a burnisher, as illustrated by Figs. 60 and 61, p. 110.

A feeling as if a second blow is necessary in order to gain a given result, and the impossibility of obtaining a quick repetition or tremulo effect in quick passages, indicate that the action does not bed firmly on the keys; should the fault extend all across the keyboard, the action is not in its proper place. Occasionally the key frame may sag in the middle, owing to the twisting of the wooden frame; this is more noticeable in sticker action instruments and in the cheap class of check actions. It may be somewhat minimised by taking out a few keys at the worst point and packing up the key frame with cardboard; and though this treatment has the disadvantage of bringing the tops of the keys above

their fellows, the fault may be rectified by substituting thinner washers, or by taking a few shavings off the underside of the keys by means of a small iron plane. In the case of the better class of check actions, especially those in which the actions are built into and form part of the key frame, the fault must be rectified by means of the screws provided for the purpose.

The cause of keys sticking down is generally dampness. In order to make them work easily, take out the tight keys, rub a piece of fine emery cloth up and down the pivot and guide pins (otherwise called key pins), and wipe on a little grease, not oil. If this does not remedy the defect, open the centre and front holes a little; if the holes are bushed with cloth, the tail end of a tuning fork, being slightly taper, will make a capital tool for the purpose. However, avoid making them any larger than is necessary to secure freedom; otherwise, instead of squeaking, rattling may result. If the holes are not bushed, a small flat file is best for the front holes, though they are often forced open with a brass wedge held in a wooden handle.

Keys may stick down or be sluggish in their movements when the guide pins are rusty or strained, or when dampness has caused the mortise holes to swell. If so, free both balance and guide pins from rust. Also guide pins of oval shape sometimes twist. In the case of pianos fitted with sticker actions, keys will fail to rise promptly if the hopper spring is broken or has slipped out of its groove; the remedy is obvious.

If the notes at the treble end of a German pianoforte do not repeat properly, see if the sluggishness lies in the keys or hammer-butt centres. See also that the keys work freely on the guide and pivot-pins; to ease the holes, proceed as just described. Should the fault lie in the centres, take out the action, and remove the hammers one by one; remove any grit or rust, and lubricate with dry blacklead, not oil. Damp is the main cause of such sluggishness.

Should a clicking noise be heard when playing, look

to the baize and felt washers under the keys ; these may have worn and require renewing. See also that the pedals work truly and easily, and, if a sticker action, it may not be amiss to take out the action and rub a little dry blacklead on the tops of the hoppers.

When hammers stick, the probable cause is damp, which has made the centres swell. The best remedy is to remove part of the case and expose the interior of the instrument for a few days to the influence of warm air or sunshine ; or the action may be taken out, placed in a warm room, and the offending hammers freely worked about, a little powdered French chalk or blacklead being sprinkled in the centre joint as a lubricant. Hammers will stick, too, if there is rust on the centre wire, which should be replaced by a new one.

Oil should never be used as a lubricant in a piano ; it causes the cloth and wood to swell ; blacklead or French chalk in powder should be used instead. Any butts that have been oiled in ignorance should be freed from grease by the application of benzoline, and the holes rebushed with new cloth before putting into position again.

When hammers at the treble end of a sticker-action piano get loose at the butts, it will probably be found that the red bushing cloth where the hammer butts are threaded on the centre wire is much worn and should be replaced, or possibly a stouter centre wire may meet the case.

When hammers strike only two wires instead of three, should the action be of an old type, with a shifting hammer rail or sliding keyboard, see that the pedals and springs have sufficient play and power; if necessary, put in new springs. Take out the action, unscrew the slips of wood at the back that keep the hammer rail in its place, and lubricate all sliding parts with a mixture of blacklead and grease. When putting the slips on again, do not screw up too tightly. If only a few hammers are at fault, and these at irregular intervals, the defect may be in the centres, which

perhaps require rebushing or a new centre wire. Should they be firm at the centre joint, the hammer heads should be cast over to the side required.

Copper and iron tongs are made specially for "casting" hammer heads (see p. 109). The tongs are heated, and the head of the hammer is gripped at the point where the shank enters. The warmth softens the glue and enables the head to be twisted in the direction required. It will sometimes suffice, instead of disturbing the glue, merely to bend over the shank itself; but owing to its brittleness it is likely to snap. A makeshift tool can be made by heating an old flat file, pressing it against one or both sides, and then twisting the hammer with the fingers or with pliers.

If the hammers of the two top octaves in an old table piano strike only one wire instead of two, the treble end of the hammer rail has shifted towards the key-board. The rail on which the vellum-hinged hammers are secured will be found fixed either on iron standards or by screws passing through slotted holes. Adjust point, and tighten up.

In a case where a few hammers at the treble end of a piano strike against the bridge pins, it may be advisable to shorten the hammer shanks, if the shrinkage of the soundboard and bearing-down pressure has not interfered with the tone of the instrument. The heads may be removed by heating black hot an old flat file or piece of flat iron and holding it against the sides of the head sufficiently long to soften the glue; twist carefully to avoid breaking the heads in the butts.

Sticker actions have one spring (called a hopper spring) to each hammer; these springs are inserted into hoppers mortised into each key at the back. Check actions have three springs to each hammer; these springs are called respectively, jack spring, damper lever spring, and hammer spring.

The following describes the method of inserting a new spring in a check-action piano (under-damper arrangement), it being supposed that there is a faulty hammer

spring, one end of which is inserted in the hammer butt, the other pressing against the upper or hammer-spring rail. First release the tape from the stirrup or bridle wire. The hammer butt turning on a separate centre-pin in the hammer flange is secured by a screw passing through a metal clip. Slack out this screw by means of a long, thin, round-bladed screwdriver. A slight wriggle will release the centre-pin from its bearing and enable the hammer to pull forward over the

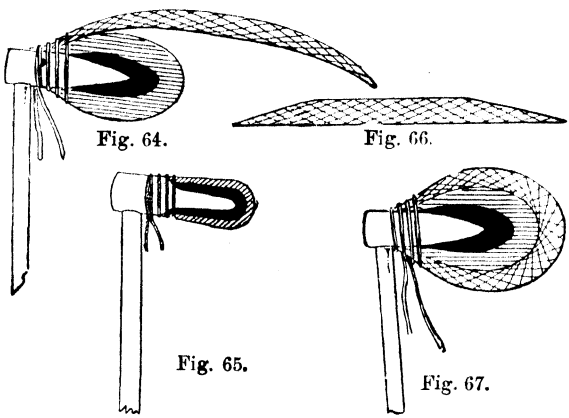

Fig. 64.

Fig. 66.

Fig. 65.

Fig. 67.

Fig. 64.—Re-covering Piano Hammer. Fig. 65.—Hammer with Different Core. Fig. 66.—Skived Piece of Felt. Fig. 67.—Securing both Ends of Skived Felt.

hammer rest whilst the action is at rest in the instrument. It should not be necessary to remove the whole of the hammers starting from one end. If, however, the space at command is so cramped as not to allow sufficient freedom to work, extra hammers (one on each side of the faulty one) might easily be released.

Hand-covered hammer heads are prepared one by one, and a set of hammer heads covered ready for use can be bought for about twelve shillings. The core for the hammers is usually made of beech, though mahogany

is sometimes employed; they graduate in thickness, as shown in Figs. 64 and 65, which represent one from each end. In re-covering, the hammer heads must be done one by one. The felt is supplied in strips about 45 in. long, 3 in. wide at the bass end and 2 in. at the treble, and graduating in thickness from $\frac{3}{8}$ in. to $\frac{1}{8}$ in.; it is sold in various qualities at prices ranging from 3s. to 12s. a strip. Before use, it must be skived into shape as shown in Fig. 66, and then cut into segments about $\frac{1}{2}$ in. wide, giving about eighty-five or eighty-eight pieces as required. The hammer heads are generally $\frac{5}{8}$ in. wide, and the extra width given to the felt segments allows for overlaps on each side, which must be trimmed off with a sharp knife after the glue is set. The action must be removed from the instrument and laid across a table, hammers upwards. Then with a sharp knife cut through the old coverings where they strike the wires, taking care not to cut the under-coverings or woodwork. The old felt can then be readily pulled off. The new felt, which is cut up, should be left on a board with the segments in sequence, and should be put on with fresh-made Scotch glue, the bevelled side being put on the hammer head. In the trade, spring clips are used to hold the felt till the glue has set, but as a makeshift very narrow tape or thin twine may be used, as shown in Fig. 64; this illustrates one end only of the felt secured, which is the correct method, though it is not uncommon to secure both ends at the same time, as shown in Fig. 67. Owing to the limited space between the hammers for working and the liability of the tying material to become entangled, alternate hammers should be operated on, starting at the bass end, and by the time the treble end is reached some of the tapes may be removed for use on the other set. The felt should not be heavily coated with glue at the point forming the back of the striking part; in fact, the less the glue at this point the better. The hammers at the treble end being smaller, have only a single lining between the felt and wood. If the felt is

stretched fairly tight over these hammers it may have the effect of brightening the tone. The felt for re-covering can be obtained from most large music shops, and it can be obtained from some firms ready bevelled for use.

