EVERY BOY HIS OWN MECHANIC

BERNARD E. JONES

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USING THE HACK SAW

(Work is several inches too high for comfort and efficiency)

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BY

BERNARD E. JONES

Editor of "Work"

ASSISTED BY A

NUMBER OF EXPERTS

Illustrated by Sixteen Full-page Plates in Half-tone and Four Hundred Diagrams in the Text

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To My Own Boys,
Lewis and Anthony

PREFACE

In this book I have tried to tell boys how to do some of the things I have found them always eager to attempt. I have explained and illustrated for them the everyday tools of the worker in wood and metals, and shown how to use them. I have described a variety of handiwork and useful jobs about the house, and have introduced my readers to a number of mechanical hobbies, such as model electric lighting, wood and metal turning, model locomotive and railway work, fretwork, boat building, toy making, telephone construction and erection, etc., etc. I may say that in almost every chapter I have sought not only to present some interesting work or hobby, but to show my boy readers how to make themselves useful in their homes.

Much of the information in this book is " technical," but at the same time it is simple. In other words, I have sought to explain in straightforward sentences the " why and wherefore " of the methods and processes described, believing that the need of the future is for boys and men who understand what they are doing, and why they do it. I have done my best to make every statement easy of comprehension, and to use simple language devoid of unexplained scientific or technical terms.

Preface

It is a pleasure to make a few acknowledgments of help freely rendered me by personal friends. Mr. Henry Greenly, the well-known model engineer, has contributed two chapters on his own subject. Mr. A. Millward, a highly skilled amateur mechanic, has explained how to do simple turning in wood and metal. Mr. B. Clements-Henry, electrician, craftsman, author (and ever so many other things besides), has been good enough to go to the trouble of designing an especially simple form of house telephone, and of describing it in the very closest detail. Then there are Mr. R. S. Bowers, who has drawn a number of the best illustrations in the book, and Mr. J. G. Ross —a technical chemist—who has kindly revised the chapter on silvering glass. And I certainly must not forget to thank my boy friend Ronald Gaze, and my son, Lewis R. Jones, both of whom took pains in posing for a number of the photographic plates. Still further acknowledgments are made in certain of the chapters.

May my young readers find delight in putting into practice the information which I give them in the pages of this book.

B. E. J.

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EVERY BOY HIS OWN MECHANIC

HOW TO USE WOODWORKING TOOLS

The Bench.—The average boy mechanic is in my mind as I write. He will be interested in a variety of mechanical work, of which wood-working will be just one branch, and possibly he may have no convenience for a bench of his own, in which case perhaps he can use another's or can adapt a strong table to his purpose. Table benches are useful for light work, particularly so if there are side and cross rails near the floor, as these add tremendously to the rigidity of the construction. The average kitchen table is not rigid enough to withstand the stresses set up by planing, but if it is used in the corner of a room or against a wall, and the planing is always done towards the wall, the table may be made to serve very well.

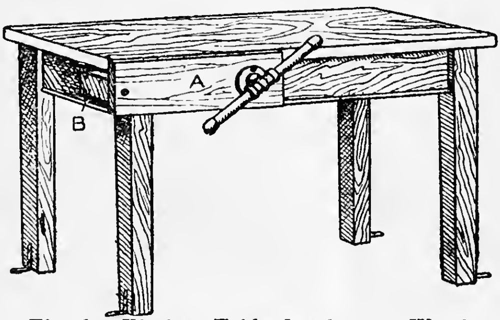


Fig. 1.—Kitchen Table fitted up as Woodworking Bench

Its chief lack will very quickly be discovered. There is no vice in which to hold pieces of wood for chiselling, tenon-sawing, etc., and the worker will not long be satisfied without one. Fortunately, a vice can be added to a kitchen table at small expense (*see* Fig. 1). Nearly every tool catalogue shows both wood and iron bench screws, both of them fairly cheap, and the iron ones (*see* Fig. 2) can be rapidly converted into efficient vices. Should the table-top overlap the side rail, as it almost certainly will, first screw on a piece of wood as wide as the table rail, of any suitable length, say from 6 in. to 12 in., and of such a thickness that its outer face comes flush with the edge of the table-top. If one piece of wood is not thick enough, use two or three, and screw all together. For the cheek of the vice you will need a piece of good hard stuff of any convenient width, say, 6 in. wide and roughly 18 in. long. The iron screw will vary in diameter, about eight sizes between $\frac{9}{16}$ in. and $1\frac{3}{8}$ in. inclusive being obtainable. You will need a centrebit that will cut a hole through which the screw will easily pass. With this bit cut a hole in the vice cheek, and right through the thickened rail of the table. On the screw is a nut which must be removed and screwed on the back of the rail in such a

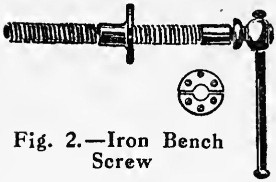


Fig. 2.—Iron Bench Screw

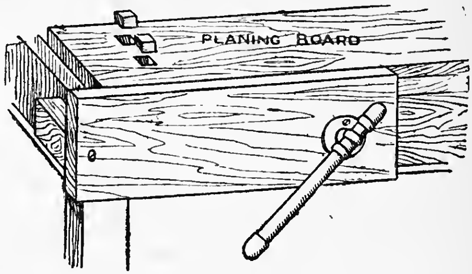


Fig. 3.—Bench Vice on Kitchen Table

position that the bench screw engages with it freely. There is also a collar which in the simplest form of construction is split (*see* Fig. 2). In attaching the screw to the vice cheek, it is pushed in as far as it will go, the split collar placed in position so as to engage in a recess cut in the screw, and the collar attached to the cheek with half a dozen small screws. On turning the screw by means of the lever handle, the vice cheek is moved to and fro, but owing to its length it will not move perfectly parallel with the table unless a "runner" is fitted to it. Now, B in Fig. 1 shows such a runner, and A is the vice cheek, and Fig. 3 is another view of it. The runner may be of 1 in. stuff by 1½ in. deep, or any size similar, and 1 foot or more in length, tenoned into the end of the vice cheek, as shown in Fig. 4, it being made a tight fit, and screwed from the front as indicated in the other views. A long, narrow box in which the runner slides easily is next made, but it is not fitted into position until careful testing has shown what its exact position should be. The presence of the runner, which should fit its box well, but not tightly, will ensure that the vice cheek is kept parallel with the side of the table when the screw handle is worked. Full details of the arrangement, which you can easily follow, are given in Fig. 5.

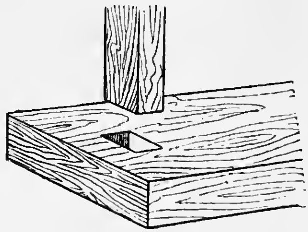


Fig. 4.—Runner Tenoned into Vice Check

Two details of the illustrations need a word of comment. In Fig. 3 is shown a planing board which protects the surface of the table, and in which two little mortises have been cut. Two pieces of wood (shown suspended over the holes) fit the holes tightly and can be slightly raised when required to form stops against which the work will be held for planing. The other detail is the little L-iron pieces screwed to the feet of the table legs in Fig. 1, and

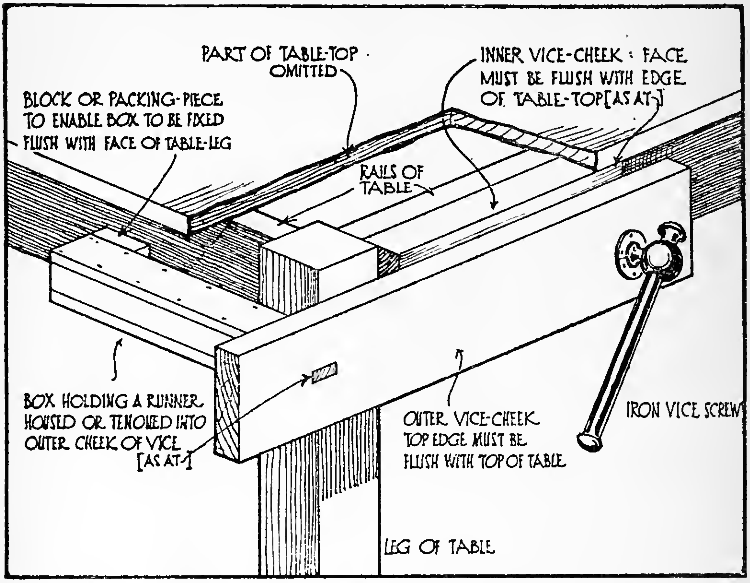
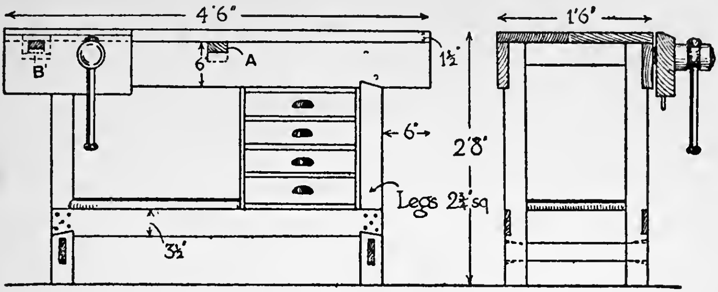


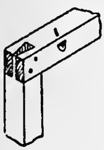
Fig. 5.—Constructional Details of Kitchen-Table Bench

also to the floor to render the table immovable when doing heavy work such as planing.

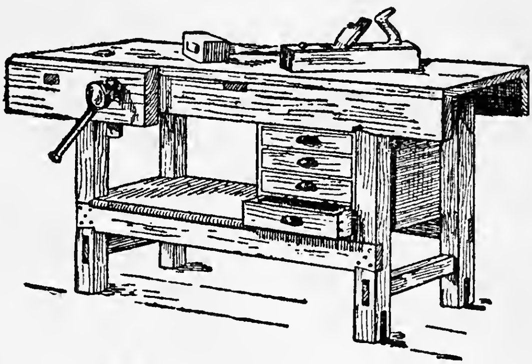
Of course, if you can afford to buy just the bench you want, there are many excellent designs available. Those with drawers or cupboards (*see* Fig. 6) are first-rate, and full details of construction are shown on the opposite page. The great advantage of a strongly-built "portable" bench is that the whole construction is held rigidly by means of



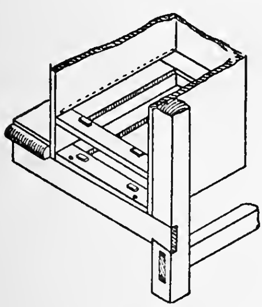
Front and End Elevations of Bench



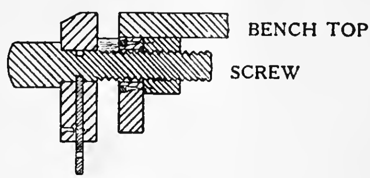
Top of Leg
Dovetailed
to Rail



Sketch of Complete Bench as in use



Arrangement of Drawer
Runners, etc.



Section showing how Vice
is fitted

Fig. 6.—Sketch and Working Drawings of Bench with Shelf and Tool Drawers

wedges which can be easily knocked out when it is required to take the bench to pieces for removal. The pin-board on the front of some benches is for the purpose of supporting long boards, one end of which will be held in the vice and the other supported on a wooden peg pushed into one of the holes at a suitable height.

Tools.—Sawing, planing and chiselling make up the bulk of woodworking, and I advise you to buy just the few tools that are essential and not to bother your head or empty your pocket by obtaining a fitted tool chest. Most of the tool boxes I have seen contain a number of tools that are seldom required, and only the best of these fitted boxes contain tools of really high quality. You can do a lot of things with just a few simple tools of average size and of good quality, kept in thorough order, and used with as much care and skill as you can muster. I am not going to bother you with a long list of the tools required (I show two groups of them in Figs. 7 and 7A), except to say that you will need a saw, a plane, two or three chisels, and the everyday tools that most households possess, such as a hammer, bradawl, gimlet, screwdriver, 2-ft. rule, etc. One or two other tools that would be extremely useful will be referred to as the occasion for their employment arises. The number of tools required depends so much upon what you want to make and upon the size and condition of the wood which you can get for the purpose. For example, if you can obtain at a local sawmill or carpenter's shop wood of any convenient length, width, and thickness accurately cut and properly planed, there is no need to buy a hand saw or a jack plane, extremely useful though those tools are, and you

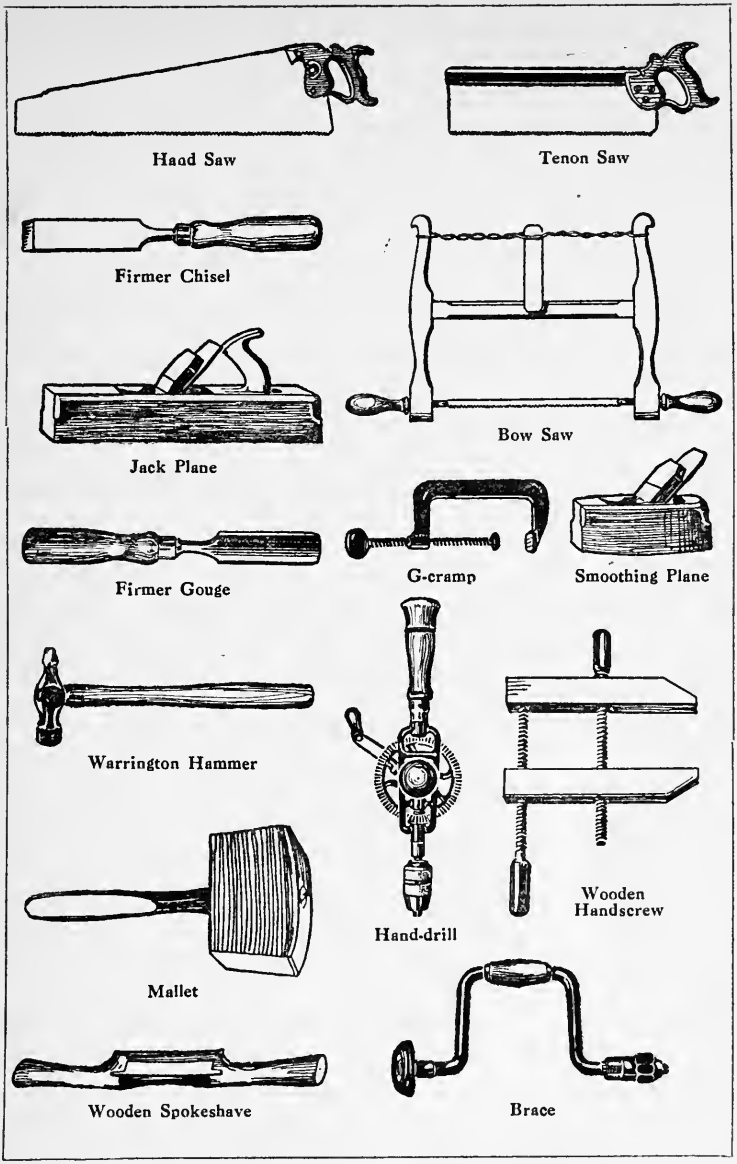


Fig. 7.—A group of fourteen of the Woodworker's chief Tools and Appliances

can keep the money by you until you take in hand an ambitious job where the tools mentioned cannot easily be dispensed with. Under such conditions as I have named a good tenon saw would answer most purposes, but don't get a cheap one, and don't buy one at a "clearance sale" unless you get with it a guarantee that it is by a good maker.

The hand saw is used for severing a board, and may be used either with or across the grain, for which reason it consists of a single piece of fine steel slightly tapered in thickness towards the back so that it works sweetly in the cut or kerf. The tenon saw is used chiefly in shaping work in the making of joints and for other accurate cutting of a finer and slighter nature than that which is generally accomplished with the hand saw. It has a thinner blade than the last mentioned, and very much finer teeth, and to prevent its twisting or buckling when in use it is strengthened with a back of brass or iron, as shown in Fig. 7. Some tenon saws have a hinged back, which can be pushed out of the way to allow of the saw being used as a hand saw, but I have not yet seen a tool of fine quality made in this way. A small brass-backed dovetail saw will be found useful. Saws for cutting small curves are the turn saw, compass saw, and keyhole saw.

How to Use a Saw.—Let our first attempt at woodworking be the sawing of a piece of board accurately to a line. The saw is to be started and maintained at work so as to make a neat cut at right angles to the face of the timber. Plenty of boys wonder why they cannot saw off a piece of wood with a perfectly straight and square edge. They get an edge which alters in its angle at every half

RIP-SAWING

Front and Side Views, showing correct position for Hand-sawing

inch, and in trying to correct it they produce another edge just as bad and run the risk of making the work too short for the purpose intended. The reason is that they

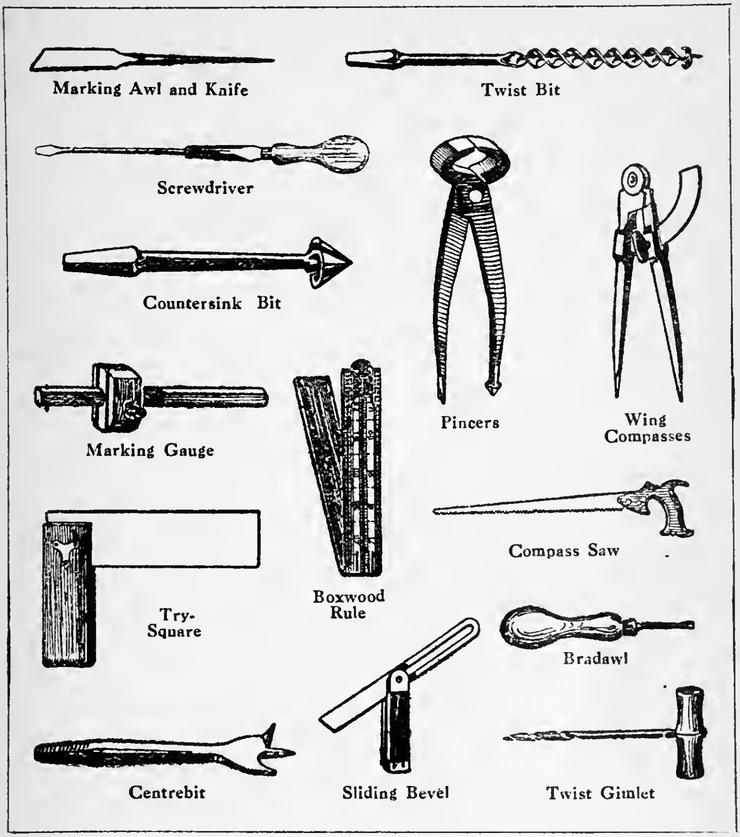


Fig. 7A.—Another group of fourteen of the Woodworker's chief Tools and Appliances

do not adopt the proper position. One of the photographic plates in this book shows the position for ensuring that the saw is cutting square to the face of the work.

Look at it closely, and you will discover the secret of accurate cutting. You will note that the saw, the forearm, and the right eye are in one vertical plane, and if you accustom yourself to working in this position you will soon get into the habit of square cutting. Every now and then you can test the accuracy by means of a try-square (Fig. 8).

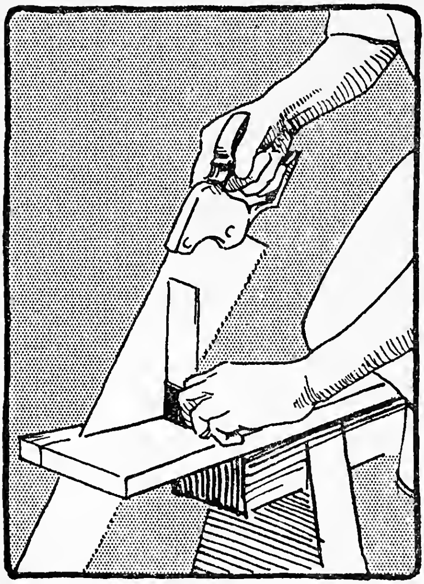


Fig. 8.—Testing Accuracy of Sawing by means of Try-square

The saw must be held as illustrated in the photograph from the very first cut to the last. At starting it is guided to the spot required by the thumbnail of the left hand (Fig. 9), and the first stroke is a short upstroke which just abrades the edge of the work and makes an easy path for the down stroke, which is the real cutting stroke. On the return upstroke take all pressure off the saw, as the teeth are so shaped that each one removes a little scraping when the saw is thrust forward, but has only a slight bruising action when drawn backwards in the cut. The carpenter who presses the saw into the work on the back stroke soon dulls his tool. Even on the downstroke do not press too heavily, and do not grip the handle too tightly or the vibration will soon cramp the fingers and tire the muscles of the arm.

To keep the saw to the line, the handle is very slightly lowered occasionally, the eye observing that it is following the path intended. But in taking pains to keep to the line do not " lay " the saw too much, as you will then be in effect increasing the thickness of the stuff and making the job a harder one. But, as I have said, unless you lay the saw to some extent, you cannot be sure of following the line.

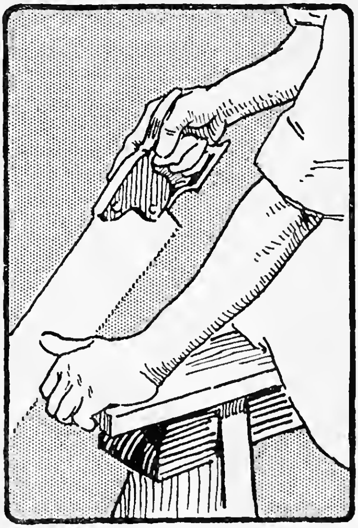


Fig. 9.—Starting a Saw Cut

In rip-sawing—cutting with the grain—you will need to support the work at both ends, whilst for cutting across the grain, it is usual for part of the plank to overhang the box or sawing stool. In both kinds of sawing the parts requiring the most care are at the beginning and the end of the cut, the first because accuracy and neatness depend upon it, and the second because without careful work it is easy to break off the partly-severed piece and leave an ugly splinter. Thus you need to go slowly and gently when approaching the end of the cut, and you or a helper must support the work until the saw has completed the cut. The method of starting the cut is the same for both rip-sawing and cross-cutting. In your early experiments, and especially if the saw is not in good condition, the tool may become nipped when well into the wood. This is because you have run the saw slightly out of the straight, with a consequent tendency to bend it in its width. You can overcome the trouble, as a rule, by wedging open the cut with a chisel, or by starting the cut at the other end of the board.

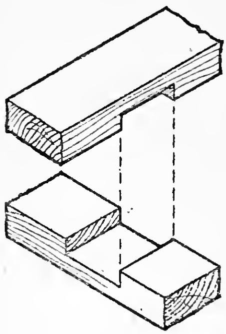


Fig. 10.—Cross Halving

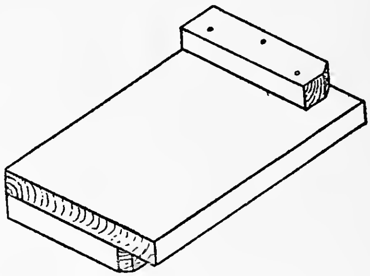


Fig. 11.—Bench Hook

Using a Tenon Saw.—Tenon-sawing needs to be much more accurately done than hand-sawing. You use the tenon saw in preparing the ends of two pieces of wood to be joined together, and any inaccuracy will probably betray itself in the finished job. But with a little care and using a good sharp saw you will rapidly overcome any initial difficulty, and will soon learn to make a straight square cut. It is held and started in the same way, but otherwise is used differently, as it is frequently necessary to cut a kerf the whole width of the board, and the "laying" of the saw condemned in the case of the hand saw is now unavoidable. In tenon-sawing it is often necessary to grip the work in the bench screw, and alter its position from time to time so that all saw cuts can be made in the vertical plane.