Soft felt on hammers gives a weak sound and needs hardening. A hot laundry iron held against the tips of the hammers will sometimes harden the felt; if this does not suffice, try dipping a piece of rag in clean water, place it over the felt, and press with the hot iron. The use of a cheap soft quality of felt may cause a weak tone.

The re-covering of hammer butts B (Fig. 68) is

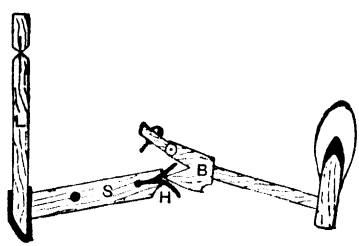

Fig. 68.—Re-covering Hammer Butt.

sometimes necessary. The butt B (Fig. 68) is that portion of the action through which the centre wire passes and into which the hammer shank is inserted. The leather hinge H which operates the butt is inserted into the sticker or long rod S that intervenes between the lever L and hammer butt. Remove the stickers from the levers and take the hinges from the butts; number them with lead pencil so that each may go into its proper place again. Pull the old leather out of the grooves with a pair of pliers. To re-hinge, obtain fawn-skin sticker-hinge leather about 1 in. wide (ask for it as passed through a thicknessing machine); fold it along the middle and strike it with a hammer over a piece of iron or other hard

substance, so forming a hinge, smooth side out. Cut into lengths sufficient for six. Glue the groove, and press the leather in with a piece of thin steel secured in wood (see Fig. 54, p. 108); a stay-busk makes a capital substitute. The levers may be recovered with fawn skin, but it will probably be cheaper to buy a new set.

To put the stickers into position again, first separate them by passing a thin, sharp knife between; then lay the action down on the bench and glue the bottom of the sticker and hinge at one time. Put the bottom on the lever, and hinge on the butt, and with a sticker hook (shown by Fig. 55, p. 109) press the leather to the butt front and back. After the glue is dry, ease the stickers backwards and forwards—not too much, only so much as is necessary when in the piano.

The simplest way to put new tapes in a check action piano is to take out the centre wire and lay the hammers in their proper sequence on a table or board, to enable them to be dealt with singly; then pull out the old tapes with pliers, leaving one as a guide for inserting new tapes. Insert one end of a piece of wire, 6 in. or 8 in. long, in a small bradawl handle; heat the other end, and hammer out flat. Then bend over at right angles a piece at least $\frac{5}{8}$ in. long, file up smooth, leaving a blunt point. Touch the underside of the tape with hot, thin glue, at about $\frac{1}{2}$ in. from the end, then press well home with the point of the hooked wire. When inserting new tapes, it is not the practice to remove the stems that secure the tapes in position. The difficulty is often overcome by making, immediately under the stems, a series of incisions into which the tapes are firmly pressed after touching the tips with good, strong glue. The incisions can be made easily by means of a sharp $\frac{1}{4}$-in. mortise-chisel.

For renewing hopper hinges vellum is commonly used, and a piece can be procured from most music shops for a few pence. Generally an old banjo head is

used for the purpose. The tips of the levers that rest on the top of the hoppers are covered with fawn skin or a good quality chamois or window leather. The old vellum should be removed from the channels with square-nosed pliers or by the aid of a metal-worker's thin-bladed saw. The flanges, before being fixed into position again, should be worked backwards and forwards a few times in order to take the stiffness out of the vellum. Refix with good hot glue.

If the silk loop in the hammer butt of a check-action piano has merely become detached, glue will be sufficient to hold it in again ; press the ends well home with the point of a knitting needle and allow sufficient time for the glue to set before coupling to the spring. If, on the other hand, the loop and spring are uncoupled, they may be secured again by taking hold of the loop

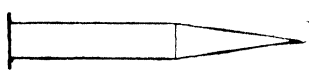

Fig. 69.—Re-bushing Hammer Butt.

with a crotchet hook held in the right hand, pressing the spring under at the same time by means of a thin taper penholder—with a notch filed in the end—held in the left hand. Should the damper wires be in the way, lift them up free from their sockets, resting them against the damper rail.

The following describes the method of rebushing piano hammer butts. Pick out carefully one of the old bushings as a guide, cut the new cloth into strips of the same width, then into three or four sections, and point each section to a long angle, as shown by Fig. 69. Moisten the angle with thin glue and roll into a long thin point that will lead into the holes in the butts. Insert the pointed cloth into the butts and draw partly through. Then with good thin hot glue (using a chip of wood as a brush) glue the cloth at the place where it rests against the wood ; then pull through into the proper position. Run a piece of wire (a trifle smaller than the proper

centre wire) through the bushing in order to set it against the sides of the hole; then put aside for the glue to harden. When all the butts are finished, trim off the surplus cloth with a sharp knife or chisel, keeping the tool flush against the sides and cutting with a firm, quick motion, so that the cloth is severed at one stroke, thus avoiding a jagged edge and also the risk of pulling the cloth away from the wood. Broaches are sold for the purpose of opening out the holes to the size of the centre wire.

Defective damping, when it affects the whole set, is generally due to some fault in the pedal arrangements. The rods that extend from the rockers may be too short or too long; in that case, screw down or release the nut on the hook that passes through the pedal and rocker.

The process of re-covering piano dampers is as follows:—Damper felt, a specially made material, being of a soft, open texture, requires practice to ensure clean, even cutting. This is done with a sharp knife, not scissors, generally after being sewn to the foundation of red or blue cloth. The foundation cloth greatly adds to the appearance, and forms a more solid base to enable the glue to secure the material to the damper heads. The felt is cut into strips about ¾ in. wide, and the cloth a trifle wider, the felt and cloth being sewn together by a single or double running stitch, right down the centre of their length. These strips are then cut into pieces the same width as the blocks, to which they will be affixed by glue. The old dampers being at hand, careful note should be made of them as regards the method of cutting. The strips of felt and cloth may in some instances require a reversal of the method; instead of cutting all the strips of an equal width in short sections, those to form the grooved dampers may require cutting double width, so that when reversed the stitched portion will form the bottom of the groove; and in glueing them into position see that they are in line

top and bottom in order to ensure uniformity as regards the finished appearance of felt and damper wires.

Soft pedal effects may be gained by a sliding hammer rail, this causing the hammers to strike one or two wires instead of two or three. In other cases a strip of felt rises between the hammers and wire when the foot pedal is pressed; this is called a "celeste." The celeste felt is of very soft material, and likely to wear away or be moth-eaten. If necessary, put on a new strip, but take care that the top edge is afterwards cut level by means of a sharp knife—not scissors—and that when at rest the felt falls out of line with the hammer movement. In modern pianos with under-damper action the result is gained by a pedal movement that moves all the hammers nearer the wires, thus causing them to give a shorter blow. In the case of pianos with sliding hammer rails, see that all sliding movements are well blackleaded, and that the spring on the right hand or treble standard of the action, where it presses against the hammer rail, is sufficiently strong for the purpose.

The pedal rods are apt to come unglued from the rockers; before putting glue there again clean off the old glue, and put a piece of thin soft leather or cloth on the end of the rocker. Touch the end of the rod with glue, and press into position.

Loud pedals will not always shut off if the rod is too long or the regulating nut on the rocker is screwed down too tight. Should the fault lie in single notes, see whether the damper wires have jumped up out of the sockets or whether, owing to rust, they bind tightly in the cloth-lined holes. In slight cases, a few vigorous up and down movements will remove this fault, but should the wires be very rusty, clean with fine emery cloth. In all cases where blacklead is advised it should be mixed into a paste with methylated spirit or grease, not water.

Squeaking may be caused by the pedals rubbing

against the side of the hole in the plinth. These holes are generally lined with cloth, which may be worn or have become hard; therefore, if necessary, reline, or lubricate with blacklead. Some pedals pass underneath the piano, and are hinged, or have a screw passed through the tail end; if the trouble lies there, put the piano on its back and oil the hinges or slack out the screws. The pedals actuate, inside the piano, rockers which have springs on the under side; press them up with the point of a screwdriver and put grease or soap under them as a lubricant. Pedal rods pass from the other end of the rockers to the action for "loud effects," or to operate the celeste for "soft effects," and these rods are sometimes kept in position by screws passing through slots. See that the screws are not too thick or turned in too tight (see F, Fig. 22, p. 49).

Blacklead as sold in packets in powder form should be employed for lubricating a piano action. When used as a lubricant on sliding portions, as for a shifting hammer rail or a key frame, the lead should be mixed with tallow. On parts that are to be burnished, such as hoppers and regulating studs fixed at the extreme ends of the keys immediately under the action, the blacklead should be mixed with methylated spirit. Apply the mixture with a chip of wood to the parts to be burnished, then with a burnisher rub off and polish up bright. The burnisher closely resembles a razor strop (see Figs. 60 and 61, p. 110); it is a flat piece of wood about 1 in. wide by 10 in. long, with a handle cut at one end, and is covered on both sides with chamois leather, one side of the leather being touched with blacklead.

CHAPTER VIII.

RESTRINGING AND OTHER REPAIRS.

THE removal of a broken string merely consists of turning the tuning pin once or twice leftwards by means of the hammer so as to loosen the coil and to enable that end to be taken off, while the opposite end of the string has only to be unhooked from the hitch pin. Generally the wire will be seen to be broken near the wrest pins, and the severed parts should be removed without delay.

Before procuring a fresh coil of wire, which can be got at sixpence per ounce from nearly all music sellers, it will be necessary to ascertain the gauge number. This is invariably twelve at the extreme treble, increasing to twenty-one at the bass; the sizes are indicated on the piano, just below the tuning pins, and the number nearest to the right of the broken string is the correct one to purchase. When ordering new wires, of which ¼ lb. of each size is required for a complete restringing, it will be sufficient to quote these numbers, and the dealers will (if asked) label them their respective sizes. A music-wire gauge is indispensable if the wires get mixed; the standard wire gauge should not be relied upon.

The gauge numbers should be found by careful search among the wrest or tuning pins. If they cannot be found, and assuming that the instrument has six octaves and is bichord, that is, two wires to each note, the following sizes may suit: Starting at the treble end, put on six notes of No. 10 wire, six notes of No. 11, and six notes of No. 12 (about 2 oz. of each size); eight notes of No. 13 wire, ten notes of No. 14, eight notes of No. 15, and six notes of No. 16 (about 4 oz. of each size). If the covered wires must be replaced by new ones, the makers will require a rubbing on paper. A strip of

newspaper or thin brown paper that will reach from the top to the bottom is stretched over the pins that secure the covered wires. Shoemaker's heel-ball is then rubbed over the hitch pins, and bottom and top bridge pins; this should make a clear imprint of the pins and show the maker how much of the wire is required to be covered. The sender's name should be clearly marked on the paper, and the name of the maker of the instrument should also be stated. It is also wise to send a short section of the first and last wires as a guide to the thickness of the covering.

The least mechanical skill should enable anyone to attach a new wire; before doing so, however, the pins must be taken out by turning the hammer leftwards, as already shown, and chalked. This done, replace them by one or two gentle knocks, so that the pins are merely inserted far enough to fix them for the next operation, which is that of passing the wire through the hole in each pin. A little judgment is here required to leave sufficient wire wherewith to form the requisite number of coils around the pins. It will be found that 2½ in. above the pin is a safe rule. When the pins have been turned two or three times to the right, after the insertion of the wire, they may be knocked into their holes as far as they will go.

Remember that the wire should be handled as little as possible by hot perspiring hands, and in attaching it, draw out from the coil as much as may be required; push one end through a hole in the tuning pin, and with the tuning hammer turn till there are about three coils around the pin. Pass the wire down, fitting it on the right-hand side of the bridge pin and round the hitch pin, then bring the wire up again, fitting it on the adjoining bridge pin, and cut it off about 2½ in. above the tuning pin. Insert it through and coil it round the next pin, taking careful note of the surrounding pins as to how the wires are threaded, especially as regards their order in overlapping as counterpart of the next note if there should be three wires to a note.

In restringing a trichord piano, perhaps the simpler plan is to make an eye and to thread each wire separate. In a wood frame piano the strings are usually arranged as shown in Fig. 70, whereas in an iron frame piano they are arranged as in Fig. 71; A shows the plank bridge and B the long bridge. In both figures it will be seen that at least one string forms a counterpart of its neighbour—in the wood frame it is the outer string, in the iron frame the

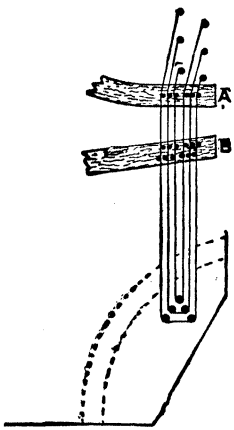

Fig. 70.—Strings in Wood Frame Trichord Piano.

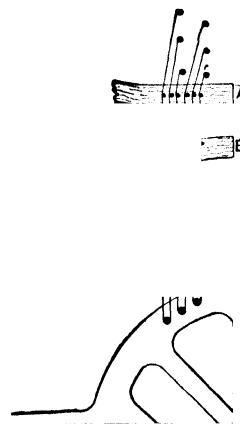

Fig. 71.—Strings in Iron Frame Trichord Piano.

inner one; thus the wire coiled on the top wrest pin of D would return to the bottom pin of C sharp in the case of the iron frame, whilst in the case of the wood frame the reverse would be the case—the bottom pin would counterpart with the top one.

The work for two wires to a note is quite simple. Should a wire be required with a loop to secure it to a hitch pin, with a pair of pliers turn up the wire so as to form a loop, letting the end be at right angles to the other portion; then coil the end two or

three times round the wire, leaving about ½ in. projecting. Place the loop thus formed on the hitch pin, with the portion that projects pressing against the wood of the instrument; this will prevent its slipping as the wire is tightened up.

There is a form of loop known as the "Broadwood eye," but there is now no apparent difference between this and any other eye. The chief thing is to so twist the wire that it will not uncoil again; in a general way this is effected by turning the extreme end to a sharp angle. A method that has not yet been referred to is to grip an odd hitch pin firmly in the bench vice or to drive it in near the front edge of the work bench; then take the wire, grip one end with the pliers, give one or two turns around the pin, let go, twist the short end round the long length several times, and then bend the extreme end over quite sharp at right angles to prevent its running back.

Should the repairer be required to restring an old-fashioned model of Broadwood grand piano, he will find it convenient to replace the tuning pegs (which are without holes for the insertion of the wire) with a new set of pegs (wrest pins); their use will save a vast amount of trouble and give greater security when putting on the new wires. If, however, the present pegs have a good grip and it is desired to retain them, lay ¾ in. of wire along the pin, bending the wire at right angles, and binding tightly over the bent portion. The ends of the wires looped on the hitch pins may also give trouble by running back under the strain. To prevent this running back, make a loop by twisting the wire round a stout headless nail driven into the work bench in such a way as to leave about ½ in. of the nail standing out. The eye may thus be formed by twisting round it several times a short length of wire, leaving a piece projecting at least ¾ in.; this piece must stand out at right angles and be pressed against the plate when the loop is placed on the hitch pin. The sizes of wires

about to be given are suitable for an old-fashioned Broadwood grand :—Steel wire, music wire gauge sizes : ten notes of No. 10 wire, ten notes of No. 11, seven notes of No. 12, seven notes of No. 13, six notes of No. 14, six notes of No. 15, and five notes of No. 16. Brass wire : seven notes of No. 18, and seven notes of No. 20, then finish with seven notes of copper-covered strings. The wire is sold in 2 oz. or ¼ lb. rings, and one of the old copper-covered wires should be sent as a pattern.

Following the attachment of the wires, comes the first tuning; in pulling the wire up to the required tension, a quill should be used to twitch the string of the octave below, besides the one in course of tuning. This will enable the operator to estimate its pitch quite easily ; it can then be finished by the method explained in Chapter V. A new string will be sure to stretch, and to obviate this it is usual to press a piece of wood, covered with leather or thick glove-kid, upon that part of the string struck by the hammer until the pressure so used ceases to affect the pitch.

It is not always necessary to restring a piano right throughout. When there is any doubt, first try the covered strings. Those emitting a clear metallic ring when struck with the hammer might be retained ; only those sounding "tubby"—that is, having a dull tone caused by the corrosion of the outer coverings—need be replaced.