When making a halved joint (*see* Fig. 10) the tenon saw is the chief tool used, and the work is generally held, not in the vice, but in a simple device called a bench hook (Fig. 11), which is used as illustrated in Fig. 12. This bench hook is a piece of wood of any suitable dimensions with narrower pieces screwed across its ends, one on one face and one on the other. The left hand holds it and the work which it supports firmly on the bench, the underneath strip which abuts against the edge of the bench top preventing it from slipping.

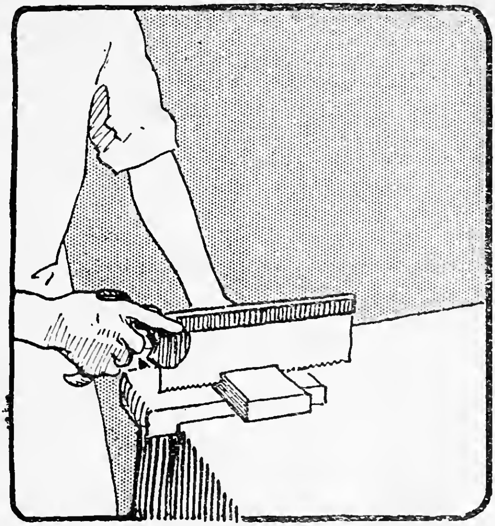


Fig. 12.—Sawing Halved Joint in Bench Hook

However well a joint may be set out on the work, it is quite easy to spoil it in cutting by inattention to one important point. It must always be remembered that a saw wastes an amount of wood of a width equivalent to the thickness of the saw measured across the face of the teeth (*see* end view, Fig. 13). To give the saw clearance, alternate teeth are bent or hammered sideways, the remainder being bent in the opposite direction. The result of this " set " is that a saw cut or kerf is of appreciable width, quite enough in itself to make all the difference between a good-fitting and a bad-fitting joint.

For example, two pieces of wood sawn off a length of stuff measuring 3 in. by 1 in. are to be halved together to make a cross. It is quite obvious that in each piece must be cut a recess measuring exactly 3 in. wide and ½ in. deep. Two lines are scratched or pencilled on by the aid of the try square at right angles to the edges of each piece, and exactly 3 in. apart. These lines are continued across the edges of the stuff, also by means of the try square, and a line midway between the two faces is drawn upon the edges by means of a marking gauge (Fig. 7A). To avoid mistakes in cutting, pencil a heavy cross on the face and edges of the part that is to be removed, and next make the cuts with the tenon saw. If both cuts are made exactly on the lines, half of each cut will be in the body of the work and half in the waste that is to be removed, and when the recess is finished, you will find that you will have a loose fit, the recess being too wide by the width of the saw across the teeth. If the cuts are made outside the lines, the greater will be the discrepancy. You will take care, then, to make the cuts *inside* of and touching the lines. That is, in joint making saw-cuts must always be made in the waste, whilst in cutting off a piece that is required to be of precise length the cut must also come inside the line, so that the piece is not

Fig. 13.—End view of Saw Teeth, showing " Set "

robbed of an amount equal to the thickness of the saw teeth.

Planes.—Everybody recognises a plane when he sees it. The body is of wood or metal, and in it is held a cutter or chisel at such an angle that it takes a shaving off the wood when the plane is pushed forward. Long planes are used for making the work flat and true, short ones for bringing the work to a smooth surface. Trying or trueing planes are among the longest in general employment; next comes the jack plane, the most popular of all; and the small plane is the smoothing plane.

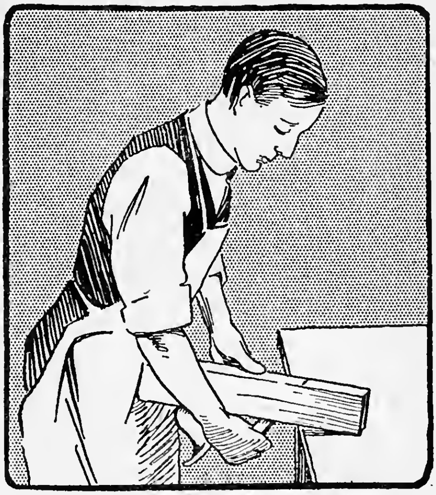


Fig. 14.—Striking Plane on Bench to loosen the Wedge

In wooden planes the cutter is held by a wedge. Modern planes are often of iron or steel, and the cutter is held in position and is adjusted by means of a simple screw. It is of not much use telling you how to use a plane unless first of all you know how to take it apart, sharpen the cutter, replace the iron wedge, and adjust it to get a good result.

If you have an up-to-date metal plane, the method of removing the cutter will be too obvious to require description here. In the case of a wooden plane, either jack or smoothing, the cutter can only be removed by first loosening the wooden wedge. Take a jack plane in your hands as in Fig. 14, which shows the tool upside down. The wooden part is held by the left hand, while the right holds the wedge and cutter. Bring the plane down smartly on the top of the bench, and this will have the effect of releasing the wedge, and allowing the iron to be withdrawn ; or, if you prefer, hold the plane as in

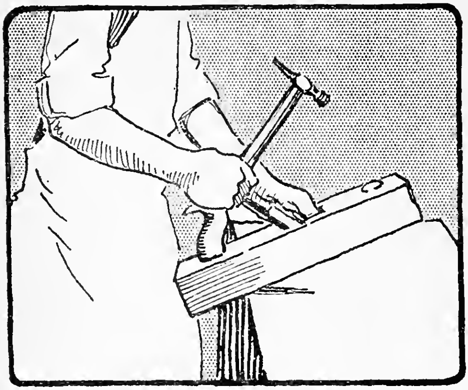


Fig. 15.—Striking Plane with Hammer to loosen the Wedge

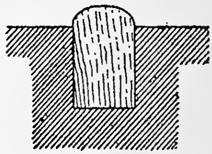
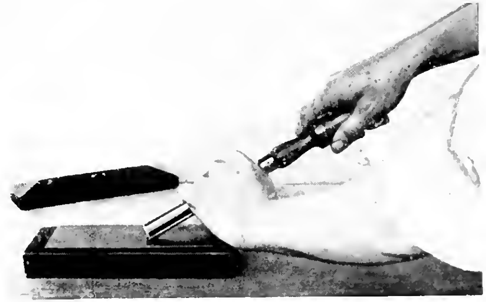


Fig. 16.—Hammer-stop or Striking-button in Plane

Fig. 15, the right side up, the fingers of the left hand reaching to its face, and the thumb being inserted in the opening (which is known as the throat), and press on the face of the iron. Take the hammer in the right hand and give two or three smart knocks on the top of the plane in front of the left hand. This is a more gradual method of loosening the wedge, but the hammer is liable to mark the plane unless the latter has what is known as a "hammer stop" let into it. Fig. 16 shows such a stop in section. It is simply a plug of hard wood with a

TOOL SHARPENING

Sharpening a Plane Iron



Sharpening a Gouge

Finishing a Chisel

Finishing a Gouge

rounded top glued into a hole that has been bored in the plane stock for its reception. This plug takes the hammer blows and prevents disfigurement.

The plane is now in three parts—the stock, the wedge, and the cutting iron (Fig. 17). Now, the last-mentioned is itself in two parts (*see* Fig. 18); one of these is simply a wide chisel with its corners very

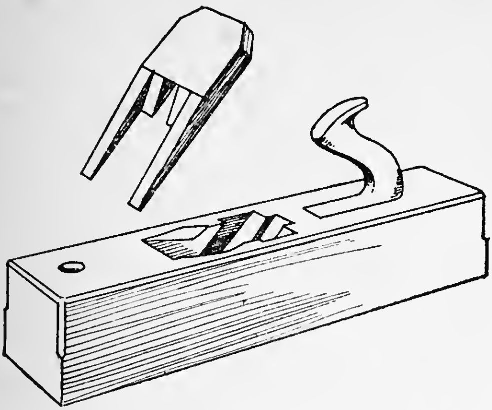


Fig. 17.—Stock and Wedge of Jack Plane

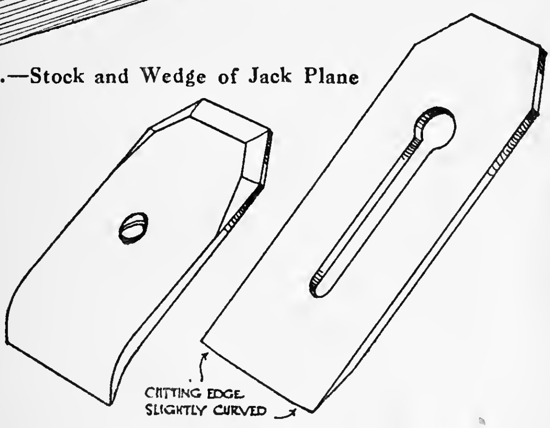


Fig. 18.—Plane Cutter and Cap- or Break-iron

slightly rounded off so as to prevent the cutter digging into the wood and leaving ridges. Screwed to the cutter is the cap-iron, or break-iron, which does not reach quite to the cutting edge, and which must be removed before the cutter can be sharpened. If you look at Fig. 19 you will see how a plane does its work. The cutter is projecting slightly from the face or sole, and pares a shaving from the wood over which the plane is pushed. This shaving enters the plane through a narrow mouth where it meets with the rounded end or face of the cap-iron, which breaks its stiffness and gives it a curved shape, so that as the plane continues to work the shaving easily passes out through the wide throat. In an old plane reduced by much wear the mouth has become wider than it was originally, and the shaving tends to split away from the work because there is not enough wood immediately in front of the cutter to hold the grain down. Very often an old tool is made serviceable again by gluing in a block across its face so as to reduce the width of the mouth.

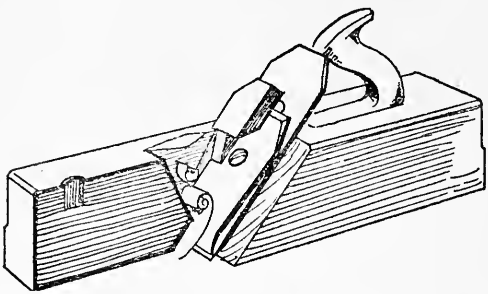


Fig. 19.—"Cut-away" view of Jack Plane, showing the working principle

To remove the cap-iron from the cutter is simply a matter of undoing a screw. Now we have the cutter to sharpen and set, and the work will afford us an example of how all woodworking chisels are prepared for their work. The hand chisel, for example, is sharpened and set in almost exactly the same way as a plane iron, and the one explanation will do for both of the tools. There is just one difference. The edge of a chisel is straight, whilst that of a plane cutter is very slightly curved for a reason already explained.

Sharpening Plane Irons and Chisels.—When you receive a new plane, you may find that the edge of the cutter has been ground but has not been sharpened. Such a cutter may be sharpened many times for every once that it will require to be ground. The grinding angle is about 20°, and the sharpening angle about 30°,

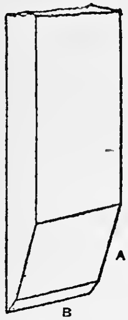


Fig. 20.—End of Chisel, showing Grinding Angle (A) and Sharpening or Setting Angle (B)

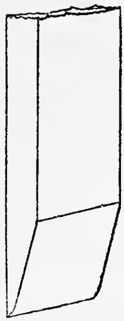


Fig. 20A.—Showing how Edge of Chisel is spoilt by Bad Setting; note the Rounded Angle

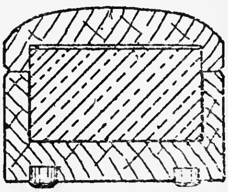


Fig. 21.—Cross-section through Oilstone and its Case; the Rubber Plugs hold Case to the Bench

as indicated in Fig. 20. You can go on resharpening the cutter from time to time until much of the grinding angle has been worn away. Then the cutter must be taken to somebody who has a grindstone and a new bevel of 20° ground on it. I won't trouble you with the grinding, as not many boys have a grindstone of their own, but the sharpening for which an oilstone is necessary is an operation which you must master. The professional woodworker gets easier and better results with edge tools very largely because he thoroughly understands how to keep them in order, whereas a great many amateurs fail in this respect.

First you will need a good oilstone, and preferably it should have a case (Fig. 21). If you have one already in the house make that do. If you propose to buy a new one, ask for a Washita, or an Arkansas, both of them natural stones, or for a medium grade India stone, which is an

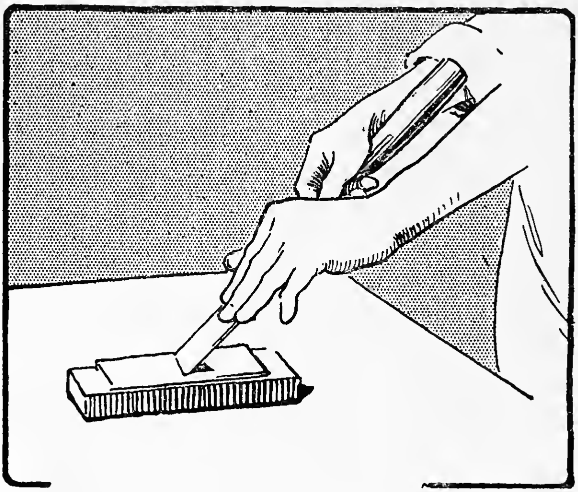


Fig. 22.—Sharpening or Setting a Chisel; the Handle is here shown a trifle too high

artificial product of a reliable quality. Have some sweet oil in a can handy on the bench and grip the cutter or chisel with the right hand, as shown in Fig. 22. Place the fingers of the left hand lower down the tool so as to provide pressure, whilst the right hand will see that the proper angle (about 30°) is kept. This is where difficulty will come in at first. The right hand will not move to and fro quite parallel with the face of the stone, and the sharpened face of the cutter will have a rounded instead of a perfectly straight surface (*see* Fig. 20A), but that is a matter which care and practice will put right.

Anoint the stone with oil and start the rubbing. I expect it will take you at least ten minutes at first to get anything like a good edge on a blunt-ground chisel. Your arms will ache and your hands be cramped, and you will be tempted to leave off before you ought to and make do

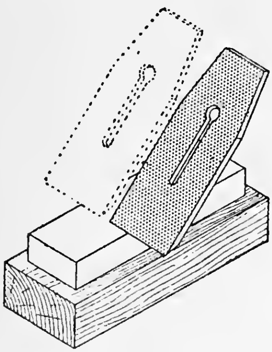


Fig. 23.—Diagram indicating Side Movement in Sharpening a Plane Cutter

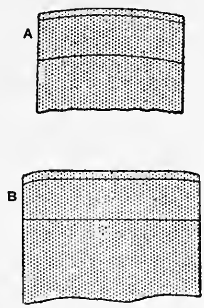


Fig. 24.—Rounded Edge of Smoothing Plane Cutter (A) and Jack Plane Cutter (B)

with an inferior edge. If you fall to the temptation you will work far harder at a later stage than ought to be necessary. You will waste time, and will fail to produce that proper, cleanly-cut surface which should be the pride of every craftsman. Keep a chisel moving to and fro in the same path, but a plane cutter should be moved slightly from side to side (*see* Fig. 23) to produce the slight roundness of edge of which I have already spoken. A (Fig. 24) shows the edge of a smoothing plane cutter, and B that of a jack plane cutter.

In the course of a few minutes you will see that the rubbing is beginning to tell, but do not try the edge with your finger, for obvious reasons; the eye alone will tell you when the bluntness has been rubbed off. Wipe the tool when it has reached this stage on a piece of rag, and notice that on the opposite face of the chisel a wire edge has been turned up. This is removed by placing the tool perfectly flat on the oilstone—avoid the least suspicion of an angle—and giving one or two gentle rubs. The cutter should now be in good condition, but can be made even keener by stropping it on a piece of leather into which has been rubbed a mixture of tallow and crocus powder.

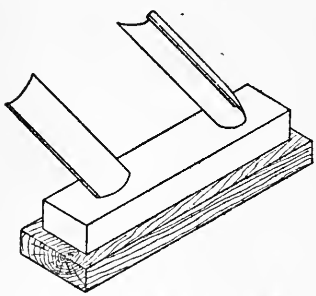


Fig. 25.—Sharpening Gouge on Oilstone

Sharpening Gouges.—Let me drop a note in here on the method of sharpening a gouge, which, after all, is only a chisel of curved section. There are two sorts of gouges as there are two sorts of chisels, the firmer and the paring gouge, the firmer having the bevel ground on the outside, and the paring gouge having an inside bevel. The firmer gouge is sharpened in the same way as an ordinary chisel except that the tool must be kept turning to and fro as the curve demands (Fig. 25). A wire edge will be turned up as before, and this must be removed on an oilstone slip of curved section on which the gouge will lie in intimate contact while being gently rubbed.

The paring gouge must be sharpened from the inside on an oilstone slip, it being customary to hold the tool still and move the slip to and fro, taking great care that the correct angle is maintained. To remove the wire edge in this case, place the gouge flat on an oilstone and give a gentle rub or two whilst slightly revolving the tool, in this case, also, taking the very greatest care not to produce an opposing bevel. Gouges should be well stropped.

Re-assembling the Plane. — Now we can get back to the plane. The cutter has been sharpened and stropped to a wonderful keenness, and we wish to get it back into the stock and see what it can do. Holding the cutter in one hand and the cap-iron in the other, slide them together until the cutting edge projects by, say, two or three thirty-seconds of an inch. Then tighten up the screw, and place the double iron in the throat of the plane. The thumb of the left hand will hold the cutter in position until the wedge can be pushed in firmly. Lean the back end of the plane on the edge of the bench in such a position (*see* Fig. 26) that you can sight down the sole or face and observe the exact amount by which the cutter projects. A very slight projection is all that is required. Give the wedge a tap or two with the hammer, and the cutter will

Fig. 26.—Sighting along Sole of Plane for Projection of Cutter

be fixed. Again sight down the face, and if the cutter projects too far give the front of the plane a light blow with the hammer and again give a tap on the wedge. On the other hand, if there is not enough projection, give the cutter a gentle tap from the back, all the while sighting down the sole to see you don't over-do it.

Fig. 27.—How to hold the Jack Plane

Using a Plane.—You will be anxious to try the plane. The method of holding it in the case of a jack plane or other large tool will be quite obvious from Fig. 27. The handle, called a toat, is grasped by the right hand, while the left hand bridges the front, the thumb being on the near side and the four fingers on the other side, as illustrated.

A smoothing plane has no handle and needs to be grasped firmly at the back by the right hand, as in Fig. 28, whilst the left is passed right round the front end, the thumb lying on top of the plane, and the fingers extending to the far side.

The jack plane should be given a straightforward thrust, each stroke being as long as the work demands or

PLANING

Holding a Jack Plane

Position when Planing

Testing Planed Wood Across the Grain

Sighting a Piece of Planed Wood for Straightness

as the craftsman can make it. Just as the cut starts, the left hand presses down the front of the plane, but gradually this pressure is released as the stroke nears its end. You will need to hold yourself correctly. Standing in front of the bench, the right foot will point towards it whilst the left will be parallel to it, the direction of planing being towards the left. If the tool fails to take off a thin even shaving and if you are convinced that it is in good order, you had better make quite sure that you are not working against the grain, as this has the effect of splitting off the shavings as they are formed. Should it happen, reverse the work. Of course, wood with a very curly grain is not easily planed; indeed, sometimes planing has to be replaced by the use of a woodworker's scraper, which is a piece of flat steel with a keen but turned-over edge.

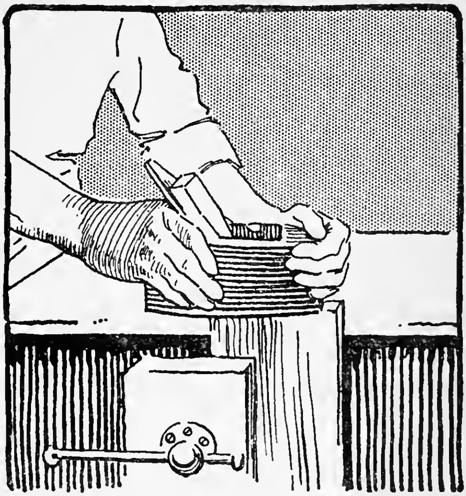


Fig. 28.—How to hold the Smoothing Plane

Much the same advice applies to the manipulation of the smoothing plane. It must be lifted sharply on reaching the end of the stroke so as not to leave a mark; and it is unwise to attempt at first to plane end grain with it, although in cases where this must be done it is usual to pare away the extreme end of the edge that is to be planed; another dodge is to clamp on a piece of waste stuff so that if the grain of the wood is split by the plane the damage will occur to the waste and not to the work.

The Scraper.—Not many amateurs can use this simple tool successfully. I mention it because it is an alternative to the plane when working on curly-grain woods, whilst on other woods it is used after the smoothing plane. Fig. 29 shows the principle on which it cuts, and Fig. 30 the tool itself. The cutting edges are A B and C D, and the rounded corners should be noted. It is used as in Fig. 31, the scraper being pushed away from the worker, as from A to B, but occasionally it is manipulated in the reverse direction. The scraper must have been ground with square edges, and these should be brought into perfect condition by rubbing on the oilstone in the position shown by Fig. 32, afterwards placing it flat on the stone (as in Fig. 33) and removing any burr. Then rub with a polished gouge (as in Fig. 34) till the sides are polished, again squaring the edge on the stone should any burr be caused. The next proceeding is to turn up a very fine burr (this is much exaggerated in the diagram, Fig. 29), to do which the scraper is laid flat on the edge of the bench, as in Fig. 35, and a polished gouge or any similar smooth steel tool used in an upright position is lightly pressed about twice along the edge at right angles to the flat sides of the scraper. You will probably need to make a good many attempts before you succeed (re-setting the tool on the oilstone every time), but success is worth while, because the scraper is a wonderful tool—a real cutting and not a scraping tool—and its "sweet" use gives a lot of pleasure.