An old-style model, with wood frame and a cast-iron bed-plate on which the greater portion of the wires are hitched, will need very careful treatment in restringing and in the after tightening up, or a part of the cast-iron plate may be broken away, and it is very doubtful whether a plate similar to the broken one can be procured unless specially cast. Wrought-iron plates are now used for similar instruments. A new cast or wrought plate cannot be inserted without removing the greater part of the strings, and many of these would not be fit to use again. To obviate this trouble, if the plate is not materially weakened by the small portion that has

pulled away, and if it appears likely to withstand the strain without further breakage, hitch the wires that pulled away on to short sections of similar wire, the other end of the short sections being hitched on to round-headed screws inserted underneath the piano. To do this readily, the instrument must be turned on its side or laid on its back across trestles or boxes. These screws will probably come in line with the foot pedals; if so, put a strip of wood about ½ in. thick under the tail end, or cut away sufficient wood to allow clearance for easy working. Be sure to put a thickness of cloth on the plate where the wires cross over so as to prevent any jarring noises.

Wrest-plank repairs will now be dealt with.

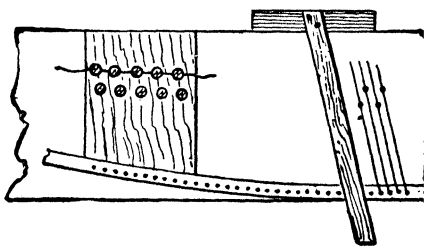

Fig. 72.—Repairing Wrest-plank.

When a wrest-plank consisting of one straight plank of beech, without veneer crossing it to bind it together and prevent splitting, is split in two or three places, ascertain by measuring from the top edge whether these splits are in line; if so, it will be safe to conclude that it is a straight plank. A good workman may attempt to repair it before resorting to the extreme of putting in a new wrest-plank. Take out the wrest-pins where the splits are, and chop the wood down from the top side of bridge to the top of the wrest-plank, ⅜ in. deep; fill the old holes up with pegs of hard wood, beech or oak, well glued. Now level off, and make as flat as possible; scratch the surface with a saw to make it rough, so that

the glue will adhere better. Now procure a piece of $\frac{3}{8}$ in. beech the size required, fit it nicely, and scratch the surface as before; having made it hot, glue it well down. Screws can be put in where they will not come in the way of wrest-pins. This wood crossing the plank with the grain the opposite way will make it impossible to split again. This is patching, and if there is any fear of the split extending, the best plan would be to chop out from treble to bass end above the bridge, and having put the wood in as described, then to glue a sheet of veneer (sycamore or maple) the whole length, running in the same direction as the wrest-plank. This would make a neat job of it. Allow it to dry for a few days, then mark the plank and bore new holes, a little out of the line of the old ones, taking care to bore so that the pins will fit tight. Fig. 72 makes the foregoing clear, it showing the fracture and the piece of wood let into the plank, as well as the bevel made of two slips of wood. This is used for making lines from each bridge-pin across the plank to get the position of the wrest-pins. It is advisable to take out the back of the piano, and if any part of the wrest-plank is found exposed, to glue some blocks of scantling across it. This will materially add to its solidity.

The insertion of a new wrest-plank will now be described. Good wrest-planks should be built up of three sections—a beech centre, a maple or sycamore facing $\frac{1}{4}$ in. or $\frac{3}{8}$ in. thick, and a pine backing. If the facing alone is split, it is necessary to replace only that portion; but if the plank is so split that a new one must be inserted, proceed as follows:—First remove all the wires. If the covered ones can be used again thread them on a piece of wire in the order in which they were taken off. Remove the wrest-pins, and with a stout piece of brown paper and heelball make a clean imprint of the holes, bridge, etc. Carefully remove the bridge screws or bolts; the old plank may then be chopped out with a mallet and stout chisel. A dealer will supply a specially prepared

plank. This should be cut to the exact length, and secured in position with good hot glue, and screwed up tightly for several days with iron cramps having deep jaws. When these are removed, clean up the face for the bridge and the holes for the wrest-pins, their exact positions being determined by means of the brown paper, which is laid in position, and secured while a sharp tap is given with a hammer and centre punch where the holes should be bored. The bridge should be fastened with hot thin glue and brass pins and the necessary bolts, screws, or dowels, and a piece of mahogany or birch capping laid on. But if the instrument is fitted with a half lid this will not be needed; it should have a final cleaning up, and several coats of white hard spirit varnish should be applied before the wrest-pins are inserted.

With regard to the re-setting of a wrest-plank, it is necessary to glue and to cramp tightly a wrest-plank into position before screws or bolts are inserted. If both glue and screws give way owing to the excessive strain of the wires, before the plank will return to its former position, this strain must be released by slacking out the wires, and it is doubtful whether a really sound job will result from merely inserting bolts in place of the screws. The correct plan of procedure would be to slack out the wires and remove the top capping (a thin board glued on top of the plank); this will be destroyed by removal, and must afterwards be replaced. The defective joint thus exposed to view should be freed from old glue, chips, and shavings, and two wedges should next be driven in to open the joint at least ¼ in., and on each side of this joint, and extending the whole length of the instrument, two narrow slips of wood should be fixed by fine brads, to form a channel. Hot glue is run into the channel, and is then worked well into the joint by means of a table knife with a long thin blade, which has been warmed by dipping into hot water. A powerful

cramp should be fixed at the middle of the plank, a block of wood being put against the face of the plank first. The wedges being removed, the cramp is tightened up, two extra cramps being placed on each side. All the cramps are tightened up so as to force out as much glue as possible. Allow the piece to stand in the cramps at least twenty-four hours, and as these are removed, bore holes right through where the screws were formerly inserted, and put bolts through in their places with washers under the nuts. The slips forming the glue channel may now be removed, the surface levelled and freed from glue, and a new capping put on. The instrument will require to be tuned several times before the wires will settle to their normal position; at least three days should be allowed for the glue to harden before tuning is attempted.

The sound-board of a piano is built up of thin Swiss pine (free from knots) strengthened on one side by transverse bars which are glued on; these bars are planed up slightly camber in their length, thus giving the board a slightly arched appearance somewhat resembling the front or back of a violin. The sound-board is placed immediately behind the wires, extending from the wrest-plank (in which the tuning pegs are inserted) downwards to the iron plate on which the wires are hitched. The sound-board is suspended by screws at the sides; on one side a portion fits into a rebate on the crescent-shaped piece of wood on which the treble end wires are hitched. If the instrument is of iron-frame type, the sound-board may be of larger size; in any case there are no pegs, such as are found in instruments of the violin class; and the support given by the bars is generally sufficient. If these become loose by reason of the glue giving way, the instrument acquires a tubby or wooden tone.

If the sound-board joints of a piano have become unglued owing to damp, and if the joints have sprung much and the bars at the back have become unglued,

the whole of the wires will have to be removed. Lay the piano on its back across two trestles, and cut off the cheeks, which are usually dowelled on. This will enable the sound-board to be taken out, when it must be rejointed up and the bars secured on again But before doing this the repairer might try securing the bars at the back, putting in good hot glue, wedging them up tight, and then inserting brass screws from the front. Several additional bars may be put on, running parallel with the others; these should be planed on the face edge slightly camber to bed against the sound-board. Then scrape the varnish off the joints at the back at their worst points, and either wedge in slips of pine or glue strips of tape along.

A split sound-board of a grand piano can be repaired as follows: should it be decided to restring the instrument, there would be little difficulty in removing and repairing the sound-board when the old strings have been taken out. Should the expense be considered too great, turn the piano on its side, remove a few screws that secure the bridge at the fractured parts, run some clean hot glue into the joints, and wedge up tightly from the front. Bore fresh holes at the back and secure the soundboard to the bridge at fresh points. Scrape off the surplus glue and varnish along the fracture at the back, and finish by gluing some strips of tape along about 1 in. wide.

A method of dealing with a split sound-board of a square piano is to take off or slack out a few wires at the treble end and insert into the cracks wedge-shaped pieces of clean pine, red deal, or spruce, and, if possible, glue strips of tape on the underside. Prise up the sound-board where it is dropped, and, to keep it in place, glue a strip on the outer edge.

The bent side is the crescent-shaped wood at the treble end of a piano, into which the hitch-pins are inserted If this is found to be much worm-eaten, it should be replaced with a new one; but this would necessitate nearly one-half of the strings being re-

placed, and the sound-board disturbed. If the decay is not very pronounced, its progress might be stayed by frequently saturating the side with wood naphtha, and then planting on an iron plate, with the hitch-pins riveted in positions corresponding with those now occupied in the bent side.