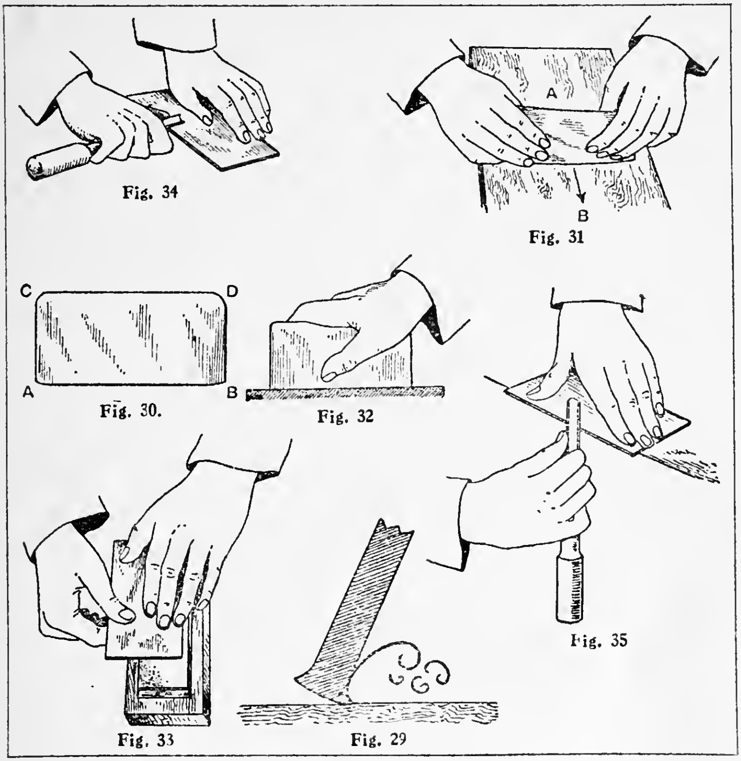


Fig. 29.—Working Principle of Woodworker's Scraper
Figs. 30 and 31.—Scraper and how to hold it
Figs. 32 to 35.—Four Stages in sharpening the Scraper

Chisels.—The boy mechanic will show his excellence as a carpenter by his skill in the use of a chisel. Everybody knows the shape of the ordinary chisel, and I will only say that the long thin chisel is used for paring, and a shorter one, the firmer chisel, for making mortises, etc., for which purpose it is driven with a mallet. Carpenters have a very thick chisel known as a mortise chisel with which to lever chips out of slots. Ordinary chisels vary in width from $\frac{1}{16}$ in. to 2 in., and they are sharpened exactly as a plane iron (*see* p. 19), except that the edge forms a straight line, whereas in a plane iron the corners are rounded off. On a grindstone a chisel is ground to an angle of 20° or 25° (the latter for hard wood), but this is not the angle adhered to when the chisel is placed on the oilstone. Something a trifle blunter is aimed at, so as to give the edge greater strength; thus the set or sharpened edge forms an angle of about 30° to 35°. Fig. 20, on page 19, shows the working end of a chisel, and it will be seen from this that the tool can be repeatedly rubbed up on an oilstone until most of the ground bevel has been worn away. Then regrinding on a grindstone becomes necessary.

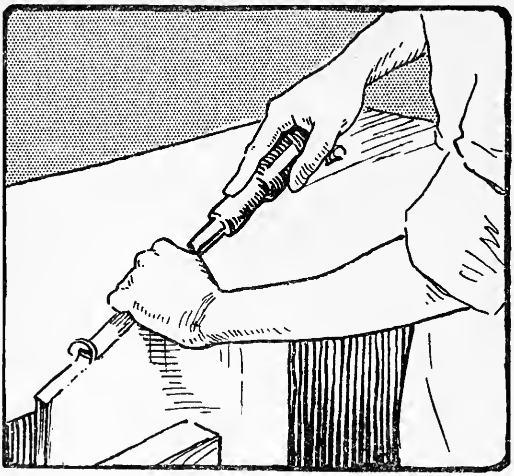


Fig. 36.—Paring on the Slant

I believe the great trouble in using chisels is the difficulty of making and keeping them sharp. Beginners don't seem to be able to get a straight bevel. They get, instead of the flat facet, a rounded face surface with which sweet cutting is impossible (*see* Fig. 20A). Practice sharpening the tool until you can do it really well, and the actual use of the chisel will then be a much simpler matter.

A chisel is used for two purposes—paring by hand and chipping when driven by a mallet. By the way, don't hit the handle of a chisel with a hammer; use a wooden mallet. Just because a chisel is sharp, and you like to swing your mallet, do not be tempted to take out deep chips. It is so easy to overstep the mark, and also to splinter the work on the side farthest from you. The best practice is to remove a chunk of wood by means of reasonably thin parings, and paring may be done horizontally or vertically, whichever you find the more convenient.

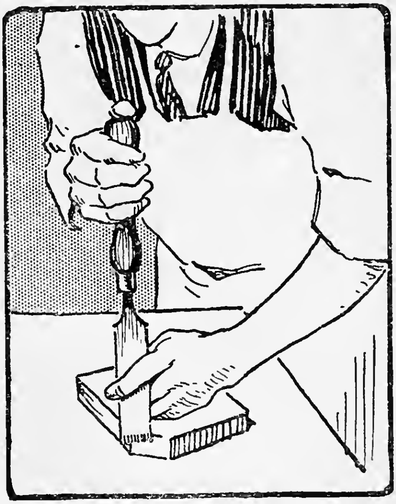


Fig. 37.—Vertical Paring of Corner

Sometimes paring is done on the slant, but, of course, do not try to pare against the grain, or you may split the work. In other words, when paring off a corner (*see* Fig. 36), start from the side, and cut slantwise across the grain, the wood being held upright in the vice so that the pared surface is approximately level. You can pare off a corner by having the wood quite flat on a bench, and here again you must start at the side of the wood and work towards the end (*see* Fig. 37), as otherwise the chisel may easily dig in and split the work down the grain when the chisel nears the side. An experienced woodworker would use the chisel in a job of this sort with a to-and-fro motion, so that the edge of the tool enters the work much as would the blade of a knife. If you take up a stout piece of wood, and try to remove a thick chip from the end with a knife you will almost unconsciously give the knife a slight movement lengthwise as well as forwards so as to facilitate the cutting action. The same principle frequently applies in using a chisel. Try to sharpen a thick pencil with a chisel and you will get the idea at once.

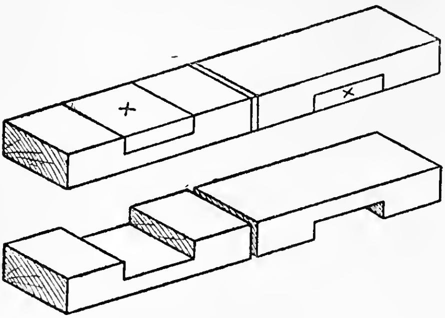


Fig. 38.—Setting-out and Working Cross-halved Joint

Making a Halved Joint.—There is a common joint which will afford us some practice in using a chisel. It is the halved joint (Fig. 10, on page 12) to which I remember my first introduction was in the making of a toy sword, in which it is customary to sink the crosspiece flush with the handle.

By means of a square two lines are set out on the face of each piece, the distance between these lines being the width of the stuff. On both sides of each piece the lines already drawn should be squared over (Fig. 38), and at half the thickness, there is drawn a line with a gauge parallel with the face of the work; thus both pieces are set out in exactly the same way. Mark with a cross any pieces to be cut out. Next, with a fine saw held perfectly upright, cut down on the lines until the half thickness is reached, treating both pieces in the same way. On your discretion in cutting these lines will depend whether the joint is a good fit (*see* page 14). If you were now to take a chisel and a mallet, place the edge of the chisel on the horizontal line connecting the bottoms of the cuts, and then give a good blow with the mallet, probably two things would happen. A notch with an uneven slanting bottom would be formed, and the farther side of the work would be badly splintered. So first study the grain, and if you can see that such a course would be safe, you can take a good thick chip to start with, and then, using the chisel carefully—if the notch is a wide one adopt the sideways movement of the chisel—pare down, as in Fig. 39, until you have formed a flat surface flush with the line scribed on the side. Treat both pieces in the same way, test the bottom of the halvings for flatness and squareness,

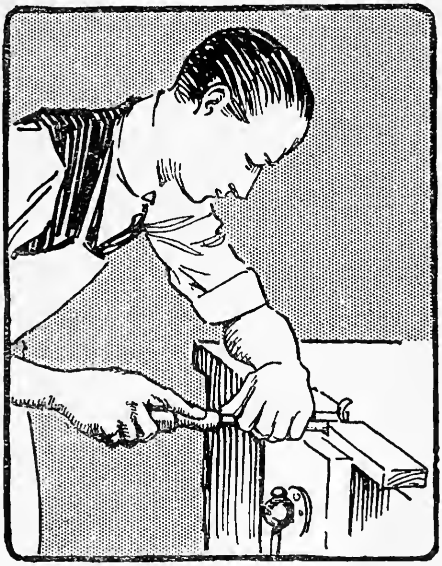


Fig. 39.—Horizontal Paring in making a Halved Joint

fit the joint together, and make any adjustment required. In deepening the notch by a slight shave, if this should be necessary, the chisel is afterwards used as a knife to detach any parings that may still be held by their edges (*see* Fig. 40); it is drawn along in the angle of the cut with its front point raised, the flat of the chisel being in contact with the wall of the notch.

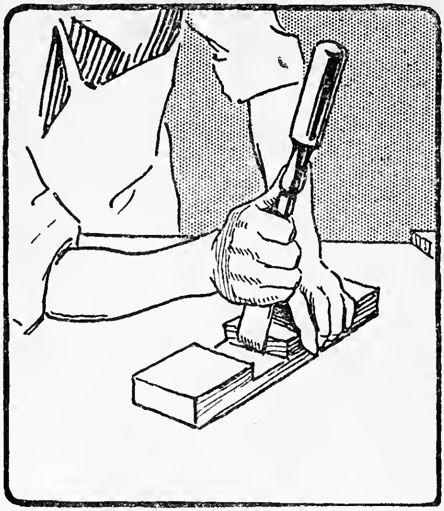


Fig. 40.—Cleaning out the Halving with Corner of Chisel

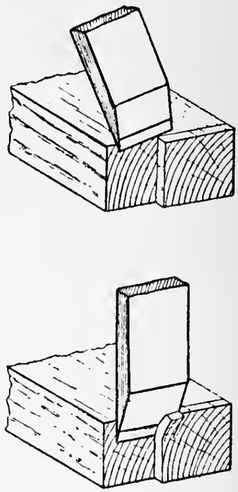


Fig. 41.— Starting Chisel on the Slant in Overhand Paring

Overhand Paring.—For paring a short length off the end of a piece of work, start the chisel on the slant, as in Fig. 41, and when you feel that it is making progress bring it to the upright. Cut only a little at a time, and the work will be easier and of cleaner finish; this applies to all chiselling. It will be obvious that in vertical paring, known as overhand paring, a great deal more power can be applied to the chisel. The work should be so held

USING SCREWDRIVERS

Narrow Screwdriver Injures the Screw-head

Slanting the Tool Injures Screw-driver and Screw-head

Removing Damaged Screw with Spanner

Using Screwdriver-bit in Brace

that the eye can look down the chisel and see that the paring is quite vertical. The left hand will hold the tool near the point and guide it to its work, while the right will grasp the handle, the thumb coming on top (*see* Fig. 36).

In later chapters I will show you how to make a few simple joints—the dovetail among them—and will illustrate and describe a few wooden constructions upon which, if you can get the material, you may try your 'prentice hand.

Screwdrivers.—The selection of a screwdriver is more important than some boys think. One of the plates in this book shows a narrow screwdriver used on a stout screw, the effect being to spoil the edge of the screwdriver and injure the head of the screw. To the right of this in the plate is a screwdriver held at a slight angle, a common ault with careless people. Here, again, the head is easily damaged, and once broken it may be difficult to get the screw out again. One method is to square the head with the file and to withdraw it by means of a spanner, this operation being shown in the plate. The screwdriver point or end should be almost parallel in thickness, and a fairly good fit in the nick of the screw. A powerful form of screwdriver is a brace into which a screwdriver bit has been inserted, such a combination being shown in use in the plate already referred to. I often use this device for driving long thick screws, but I find it has a big disadvantage; it is difficult to maintain the pressure so as to prevent the bit slipping from the head of the screw. The arm or crank of the brace gives enormous power, so much so indeed, that if the head of the screw is weak, or the point of the screwdriver bit is inclined to be hard and brittle, either or both may be broken.

The effect of using a screwdriver wider than the screw is to mark the work should it be necessary to insert the screw flush with the surface. The ordinary wood screw, actually of steel but known as a wood screw to differentiate it from screws for metalwork, has a countersunk head, and in careful work it will be necessary to chamfer or countersink the screw hole to accommodate it. The countersinking can be done with gouge or chisel or by means of a nose-bit or special countersinking bit used in a brace.

To remove rusted-in screws, put the screwdriver in place in the nick and give a smart knock with a hammer to break the rust joint; or try the effect of expanding the screw by heating it with a red hot poker.

I give some information on the use of nails and screws in a much later chapter.

MAKING AND USING VARIOUS CEMENTS

Cementing a Rim on a Biscuit Barrel.—These instructions will apply just as well to the fixing of a mount or rim to the reservoir of a lamp, a glass pepper-pot, glass inkstand, and many other things. First with a bradawl scrape away the old cement from the glass or china article and also from the mount or rim, but take care in the latter case that you don't bend the metal and spoil the fit. Put some boiling water in a cup and drop in some crystals of alum, adding more and more until the water refuses to dissolve any more of the substance. Such a solution as this, as you have probably learnt in your chemistry lessons, is known as "saturated." When it is fairly cool, put a couple of spoonfuls of perfectly fresh plaster-of-paris in a saucer, add some of the alum solution, and mix up rapidly to a rather wet consistency. Then, without waiting, put some of the cement on the vessel or in the mount, and press the two parts into close contact, taking the greatest care that the mount "sits" square and level. In half an hour's time any surplus plaster can be scraped away, and the vessel can be used twenty-four hours later.

Another way, equally good, is to use powdered alum alone. First see that the articles are free from dirt and grease. Powder the alum, place the rim upside down, fill it with the powder, and put it on a metal plate over a low gas flame or on the warm kitchen range, and you will note that in the course of a few minutes the alum will get pasty. When this occurs, press the glass or china article firmly into the rim, quickly invert, see that the rim is in its correct position, and put aside for half an hour in a cool place, when the article will be ready for use.

Cementing Celluloid and Xylonite.—Boys and girls use lots of things nowadays that are made of celluloid (xylonite is only another name for it). Girls have combs and hair ornaments and brush-backs and ping-pong balls of this material, whilst boys have celluloid knife-handles, celluloid accumulator cases and celluloid films for hand cameras and cinematograph machines. By the way, I once had some beautiful hair-brushes which I thought had backs of fine ivory, but one day I touched them with turpentine, and immediately I became aware of a faint smell of camphor. They were celluloid! You will know now how to test yours. It is just as well to find out which articles are celluloid and which are not, because, as you are probably aware, this substance ignites with an almost explosive violence.

When celluloid gets broken, it may generally be easily cemented. It dissolves very readily in a liquid known as amyl acetate, which you will know by its strong smell of those sweets sold under the name of "pear-drops." So all you have to do when you want some celluloid cement is to put a few scraps of a broken celluloid toy, etc., in $\frac{1}{2}$ oz. of the amyl acetate, and after the celluloid has dissolved apply the solution with a camel-hair brush, and bring the two parts together. An excellent solvent for celluloid is a mixture of equal parts of acetone and the amyl acetate. "Non-flam" film (made of a celluloid substitute which does not readily ignite) will not dissolve in either of the above, but will be found to do so readily in chloroform, which when not in use must be kept in a tightly stoppered bottle, a point which applies to all celluloid solvents and cements. But chloroform is dangerous stuff in the hands of inexperienced people.

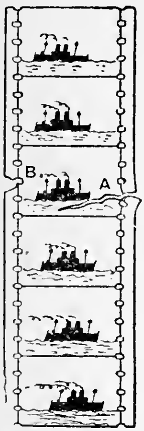


Fig. 1.—Torn Cinematograph Film

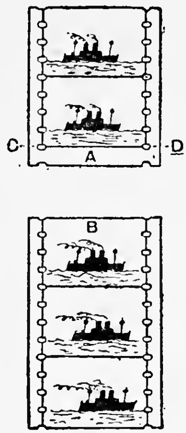


Fig. 2.—Film with Picture Space cut out

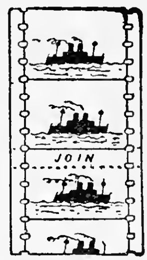


Fig. 3.—Cinematograph Film joined together

Cinematograph films are made of celluloid, and if you are called upon to repair them (they easily get torn when in use, Fig. 1 showing an example at A and B) you will need to cut out a picture, but this will make no appreciable difference to the effect on the screen. Cut the film as in Fig. 2, making one cut at the dividing line B, but leaving a little strip A, below the dividing line C D. Place the piece containing strip A on the table, and, first wetting the strip with the tongue, carefully scrape away the photographic emulsion or gelatine below the line C D, using a penknife. Then apply the cement already mentioned to the back of B, and bring the two together, taking particular care that the joint is absolutely square and otherwise correct (*see* Fig. 3). Keep under pressure till dry.

China and Glass Cements.—I suppose most of my readers are called on some time or other to repair a broken article of glass or china. There are scores of cements that may be used for this purpose, apart from those that can be bought ready made. Plaster-of-paris, mixed with a solution of alum, as already explained, will mend china, but not so strongly as to allow of the article being washed with hot water or used as a hot-water container.

An excellent cement for either china or glass is sodium silicate which possibly is employed in your household under the name of " water-glass " for preserving eggs. It should be used exactly as it comes from the lever-lid tin in which it is bought, and should be applied thinly, but it is desirable to warm the article, and the water-glass is more easily applied if it is warmed too. The article requires to be held together by tying tightly with string or by some other means until the joint is hard.

A first-rate cement for china, glass and stone is a mixture of water-glass, manganese, and zinc white all ground up together ; and a putty that answers well for glass can be made by mixing chalk with water-glass. It is even better than the usual oilshop putty in one respect —it only takes a few hours to dry.

A good many boys turn their hand to the making of an aquarium, and the usual cement used for this purpose is a mixture of various oxides of lead. One of the easiest to make consists of the best quality white-lead, bought already ground up in oil, mixed with equal parts of dry red-lead and dry litharge. But remember in using lead cements that they are poisonous; they should not, therefore, be worked up in or applied with the hands, and after they have been given a week or two in which to dry and harden, the aquarium should have many changes of water before introducing either pond weeds or fish. Perhaps the safest way is to give the cement a few days to dry, and then apply three coats of good varnish, allowing at least two days for each coat to dry before applying the next. In any case, a few small minnows should be tried in the water before introducing valuable fish.

Cementing Solid Tyres to Rims.—In the old days before pneumatic tyres were known, the solid tyres with which the "ordinary" bicycle was fitted had to be cemented to the rim. Nowadays, it is only mailcart and perambulator tyres—and those not of the best quality—which are so fixed. Should a tyre of this kind—the non-wired kind—become loose, you will find it a fairly simple matter to re-cement it in place, but it is a job requiring some amount of care. The cement used is a mixture of gutta-percha and pitch, and can be bought at any hardware stores. It may be used just as though it is sealing-wax, and the empty rim smeared with it all round, heating the cement in a candle flame or by means of a red-hot poker. The cement having been applied, stretch the tyre into place, and spin the wheel on its axle. Have ready a spirit lamp, which, as you know, has a smokeless flame, and as the wheel spins approach the flame to the rim so as to melt the cement evenly all round. Keep the wheel rotating, as otherwise there is risk of spoiling any paint or enamel on the rim, which, in any case, will not be improved in appearance. You can make a very cheap but efficient spirit lamp from a ginger-beer bottle by pouring into it some methylated spirit and then stuffing in a wick made of loose cotton strands.

In the chapter on Cycle Adjustments and Tyre Repairs I deal with the cementing of patches on pneumatic tyres.

Using Portland Cement.—If you have occasion to use Portland cement, small quantities of which can be bought at oilshops, of builders' merchants, etc., mix it thoroughly with an equal measure of perfectly clean and fine sharp sand, add a little water, and at once continue the mixing until you see the mortar is of a nice even texture. This will make a very strong cement and a more durable one than if the sand were omitted. For cementing a brick into place, or for any odd repair about the yard or garden, you can mix two measures of sand with one of cement. I put in a splendid floor to a summerhouse once with a concrete made by mixing 1 part of cement with 4 or 5 parts of sandy gravel dug up from a pit made in my garden. Such a floor will last scores of years, whereas a wooden floor often decays in a few years' time.

ERECTING ELECTRIC LAMPS AND BELLS

Batteries.—What a great convenience it is to have an electric light over your bed! I shall show you in this chapter how you can instal a tiny electric lamp more than enough to see the time by; you can make the battery, erect the wiring, and connect up the lamp yourself, and be independent of any main-supply system. I have said you can "make" the battery; so you can, but it is generally cheaper to buy it already made. However, I expect you are one of those boys who glory in making everything for themselves, and so in another chapter I am giving you full instructions on how to make a battery suitable for running a pea-lamp for a few moments at a time, using it only occasionally over a period of several months. This type of battery (*see* pages 112 to 115) is known as a primary battery, and it produces an electric current by the chemical action of the substances with which it is charged.

There is a much more convenient type of battery, known as a secondary or storage battery, otherwise an accumulator. It contains lead plates immersed in dilute sulphuric acid, and is charged with current from a dynamo, from a primary battery, from another accumulator, from the electric-light main, or from whatever source of electric current happens to be convenient. The primary battery once exhausted needs to be recharged with chemicals; the accumulator, when run down, simply requires a new electric charge. The accumulator is more expensive than the primary battery, but can receive and yield a far greater amount of current, and is a more reliable appliance.

Now for a bedroom or workshop light, one or other of these devices is necessary unless, of course, you can afford a little dynamo and to run it by means of an engine of some kind; but, generally speaking, the cost and the attention needed by the engine make such an arrangement rather out of the question, and most boys fall back on the accumulator or the simple primary battery.

In another chapter, I explain how a Leclanché cell or battery is made. A really big cell of this type, say one that will hold about two quarts, will keep a metallic-filament quarter-ampere lamp glowing brightly for several minutes, after which it needs several days to build up its reserve of strength once more. Very few primary cells can ring a bell or light a lamp for long together. But this same big cell might last a year without giving any trouble, if it were just used now and then—a few seconds at a time—for illuminating a watch-stand, the face of a clock or the reception-room of your sister's dolls'-house.

Much better results can be had from an accumulator of much smaller dimensions. A 4-volt accumulator of what is known as 5-ampere hour capacity would light a number of tiny lamps giving a total of 2 candle-power for as long as ten hours, which means that, as in "miniature" or "model" lighting, the lamps are seldom "on" for more than very brief periods at a time, the accumulator would last a long, long time on one charge, which charge, by the way, would cost only a few pence.