A common fault of wood bent sides is their liability to pull off from the gluing, thus causing the treble end to get sadly out of tune. Whether this is the case or not can be readily ascertained by trying to insert a table-knife behind the bent side and the bracings, to which it should be in close contact. If it has pulled away, remove all the movable parts of the piano, including the action and keys, putting them carefully aside to avoid damage. Then turn out all bolts and screws that are holding the bent side on, and slacken out all steel strings till they are free from tension likely to retard the cramps when being tightened up. The instrument should next be turned upside down, with its capping or top resting on the floor; then spring the bent side away at least ¼ in. by means of wood wedges, and with a tablespoon pour some hot, freshly-made glue into the joint, working it well home with a table-knife. The knife and spoon should previously have been dipped into hot water to prevent chilling the glue. Remove the wedges and put on as many cramps as possible, or if none of these is at hand, and coach screws or dowels have been used, immediately put in some ½-in. bolts with their heads at the front and nuts and washers behind the bracings. Tighten up at once, then glue stout blocks of wood behind wherever it is possible to get them; see that these fit well, removing any old glue or varnish before fixing them into position. Then allow the instrument to stand at least twenty-four hours before tightening up the wires again.

Should it be found desirable to put in a new bent side or to put a plate on its face, a careful

imprint of the present one should be made before it is disturbed. To do this take a sheet of brown paper of convenient size, put it over the bent side, and rub gently over all with a cobbler's heelball until it shows a clear imprint of all hitch-pins and the outline of the wood required. New wood bent side or plates can be obtained from dealers. If the steel wires are to be used again, slack out to release the hitch-pins, and tie them up out of the way, first removing the action and keys. Take out the canvas backing, and with a stout chisel and mallet remove the glue blocks that secure it to the bracings; also take out any bolts or screws. Lay the instrument on its back on boxes or trestles and make the imprint as just described. This is for use as a template. If the sweep of the bent side brings it up high above the key frame, it will be necessary to cut away the cheeks or front portion (secured to the upright portion by wood dowels) with a fine tenon saw. The old wood may be easily removed by prizing it up with a stout chisel; if not, cut through once or twice. The sound-board should fit into a rebate at the back, and should not give any trouble. Note that the hitch pins are inserted at an angle pointing downwards to resist upward strain. Secure in position with good hot glue, and fix with 5-in. stout screws or bolts instead of wood dowels.

Occasionally there is some trouble in preventing wrest-pins slipping when tuning a piano. If the coil of wire around the pins does not touch the wood, a smart blow on the head of the pin, to drive it further home, will often prove effective. Should this fail, the pins must be taken out. To do this the action must be removed. Uncoil the wire by means of the tuning hammer, at the same time grasping the wire and pulling it forward. Line the hole with veneer or No. 1 glasspaper, the rough side against the wood. If the holes have assumed an oval shape, by reason of excessive downward pressure, they must be plugged up

with dry beech driven home, after brushing well with good hot glue. Next day, trim off level and bore fresh holes a trifle higher than before, so leaving underneath a piece of wood of crescent shape to form a solid bearing, By first experimenting on a piece of hard wood, see that the boring bit is the exact size required. The tuning pin should be rather hard to turn into the hole just bored. Pins also slip owing to being bent, caused by the tuner straining the pin upwards or downwards instead of turning it, when the note is only a shade out. Bent pins must be replaced by new ones.

Powdered resin or chalk is useful in preventing pins slipping if, when being reinserted, the pins are not turned round so freely as to grind the material into fine flour.

There are several reasons for pianos not standing in tune. The wrest-pins may be loose, in which case try the effect of a few stouter pins. Pens should not be put in the holes with the idea of making the pins fit more tightly; the metallic face presented will cause the pins to slip instead of grip. It is better to plug the holes up as just described and to make new ones. If the instrument is an old one, of the wood-frame type, and the fault lies chiefly at the treble end, examine the bent side into which the hitch-pins are inserted—it may have pulled away from the bracings, and the thin blade of a table-knife will soon decide this; the remedy for this has already been given (see p. 137). Additional strength will be gained if two or three short lengths of scantling are planed up, the bottom end cut at an angle for appearance sake, then coated with good hot glue on two faces and placed behind the convex side between the bracings as glue blocks. Examine also the bottom plate and tighten up bolts, look along the face of the wrest plank for signs of splitting, also along the top capping for any signs of pulling over; an extra bolt or two might be inserted with advantage if the precaution is taken to get them well in the centre of the bracings. Several wires will have to be slacked out to enable this to be done.

Should the plank be split or pulled right away from its bearings, the strings must be removed and a new plank put in or the old one reset (see pp. 133 and 134).

A tubby tone—the absence of the clear, ringing, metallic tone, and in its place a dull, lifeless tone as if wood was being struck—may be caused by the hammer felt being much cut into at the treble end, perhaps right down to the wood, the sound-board may be cracked, or a bar may have become unglued at the extreme ends. Should the fault lie chiefly in the bass end, it may indicate that the copper covering has corroded or loosened; if on examination this is discovered to be the case, it may be found that a copper bit and soft solder at the weak point will sometimes repair the mischief. The hammers may be re-covered in part or whole, but the fact of only half the set being re-covered will not always ensure a satisfactory result. But in case the felt is still good and merely hard on its surface, much may be done by brushing with a wire brush (as used for cleaning files); also by the use of toning needles (see Figs. 62 and 63, p. 111). If the sound-board is cracked, the only certain cure is to take it out and rejoint it; but as this means removing the whole of the strings, it is well to try scraping the varnish off the crack at the back and gluing on a strip of tape (p. 136). If the cracks are only slight ones, they are considered by many to make no material difference to the tone. Where bars have sprung, re-glue and insert brass screws from the front. It happens sometimes that the sound-board is too hard pressed; the board may be too thin or the bridge too thick. In that case a little support at the back, in the shape of a few corks wedged in between it and the bracings, will often be found beneficial.

The repairer may be asked to improve the tone of the treble end of a piano that is rather weak. The weakness of tone may be due to the shortness of the sound-board, or to it being wedged in so tight that it cannot vibrate. Examination of high-grade German or American pianos shows an extended

sound-board, with the strengthening bars on the back put on diagonally instead of perpendicular as in English pianos; this allows of more even spacing of the bars than is possible in cheap or medium-price English pianos, where two bars are put on in the space intervening between the bracings. As this fault probably cannot be rectified in a finished instrument, assistance may be given at the front of the sound-board by the insertion of a steel or iron plate, cut as shown at A (Fig. 73) to act as a sound reflector. The plate should be about $\frac{1}{16}$ in. in thickness, with a few holes drilled through for screws. The plate

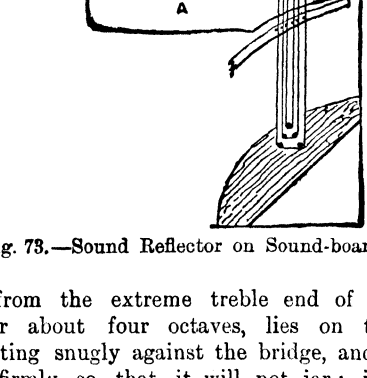

Fig. 73.—Sound Reflector on Sound-board.

extends from the extreme treble end of the wrest plank for about four octaves, lies on the wrest plank, fitting snugly against the bridge, and must be screwed firmly so that it will not jar; it extends over the bottom edge of the wrest plank about 3 in. The overhanging portion must be cut of suitable shape so that it does not touch the long bridge, and must be so fixed that it does not interfere with the vibration of the sound-board or wires. Steel $\frac{1}{16}$ in. in thickness should be suitable for a light-built instrument, but for pianos of heavy build a thicker plate would be necessary. If found suit-

able for the purpose the plate can be decorated in a style to correspond with the rest of the instrument. Pianos fitted with complete iron frames will not admit of this reflector being adopted; in that case a pressure bar at the treble end might be tried.

It is a difficult job to remedy a piano whose underwork has become much worm-eaten. It might answer to turn the instrument on end, and saturate the under-side and all infested portions with benzoline, using a painter's hog-hair brush. See that some of the liquid runs well into the holes; also be careful that the operation is performed at a safe distance from fire or naked lights. Several applications of benzoline may be given. This may prevent further mischief. To fill up the holes, soft putty coloured to match the instrument may be used; then dissolve 4 oz. of orange shellac in 1 pt. of wood naphtha, and apply liberally to the under-side. For this purpose, the brush previously used in the benzoline may be employed if it is dry, but a camel-hair brush must be used for applying the lac solution to the portions that have been French-polished. On the floor where the instrument will stand spread a sheet of pitch paper, as used for packing purposes, and raise the instrument from the floor by standing it on insulators; or, if preferred, two strips of wood at least 1 in. thick may be used. This method will allow a freer current of air to pass underneath.

When small parts only of a piano are worm-eaten they should be replaced with new wood, and the surrounding parts well dressed with benzoline.

CHAPTER IX.

POLISHING AND RENOVATING PIANO CASES.

In polishing the case of a piano, the main object is to bring into prominence what is commonly called the figure of the wood and to show to the best advantage the handicraft of the cabinet maker. A bright level surface that is clear as glass and that can be readily cleansed when required should be left, and the longer the period for which the article will stand bright without freshening up, the better the reputation of the operator. Many of the goods are finished by a layer of knife-cut veneer so thin that, when cleaned up for polishing, the polishing or lac solution that should amalgamate with the wood fibres strikes on the glue underneath, ofttimes causing it to swell, so that work which, at the moment of finishing, looks perfection, may in a short time become unsightly from circumstances over which the wood finisher has no control.

The Germans recognise the disastrous effect of undue haste, and a wrinkle for wood finishers from a German source is to coat the wood with petroleum instead of the usual linseed oil; then rub down with pumice stone and water, and allow twenty-four hours for this to dry, and if any staining is required allow sufficient time also for this to dry thoroughly. The average polisher would oil the work, use a grain filler if necessary, and begin to apply the lac polish directly.

A preparation known as Jaxa polish extract is claimed to be the polish so much admired on the German pianofortes. With the directions supplied for its application a strong point is made that, after bodying up, in which operation pumice powder is freely used, the polish being worked out very dry, an interval of twenty-four hours must be allowed for the polish to harden before finishing off.

Generally, the work is left bodied up overnight and finished off next morning, thus often leaving little more than fifteen hours as against twenty-four.

It is also interesting to note that, by whatever method the resultant finish is obtained, those goods in which the natural figure is most prominent remain bright much longer than do those which are artificially faked.

Practically the French and English methods of finish are the same—that is, solutions of shellac and other suitable gums are laid on by means of pads of wadding or wool, and the film thus deposited is polished out bright, all trace of greasiness being removed, and the final lustre imparted with spirits. Occasionally one may meet with high-class goods on which the surface has been built up by successive coats of varnish, which has been ground to a dead level by rubbers of felt and pumice powder, those left dull, such as an Erard grand piano, being known as parquet finish. For a bright finish, the already ground-down surface is polished with rottenstone to a fine lustre and cleaned up with sweet oil, this in turn being cleaned off with fine soft rag or silk made slightly damp with alcohol.

It may be useful to know that spirit varnish finish may be freshened up by the usual methods of revivers made of vinegar and linseed oil, and clearing out with spirits. On American goods of "piano oil finish" a reviver made of 1 part sweet oil and 6 parts turpentine is advised.

With regard to the use of petroleum instead of linseed oil for the preliminary coat, pianos thus treated have been known to go very light in colour, as if a bleaching agent had been at work, giving to the goods what might be termed a stone or lifeless appearance without disturbing the brilliancy of the polish, and since the petroleum treatment was abandoned and linseed oil used again there has been no recurrence of the trouble.

High-grade American pianos are mostly of massive

build, and are finished in a manner very different from that usual on English goods. The latter are of French-polish finish, whilst the Americans build up the surface with varnish; and in this matter it is interesting to note that the varnisher has high-grade goods on his hands for nearly three months, varnishing and drying, re-varnishing and re-drying, till a surface is built up that will stand scouring with pumice powder, each application of varnish being allowed to stand several days before the next is applied. The operations of varnishing, drying, and smoothing down are carried on in order until a perfect gloss is gained and the grain of the wood reflects all its beauty.

It is also interesting to note that even on some expensive instruments of American make choice veneers are seldom used, the finishers being thoroughly expert at closely imitating Nature's handiwork. The figure is gained for the most part by mechanical means, such as soft-leather graining rollers, thus ensuring greater uniformity of figure and colour. Each part of a piano is thus varnished at least six times and placed in a warm drying-room, the surface each time being smoothed and dulled down, till the last or "flowing" coat is applied, for which purpose the finest badger-hair brushes are used. This gives a level, bright finish, somewhat similar to that seen on best carriage work. Toning down is effected by rubbing with finest possible grade pumice powder and rottenstone, finishing off with the workman's bare hand, which imparts a better finish than cloth. Finally, the lustre is brought to a high degree of perfection by rubbing with piano oil cleared out with alcohol.

The composition of the varnish used on American pianos differs very much from that used by French polishers, being very elastic, yet tough enough to withstand the grinding-down process; consequently, the varnish cannot be satisfactorily made on a small scale.

Another characteristic of American instruments is

the frequency with which one meets dull panels, which considerably enhance the beauty of the bright portions. Unfortunately, in large towns with sulphur-laden atmospheres, these varnish-finished goods soon bloom or acquire a smoky appearance unless often rubbed up; and as constant rubbing by dry dusters eventually produces a scratched appearance, the better plan is to freshen up occasionally with piano oil. For this, mix sweet oil and turpentine in equal parts; but before using it, every particle of dust or dirt should be removed. A lump of common washing soda the size of a walnut should be dissolved in 2 qt. of rainwater, and the case washed down with this, using a soft chamois leather. Rub on a little of the piano oil, using wadding, and wipe off with soft rag, and then wipe with another piece of soft rag or old silk handkerchief with a few drops of alcohol sprinkled on its face, and well pressed in. Vapour up to a fine polish by applying very lightly at first, and working always in a straight direction.

To those who are thoroughly conversant with the art of French polishing, a piano should present no more difficulties than the ordinary run of best furniture. But even those who have but a rudimentary idea of the process need not despair nor feel afraid to undertake the task of improving the exterior case of their instrument, especially if they have cleaned up the interior according to the directions given in Chapter IV.

The piano whose case is to be renovated may be only a few months old, or it may be fifty years old; it may be of German, French, American, or English manufacture, each of which has a finish peculiar to itself; and even if it should be of well-known London make, it is doubtful if any two firms finish their pianos by exactly the same method in every detail. It is necessary, therefore, to state that only general principles and methods can be laid down, and that if it should be found that one plan does not give

satisfactory results at first efforts, it is well to try again, or even do a bit of "humouring" and adopt other tactics.

The instrument having been taken apart as much as possible in order to facilitate the work by enabling the operator to polish the parts separately on the work-bench or table, also gives one a better chance of clearing out well in the corners—a point which should receive particular attention; no matter how much labour may be bestowed, it is practically thrown away if carelessness as regards details is permitted.

For taking the piano apart, remove the top lid by withdrawing the wire hinge-pins by means of pincers. If this is not practicable by reason of rust, or should it be what is known as a half-lid, remove by taking out the necessary screws.

The top front, on which the turnover desk and candle sconces are fixed, may generally be removed by pulling gently forward after turning the oblong buttons at the back till they are clear of the dowel pegs or niches into which they may be turned. Some fronts fit into grooves; in that case they require to be lifted up several inches first.

The fall, the part immediately covering the keyboard, may be removed by taking hold of the back portion and lifting upwards, then pulling forward. If the fall is furnished with wood or brass bolts, shoot these back, then pull the fall gently forward.

The nameboard, a strip generally fitting over the keys (underneath the fall), on which the maker's name is generally inscribed, may be secured by screws, fit-over pins, or in grooves. Remove this so that when polished a new strip of red cloth may be glued on the bottom edge.

The bottom door may simply wedge in tight or be secured by buttons or props immediately under the keyboard; release these, then pull forward.

If the instrument is a comparatively new one with

the polish merely gone dull or gloomy, or if the polish is perfectly sound and merely wants freshening up, revivers will generally suffice. Of these, several recipes are given: (*a*) Equal parts of raw linseed oil, lime-water, and turpentine. The lime-water and oil are first thoroughly mixed; then thin out with turps, apply with wadding, and wipe off with rag; then finish with a swab of clean soft rag made fairly moist with methylated spirit. Should any trace of grease remain, change to a clean place of the already moist rag, and sprinkle a few drops of glaze on its face. Apply lightly at first —pressure may be applied as the spirit dries out; finish in the direction of the grain. (*b*) Mix four tablespoonfuls of sweet oil, four of turpentine, a teaspoonful of lemon-juice, and ten drops of household ammonia. Shake well and apply with an old silk or flannel cloth, rubbing thoroughly. Use a second cloth to rub the mixture well in, and a third for the purpose of polishing. (*c*) ½ pt. of raw linseed oil, 1 oz. of spirits of camphor, 2 oz. of malt vinegar, ½ oz. of butter of antimony, and ¼ oz. of spirits of hartshorn. Shake well each time it is used. Apply a little at a time, and well rub in with flannel or wadding; clean off with plenty of clean rag. (*d*) A mixture of paraffin and water is recommended for the renovation of an ebonised piano, the proportions are about a teaspoonful of oil to a teacupful of rain or soft water. Dip a piece of cloth into the mixture, and rub thoroughly to remove dirt and grease; dry thoroughly with a second cloth, and finally finish with a clean soft duster. This may also be used on walnut, rosewood, or mahogany goods.