Some Electrical Terms.—Amperes and candle-powers are all very well as terms, but what do they mean? asks the reader who is new to this sort of thing. Well, we speak of the volume of an electric current in "amperes," just as we speak of so many "gallons" of water. The force that drives a volume of current through any substance is measured in "volts," and the resistance which anything offers to the passage of the current is measured in "ohms." You must always remember these three terms—volts, amperes, and ohms. You must try to imagine a piece of any substance striving to prevent by

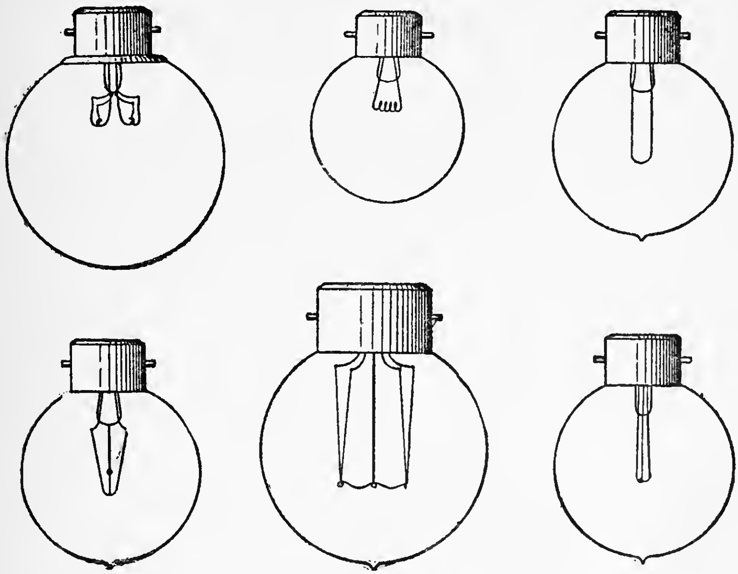


Fig. 1.—Miniature Metallic-filament Electric Lamps

means of ohms of resistance the passage through it of amperes of current which are being pushed along by volts of pressure or electromotive force. The pushing power is often referred to as "E.M.F.," meaning electromotive force, or as "difference of potential," or simply as "pressure." Amperes multiplied by volts gives us another term—watts. If I tell you that with small metal-filament lamps you can get 1 candle-power of light from 1 watt of current you will understand that a 1-candle-power lamp marked 0.25 ampere will require a pressure or voltage of 4, because a watt is simply the product of amperes and volts multiplied together. Quarter-ampere multiplied by 4 volts equals 1 watt, and 1 watt in the type of lamp we have in mind equals (about) 1 candle-power.

Systems of Connections.—Perhaps you know that when glow lamps first became popular their filaments (very fine wires) were of carbon, but nowadays lamp filaments are made of one of the rare metals, chiefly tungsten, and they give a better light than the carbon lamps and use less current.

Why does the lamp glow? Simply because its filament offers such a high resistance to the passage of the current that it become intensely hot, and, as everybody knows, most substances when raised to very high temperatures emit light. The filaments cannot burn because the bulbs have been exhausted of air. If you obtain a catalogue from a dealer in the smaller electrical supplies you will find in it particulars of a great variety of miniature lamps of different shapes and powers, and you will have no difficulty in selecting them to suit the supply of current you happen to have, but before you can tell exactly which lamps to order, you must know how you propose to arrange them, and must understand the two or three methods of connecting up both batteries and lamps. There are two poles or terminals to both of these devices (*see* Fig. 1A). A battery has a positive pole at which the current is supposed to return. Inside the battery, current is supposed to pass from the negative pole to the positive.

Thus the very first lesson to be learnt is that you must provide a circular path for the passage of a current. Not

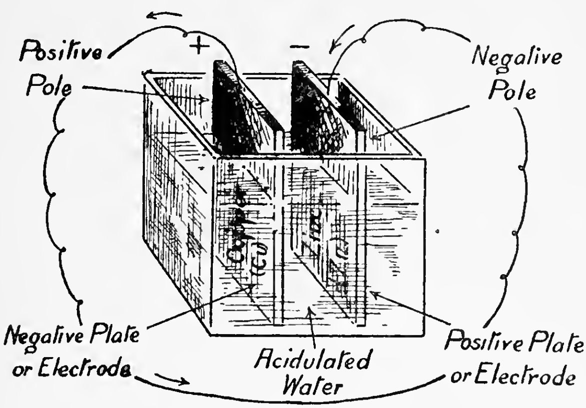


Fig. 1A.—Experimental form of Electric Cell or Battery

only must you take the current out, but you must bring it back again. We will take a little cell and a two-yard length of copper wire. We will attach one end of the wire to one pole, and the remaining end to the other pole. In this way we have provided the circular path (as in Fig. 2), and current will instantly flow; indeed, it will flow so easily that the battery will rapidly run down. The more resistance we offer to the passage of the current the longer will the battery remain in condition.

We will cut the wire in the middle. There are now in effect two wires, one from each pole, and no current can flow. Taking a miniature lamp or even an electric bell,

Fig. 2.—Cell and Simplest Circuit

we connect the outer ends of the wires to the terminals (Fig. 3). Once again the circular path is provided; we have "completed the circuit," and the current will at once do its work by causing the lamp to glow or the bell to ring.

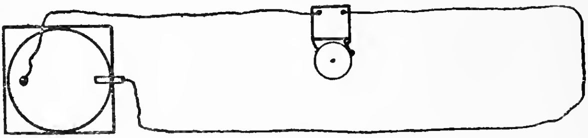


Fig. 3.—Cell, Electric Bell, and Simplest Circuit

We have now an electric circuit of the simplest possible kind. We can cut again where we like, and introduce a simple switch or push, by means of which we can "make"

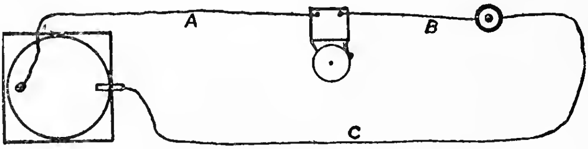


Fig. 4.—Cell, Bell and Push, and Simplest Circuit

or "break" the circuit and glow the lamp or ring the bell whenever we like (*see* Fig. 4).

Lamps or batteries so arranged that the whole of

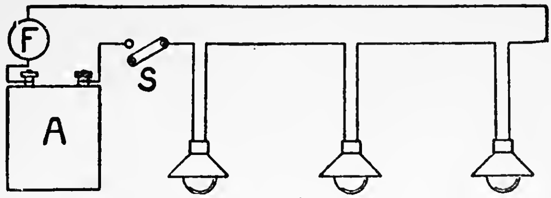


Fig. 5

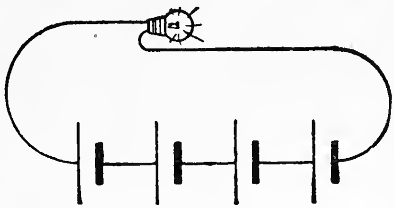


Fig. 6

Figs. 5 and 6—Examples of Lamps and Cells connected in Series (A, accumulator; F, fuse or safety device; S, switch)

the current passes through each and all of them are said to be connected in " series " (*see* Figs. 5 and 6). Essentially the entire circuit is one endless path with the bells or lamps or batteries distributed to suit convenience.

In a battery of cells connected in series the total voltage equals that of all the individual cells added to-

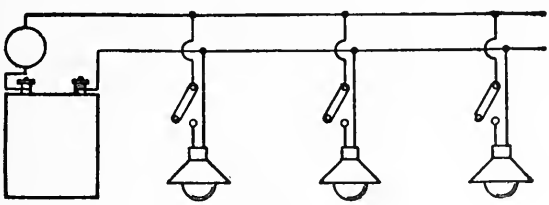


Fig. 7

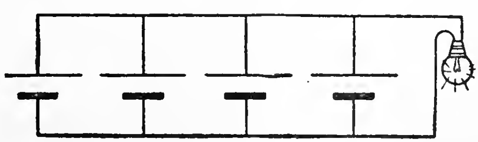


Fig. 8

Figs. 7 and 8.—Examples of Lamps and Cells connected in Parallel gether, but the current in amperes is no greater than that of one cell. For example, two 2-volt cells each giving 1 ampere of current give, when connected in series, a current of 1 ampere at a pressure of 4 volts.

In what is known as the " parallel " system, the current consists of the two main wires with the bells, batteries, etc., disposed between them—bridge fashion—with one

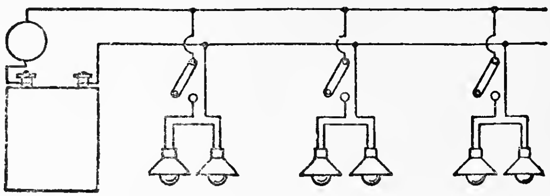


Fig.

Figs. 9 and 10.—Examples of Lamps and Cells connected in Series-Parallel

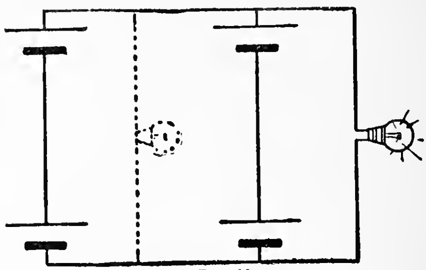


Fig. 10

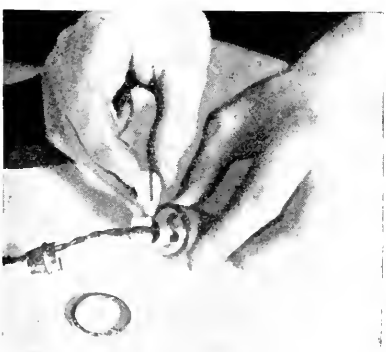
pole of each connected to one main and the remaining pole to the other. Such a system is clearly shown in Figs. 7 and 8. Cells connected in parallel to form a battery have a total voltage equal to that of one cell only, but the yield in amperes is multiplied by the number of cells. Thus the two cells already mentioned would give in parallel a current of 2 amperes at a pressure of 2 volts.

Often a circuit has batteries connected in series and lamps or bells in parallel. This is known as series-parallel

WIRING ELECTRIC LAMPS AND SWITCHES

Tightening the Pinch Screws

Cutting off Ends of Wire Strands with Scissors



Fixing Cord Grip of Lamp Holder

Wiring-up a Wall Switch

(*see* Fig. 9). In Fig. 10, there are four cells disposed in two sets. The two *cells* in each set are in series with one another, and the two *batteries* so formed are in parallel with one another. If each individual cell is 2-volt, 1-ampere, the current yielded by the whole battery will be 2 amperes at 4-volts pressure.

Erecting Lamps and Bells.—With this theoretical information we may pass on to the practical work of installing one or more lamps or bells.

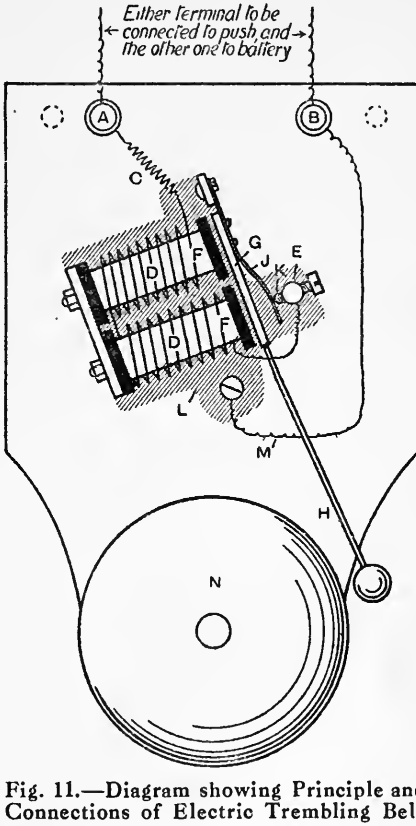


Fig. 11.—Diagram showing Principle and Connections of Electric Trembling Bell

You will have decided on the type of battery you are going to use. Unless it is an accumulator or a home-made device, you will probably prefer a dry cell or cells, because they are non-spillable, clean, and give the minimum of trouble. You will choose a nice dry situation, but not a hot one. The contents of this type of cell are really moist, not dry, and if you put it in too warm a place such as over a stove, or near a chimney breast, it might soon fail, as a result of evaporation. It is better to get a box that will take it just comfortably and protect it from the atmosphere, and from your brother's prying fingers. If it is for a bedroom light, perhaps the box can go on a shelf, and be hidden by some books, or possibly room can be found for it in a cupboard, but not a damp one; it generally happens that small holes will have to be bored in the woodwork to allow the wires to pass. As only a few yards of the conducting wire will be wanted —*the shorter the run of wire the better*—your best plan will be to buy the best insulated electric-bell wire (Standard Wire Gauge, No. 16), and connect a length with one pole or terminal of the battery. To allow of slight adjustment of position, and to prevent vibration causing the wire to be disconnected, it is usual to form the last few inches of the conductor into a spring by winding it round a lead pencil, and then removing the pencil.

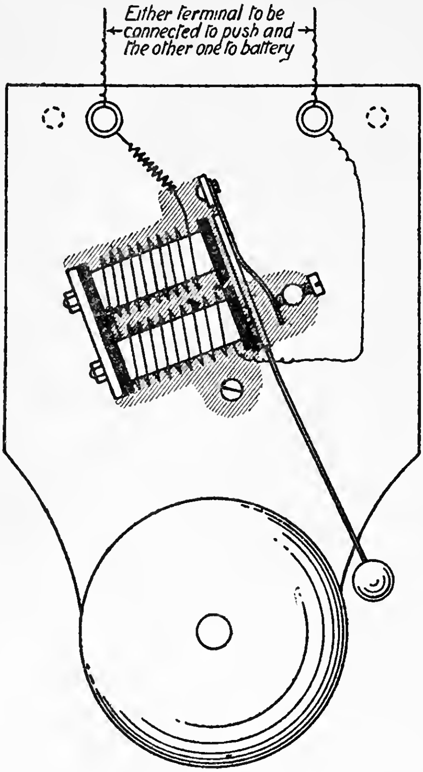


Fig. 11A.—Diagram showing Principle and Connections of Electric Single-stroke Bell

Doubtless you have seen it hundreds of times when examining electric bells. You have now to decide the positions of the lamp and push or switch.

In many of these arrangements I am now going to describe you can use either a bell or a lamp, providing that the battery is sufficiently powerful. You can easily prove by simple experiment that a little flash-lamp battery will ring an ordinary electric-bell quite vigorously, but not for long. A quart-size Leclanché cell will ring a bell or light a miniature lamp for a second or so at a time at fairly long intervals over a period of a year or more.

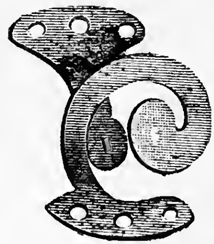


Fig. 12.—The Contact Springs of a Bell Push

How an Electric Bell Works.—Perhaps I had better make it plain how a bell works. It consists, as in Fig. 11, of an electro-magnet D, a contact maker and breaker E K J, an armature and hammer G H, and a gong N. The electro-magnet is two cores of soft iron wound with fine wire. Its poles F attract the armature and hammer only when current is passing through the coils. Immediately the armature is attracted and the gong in consequence struck by the hammer, the circuit is broken, current no longer flows through the coils, and the armature is released, only to re-establish the circuit again, ring the bell, again "unmake" the circuit, and so on. You can follow the passage of the current from terminal A, through spring C to coils D, then to the insulated contact pillar E, platinum contacts K, spring J, and thence by means of the metal frame L (indicated by the stipple lines) and through wire M to the terminal B. The above is an ordinary "trembling" bell, a type that does not work well when connected in series with a similar bell. For series working, one trembling bell and the rest single-stroke bells (Fig. 11A) should be used; in the latter, there is no "make-and-break" effect.

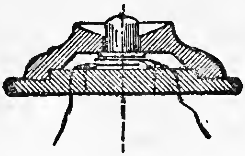


Fig. 13.—Vertical section through Bell Push

A Simple Circuit.—You wish to light one lamp or ring one bell at pleasure from a push. This is the simplest of all electrical arrangements, and has already been shown in Fig. 4. Put the lamp or bell in the required position. From one terminal run a wire A to the battery. (In electrical diagrams the usual symbol for a battery is |||). From the battery's other terminal run a wire C to the push, continuing with wire B from the second terminal of the push to the remaining terminal of the lamp or bell. Fig. 4 shows a bell, but the diagram is equally correct for a lamp.

The push is simply a little device for momentarily "making" or "completing" the circuit. It contains two springs, usual patterns of which are shown in Fig. 12, and the wires are connected individually to them. Normally these springs do not touch one another (*see* the section, Fig. 13), but they are made to do so when the little bone or ivory knob is pressed in, thus completing the circuit. A push is better on a miniature lamp system or for bell work than a switch (Fig. 14), because with the latter you may be tempted to leave the lamp or bell at work for too long

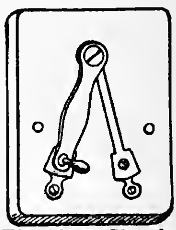


Fig. 14.—Simple home-made One-way Switch

Suppose that the gas-pipe connection is out of the question, and that the electric bell is in your workshop at the foot of a long garden and the push is in your house, the bell being used to summon you to meals. You can still dispense with a second wire. At each end of the system bury at about 4 ft. or so some old waste piece of metal—an old clean oil-can or a leaky galvanised iron bath—and make good electrical connection with bell at one end of the circuit and push at the other. Pack round it some coke or gasworks breeze, and there you are! But you need a rather damp soil to give good conductivity.

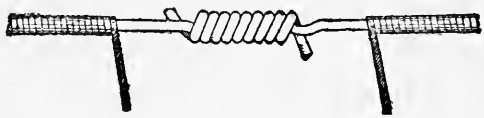


Fig. 22.—Making Joint in Electrical Wires

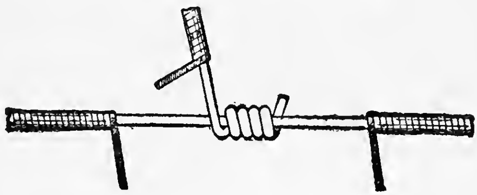


Fig. 23.—Making a Branch Joint

Joints in Electrical Wires. — You will need to know how to join two electrical wires together. For purely temporary purposes simple twisting together is good enough. For permanent work, bad joints must never be allowed, since they oppose resistance to the current and waste it. Moist air soon corrodes exposed joints. First scrape off the covering, clean the ends of the wires with emery cloth, cross them and wind one round the other as in Fig. 22. Smear with "Fluxite," and use stick solder or coat with "Tinol" instead, applying heat with a bit or a Bunsen or blowpipe flame. In the case of branch joints (T joints), the connection is as shown in Fig. 23.

In all cases after soldering, replace any of the old insulation if this is possible, or, instead, wind on prepared rubber tape smeared with rubber solution, finishing with paraffined cotton. All these insulating materials are obtainable from the electrical dealers.

If the Bell Fails.—Faults in electric bell systems often necessitate the use of a galvanometer for their detection, an instrument which not every boy mechanic is likely to have, but in simple systems of the kind which I have described in this chapter, providing that the wiring is erected carefully and in a common-sense way, there should be an entire absence of line faults, and what troubles may occur will be due rather to exhausted batteries, defective bells, and loose or dirty connections. If the bell rings sometimes and will not ring at others, you may suspect a loose connection somewhere in the system, and you may look for it especially at pushes, switches, and the bell. The scraping of contacts—especially the "platinum" contacts in the bell—with a knife or rubbing with a piece of emery cloth often works wonders on old bells and other fittings that have been in damp places. Many fittings contain a lot of brass, and brass is very susceptible to damp. Corroded brass always gives trouble electrically.

If much trouble from damp is to be feared, take time in the first place to make really good contacts between the wires and fittings, and then touch the connections with vaseline, which will defy the damp for a long time.

The use of flexible cord or cable is a great convenience, both for bell and model light work, but the tiny wires of which the cables are composed cause trouble if one or two are left loose; thus one tiny wire projecting from a connection may easily cause a most baffling occasional ringing, and will exhaust the battery.

In the course of time the battery will need renewal. If a wet Leclanché is in use the re-amalgamation of the zinc and the renewing of the sal-ammoniac solution will often work wonders, but in the case of a very old battery it may be necessary to renew the porous pot as well. But do not rush to the conclusion that the battery is at fault until you have examined the system in its every detail.

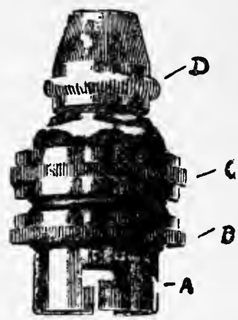


Fig. 24.—Cord-grip Electric Lampholder

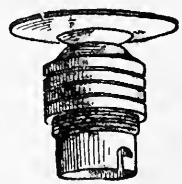


Fig. 25.—Flanged Electric Lampholder

Wiring up a Lampholder. — The lampholder to receive miniature lamps may have a cord-grip or a flange as shown respectively in Figs. 24 and 25. Flanges are for use on battens, etc., and the wires need to be conducted, to the terminals, behind the flange which is screwed to its support. The cord-grip holder is more generally convenient, as it may be suspended with a minimum of trouble exactly where it is wanted. It has a cord-grip D (Fig.24) which takes the weight of the holder and lamp off the actual terminals, thus preventing a fall of the lamp through the failure of the connections. The milled ring C holds the brass body to the porcelain interior, and the milled cap B supports a shade, whilst A is the cylindrical part or socket in which is the well-known bayonet slot to receive the lamp. Inside the brass body above ring C is the porcelain fitting with terminals to receive the two ends of the circuit wires, the last-mentioned being bared of their insulation only just sufficiently to allow of their being clamped or pinched tightly into place. The terminals have little plunger contacts at the bottom which make flexible contact with the actual lamp terminals or with crescent-shaped brass plates in the lamp socket.

Now in wiring up such a lampholder, the parts are, threaded in the following order: First the cord-grip, then the brass body, and then the porcelain interior; the milled rings and socket containing the bayonet slot can be put on afterwards. The bare wires pass through holes in the porcelain body, and are held by the screws in the terminal blocks. Be careful when you are using flexible cable, which, as I have explained, consists of a large number of very fine wires, that no odd wires stray across to the opposite terminal, or even touch the metal sides of the lampholder, and so cause a short circuit. The bare wires having been connected, all surplus must be cut off close to avoid risk of short-circuiting. Then bring together the brass lampholder and the porcelain fitting, and screw on the milled ring which holds them together. The cord-grip contains two wooden fittings which are now to be put in place, taking care that they fit into the little groove which prevents their being twisted when the cord-grip is screwed down. The grip wedges the fitting to the support wires, and, as already stated, relieves the actual electrical connection of any strain.

To put on the lamp shade it is generally necessary to invert the holder. Then the shade can be carefully inserted over the screw threads, and the second milled ring or cap screwed on to hold it in place, but do not screw it up very tightly, or you may crack the glass shade.

Attaching Wires to Walls, etc.—You may need a word or two with regard to the method of running the wire for a permanent job, but you will not forget my advice to get the best wire you can afford. Primary batteries easily run down if there is a small leakage anywhere, and leakage easily occurs when insulation is defective. Therefore, when putting up wire for a model lighting or an electric bell system in your den or workshop, and particularly if the wire has to cross places which are subjected to dampness, you would do well always to use wire having at least a rubber and double-cotton covering. A single-cotton insulated wire is all very well for temporary use in a dry situation, but not for much else. If you are putting up a system which is expected to last for years and the wires cross an open garden, you ought to use nothing inferior to a double-rubber or even a vulcanised rubber insulation. For a little system installed in your bedroom or den which will not be subjected to dampness, quite a cheap form of insulation will be good enough. But use nothing smaller than No. 16 gauge wire, remembering that the smaller the cross-section of the wire, the greater is the resistance opposed to the passage of electric current, and the less useful effect will you get. The circuit from battery to lamp or bell should be as short and direct as possible, for every extra foot of wire introduced means extra resistance for the current to overcome before it can start to do any useful work for you.