These revivers are seldom effective if the instrument has at any time been cleaned with furniture creams or paste having wax and turps as its basis; these substances are not of much use. If the instrument has been thus treated, or is otherwise so dirty as to render the use of revivers ineffective, wash it off with weak soda-water. A small handful of common washing soda dissolved in at least 1 gallon of warm water will answer

admirably for the purpose. Apply with rag and wipe quite dry before using the reviver.

The flat polished surfaces having been polished up to satisfaction, the carved trusses, turned portions of the legs, the reeded end cheeks and mouldings next demand attention ; in the usual way these are finished out in varnish and glaze. Those who prefer to buy their varnish ready made should procure brown hard spirit varnish, but should dilute it by adding an equal bulk of French polish ; or a useful varnish may be made as follows :—Methylated spirit 1 pt., best orange shellac 4 oz., pale resin 2 oz., benzoin 2 oz. ; dissolve by gentle heat, and carefully strain. Apply the varnish by means of a camel-hair brush. Those who have had experience in polishing will much enchance the appearance by levelling the varnish and finishing off with a rubber made fairly wet with equal parts of polish and glaze.

Should the foregoing treatment fail to give perfectly satisfactory results at the first attempt, the beginner is strongly advised to try again before undertaking the task of repolishing a piano. Still, if it must be done, take in hand first the least important parts, such as the ends, and inside and outside of top lid, leaving the more prominent parts till some degree of proficiency has been gained.

The whole of the instrument having been cleansed with the soda water and wiped perfectly dry, wipe over with raw linseed oil, to enable the new polish to take more kindly to the old, then wipe off again with more rag. Now make a bottleful of French polish by dissolving 6 oz. of best orange shellac in 1 pt. of methylated spirit; have at least another ½ pt. of spirit at hand, a pot of linseed oil, a sheet of wadding, and a goodly supply of clean soft rag. Take a piece of wadding, about 6 in. square, fold it into shape resembling a pear cut in half, well saturate it with polish, and put a piece of clean rag over it as a covering. Apply to the piano in a straight direction, then circular, then straight

again ; repeat as often as required ; thin out the polish in the rubber by means of the spare spirit referred to ; put a few spots of oil on the face of the rubber as occasion requires, in order to prevent its sticking, and finally finish off by means of a pad of clean soft rag made fairly moist with spirit, or the rubber of half polish and glaze, as advised for the varnished work. Polishers' glaze is made by dissolving 6 oz. or 8 oz. of gum benzoin in 1 pt. of methylated spirit. Carefully strain before using.

A panel of a piano may always appear smeary, a kind of sweat working through the polish. This trouble is more frequently met on rosewood goods than on any other class, and it may be due to several causes, such as indifferent work in the early stages of polishing, owing to the coarse, open grain of the wood, or Russian tallow may have been used as a grain filler, or in the effort to gain a solid foundation excess of oil may have been used with the polish. This grease or oil must be absorbed somewhere, and as the glue underneath the veneer will not let it go in that direction, it breaks through the film of lac, called polish. The annoyance is greatest in hot weather, or when the instrument is kept in a warm room. The trouble is difficult to cure except by repolishing, and even this must be done two or three times. The grease, as it shows itself, should be cleared off with a soft rag slightly damp with benzoline, or even rain-water in which a small piece of common washing soda has been dissolved. Freshen up again with a mixture of raw linseed oil and vinegar—equal parts of each—and polish up to a good lustre with a silk handkerchief slightly damp, not wet, with methylated spirit or whiskey ; apply lightly at first, exerting slight pressure as the spirit dries out.

Dents in a polished piano lid may be raised to a great extent by laying a piece of thick wet brown paper or rag over them and well rubbing a hot iron over the paper ; but this treatment will also remove the polish. This process may have to be repeated several times.

A better and more speedy result would be gained by removing the polish and upper surface with a steel scraper or finely-set plane, the latter only being used if the case is built up of solid mahogany, not veneered. Finish off with fine glasspaper, and French or wax polish again. If the instrument is veneer-faced, it will require skilful handling to prevent its buckling up. In piano shops, the worst places would have new pieces of wood let in ; the other places, if not readily amenable to the hot-iron treatment, would be filled up with beaumontage—a mixture of shellac, resin, and wax. A cabinet-maker's steel scraper is used for cleaning up level.

If the brasswork has not been sent out to be properly cleaned and relacquered whilst the polishing was proceeding, much may be done by cleaning the hinges and pedals by means of bath brick and paraffin or any brass-cleaning paste, the candle sconces being cleaned by well washing in warm soapy water, to which has been added a small quantity of liquid ammonia. If any panels have been removed for the purpose of polishing, be sure they are firmly secured again, to prevent annoyance being caused by their chattering.

CHAPTER X.

RENOVATING PIANO KEYBOARDS.

PIANOFORTE keys of ivory or celluloid requiring renovating, should be lifted up at the front, taken out one by one, and laid aside in rotation on a separate board or table, to enable the accumulated dust to be removed from underneath by means of a dusting brush (sash tool). Before proceeding further with the keys, it is a good plan at this stage to take a housemaid's black-lead brush, and brush it well over the steel wires, bent side-plate, and wrest-pins. With a view to removing any signs of rust that may still remain, give a final dust-out and a good blow with the house bellows; then wipe over the woodwork at the bottom, pedal rockers included, with a cloth and soap-powder water, not omitting any other portions of the interior woodwork that may require it. Dry the woodwork by wiping with another cloth. Precaution having been taken not to remove any of the paper, felt, or cloth washers with which the key-pins are studded, set that part of the instrument aside, and decide what shall be done with the keys.

To distinguish ivory keys from celluloid, wipe them over with methylated spirit; if they are of celluloid they will emit a strong smell of camphor.

Should the key coverings be turned a bad colour they should be repolished. It is the usual practice to fix the whole of the keys in a frame, replacing the much-worn by thicker ones, bringing the upper surface to a dead level with packings of brown paper, then securing them by means of cramps to enable a thin shaving to be removed with a finely-set iron plane, finishing off with a steel scraper and glasspaper; the keys are then polished with whiting, pumice powder, or putty powder. But as

the instrument now being considered will have to be dealt with in the home or domestic workshop, other tactics will have to be adopted. For this reason the keys may be treated one at a time by placing them on a block on the face of which have been nailed two strips of wood to form a suitable groove. If a suitable iron plane is not available, much may be done by means of a finely-set smoothing plane, though it is possible for good work to be turned out by means of a steel scraper and glasspaper only. In fact, unless the coverings are really of ivory, it is best not to use the plane, the object in view being to remove the upper surface in order to make the keys more level and whiter.

In order to get a good polish again, suitable pads are required. These are best made of thick felt, such as

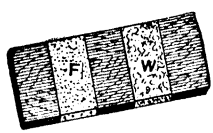

Fig. 74.—Pad for Polishing Keys.

is used for covering the hammers; but good work can be done by using several thicknesses of light-coloured woollen cloth. Scraps can usually be obtained from a tailor's for a few pence. The felt or cloth F (Fig. 74) should be stretched tight across a smooth board about 2 ft. long, 7 in. to 9 in. wide, and $\frac{3}{4}$ in. or 1 in. thick, and securely tacked to the outer edges with a piece of buff or washleather W by its side, as shown in Fig. 74. Owing to the thinness of the latter it is advisable to place under it a thickness of cloth or several thicknesses of stout brown paper. Before the polishing of the keys is begun, the sharp edges of the key coverings should be removed by rubbing with a piece of worn glasspaper.

Ivory keys are now polished by first liberally wetting the cloth with methylated spirit, then rubbing whiting on till a thin paste is formed. Taking the keys in hand one at a time, they are turned face downwards and

rubbed briskly to and fro till a fair polish is gained; the surplus is wiped off the key with a piece of rag, and the final polish imparted by giving an extra rub on the washleather pad, which has been previously sprinkled with dry whiting or, better still, some putty powder.

Celluloid keys are polished in a similar manner, except that, instead of whiting and spirits, finest-grade pumice powder and benzoline are used. As celluloid varies in quality and texture, it is sometimes advisable to try some other polishing materials in order to gain a first-class result; thus, the following may be tried in succession :—(1) a mixture of soft soap, flour-emery, and whiting, thinned out with spirits; (2) pumice powder and turpentine; (3) pumice and milk; also an additional cloth pad, on which may be used sweet oil and putty powder, not forgetting the washleather and dry putty powder for imparting the final polish. Owing to the inflammable nature of benzoline it is advisable to use it in daylight only.