If the wire has a proper insulation no more elaborate method of running it need be adopted than that of simply securing it to the woodwork by means of staples, but do not drive them too far home, as the very first thing to be remembered is that the insulation that covers the wire must on no account be damaged. For instance, if the two wires carrying current to and from a lamp or bell be placed under one staple, and you drive this home in such a way as to injure the insulation, the staple will form part of the circuit, which will now be "shorted." The lamp or bell might get a little current, but not much, and in the event of the push or switch being between the staple and the lamp, etc., your battery will rapidly exhaust itself. Ordinary wire staples can be used with care, and you can introduce a tiny scrap of old inner tube or any similar insulating material just under the head so as to minimise the risk of actual metallic contact between staple and conductor. Or you can obtain from the dealers special insulating staples, just as you please, or, better still, you can use a twin flexible cable and run it through insulated screw-eyes. This "twin-flex" is two cables twisted together, each consisting of a number of fine wires.

The professional electrician runs wires through walls, floors and ceilings, but that is a proceeding which I do not advise the boy mechanic to attempt unless he has full permission to do the work, and also is perfectly sure before he starts as to what he proposes to do, how he will do it, and that in the course of the job he will not cause much unnecessary injury to the building. My firm advice is not to cut holes anywhere unless it be in a garden shed or workroom of rough construction where a few holes will do no particular harm. Wires are never drawn through the rough holes cut in brickwork, but for all such positions should be encased in metal piping. Holes are frequently cut in wood partitions by means of long gimlets (electricians' or wiremen's gimlets), and if care is taken to see that the holes are perfectly smooth, and that the wire is well insulated and not drawn too tight, I see no reason why for bell work or model lighting you should not dispense with tubes in such places. Generally avoid cutting and drilling, and run your wires wherever possible in such inconspicuous positions as the tops of cornices, picture rails, and skirtings, under window sills, etc. Sometimes you can run your wires up pipes to which you can secure them with little clips in the form shown in Fig. 21, or, as already described in this chapter, you might make the pipes themselves part of the circuit and simply connect the wires to them, using the same clip, and seeing that both pipe and wire are perfectly clean and bright so as to get good electrical contact. You can even dispense with clips by binding the circuit wire to the pipe by means of three or four turns of fine wire, everything being bright and clean as before.

It saves much time and trouble to employ the twin flexible cable already mentioned, insulated with rubber and cotton, or, better still, rubber and silk, and simply to run it through insulated screw-eyes which are obtainable from all electrical dealers. A great advantage of using these special eyes, either closed or open, is that the wire is kept clear of the surface, and is therefore far less affected by any dampness which may be present in the walls or ceiling. The screw-eyes can be inserted at suitable places, and nothing is better and likely to do less damage than this method. The only difficulty may be in the case of ceilings, as unless the screw enters the lath behind the plaster, no fitting depending on it will be safe. Unless a slight discoloration shows the difference between the laths and the spaces between them, there is only one way of determining their position, and that is to probe in one or two places with a very fine sharp awl. When the screw-eyes are used, the flexible cable will need to be drawn very carefully through them, unless you go to the expense of using the sort with open eyes. These are very convenient, as all that is necessary is to lay the flexible in them and give the porcelain part a turn so as to close the eye.

THE HEKTOGRAPH COPIER: HOW TO MAKE AND USE IT

I WELL remember when I was a small boy making a jelligraph of my own invention, and thereby earning the sum of one halfpenny as profit, the writing out of a sheet of instructions on using the copier being thrown in gratis. Did I but know it, I ran the risk of an action for infringement of patent rights, because at that time the hektograph, as the jelly copier is called, was the subject of a patent which did not expire until 1894. The jelligraph I invented consisted simply of one pennyworth of glue with, I think, a little moist sugar added, and it worked quite well until it dried up or went mouldy. It so happens that glue is the foundation of the proper hektograph jelly. It ought to be the best and clearest glue you can buy, and will be in the form of hard cake, not cloudy, nor should it have a decidedly unpleasant smell. If you can get the use of a flat metal tray holding about half a pint of water, you will need not more than 2 oz. of the hard glue, and as such a small quantity is required you can just as well afford the best as the worst. Wrap it in a piece of canvas, break it up with a hammer, place the fragments in a basin, and just about cover them with water. After a few hours you will find that the glue has swollen up into a jelly. Place this in an old clean handkerchief, or in a piece of muslin, and squeeze off any surplus water. Borrow a 2-lb. earthenware jam-jar, and in it place the glue jelly, covering it with 10 oz. of glycerine. Put the jar in a saucepan containing a small amount of water, and bring the whole to the boil, afterwards allowing it to simmer, and stirring it from time to time to be quite sure that the glycerine and glue have combined to make a nice syrupy solution. The object of adding the glycerine is simply to prevent the glue drying to a hard cake and to allow of its being melted up time after time without losing its moisture. Another addition has now to be made, this time for the purpose of preventing the composition going mouldy. If you have ever discovered a piece of cake glue in a damp cupboard, you will know the state glue quickly gets into if not kept in a dry and airy place. A few drops of any essential oil—say, about ten drops of oil of cloves—will be all that is necessary. You can often detect the smell of oil of cloves in office pastes and similar compositions. Stir the oil into the composition, and straightway pour the contents of the jar into the tray prepared for it, placing the tray on a perfectly level table in a cool place until the jelly is set. I made the lid of a biscuit tin serve my purpose, but something a trifle deeper would be better. It is not difficult to make a tray at home from thin tinplate cut out to the pattern shown in the

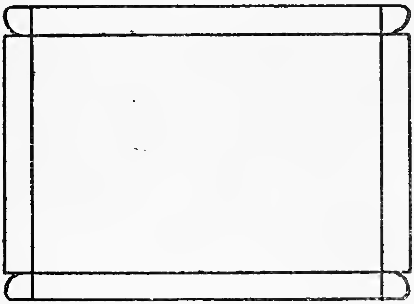


Fig. 1.—Pattern for Metal Tray to hold Hektograph

diagram (Fig. 1), and bent up on the inside lines, the little extra pieces or lugs to be bent round the corners where they will be secured with solder. Instructions on soldering are given in another chapter. The bending of the metal can be done over the perfectly square edge of a piece of board. I have often seen in ironmongers' shops trays costing only a few pence that would serve the purpose splendidly.

I suppose you know how to use a hektograph ? Perhaps your school magazine may have been "printed" on such a device. The original must be written with a certain kind of ink, which is best bought ready made, but which, if you wish to do everything yourself, you can prepare at home by mixing together 2 oz. of methylated spirit, 2 oz. of water, and 4 oz. of glycerine, and adding about $\frac{1}{4}$ oz. of aniline dye. Aniline violet will do for the blue-violet colour so common, aniline black for black ; methyl green for green ; eosin for red, etc. etc. The quantities given will make a good-sized cupful, which is probably ever so much more than you will need, but I don't think you can generally buy a smaller amount of the aniline colour I have mentioned. I am told that Judson's violet dye and Stephens' ebony stain answer very well as hektograph inks ; but personally I have never given them a trial.

You will find no difficulty in using the hektograph. Gently stroke its surface with a soft, clean sponge, take off any surplus moisture with a piece of fluffless blotting paper or with a clean handkerchief, and then place the written matter face downward on the jelly and gently rub it into close contact with a handkerchief made into a pad. Leave it for about three minutes, and then peel it off by first raising it at one corner. To take a copy, simply place a piece of paper in contact with the jelly, gently press it into contact with the handkerchief pad, leave for a moment or so, and peel off as before. The later copies will require a much longer contact than the early ones.

It helps to preserve the margin of the jelly surrounding the transferred writing A (Fig. 2) from scratches, etc., if you lay down on the moist surface four paper strips B. A corner piece C just clearing the written matter makes it easier to raise the "printed" sheets.

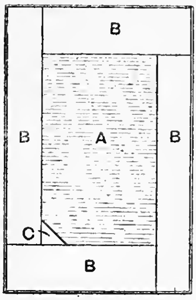


Fig. 2.—Paper Strips protecting surface of Hektograph

The number of good copies obtainable will depend upon the quality and quantity of the ink (by the way, never blot the ink when writing the original, but allow it to dry naturally), and the care with which the hektograph has been used, but it ought not to be less than about twenty, and is not likely to be more than twice or thrice that number.

When the jelly is finished with, gently re-melt it in its tray over a small peep of gas or in a slow oven, and remove to a level surface to cool as before. In course of time the jelly will become coloured with the ink absorbed, and its appearance will be improved by mixing in a small amount of very fine whiting.

A Putty Hektograph.—Some people think that the "putty" hektograph is far superior to the jelly. It certainly is more convenient in use, inasmuch as should any accident occur to spoil the smoothness of its surface, which in the case of the jelly would necessitate re-melting, all that you need to do is to smooth it down again with a flat piece of wood. Then, too, after the number of copies has been taken, and you need to transfer or lay down another original, all you do is to wipe the putty with a wet sponge, blot up the surplus moisture with some fluffless blotting-paper pressed into close contact, and the hektograph is immediately ready for use again. It is a trifle more troublesome to make. Get 1 lb. of the finest whiting. You had better go to an artists' colourman and ask for "gilder's whiting." First of all only half the quantity is used. It must be in the form of a fine powder, and should be thoroughly mixed with, and beaten up with, 8 oz. of glycerine. Then leave it till the next day, by which time some of the glycerine will have come to the surface. The rest of the whiting, also in powder, should now be added. It will not be easy to incorporate the whole thoroughly well, but if you work at it in stages and put it aside for a few hours, you will find that in due course the glycerine will permeate the whiting. Finally, the mass will resemble dough, which will need to be placed in a tray and rolled out perfectly smooth and flat with a ruler which will run on the edges of the tray. The method of taking the copies is the same as before.

Let me revert to the jelly copier and give a word of advice. Materials vary, and the proportions given may occasionally need to be altered. If the jelly appears to be too soft, put it back into the jar and add a little glue, or, instead, keep it at the simmer for some little while. On the other hand, if the jelly gets too hard, re-heat and add glycerine, gently simmering for a time as before.

INSERTING A WINDOW PANE

How often used I to watch a glazier at work and think how easy the job was! I have not altered my opinion very much, but I know now that there were some things about the job I did not know then. Amateurs and especially boy mechanics, are so anxious to get the new glass in position that they do not take sufficient care to see that every particle of the old glass and especially of the putty that held it is first removed. That, after all, is one of the secrets of successful glazing.

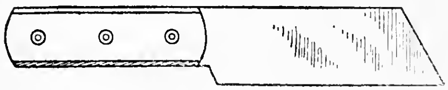


Fig. 1.—Hack Knife

Let me assume (I am drawing on my personal history) that a cricket ball that never should have been "played about" with so close to the kitchen window has made a mess of one of the panes, and that you have offered to repair the damage done!

To remove the old putty, you will need a hack knife, and generally there is no need to buy the special tool shown in Fig. 1. Most houses possess a table knife that has been broken off short, and that will be the very tool for your purpose. With that and a hammer, you can cut out every morsel of the old putty. But be very careful that you do not chip into the woodwork of the frame.

You may come across a few brads, or tiny triangular pieces of sheet metal which have been driven in flush with the surface of the glass to assist the putty in holding the pane in place. Remove them with pincers. Thoroughly clean out the rebate or open groove until you are down to the bare wood. If there is an undercut groove in the top bar, take care to pick out all the old putty from it. If the hack knife is not of much use there, try a thin chisel, a bradawl, or a small screwdriver, but see that the putty does come out.

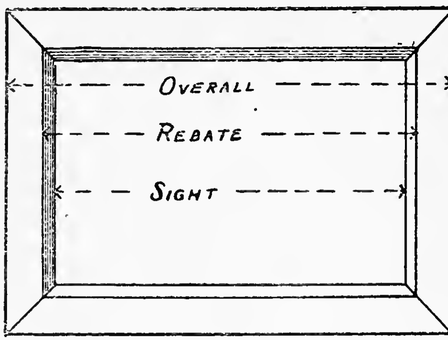


Fig. 2.—Diagram indicating the Three Sizes of a Frame to hold Glass

Next carefully measure the rebate size of the frame. I may just remark that every frame that takes a piece of glass (*see* Fig. 2) has three sizes—the over-all size; the sight size, that is, the measurement of that portion of the frame or glass through which the light passes, and thirdly, the rebate size, that is, the measurement across the frame, including the rebates or open grooves in which the glass lies. For example, a picture frame in front of me as I write measures 16 in. by 19 in. over-all; the sight size—that portion of the glass which one can see from the front—measures 10½ in. by 13½ in.; the rebate size is 11 in. by 14 in., which means that the glass is resting in a rebate about ¼ in. wide which has been made on the back inside edge of all four pieces of the frame.

Now if this picture-frame were a window-frame, the piece of glass required to fit it would not measure 11 in. by 14 in., the actual rebate size. A glass of such dimensions probably would not go into the frame, but if it did it would be far too tight, and in very hot weather when the glass would expand, or as the result of any stress that might come upon the frame, the glass would easily crack. This, indeed, is the secret of those mysterious cracks which occur sometimes in picture-frame glasses when a room is unduly heated. So the piece of glass should be $\frac{1}{8}$ in. smaller each way than the rebate size; in other words, the glass will measure $10\frac{7}{8}$ in. by $13\frac{7}{8}$ in. Take the exact dimensions to the glass-cutter, tell him what the glass is to be used for, and he will give you the right sort and exact size.

Qualities of glass are known chiefly by the weight per square foot, the thinnest being "15 oz.," and a usual quality being "21 oz.," which is about $\frac{1}{10}$ in. thick. For fairly large panes, "26 oz." glass is used, this having a thickness of roughly $\frac{1}{8}$ in.

The first thing to do in inserting the glass is to prepare a bed for it by squeezing putty all round the rebate in one even thickness. This is generally done with the fingers, and there is nothing poisonous in glaziers' putty. Then the glass is pressed into position, rubbing it near the edges (not in the centre) with the fingers of both hands at once. Of course, use as much care as possible, especially if the glass is poor and thin. The pressure will cause the putty to squeeze out at the back (*see* Fig. 3), and you must continue the pressure until only a thin layer is left. If the pane is of fair size, and there is any risk of its being blown out before the putty is hard, it will be as well to insert a few fine brads, driving them in sufficiently far that they will be covered by the facing putty when this is applied. These brads can be driven in with an old chisel. Sometimes professional glaziers use triangular pieces of zinc, quite tiny scraps (*see* Fig. 4), instead of the brads.

Fig. 3.—Glass bedded in Putty

Fig. 4.—Zinc Triangle

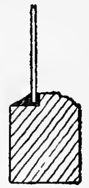


Fig. 5.—Section showing Glass and Front and Back Putties

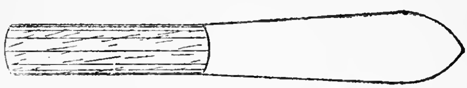


Fig. 6.—Putty Knife

The front putty is now put in (*see* Fig. 5), cutting it to a nice bevel with the putty knife (Fig. 6) which may be either a special tool bought for the purpose or a short stiff table knife. After this is done, but not before, use the same knife to cut away the surplus putty which has been squeezed through at the back. It is as well to leave the pane untouched for a week after completing the job.

VARIOUS WORKSHOP METALS: HOW TO IDENTIFY AND WORK THEM

So many metals (iron, copper, aluminium, lead, zinc, etc.) and alloys (steel, gunmetal, brass, solder, etc.) are used in metalworking, that the boy mechanic may be at a loss to distinguish one from the other. Even experts find it difficult to tell some steel from some iron, and to distinguish between certain qualities and varieties of steel itself. Then again the alloys are legion, and only a skilled metallurgist and chemist could identify some of them from others. So I shall speak in this chapter only of those everyday metals and alloys which the reader is likely to handle in his home workshop.

Cast Iron.—This is a very impure iron obtained by smelting iron ore. Pure iron does not exist in the engineering workshop or in commerce. Indeed, it is the impurities, sometimes, which give iron its special value. Cast iron is harder than mild steel, but softer than hardened steel, as to which I will give more information later. The weight of a metal or alloy will be some guide in identifying it, and in every case I will give the weight in ounces per cubic inch. Cast iron weighs slightly over 4 oz. per cubic inch. It is very brittle, so much so that dropped on a stone floor a cast iron article will generally break. It cannot be bent, but can generally be filed, chipped with a chisel, or sawn with a hack saw; but in using a chisel, always remember that the metal may be so weak that the whole of the casting may be broken by a heavy blow. In cutting cast iron with a file a powder is produced, whereas when wrought iron is worked, the filings take the form of very small shavings. This is because the cast metal is very brittle, and the wrought metal tough and fibrous. Touch a piece of cast iron with a drop of nitric acid, leave it on for a few minutes, wipe off, and thoroughly rinse with water; you will see a dull black spot representing the carbon in the metal which has been laid bare by the dissolving away of some particles of the iron.

Wrought Iron.—This is refined cast iron, most of the carbon and impurities having been removed by re-melting, and it is usual for the wrought iron to be rolled into plates, rails, bars, and rods. The weight of a cubic inch is about 4½ oz., but varies slightly. What a different metal this is to the cast iron! Its brittleness has vanished, and in its place is a toughness which renders it, next to steel, the most reliable metal in the world. It is of a fibrous nature (cast iron and steel are not), it can be bent double without breaking, and it can be filed, sawn, drilled, and chipped quite well, although its tougher nature makes the work a little more arduous than is the case with cast iron. In working wrought iron, you can use a lubricant —either oil, or very soapy water. Tested with nitric acid in the way already explained, you will reveal a dull greyish spot, there being very little carbon in this metal to be brought into prominence by dissolving away of the iron particles. Wrought iron can be welded—that is to say, two pieces of it made red hot can be hammered together to form one.

Mild Steel.—There is more than one way of making mild steel, but the principle is to refine cast iron, add carbon and put the metal through a process which actually alloys the carbon with the iron. The steel is squeezed out between rolls to the shape required. A cubic inch of mild steel weighs about 4½ oz. It is softer than most other irons and steels, and like wrought iron it can be easily bent cold, is weldable, and can be worked with file, saw, and drill, although with greater difficulty, as it is a tougher metal. Unless a file is rubbed with chalk or oil it soon becomes "pinned" with either wrought iron or mild steel; that is, the spaces between the teeth get filled up with the detached particles of the metal.

Cast Steel or Tool Steel.—This is commonly called crucible cast steel; it is a "high carbon" steel, that is, it contains a fairly high percentage of carbon actually alloyed with the iron, and the result is to change the whole character of the metal, which becomes quite different from cast iron, wrought iron, or even mild steel. It now has a property which not one of the materials just mentioned possesses—it may be hardened by heat treatment: Made red hot, and suddenly plunged into oil or water, it becomes extremely hard and brittle. If it is too hard or too brittle for the purpose in view it needs to be heated to a temperature much below the first and then either allowed to cool of itself, or plunged into oil or water as before. This second treatment is known as tempering, inasmuch as it has "tempered" the extreme hardness. It is this ability to be rendered extremely hard at the will of the worker that makes carbon steel so useful. A tool made from it can be ground and sharpened to a cutting edge, and the steel will be hard enough to retain it, whereas a cast-iron tool would be broken the first time the tool were used, and one of wrought iron or mild steel would be turned up.

Tool steel is manufactured by melting some such material as blister steel in a crucible and adding an ore rich in carbon. The blister steel mentioned is itself sometimes used for the making of inferior tools, and is the result of heating cast iron and charcoal to a high temperature, the steel when cold showing blisters on its surface. Cast steel is obtainable by the worker in the form of rods and bars. It may be filed in its unhardened state, but it is wise to use an old file for the purpose. Frequently it is difficult to work tool steel unless it is first annealed, a process which consists in slowly but thoroughly heating the metal, and then burying it in cinders or ashes so that it cools very slowly, this having the effect of thoroughly softening the steel. The same lubricant as used for wrought iron and cast iron (oil or very soapy water) answers when filing, sawing, drilling, etc. As brittleness always accompanies hardness, it is possible to break off a piece from a steel bar or rod by first filing or chiselling a nick all round, and then giving a blow with the hammer. Very hard steel will scratch glass, so that you will quite understand it is out of the question to think of filing or sawing it, but until the hardness has been given it by the heat treatment already referred to, it can be worked with the ordinary cutting tools. A piece of tool steel tested with nitric acid, as already explained, will show a brownish black spot.

Copper.—This metal is obtained by smelting certain ores and refining the product a number of times. One cubic inch weighs about 5 oz. It is softer than tin or zinc, and is very malleable, more so than iron or steel. Filing, sawing, drilling, etc., are affected by the clinging nature of the metal, but the work is all the easier for using a soapy water lubricant.

There are many valuable alloys containing copper, the strongest being phosphor-bronze, a mixture of copper, tin, and phosphorus, capable of standing great wear, and for that reason used in machines for bearing surfaces, etc. Bronze or gunmetal is another very valuable alloy, containing from 85 to 90 per cent. of copper and 15 to 10 per cent. of tin; this alloy is fairly easily worked, but as the percentages of the two ingredients vary so much, it is not easy to give definite particulars. A cubic inch weighs roughly 5 oz. Brass is an alloy of 70 to 80 per cent. of copper, with 30 to 20 per cent. of zinc, an average brass weighing nearly 5 oz. per cubic inch, and being harder than silver. Cast brass is softer than tin, but the drawn brass is harder than that metal. Brass is very easily filed, chipped, sawn, drilled, etc., but needs to be treated cautiously owing to its lack of strength. Neither brass nor gunmetal requires a lubricant in working. It is extremely important to work in a new file on brass, and afterwards use it on iron and steel.

Tin.—This is a metal which is not often used alone. It is obtained by smelting certain ores, and its chief use is to alloy with lead to make solder, and to alloy with zinc and copper to make babbit metal, which, being harder than lead, but easily melted, can be readily moulded and cast, and is commonly used as a bearing metal. Tin itself is harder than lead, but softer than zinc, and a cubic inch of it weighs about 4¼ oz. You frequently see in a book some such instruction as "Take a sheet of tin and bend it," etc. etc. What is meant by an instruction of that sort is, take a piece of "tin plate," which nowadays is thin mild steel that has been coated with tin to protect it from attack by atmosphere and moisture. Tinning is a very easy process, as any metal which has been perfectly cleaned, and made hot, will take a coat of tin if brought into contact with that metal; see, for example, what another chapter has to say with regard to the tinning of a soldering bit.

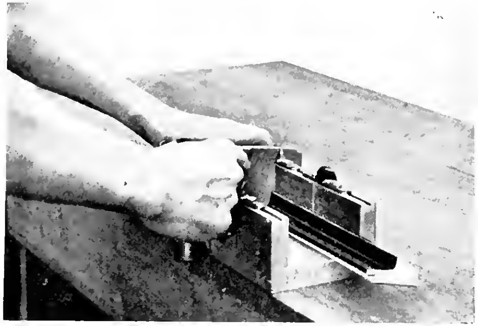
Lead.—This is the softest of workshop metals, but a very valuable one. It is extremely malleable, and will go into almost any form when worked by a hammer. It is so soft that it can be cut with a knife, which will leave a bright metallic lustre. It is heavy, a cubic inch weighing slightly more than 6½ oz. Few acids have any effect upon it, but either nitric acid or aqua regia (1 part of nitric acid mixed with 2 parts of hydrochloric acid) readily dissolves it. It is easily filed, but very rapidly gives trouble owing to the clogging up of the file, for which reason, a single-cut file (*see* p. 98) is preferable to the ordinary double-cut file, this also applying to solder, aluminium, and copper.

Zinc.—This is another useful metal at times, but is chiefly used alloyed with copper to make brass. It is of about the same hardness as tin. It is a bluish white metal, and weighs about 4 oz. per cubic inch. Used in batteries it requires to be amalgamated with mercury (*see* p. 112).

Aluminium.—This is made in the electric furnace and has proved to be one of the most useful metals ever discovered. It is the lightest workshop metal, a cubic inch weighing barely 1½ oz. It can be bent and worked without difficulty, a good lubricant being ordinary paraffin oil or turpentine. A file is soon clogged by it. I mentioned just now the ease with which metals are tinned, but aluminium is the exception, and this accounts for the great difficulty in obtaining a really satisfactory soldered joint in this metal. Should you ever try to solder aluminium, get one of the special solders containing phosphorus, and use a bent copper bit by means of which you can well scrape the solid surface before and while melting the solder. Hot aluminium oxidises with extreme rapidity, and immediately a film of this oxide forms it must be scraped off and the soldering instantly proceeded with unless the flux or the solder used has the property of dissolving aluminium oxide. The phosphor solder has this property, and when combined with the use of a bent bit, gives undoubtedly the best results obtainable, short of welding by means of the oxy-acetylene blowpipe flame. Aluminium bronze is a useful alloy, this being made by melting together either copper or bronze with 5 to 10 per cent. of aluminium.

Expensive and Precious Metals.—Silver, gold and platinum have valuable qualities from the metalworker's point of view, but their expense prevents their being generally used. Silver, however, is commonly employed

PICTURE FRAMING



Sawing a Mitre in the Mitre-box

Driving in Sprigs with Old Chisel

Shooting a Mitre with the Plane

Nailing a Frame in the Vice

in soldering (*see* p. 135). It is harder than gold, but softer than brass or tin, and a cubic inch of it weighs about 6 oz. Gold is the only yellow metal, and resists the action of most commerical acids, although it is easily dissolved by aqua regia, the proportions of which have already been given. It is harder than lead, but softer than silver, and its weight is about 11·16 oz. per cubic inch. Platinum, which is one of the whitish metals, and is even harder than gold, also resists the action of acids, even aqua regia having only a slow action upon it. In hardness it is below most qualities of drawn brass. It is extremely heavy, a cubic inch of it weighing from 12 to 13 oz., according to the preparation and treatment the platinum has received. Its extremely high cost puts it beyond ordinary reach.

MAKING PICTURE FRAMES

One of the most useful and pleasurable jobs falling to the lot of the boy mechanic is the framing of a picture. This is a simple matter if the frame is already made and supplied with glass cut to size, but I propose to show you in this chapter how to do the work from the beginning.

Not that I shall go into the making of the moulding from which the sides of the frame are cut. Few people

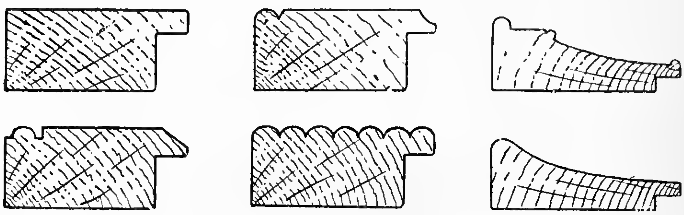


Fig. 1.—Sections of Picture-frame Mouldings

make their own mouldings nowadays. The manufacture of composition mouldings is a trade to itself, and the more desirable mouldings in oak, rosewood, ebony, etc., are seldom made nowadays with shaped plane cutters, but instead are produced in length and with ease on a machine known as the vertical spindle. This is a rapidly revolving spindle to which is clamped a cutter block containing four shaped cutters. The spindle revolves at a very high speed, and strips of wood are guided past the cutters, which instantly remove the chips and produce the moulding before your eyes. All sorts of mouldings are obtainable at picture-frame supply shops, but take my advice and for your early efforts use solid stuff, neither veneered nor faced with plastic composition. Fig. 1 illustrates in section a few of the many patterns of solid oak mouldings available. Flat gilt slips (Fig. 2) may be used with simple mouldings of the kinds shown.

Equipment.—Your woodworking tools will be required

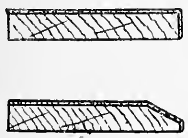


Fig. 2.—Sections of Gilt Slips for Picture Frames

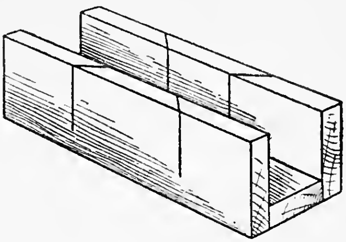


Fig. 3.—Mitre Box

in frame making, and, in addition, one or two special appliances for cutting and finishing the mitres at the frame corners. First these mitres are cut with a fine saw —tenon or dovetail—and are then faced up with a keen finely-set plane-iron, and for both of these jobs some special device for guiding the tools must be adopted. For sawing the mitres, either a mitre box or a mitre block is necessary—preferably the former. It is a trough (Fig. 3) across the top edges of which have been set out, with extreme accuracy, two intersecting angles, each of 45°, the lines being squared over on the sides as indicated. A saw is then run down in two directions so as to form slanting cuts, those on one side being, of course, in perfect alignment with those diagonally opposite. Any good odd stuff will do for the box, 1 in. being a suitable thickness. After the box has been in use for some time, the entrances to the saw cuts will become worn, to prevent which a set of four pairs of iron guides may be bought from a tool-dealer and screwed on. Very convenient forms of mitre boxes are sold, and, in general, the amateur is well advised not to make his first appliance of this kind. The mitre block (Fig. 4) is on the same principle as the box, and need not be particularly described; it is an alternative to the other, but is not recommended in preference to it.

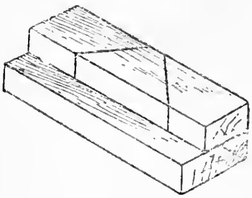


Fig. 4.—Mitre Block

Cutting the Moulding Lengths.—Before cutting up moulding, make a rough drawing of the frame or frames required (it generally saves time to make two or three frames together), and be absolutely certain as to your measurements. Remember that a frame has three distinct sizes (as explained on p. 71)—the over-all, rebate and sight—and the picture and glass should be *very slightly smaller* each way than the rebate size of the frame. A little scheming will make for economy. A length of picture moulding is usually about 12 ft. To estimate the length of moulding required to frame a picture, add together the lengths of the four edges of the picture mount, add four times the width of the moulding, and allow a trifle for cutting. Thus, a 12 in. by 10 in. picture will require of $1\frac{1}{2}$ in. moulding:

12 in.
12 in.
10 in.
10 in.
6 in. ($1\frac{1}{2}$ by 4)

———

50 in.; add to this 4 in., an ample allowance—total, 4 ft. 6 in.

Thus a 12 ft. length of moulding would make two frames of the rebate size above mentioned, and have a surplus of 3 ft. or slightly more.

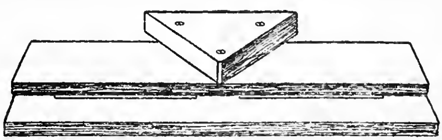


Fig. 5.—Mitre Shooting-board

It is Easy to Cut the Moulding in the Wrong Place.—Moulding is expensive, and if cut thoughtlessly will often be wasted. For cutting, hold it in box or block, and run down the fine saw, using it lightly. Cut a long side first, from it scratch off the length of the opposite member, and proceed to cut that. There will be trifling differences in the lengths, I expect, but you can correct these when "shooting" or finishing. Do the shorter sides last and cut the pairs of sides for all the frames in hand before proceeding further.

"Shooting" the Mitres.—The sawn edges or faces are sufficiently rough and inaccurate to prevent all four joints being of neat appearance when viewed from the front. They have yet to be planed on a mitre shooting-board, which is a device for holding the moulding in such a position that a plane lying on its side and guided by

Fig. 5A.—One-piece Frame with Ornamental Head

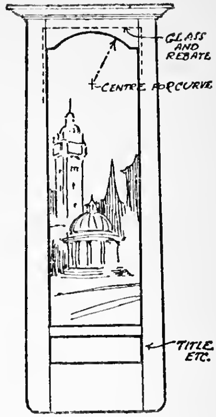


Fig. 5B.—Jointed Frame with Bar

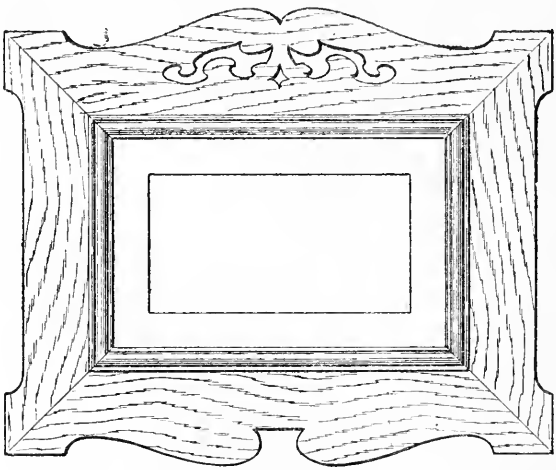


Fig. 5C.—Mitred Frame with Fretwork Ornament contact with the board may be "shot" across the sawn face and caused to remove the saw marks. The mitre shooting-board may be bought or can easily be made by a careful amateur from ¾ in. to 1 in. stuff, well planed and perfectly parallel, by screwing a narrow board to a wide one, as in Fig. 5, and then screwing on an equilateral triangular piece (known as the fence) also as shown. The edges of the triangle will make angles of exactly 45 deg. with the front edge of the narrow board. The plane is

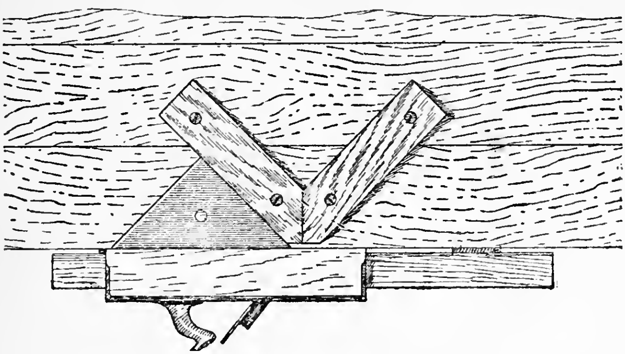


Fig. 6.—Mitre Shoot in use; showing also how to set the Fence with help of Set-square

used on its side, edge of cutter towards the triangle (*see* plan of a different pattern of shooting-board, Fig. 6), and will need to be in perfect condition, the cutter being very keen and projecting only slightly. For shooting joints, the cutter needs to be sharpened like a chisel, quite square or straight (*see* p. 21).

A still simpler mitre shoot which anybody can make for himself is shown in Fig. 8. It is a wide piece of wood, A, with one edge planed straight, screwed down upon it at an angle of 45° with the edge being a wooden

Fig. 7.—Small One-piece Frame for standing or hanging

strip—the fence. The angle line can be set out with set-square or bevel-square.

To use a mitre shooting-board, lay the moulding down face uppermost and with its outer side (not the rebate side) in close contact with the fence, the sawn end just projecting over so that the plane, worked by the right hand while the left holds the moulding, will merely clean off the roughness and nothing more. Do both of the ends, of course, then proceed with the other pieces, and again compare and check the lengths of opposite pieces, placing the rebated edges together for the purpose, and effect any correction necessary.

You will see in the tool catalogues quite a number of special tools and appliances for frame making. I can only say of them that the professional frame-maker leaves most of them alone, but there is one that is

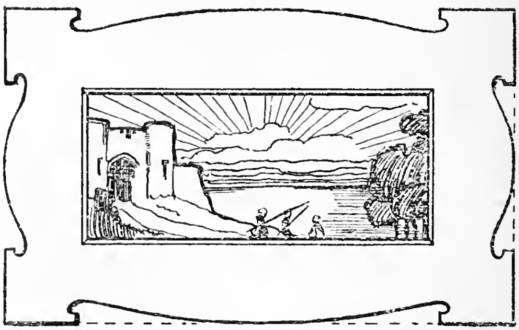


Fig 7A.—Another simple One-piece Frame

coming more and more into popularity, and that is the mitre trimmer, cheap patterns of which are now available for amateurs' use. The sawn moulding is put into the trimmer, a lever pulled, and a keen chisel-edge takes a light cut over the mitre and effects a great saving in time as compared with the use of plane and shooting-board.

Gluing and Cramping.—The mitred members are now to be joined together with glue and nails, and I will explain just one way, and that the simplest, in which this may be done. Four corner blocks (Fig. 9) for each frame will be wanted. They can be cut with a turn or compass saw from thick wood, or, more easily, sawn off from a circular piece of stuff 2 in. or more in diameter. Cut out the square notch to receive the frame corner, and cut one or two string grooves with a saw as shown, finally cleaning the whole up with glasspaper to remove any roughness that might abrade the string used in tightening the joints. Build up the frame on a sheet of newspaper covering a bench or table, and put a block A (Fig. 10) at each corner. Pass a length of strong smooth string B round the whole two or three times, and tie the ends securely. Get four short sticks C, insert them between the strings and twist several times so as to tighten the string and pull the joints close together, as in Fig. 10. If they go right home and the work needs no further correction, loosen the string, remove the mouldings, coat the joint surfaces with good

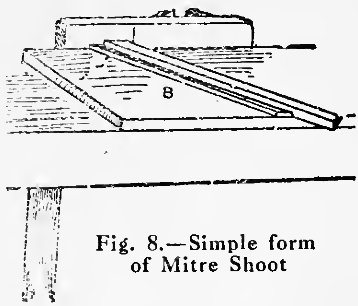


Fig. 8.—Simple form of Mitre Shoot

hot glue, replace, and again tighten up, leaving all night for the glue to get hard. Apply the glue smartly, and have the mouldings fairly warm in readiness. If the frame is of any size, strengthen each joint next day by inserting a fine nail or screw from the side (*see* Figs. 11 and 12), or by gluing in one or two pieces of veneer, as in Fig. 13, first making a saw-kerf, as at A, inserting glued veneer, as at B, and cleaning off when dry and hard.

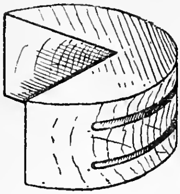


Fig. 9. — Corner Block for Picture-frame Cramp

Plenty of special frame cramps are obtainable at dealers', but the one here described costs almost nothing and is quite efficient.

Fitting Up a Frame.—Next we will proceed to fit up a frame with glass, picture, backboard and screw-eyes. You will probably get the glass cut to size, $\frac{3}{32}$ in. less each way than the rebate size of the frame. But if you cut it yourself with diamond or wheel glass-cutter, see that it is

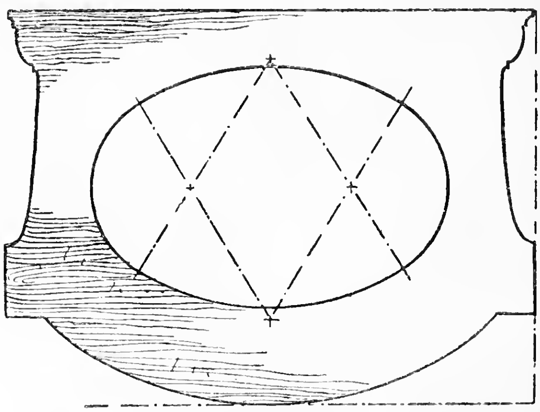


Fig. 9A.—One-piece Frame with Oval Opening bedded perfectly flat upon a freshly-dusted table top on which a newspaper has been spread, and use the instrument with steady uniform pressure; otherwise you are almost certain to crack the glass. All that the diamond or wheel-cutter does is to scratch the surface, and the glass, being very brittle and weak, easily parts at the scratched

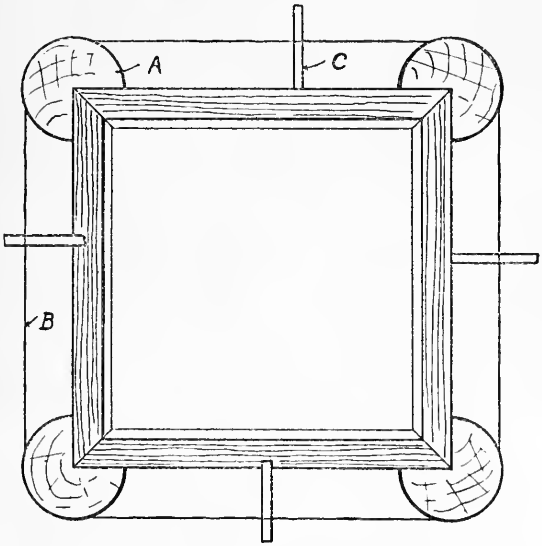


Fig. 10.—Cramping Picture Frame with Corner Blocks and Twisted String

line. A fine file can often be converted into a cutter for common qualities of glass. It must be "glass-hard," and can be made so by heating in a fire or blowpipe flame to bright redness, and immediately plunging into cold water. It will now easily break, leaving extremely sharp edges which can be used exactly as a diamond. They wear rapidly, but a new cutting point is easily made by breaking off a further piece.

The cut glass should be well cleaned, and personally I have always used methylated spirit, which dries quickly and leaves a bright polish; but you can do quite well without it.

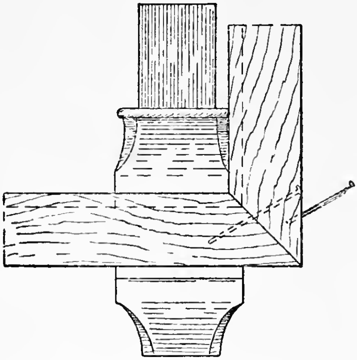


Fig. 11.—Nailed Frame Joint

The backboard of a frame is thin, rough-sawn and often faulty stuff, which can be bought in lengths of about 6 ft. and in widths up to 12 in. It will need to be sawn or cut with a knife or chisel to size. The rebate in the frame should be deep enough to take glass, picture and backboard, but it often proves to be too shallow, in which case the margin of the backboard must be bevelled, as shown in the section (Fig. 14), to permit of the headless tacks or sprigs being inserted. I find that the best means of driving in the sprigs is an old chisel used flat, so that its side near the point acts as a hammer, and I place a flat iron on the bench or table against the frame so that its weight is added to that of the frame and makes the nailing easier.

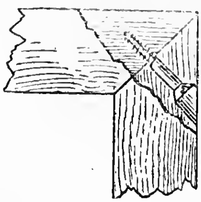


Fig. 12.—Screwed Frame Joint

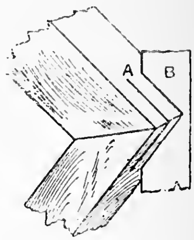


Fig. 13.—Keyed Frame Joint

Smoke and dust have a wonderful way of working into a frame, and it is always wise to cover the whole of the back with a sound piece of brown paper pasted on at its edges. To make assurance doubly sure, you can first of all paste on 2 in. strips of paper to hide the rebate and any joints in the backboard (*see* Fig. 15), afterwards covering all with one piece.

Fig. 14.—Section of Fitted Picture Frame showing Bevelled Back Board secured with Sprigs

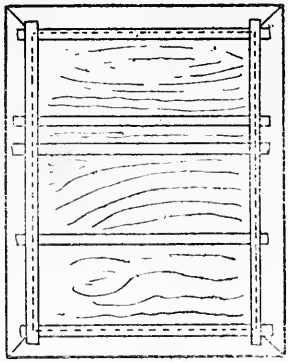


Fig. 15.—Paper Strips pasted over Cracks to exclude Dust

Screw-eyes or screw-rings need to be inserted to complete the job, first boring little holes for them, but making certain that the screws do not come through to the front of the frame. Special cord for picture frames is sold, but I prefer wire, which is finer and neater. Brass wire soon corrodes, but gilt copper wire will last a long time.

Bench and Vice.—Most metalworking demands a heavy bench or table, but perhaps you can make do with a small rigidly-built table with a 2-in. thick plank laid on it to receive the roughest of the wear. A vice of some sort is a very great convenience. You can get along

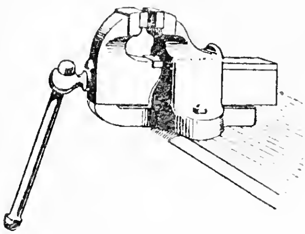


Fig. 1.—Heavy form of Bench Vice with Parallel Action

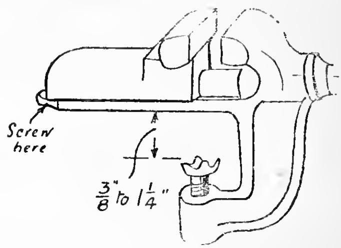


Fig. 2.—Table Vice, fixed by Turnscrew from underneath

without one, but not easily. The heavier and stronger th vice the better it will be, but a small vice is better than nothing. I give in Fig. 1 a diagram of a good solid type, and you can look up prices and pictures of other sorts in almost any tool catalogue. A leg vice that, besides being attached to the bench, actually rests on the floor, is an advantage, particularly when the bench is too slight to stand much heavy work. Fig. 2 shows a type often favoured by amateurs.

How to Use Metalworking Tools

Hack Saws.—Immediately we start to do any metalwork, however rough and simple, we notice the particular need of saw and files. A hack saw is a very hard steel saw with fine teeth, and it is used for cutting brass, copper and even iron and steel. The saw itself is a blade held in tension by a frame, one of the simplest kinds being shown in Fig. 3. In this, after the blade is inserted, the winged nut on the outer end has to be turned until the saw is

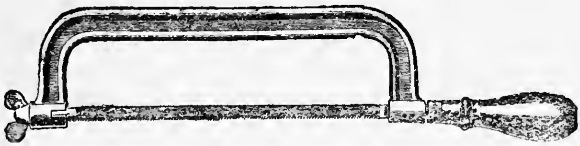


Fig. 3.—Cheap Cast-iron Hack Saw Frame

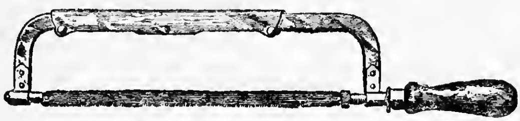


Fig. 4.—Sleeve-adjusting Hack Saw Frame

taut. A saw that I have found very convenient is a cheap pattern, the length of which is adjustable (*see* Fig. 4). The two clamps are first placed in position, the saw threaded over the two pins which the clamps carry, and the wing nut then given two or three turns as may be necessary to make the blade tight. A better kind is adjusted entirely from the handle. You will note directly you get a hack saw into your hands that the blade can be set for cutting either downwards or upwards, or even sideways, either to the left or right. It is well to remember this, as the ability to use the saw sideways is often an advantage. Get the best saw blades you can afford, and remember that as the saw cuts on the forward stroke, the teeth should point away from the handle. Do not apply too much pressure when using it, and push it neither too fast nor too slow.