The coverings having been polished satisfactorily, the woodwork is next cleaned. The sides may be cleaned off with No. 1 glasspaper, held tightly around a cork pad or flat piece of wood; but the tops will require the aid of a steel scraper, finishing off with glasspaper wrapped round a strip of wood about 1 in. wide, resembling a file.

A convenient plan of holding the keys to enable the tops to be scraped and papered is to sit down at a table; pull the drawer out a little way on which to rest the tail end, meanwhile pressing the body against the front. This will leave both hands free. Similarly, they may be dealt with standing up, by first securing a strip of wood on the bench or table against which the keys may be pressed. This being done, give the keys a good look over, and, before putting them back again into position, clean off any trace of whiting, etc., that may be on the fronts with a rag damp with spirits.

Should the front of the keys be much discoloured they may require a similar treatment to the tops; in

that case, it is easy to devise some suitable pads, etc.; for instance, a polishing pad may be made resembling a razor strop in shape. Should the fronts be of wood, it will certainly suffice to clean them well with spirits, and afterwards coat with white hard spirit varnish.

With regard to the black keys, on cheap-grade instruments the sharps are made of common wood stained with logwood, commonly called ebony stain, and French-polished with black polish. Unless the staining medium used is of good quality and strikes well home, such keys frequently wear a bad colour owing to the polish rubbing off by constant friction. On high-grade goods the sharps are made of best quality black wood. Sometimes this is wiped over with stain in order to gain a uniform colour, and then polished with shoemaker's heelball. The wax is slightly warmed, rubbed on the wood, and a gloss brought up by well rubbing with soft woollen cloth. Thus treated the keys wear remarkably well, and look superior to those worked up by polish. For renovating or restoring a few keys only that may be of bad colour, the worker is advised, unless he is acquainted with the processes of French polishing, to procure a small tin of black enamel, preferably a spirit enamel, and apply it to the sharps by means of a camel-hair brush.

To fix celluloid on wood keys the finest glue, nearly transparent in colour, should be well boiled in a clean vessel. Add a small quantity of finely-crushed flake white, using just enough to produce a milky appearance, but not enough to destroy the tenacity of the glue. Soak the back or rough side of the celluloid with methylated spirit, which will slightly soften the surface, and when the celluloid is on the wood key keep the two surfaces together with pressure for several hours. The correct plan is to put the keys in the key frame, pack up level with paper, and fix the celluloid in one piece or in sections of an octave each; then place a hot level board on the top and cramp down. To fix singly, if a number of small cramps is not at hand, the keys may

be tightly bound with twine, one or two wood wedges being driven between the twine and the celluloid to ensure more perfect cohesion. The space for the sharps should be cut out after the material is fixed. The surface should be smoothed by means of a cabinet-maker's steel scraper and glasspaper, and the polishing should be done as described on p. 154.

To re-cover a set of keys proceed as follows:— Take one octave of keys at a time, and a piece of flat board wide enough to lay them on. Glue a couple of strips of newspaper, 1 in. wide, across the board, one at the back and the other at the front. Where this paper crosses put a dab of glue on the bottom of keys, and stick them on the paper level, leaving a space between each key head, so that a fine saw would pass between. Have the glue hot, about the consistency of syrup. Soak one side of the celluloid with methylated spirit; this softens it, and makes it take the glue better. After waiting a few minutes, glue the same side, and put a piece of wood (previously made hot) on the top and press down with hand-screws. When this is dry, the keys can easily be torn all together from the paper. Then turn the top side down on the bench, and cut between each key with a dovetail saw; and where the sharp comes, cut across with the saw, and draw a sharp penknife along the side of key; finish with a file. Before cutting apart from the board it will be as well to polish them. After separating the keys, bevel the edges with a fine file and polish them.

INDEX

PRINTED BY CASSELL AND COMPANY, LIMITED, LA BELLE SAUVAGE, E.C.4

30.1123

"WORK" HANDBOOKS (*continued*)

Practical Upholstery : Illustrated. Contents include : Tools and their Special Uses, Materials, Stuffings and Sundries, Upholstering Pin-cushion Chairs, Dining-room Chairs, A Carver Chair, Spring-seat Drawing-room Chair, Chairs with Loose Lift-off Seats, "Show Wood" Easy Chair, Stuff-over Easy Chair, Footstools, A Fender Stool and a Pouffe, Music Stools, A Chesterfield, A Spring-seat Couch, An Ottoman Couch, Box Ottomans. Index.

Rustic Carpentry. *Contents.*—Light Rustic Work. Flower Stands Vases, etc, Tables. Chairs and Seats. Gates and Fences. Rosery Walk. Porches. Canopy for Swing. Aviary. Foot-bridges. Verandahs. Tool Houses, Garden Shelters, etc. Summer Houses.

Simple Lathe and Its Accessories, The. *Contents.*—Types of Lathes. Some Small Lathes Described. Centres, Catch Pins, Catch Plates and Carriers. Chucks and Angle Plates. Faceplates. Mandrels. Steadies, Hand-rests and Slide-rests. Lathe Attachments. Driving the Lathe. The Woodturning Lathe and its Accessories. Lathe Speeds and Feeds. Index.

Small Dynamos and How to Make Them (including Electric Motors). Describes the construction of a number of small and model dynamos and electric motors, including a 60-watt "students'" dynamo, a hand-driven dynamo for experimental purposes, electric motors for model tramcars and locomotives, etc. etc. A feature of the book is a detailed description of, with instructions on making, a cycle-lighting dynamo driven by contact with the road wheel.

Small Electric Apparatus. *Contents.*—Electrical Units. Galvanometers. Ammeters. Milliameters. The Wheatstone Bridge. Making a 1-inch Spark Coil. Construction of a Tesla Coil. Simple Resistances. Choking Coils. Making a Morse Telegraph Sounder. Index.

Small Lathes. *Contents.*—What a Lathe is. Simple Dead-centre Lathe. Wood-bed Lathe, or Horizontal Drilling Machine. Wood-bed Lathe with Iron Headstock. Steel Bar-bed Lathe. Making 2½-inch centre. Lathe with Back gear and Slide-rest. A 1-inch Centre Lathe. Index Plate for Lathe. Making Compound Slide-rest. Turret Head for Lathe Slide-rest. Lathe Accessories and Equipment. Using Lathes. Index.

Small Workshop Appliances. This book, illustrated by more than 150 drawings, describes how to make a variety of small appliances—some of them are scarcely dignified enough to be called machines—including a mitre board and cramp, a spindle moulding jig, mortising machines, small machine saws of various kinds, including jig-saws and fretsaws, lathe attachments for planing, sawing, glass-papering, drilling, etc. etc. An essentially practical and useful book for everybody who uses tools or wants to set up a small workshop

Soldering, Brazing and Welding. Chapters include : Various Processes of Joining Metals, Soft Solders, Soldering, Aluminium, Wiping Joints on Lead Pipes, Soldering Gold and Silver Jewellery, Welding Iron and Steel under the Hammer. Managing Blow-Lamps, Electric and Thermit Welding briefly considered, Oxy-Acetylene Welding, etc. etc.

Tailoring : How to Make and Mend Trousers, Vests, and Coats. *Contents.*—Tailors' Requisites and Methods of Stitching. Simple Repairs and Pressing. Re-lining, Re-pocketing, and Re-collaring. How to Cut and Make Trousers. How to Cut and Make Vests, etc. etc. 184 Illustrations.

Taxidermy : Skinning, Stuffing and Mounting Birds, Mammals, and Fish. *Contents.*—Skinning, Stuffing and Mounting Birds. Mounting Animals' Horned Heads. Polishing and Mounting Horns, Skinning, Stuffing and Casting Fish. Preserving, Cleaning, and Dyeing Skins, etc. etc. 108 Illustrations.

Ticket-Writing and Sign-Painting. Contents include : The Ticket-Writer's Tools and Materials, Letter Spacing, Using the Brush in Ticket-Writing, Roundhand, Italic and Script Letters, Air-Brushed Tickets, Colour, Contrasts in Sign-Writing, Seasonable Signs, Tickets and Posters, etc. etc.

Tinplate Work. *Contents.*—Elementary Examples. Hollowing Tinplate. Simple Round Articles. Saucepan Making. Kettle Making. Oil Cooking Stove. Set of Workshop Oil Cans. Fancy Paste Cutters. Lamps and Lanterns, etc. etc. 210 Illustrations.

Toy Making. Contents include : A Fort and Entrenchments, the Finishing of Wooden Toys, Making of Wooden Wheels for Toys, Rocking Horses, Wooden Motor Cars and Engines, a Pair of Scales, Dolls' Furniture, etc., Wheelbarrows, Making Dolls' Heads, Casting Toys in Metal, etc. etc.

Send postcard for Cassell's Technical Catalogue.

Cassells