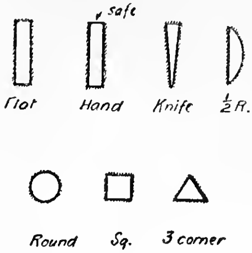


Fig. 5.—Sections through various Files

On copper and the various copper alloys for which a saw with twelve teeth to the inch is roughly correct, the speed of working should be about a double stroke every second, whereas on iron and steel, for which the teeth must be very much finer (about twenty to the inch), little more than a single stroke a second would be enough, but it is not only the speed that counts, the right method of holding the saw is a great factor. First see that the work is supported at the right height for you. It should be very slightly lower than your elbow when you stand up. The handle of the saw is gripped in the right hand, while the left hand holds

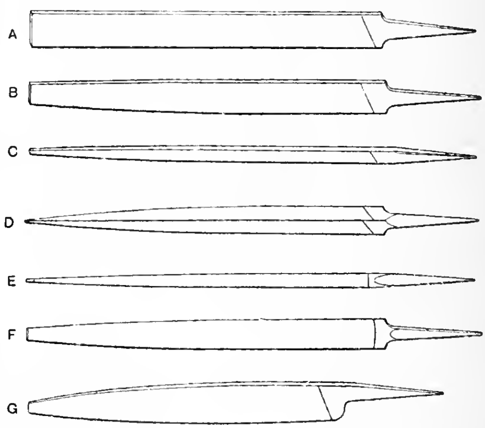
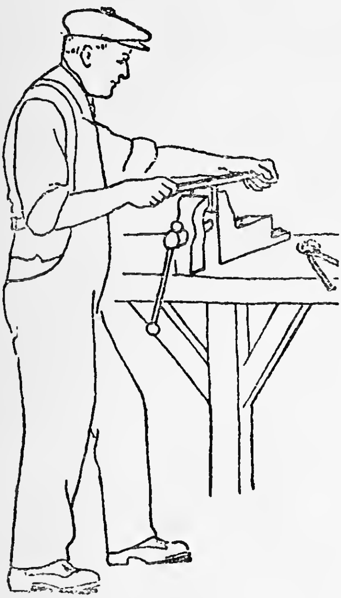


Fig. 6.—Various Files: A, Flat; B, Bellied Flat; C, Square; D, Triangular or Three-cornered; E, Round; F, Half-round; G, Knife-edge

the front of the saw frame and not only assists it to and fro, but holds it down to its work.

Files.—These are of various kinds, and you can spend a lot of money on them if you want to, but don't. Make do with as few tools as possible. In Figs. 5 and 6 I show a few of the shapes with their names. Files are made in three grades, known respectively as bastard,



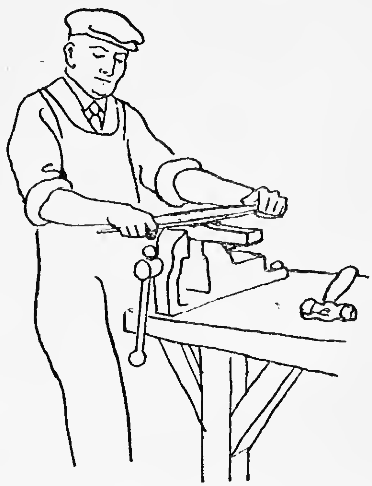


Fig 8.—Position for Draw-filing

Fig. 7.—Position for Filing

second-cut, and smooth, and, as a rule, the second and third kinds, from 6 in. to 9 in. long, best suit the requirements of the boy mechanic. A convenient shape is the flat tapering, the three-cornered or triangular file always comes in useful, and perhaps the next best choice is a half-round. By the way, in Swiss files six different cuts can be obtained instead of the three in English; and numbers three and four will be found generally useful.

Some files are single-cut, and others double-cut, that is, in the second two series of teeth have been made in the file, one at an angle to the other. The single-cut file is best for metals and alloys of a soft clinging nature, and the double-cut for iron, steel and the harder alloys, such as gunmetal, bronze and high quality brass. Fig. 7 shows you the proper position. It is so easy to get a rounded surface when filing, the work rising up in the middle and falling away at the edges. The right hand wants to drop, the left hand to rise, and you have to correct this tendency, and put in a lot of practice before you can get a flat surface by filing. Figs. 7, 9 and 10 show how to hold a file, whilst Figs. 8 and 11 show the positions of body and hands for draw-filing, the best method of dealing with long and narrow surfaces; the file should be chalked slightly and drawn over the work.

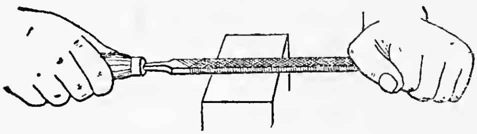


Fig. 9.—How File is held for Heavy Work

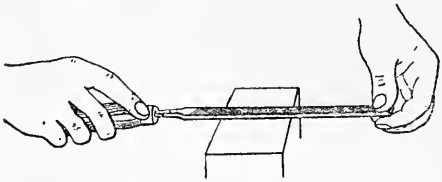


Fig. 10.—How File is held for Light Work

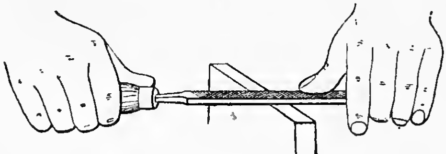


Fig. 11.—How File is held for Draw-filing

How to Use Metalworking Tools

A test often given a mechanic when entering a new workshop for the first time is to file up a piece of steel flat and square. It is ever so much more difficult than you think.

Scrapers.—I do not suppose that you will do much scraping of metals, but should you be a model engineer and attempt any serious work, you will have to know how to prepare two pieces of metal so that they will work

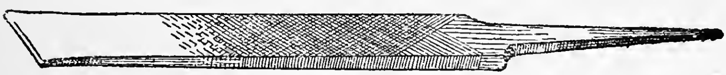


Fig. 12.—Flat Scraper

Fig. 13.—Triangular Scraper

Fig. 14.—Good and Bad Shape of Triangular and Flat Scrapers respectively

over one another and yet be so close together as to resist the passage of steam under pressure. Just as filing smoothes a surface produced by the use of the saw, so the scraper makes still smoother a surface as it comes from the finest of files. There are countless shapes of scrapers, but a lot of useful work can be done with the flat-ended and triangular shapes (Figs. 12 and 13). The first has a slightly-rounded edge and can be bought ready for use or may be made from a worn-out file of the right shapc by first annealing it (*see* p. 77) and then on a wet grindstone grinding off the teeth, afterwards bringing up the edges on an oilstone. It must be made extremely hard by heating to bright redness and cooling in water. Scrapers are used with short forward strokes, not more than ½ in., and the tool is grasped in the two hands.

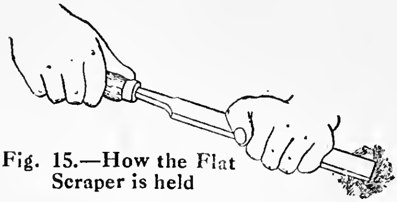


Fig. 15.—How the Flat Scraper is held

The angle at which the tools are used is shown in Fig. 14.

Hammers.—I hardly suppose you will go to the expense of a separate hammer for metalwork, but remember that "any old hammer" is sometimes a danger, both to you and the work. It may badly mark any metal on which it is used forcibly, and should it be used to propel a chisel or a punch, it might easily glance and bruise your hand. Three engineers' hammers are shown in Figs. 17 to 19. Do you know the right way of securing the head to the shaft or handle? With a really sharp knife, lightly pare the wood to the correct shape until head and handle are a tight fit. Separate them, and make a saw-cut down the handle across the

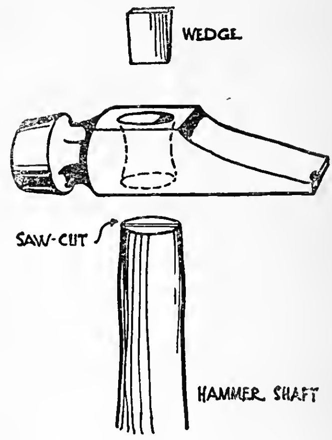


Fig. 16.—Wedging Hammer Head on Shaft

(Hammer shown is the Woodworker's "London" or "Exeter" Pattern) greatest width (*see* Fig. 16). Drive the shaft into the head again, and have ready a wedge of hard wood, and drive this into the saw-cut. Some people use an iron wedge, which holds very well for a time, but ultimately rusts, and then the head is liable to fall off. Soaking a loose hammer head, with the shaft in position, in water tightens the head.

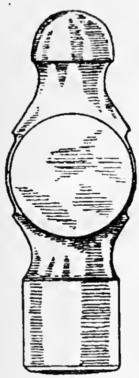


Fig. 17.—Ball-paned Hammer

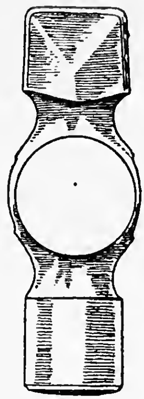


Fig. 18.—Cross-paned Hammer

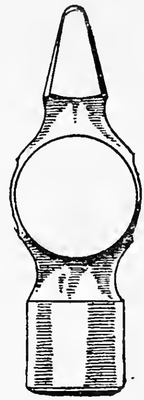


Fig. 19.—Straight-paned Hammer

Chisels.—Expert mechanics can do a great deal on iron and steel with a hammer and chisel, and you will find it worth while to emulate them to some extent. A small casting, for example, that you may be working up will probably need grooves and recesses cut in it which would mean a lot of troublesome work with a file. There are flat chisels (Fig. 20), straight-edge chisels, wide and narrow, cross-cut chisels, and diamond-point chisels (Fig. 21), and for cutting grooves the last-named will be useful. The chisel edge will not have the keenness of a wood chisel—30° for brass and copper, 45° to 50°

for most iron and mild steel, and 65° for hard steel. You remember that a plane-iron is slightly rounded at the corners to prevent its digging into the wood. Well, a metalworker's chisel of any width is treated in just the same way (*see* A, Fig. 20). With such a chisel less metal is cut at a time certainly, but the work is easier.

Drills.—For making holes in metal there are two distinct methods. Iron and steel can be made red hot and holes then punched in. That is the blacksmith's

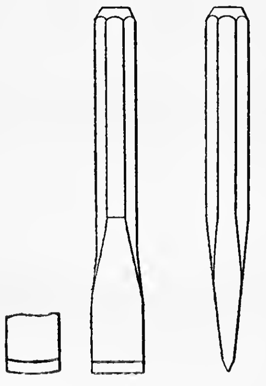

A

Fig. 20.—Flat Chisel

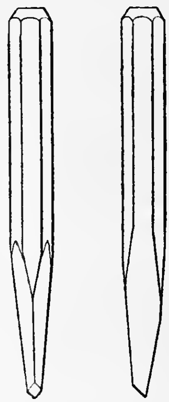


Fig. 21.—Diamond-point Chisel

method. The engineer's method is generally to drill the hole, and the boy mechanic will find one or at most two types of drill bit enough for his purpose. The simplest is the flat or diamond-pointed drill (Fig. 22). A more efficient type is the twist drill (Fig. 23) obtainable in scores of different sizes, but beware of applying great pressure to the small ones as they are easily broken, for which reason at first it is better to use the shorter kind. These twist drills work very well on iron and steel and hard metals generally, but not so well in brass, in which there is always the risk of the drill seizing and breaking unless it is frequently lifted out and the hole cleared. Better than the twist drill for brass is the straight-fluted drill (Fig. 24), but in this the waste does not automatically rise out of the hole, and frequent removal is necessary.

There must be some means of rotating the drill bit, and in the case of the small sizes an archimedean drill (described on p. 165) is the most handy, but a much more rapid tool is a hand-drill or a geared breast-drill, or even the familiar brace. But remember not to apply a great

Fig. 22.—Flat Drill

Fig. 23.—Twist Drill

Fig. 24.—Straight-fluted Drill

deal of pressure, especially in drilling holes in sheet metal, more particularly with twist bits, which have a way of screwing themselves through the metal in a moment. As a start for the point of a drill it is usual to make a light dent with hammer and centre-punch. In the ordinary way brass may be drilled twice as fast as mild steel and cast iron.

The right lubricant makes all the difference in drilling metal. It means better work and assists in keeping the drill in order (*see* pp. 75 to 80).

A hole that is slightly undersized is enlarged, not by means of another drill, but by means of what is called a reamer (Fig. 25). A rough reamer for holes in thin plate stuff is the tang of a file, or even a tapering file itself. Special tools are sold for the purpose, and should you ever

Fig. 25.—Reamer or Broach for use in Brace or Hand-drill

want one you will find a variety illustrated in almost any tool catalogue, but for simple work in bent iron, for example, a file tang is all you will need.

The Lathe.—The metalworker's most useful tool is a lathe, but of such importance is it that I propose to have it treated by my friend Mr. A. Millward in a separate chapter.

FILING AT THE VICE

(Work is slightly too low for comfort and efficiency)

GLUE: HOW TO PREPARE AND USE IT

Not many people, except craftsmen, know how to use glue. They seldom prepare it in the proper manner, and generally use it far too thick, not hot enough, and too generously. The strongest glue joint contains only a small amount of glue, and this exists in the form of a thin, tough film in intimate contact with both of the pieces that are joined together.

There are three things to remember: get the best glue, have the wood properly prepared to receive it, and do the work in a warm atmosphere. Very strong glue is made by mixing equal parts of Scotch and French. Wrap the pieces in a piece of sacking or in plenty of newspaper, and break them to fragments with a hammer. Put them into a gallipot or into the inner vessel of a gluepot, and pour in enough water to cover. After the lapse of several hours the glue will have swollen up and have absorbed all or the greater part of the water, any surplus of which should be drained off. Put the gallipot into a saucepan containing enough water to reach half-way up the outside of the pot, or, if you are using a proper gluepot, don't forget to pour some water into the outer vessel.

I do not propose to take up space by describing gluepots and brushes. You can get a small glue-kettle (Fig. 1) quite cheaply (it is a double kettle, as in the section, Fig. 2, the outer one for water and the inner for glue), and a suitable brush for a trifle. Some people prefer to make their own brush by hammering out the end of a piece of cane (*see* Fig. 3). Over a gentle flame slowly raise the glue to boiling point, and maintain it at this for about half an hour. To test it, take a brushful, and note whether the fluid runs off it like water, or almost as thickly as treacle; if the former, continue the boiling; if the latter, add some perfectly boiling water. Continue the boiling for a minute or so and try the consistency again. When it is just right the glue should fall easily from the brush and not be so thick as to break up into drops.

Fig. 1.—Double-saucepan Glue-pot

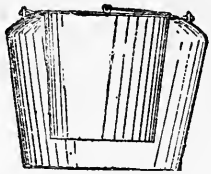


Fig. 2.—Section through Glue-pot

If you are in a great hurry, you will probably be tempted to put the gallipot in an oven or to boil up the glue in an old saucepan in direct contact with the flame of the stove, but if you do so you run a grave risk of overheating the glue and ruining its strength. The object of using the proper gluepot or of immersing the gallipot

Fig. 3.—Glue-brush made by hammering end of piece of Cane

in water is to ensure that the glue is not heated to a temperature exceeding that of boiling water.

The glue as prepared will be ready for immediate use, or, if preferred, can be allowed to cool into a jelly, and can then be quickly melted at any time as required. But after a few re-meltings its strength becomes impoverished, and it is wise to make up some fresh. If put aside in a damp place it will become mouldy, and then on no account should it be used.

Making a Glued Joint.—Now we come to the right way of using the glue. The two surfaces that are to be joined should be of a good fit one with the other. They must be clean, as even a touch of grease prevents the glue from taking a firm hold. They must be warm, as glue applied to a cold surface is suddenly chilled and half spoilt. I generally contrive to do a small gluing job in front of the fire. I have the glue boiling hot, I have previously taken care to leave the work somewhere near the fire so as to be gently but thoroughly warmed, and then, just before applying the glue, I hold the surfaces about a foot away from the fire, and when the work becomes really warm I apply a thin layer of glue to both pieces, and at once bring them into contact one with the other.

The next point is of great importance. As I have already said, the glue is required in a thin film only, and we can only ensure this by squeezing out the surplus. With two flat surfaces this is easily done by sliding one on the other a few times, and then when the glue starts to grip the two together bringing the two pieces into their proper position; if possible, put the work away under pressure for a whole day at least for the glue to get hard. In hundreds of cases the work is of such a shape that sliding one piece on the other is quite out of the question, and in all such cases we have to exercise more care in applying the glue. Whilst every spot must be covered, only a thin coat is required, and the two pieces must be brought together under pressure. Everybody will have his own way of producing that pressure, one of the easiest being to place the work between two flat boards and put a heavy weight over the top. A pile of books is an excellent weight if nothing better is available. A good

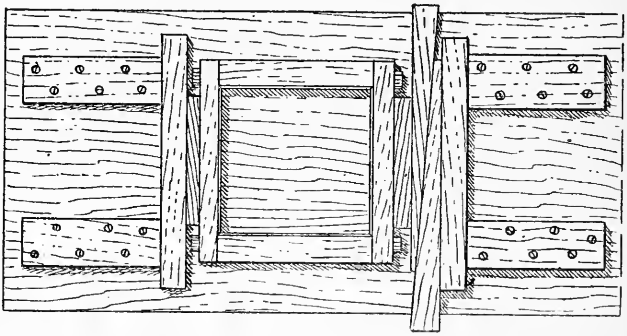


Fig. 4.—Wedge-cramp on Bench-top, etc., for Frame or other article

clamp is made with rope on the principle of the picture-frame cramp illustrated on p. 91. Fig. 5, on opposite page, shows how it may be arranged, and is as self-explanatory as the wedge-cramp illustrated by Fig. 4, in which figure the pair of folding wedges should be noted.

There are some woods that are very porous, and they tend to soak up the glue and prevent a satisfactory joint being made. In such cases put a brushful or two of glue into a pot, pour on a little boiling water, mix up thoroughly, and brush this glue size over the surfaces that are to be glued. Allow twelve hours to dry, and then proceed in the ordinary way already described.

Special Glues.—With two more hints the subject of gluing may be dismissed. For small jobs I never go to the trouble of preparing glue. It is so much more simple and easy to use seccotine, which can be squeezed from its collapsible tube in just the exact quantity required, but simply because this is a cold glue do not neglect to have your work thoroughly warmed, this making a great difference to the strength of the joint.

For some jobs ordinary glue would not long be satisfactory. It does not matter how old glue may be, it is always influenced by moisture. That is why glue is quite useless in any outdoor woodwork. The joints simply fall apart. Sometimes, though, it is very convenient to use glue for small fancy work which may occasionally run the risk of being wetted, or which may have to stand the effects of a moist atmosphere. Fortunately there is a most useful chemical, bichromate of potash, obtainable from an oilshop or chemist in the form of orange-red crystals, which can be added to our glue to make it waterproof. The curious thing is that this glue to which the bichromate has been added becomes waterproof only when exposed to the action of light, and therefore after it is prepared it must be kept in a dark place (it comes to the same thing if it is kept in a stone-

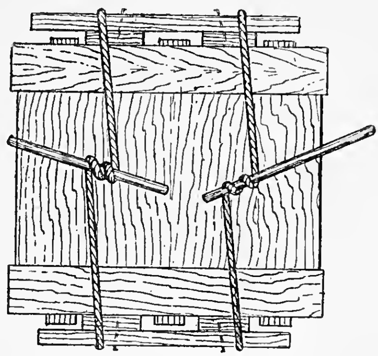


Fig. 5.—Rope-cramp

ware or black glass bottle, corked or stoppered) until it is wanted. The proportion of bichromate to be added to the glue is not of very great importance. First of all prepare the glue in the ordinary way, and while it is hot add, say, ½ oz. of the chemical for every 3 oz. or 4 oz. or so of cake glue originally used. The chemical is poisonous, and should not be touched by the hands, as it affects the skin.

I think that seccotine is the best liquid glue that I have tried, but as I am fully aware that my readers are the sort that want to make everything for themselves, I give here a recipe for a reliable cold liquid glue. Break 2 oz. of Scotch glue into fragments, and place in a bottle containing 8 oz. of ordinary commercial acetic acid, and 1 oz. of water. In due course the glue will swell up, and the bottle can then be stood in a saucepan of warm water, and *very gently* heated until the glue is actually melted. Add 1½ parts more of acetic acid, continue the gentle warming for a few minutes and allow to cool.

ELECTRIC BATTERIES AND HOW TO MAKE THEM

On another page I explain the difference between a primary battery and a secondary battery (accumulator), and I now propose to show you how to make two or three kinds of batteries, one suitable for ringing bells and very occasional flashing of a miniature lamp, another adapted for electro-plating, and a third, of the "dry" portable kind. A "battery" is really two or more "cells," but the first term is commonly used for a single cell as well.

Leclanché Cells.—There are some batteries which do not pay to make. The ordinary bell-ringing Leclanché (Fig. 1), for example, is rarely made at home, because all its parts are so cheaply bought. It consists of a jar (Fig. 2), a zinc rod (Fig. 3), connected to which is an insulated wire, and a charged porous pot (Fig. 4). These parts are assembled as in Fig. 1, and the space between porous pot and jar is filled up to the lower level of the black part with a solution of sal-ammoniac powder in plain water. 1-pint, 2-pint, or 3-pint cells are usually made, and will require respectively 3 oz., 5 oz., and 10 oz. of sal-ammoniac. An ounce more or less does not matter much. The two elements—there are always two distinct metals in a cell, carbon, in this sense, being a metal—are zinc and carbon. The zinc rod you can see in the illustrations. The carbon is in the porous earthenware pot into which it is packed with a mixture of granulated peroxide of manganese and carbon, there being holes at the top for the escape of the gas evolved in use. The tops of the jar, zinc rod and porous pot are coated with bitumen, pitch, or brunswick black, as shown, and often, too, they are further treated with hot paraffin wax, the object being to prevent the crystals in the solution gradually creeping up and corroding the connections.

Old zincs from Leclanché cells need treatment to make them as good as new. The particular treatment is amalgamation with mercury, the purpose of which is to stop internal local action when the cell is supposed to be at rest. The impurities in the zinc set up between themselves electrical action—that is, scores or hundreds of microscopic cells or batteries are formed—which in course of time runs down the cell. So, whenever a cell contains zinc rods or plates—and many cells do—it is wise to keep them well amalgamated, the method of doing which is to dip the zincs in dilute sulphuric acid to make them clean and bright, swill with water, put them in a dish, and then rub mercury over them with some tow fastened on a stick. Mercury instantly alloys or amalgamates with the clean zinc. Don't touch the mercury with the fingers and avoid inhaling its vapour.

The making of the porous pot is out of the question, but there is a good type of Leclanché cell that has a sack instead of a pot, and you can make this up for yourself if you like. Its size will depend on that of the jar you propose to use. A 3-lb. jam-jar before me as I write would take a sack 5 in. high, and not much more than 2 in. or $2\frac{1}{2}$ in. in diameter. Adopting the second dimension, you will need a piece of thin, loosely-woven canvas, not cloth, about $8\frac{1}{4}$ in. square, and a disc of the same material to form the bottom of the sack. Make the square piece into a cylinder (Fig. 5) and see that the seam is strongly

Fig. 1.—Leclanché Cell

Fig. 3.—Zinc Rod

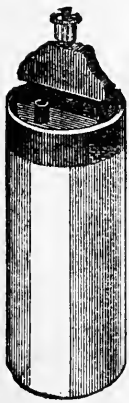


Fig. 4.—Carbon and Porous Pot

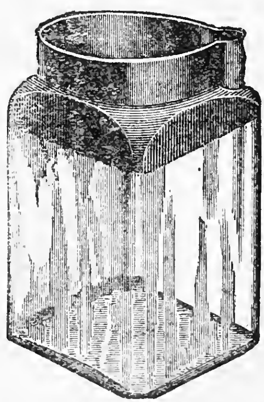


Fig. 2.—Jar of Cell

stitched. The carbon rod or plate must be bought, and if it has a terminal screw attached to it all the better; if not, get some old lead and fine sand. Make a mould for a head to the carbon and place a terminal and the carbon rod in such a position that when the lead is melted (in an old iron shovel over a glowing fire) and poured in, it will form a head and connect the screw to the carbon. Or a reader who understands electro-plating could deposit electrically a good thick coat of copper on the carbon and solder the terminal to it with tinmen's solder. In either case, on completion, coat the top of the carbon and everything up to the bottom of the terminal with brunswick black or paraffin wax.

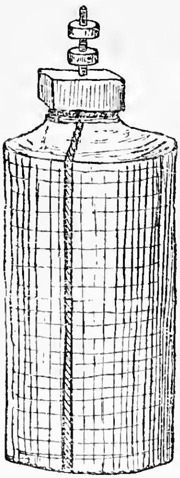


Fig. 5. — Carbon and Charged Sack of Sack Leclanché Cell

For packing the carbon in the sack, you will need some granulated carbon and manganese peroxide as fine as rice, but not containing dust. You can get them from dealers in electrical sundries. Mix together equal parts of each, and pack tightly into the sack after inserting the carbon. Tuck in the canvas and tie neatly at the top after packing in as much as the sack will take, but see that the terminal is left projecting (Fig. 5). Coat the tied end of the sack with brunswick black.

The best form of zinc element for this cell is an amalgamated plate bent to cylindrical shape. For a jam-jar measuring inside nearly 4 in. in diameter by about 6 in. high, the plate could be 5 in. or 6 in. high and 9 in. long (*see* pattern, Fig. 6), bent to form an incomplete cylinder 3 in. in diameter. A copper wire should be soldered to the connecting lug, and the zinc will need to be amalgamated as already described. The lug is bent over to form a hook so that the zinc hangs on the glass jar and does not touch the bottom. Actual dimensions are of small importance, and will depend upon those of the jar used. Made to the dimensions here suggested, there will be a clearance of ¼ in. between sack and circular zinc, and as it is really important that this be maintained, I suggest you put one or two thick rubber rings around the sack to prevent contact. All being ready, charge the battery with a solution of about 6 oz. or 7 oz. of sal-ammoniac in rain water or distilled water, leave for a few hours, and the cell is ready for use. It will, if well made, yield a current at 1·6 volt, and two such cells side by side, with the zinc of one connected straight to the carbon of the other, will give a current at 3·2 volts and would easily ring a bell or two, or occasionally glow a miniature lamp of approximately the same voltage; if more than one lamp is used connect them up on the parallel system, by bridge wires between two main conductors (*see* p. 47).

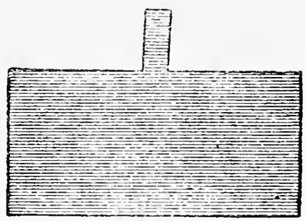


Fig. 6.—Pattern for Cylindrical Zinc of Sack Leclanché Cell

A Plater's Battery.—We will next consider an altogether different type of battery or cell from the above. For electrical experiments and for plating with gold, silver, copper, etc., you require a battery that will give a current for quite a time without running down. The

Leclanché battery, either wet or dry, is useless for such work, and instead a Bunsen, Daniell or a Wollaston battery should be used. I could tell you how to make either the first or second, but there would not be much purpose in doing so, as you would have to buy all the parts, and there would be very little " making " in the job of putting the battery together. I show you in Fig. 7 what a Bunsen cell looks like. First of all, there is a glass or stoneware jar D, in which is a zinc cylinder C, to which one of the terminal screws is attached. The zinc forms one pole of the battery. Inside the zinc cylinder is a porous pot B, and inside this again is a square or rectangular rod of carbon which forms the other pole and carries a terminal screw as shown. The zinc cylinder is kept well amalgamated by the method I have already described, and the battery is charged by pouring nitric acid into the porous pot until about three-quarters full, while the space between that pot and the outer stoneware or glass jar needs to be filled with a mixture made by pouring one volume of sulphuric acid into nine parts of water. Note the caution: do not pour the water into the acid, or you may be hurt by the spurting acid.

What is known as a French Bunsen cell has a sulphuric acid mixture in the porous pot as well as in the outer vessel, and is to be preferred to the other type because it is free from the noxious fumes generally associated with the use of nitric acid. For all sorts of small plating jobs, especially when the conducting wires are fine, and therefore offer a high resistance, either of these forms of the Bunsen cell is first-rate, but as I have said, you can scarcely " make " it; you buy it all ready for use.

Still better for small gold- and silver-plating jobs is the Daniell battery, which provides a greater volume of current at a lower pressure. This, again, is a battery which you buy ready made. It is simply a round glass jar containing a cylindrical copper plate, inside which is a porous pot

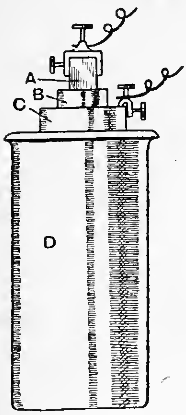


Fig. 7.—Elevation of a usual form of Bunsen Cell

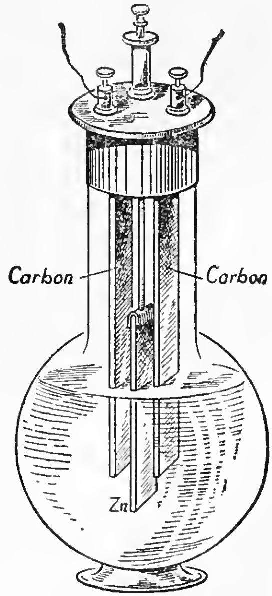


Fig. 8.—Bottle Bichromate Cell

containing a zinc rod. In the porous pot is a mixture of sulphuric acid and water (certain other solutions could be used), and outside the porous pot is a saturated solution of copper sulphate.

The bottle bichromate cell or Grenet's flask (Fig. 8) has a zinc plate, which can be lifted clear of the solution, between two carbon plates. The solution consists of 1 pint of hot distilled water or rain water and 3 oz. of bichromate of potash, to which is added, drop by drop, 3 oz. of strong sulphuric acid. The solution *must* become cold before use. This is a powerful cell, but is best bought ready made.

The best type of plating battery to be made by the boy himself at home is a copper-zinc couple of the Wollaston type. It is an interesting job to make a cell or battery of this kind, and quite an easy one, too. The idea is to support in an acid solution a piece of zinc with a piece of copper on each side of it. First look out some jars that will serve your purpose — jam-jars of stoneware or glass or specially bought porcelain jars. Two bridge-pieces of wood cut to shape, shown in Fig. 9, will be wanted to go across the top of each jar. Two cells will give enough pressure for ordinary small jobs, so four bridge-pieces will be required. Get from a plumber or from an electrical dealer two pieces of rolled zinc (cast zinc is impure and liable to break into holes when used). The recess shown in the bridge-piece (Fig. 9) is the exact width of the zinc plate, while its depth should be not quite half the thickness of


Fig. 9.—Bridge-piece of Wollaston Cell

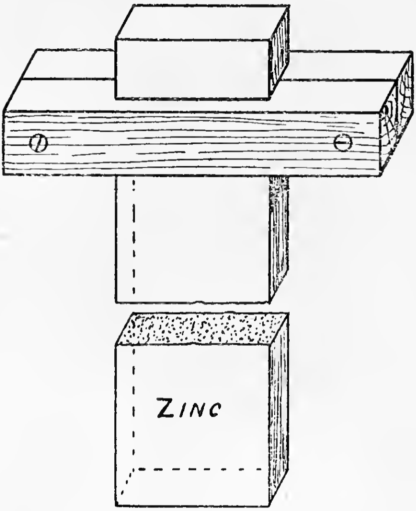


Fig. 10.—Zinc Element clamped between two Bridge-pieces

the plate, so that when the latter is put in the recess and the other bridge-piece put in place, as in Fig. 10, two screws can pass through the wood clear of the plate and clamp it in position. But before this is done both wood and zinc must be treated, the former to cause it to resist the action of any acid that may reach it and to stop the creeping up of any chemicals, and the latter to preserve it from local action. The wood should be soaked in paraffin wax or in candle wax, and the plate should be thoroughly amalgamated with mercury, as already explained.

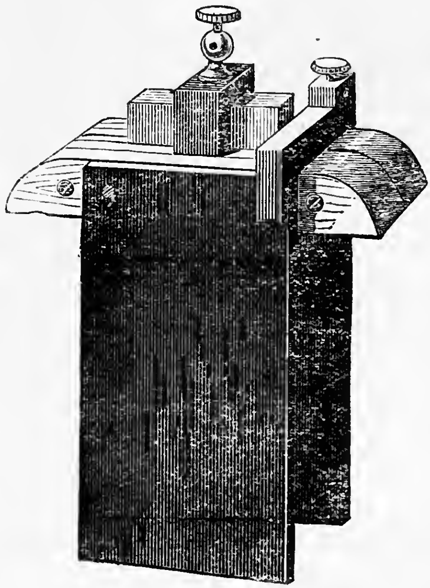


Fig. 11.—Copper Elements and Zinc attached to Bridge-pieces of Wollaston Cell

For each cell there must now be obtained two copper plates. It does not matter how thick they are, but the area of each one ought to be greater than that of the zinc which will come between them. The inner surfaces (those that will come opposite the zinc) should be scored over with a file or other tool, and small holes to receive screws should be bored at their top ends so that they may next be attached to the wood exactly as shown in Fig. 11, using brass or copper screws *sufficiently short to* *avoid touching the zinc plate.* If you like you can get special clamps which will connect together the copper plates and grip them to the bridge and obviate the use of screws. Two terminals, as shown, are essential, If the arrangement is now placed in the vessel, and a mixture of one part of sulphuric acid and ten parts of water poured in, the cell will immediately give current, and if you arrange some means of propping the plates up so that only part of them is immersed in the acid you can regulate the current yield and adapt it to your requirements. You could do this simply by having two or three pairs of different sized blocks of wood well soaked in paraffin wax to place on the edge of thc jar to support the bridge-piece. As already explained, you get a higher pressure if you connect the cells in series—that is, the coppers of one to the zinc of the other, and the remaining plates to the work. But for plating purposes great pressure is seldom necessary, and a good volume of current is more desirable, to obtain which you connect the cells in parallel, that is, any two like poles together, the other plates joining up to the circuit or work as before.

I show this particular type of battery because it is extremely easy to make, and the materials are readily obtained; but I do not profess that it is an ideal device. It needs to be carefully managed, and, in particular, the plates should not be left immersed in the acid when not in use. It is worth while, on removing them from the acid, to rinse them thoroughly under the tap and lay them aside until required. Then, too, the zincs must be kept well amalgamated, which is a simple enough job, but involves the use of mercury. In the instructions I give on page 112 for amalgamating zincs, I explain that the metal must be cleaned with dilute acid, but where this is inconvenient hot strong soda water can be used instead, although the acid is preferable. When the dilute acid in the cell appears to have a blackening effect upon the plates and there is a hissing noise, local action is excessive, and it is a sign that re-amalgamation is necessary.

Flash-lamp Batteries.—I know what a great interest is taken in the tiny batteries used in torches and flash-lamps. How often am I asked whether they can be re-charged! They cannot. Neither do I think they can be usefully made at home by the boy mechanic, inasmuch as the work would scarcely pay unless attempted in quantity. A flash-lamp battery is actually a moist Leclanché; when of the flat type it consists of three little cells, each $1\frac{1}{2}$ volts, connected in series, the total pressure being, therefore, $4\frac{1}{2}$ volts. A section through the battery is given by Fig. 12, in which A is one of the cells, B is a piece of waxed card, which insulates one cell from the other, C is the wire connecting the carbon of one cell to the zinc case of the next, and D is the terminal (a piece of flat brass) from the zinc element, the other terminal—from the carbon—also projecting through the top, but

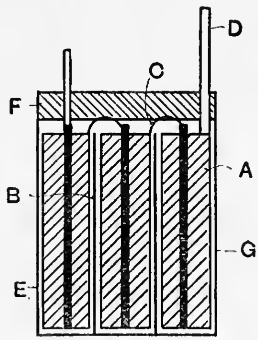


Fig. 12.—Section through a Three-cell $4\frac{1}{2}$-volt Flash-lamp Battery

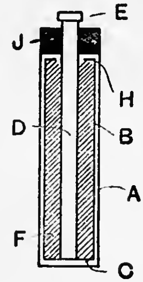


Fig. 13.—Section through one of the cells of the Flash-lamp Battery

being unlettered in the diagram. Between the three little cells and the outside container is fine sawdust or cotton wool E, while F is a sealing of pitch, and G is a paper wrapping.

Taking one of the three little cells separately, it consists of a cylinder of very thin zinc A (Fig. 13) lined with blotting-paper B, at the bottom of which is a disc of card C. Standing on the disc is a carbon rod D over the top end of which has been forced a brass cap E to allow of a wire being soldered on. Active chemical material is packed in between the carbon rod and the blotting-paper lining, as at F. The blotting-paper is turned in at the top (*see* H), and each cell is finished off with a seal J of pitch or of pitch mixed with resin.

In course of making, the blotting-paper lining to the zinc cylinder has been saturated with a solution made by mixing $2\frac{3}{4}$ oz. of sal-ammoniac, $\frac{3}{4}$ oz. of zinc chloride, $\frac{3}{8}$ oz. of glycerine, and 7 oz. of water that has been boiled. The chemical F surrounding the little carbon rod consists of some such mixture as 9 parts of finely-powdered carbon and 4 parts of manganese dioxide. These powders must be thoroughly well mixed, and then dampened with a similar solution to that already used, but note that it contains less sal-ammoniac, the proportions being 1 oz. of the last-named, 1 oz. of zinc chloride, $\frac{1}{4}$ oz. of glycerine, and 7 oz. of water. It is found that the proportion of this solution used in relation to the powder exercises a great influence on the success or failure of the battery. Not enough should be used to make the powder into a paste. The condition has been well described as a "moist powder, crumblingly damp."

Electric Batteries

There has been a tremendous amount of experimenting in the manufacture of these flash-lamp batteries, and all sorts of different mixtures have been tried. One of the best of them is said to be a mixture of 2 parts of carbon, 2 of plumbago or pure graphite (pure blacklead), and 3 parts of manganese dioxide, all in fine powder, the dampening mixture consisting of $1\frac{1}{2}$ oz. of sal-ammoniac, 2 oz. of zinc chloride, $1\frac{1}{2}$ oz. of glycerine, and 7 oz. of water.

Honestly, I do not think you will get as good results with home-made flash-lamp batteries as with those you buy ready made; but I know also that many of you will try to make them, so I feel compelled to add a few practical notes on the method of making up the cells. For making the zinc cylinders, get the lightest, thinnest zinc you can, and cut it into pieces measuring $2\frac{5}{8}$ in. by $2\frac{1}{8}$ in. Wrap them round a round piece of wood to form cylinders, and thoroughly well solder the seam, afterwards cutting discs to make bottoms for the cylinders, and soldering these in place from the outside. Or, to avoid the soldering in of the discs, you can place the open-ended cylinders on a tray and pour in a $\frac{1}{8}$-in. layer of marine glue or pitch. Cut pieces of blotting-paper measuring $7\frac{1}{4}$ in. long by $2\frac{5}{16}$ in. wide, and roll round a ruler to form a cylinder which will tightly fit the zinc cylinder already made, allowing a little of the blotting-paper to turn in and form a support for a cardboard disc, which should be pushed into the blotting-paper cylinder to form a bottom. Pour in the first of the exciting mixtures given above, allow to remain for fifteen minutes, pour out, and then place on end to drain for about an hour and an half. The carbon pencils must be tightly pushed into little brass caps. The tops with their caps should be stood in molten paraffin wax or candle wax for the purpose already explained. Place the carbon rod in the centre of the little cell, and having the black mixture moistened to the proper consistency, ram it tightly round the carbon by means of a piece of tubing. The mixture should stop short half an inch from the top of the carbon, and the blotting-paper be folded in over it. It is most important to avoid any little bridge of black mixture extending directly from the zinc cylinder to the carbon rod, as such a bridge would short-circuit the cell and very rapidly exhaust it. Leave the mixture time to get a trifle drier, and then seal with some pitch, afterwards melting a hole through the pitch with a hot wire to allow of the escape of the gases which are evolved later. The cells are connected together with No. 24 gauge wire, and the terminals are of thin spring brass, all soldered on. Three cells are laid side by side, connected up as described, partition slips of waxed paper put between them to prevent the zincs touching each other, and the whole wrapped round with brown paper, the top being packed with wadding or sawdust to prevent movement, and this being sealed over with pitch, which makes all secure. For the sake of appearance the cells are finally wrapped round with black paper.

SOLDERING

Most people associate mechanics with soldering, and suppose that a boy who is handy with tools must, of necessity, know how to use a "soldering iron." Soldering looks so easy. All you do is to put a hot iron on the kettle spout, touch it with a stick of solder, and the leak is mended. That's what they think.

Well, we don't use a "soldering iron" at all, and in the writer's humble opinion, soldering is not easy. Of course, when you have learned the right temperature for the soldering bit, how to clean the work, and how to make that annoying bead of solder flow where you want it to, the process has become easy enough. But I rather think you will find your first soldering job to be something short of perfection. On the other hand, you may have beginner's luck!

Solder.—Soldering consists in uniting two pieces of metal by means of an alloy melted by heat. An alloy is a mixture of two or more metals, and it is found that the best and cheapest solder for most of the metals in ordinary use—brass, copper, zinc and iron—is a mixture of tin and lead. As most boys will be interested in soldering such everyday metals as tin plate (which is steel coated with tin), brass, and copper, we may say that for all these an alloy made by melting 2 parts of tin with 1 of lead makes an excellent solder. In asking at the shop for such a solder as this, say that you want "tinman's fine solder." However, if you will be guided by me, you will not, at first, purchase your solder in the ordinary form of sticks such as you have seen used by the tinker and candlestick maker. There is a special preparation of finely-powdered solder, known as "Tinol," and nothing easier for the use of the boy mechanic has ever been introduced. On opening the flat tin in which the substance is put up, you find it to consist of a wet paste, and a little of this can be taken up on the point of a penknife or wooden stick and placed exactly where it is required. It has one great advantage; all soldering requires the use of a "flux," which keeps the metal chemically clean when it becomes heated. When ordinary stick solder is used the flux has to be separately applied. In "Tinol," however, the flux is already mixed with the solder, and a very excellent flux it is.

Should you particularly wish to use stick solder, you will need to prepare a separate flux by placing some pure hydrochloric acid (known also as muriatic acid) in a jam-pot, and adding some nice clean cuttings of new sheet zinc—just a few at first and then more until you notice that, although there is some zinc left at the bottom of the jar the acid has ceased to bubble up. It is important to see that what appears to be superfluous zinc is left in the liquid. Leave it overnight, and then pour off the liquid into a glass jar having a good wide mouth. This liquid is now a solution of chloride of zinc, and workmen know it as "killed spirit." For applying this flux to the metal you can make quite an excellent brush by taking a short piece of cane and hammering one end of it until the fibres become like bristles. For fine work the flux can be applied with a piece of galvanised wire or with a knitting needle.

As with solders, so with fluxes. I recommend you to use a flux already made, and one of the best obtainable is "Fluxite," a paste flux put up in flat tins; but, as already stated, if you decide for the easiest possible process, you will employ "Tinol," and leave stick solder and separate fluxes to a later date. That is all you need to know about the materials. Now for the tools.

Fig. 1.—Pointed Soldering Bit

Fig. 2.—Bit for Internal Soldering, etc.

Fig. 3.—Hatchet Soldering Bit

The Bit.—People talk glibly of a soldering "iron," when they ought to speak of a soldering "copper." Workmen know it as the soldering "bit." Figs. 1 to 3 show the three forms in which it is generally obtainable, and the one I prefer whenever it can be used is the hatchet-shape shown last. By the way, the "Tinol" firm sells a telescopic bit of the hatchet shape which will answer most small requirements. The bit is simply an iron rod with a shaped piece of copper at one end and a handle, generally of wood, at the other (*see* Fig. 4). The "Fluxite" firm also have a good collapsible bit (*see* Fig. 4a).

A bit must be heated to a temperature slightly higher than that at which the solder will melt, and the young mechanic sometimes has difficulty in finding just the right source of heat. The kitchen fire fouls the bit; the heat of the gas-ring is not concentrated enough and the bit takes too long to get hot. The flame of a spirit lamp can be used for heating the bit, but this again is a trifle slow. If you have what is known as a bunsen burner (Fig. 5) you might make that serve. An incandescent gas burner is really a bunsen burner, and if you possess one of the

Fig. 4.—Telescopic Bit

Fig. 4a.—Collapsible Bit

old-fashioned upright kind, you could take off the mantle together with its prop, turn the gas on full, light up, and then have a fair-sized smokeless flame in which, if you are ingenious, you can support the copper bit while it is heating, but we fear that at the best it will be a very inconvenient method. The tool shops sell special stoves for heating bits, some of them burning gas, and others of them charcoal, but not many amateur solderers would dream of buying one. Fortunately many readers will have already in their house a quite excellent stove for the purpose, and until they read of the fact in this place will

SOLDERING

Using the Hatchet-shaped Bit

Using the Blowpipe in Soft-soldering

be unaware of it. Hundreds of thousands of gas-heated laundry irons are now in use, and if the ladies of your establishment possess one, do your best to borrow it when you mean business in the soldering line. In the writer's experience, one of these irons has proved a most excellent heating device. Connect up the iron by means of a flexible tube to the gas-bracket, turn the gas about half on, light up, lift up the handle of the iron, and insert the bit so that the flame plays right on to the copper.

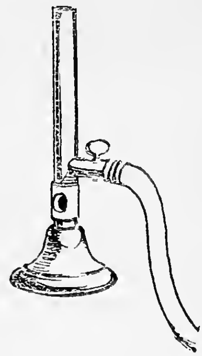


Fig. 5.—Bunsen Burner

There is still another method possible if you have a gas-heating stove (not a gas-cooker) in your house. Lift out some of the asbestos clay, and rig up the copper bit on a couple of bricks or on anything else handy and fireproof, so that the bit is held right in the top part of the flame. A small bit can be well heated in the blue flame of a "Primus" oil stove. I have dwelt somewhat at length upon the means of heating the bit, because I have found that it is the first big difficulty that the amateur solderer comes up against.

If you simply took two pieces of tin plate just in the state you might happen to find them in, and then with solder and the copper bit just as it comes from the shop tried to solder them together, you would meet with more or less complete failure. Although you might not know it, judging from appearance only, the work and the bit are dirty, and the solder when melted will not flow over or

" wet " or " tin," as it is termed, any unclean surface. So don't forget that when a job has to be soldered, the very first thing to do is to scrape it clean, using for the purpose an old knife or a file.

The bit, which is expected to convey the solder to the actual spot where it is required, must for the same reason also be scrupulously clean, and before starting work it is customary to tin it, that is, actually to coat it with the solder. Plenty of people fail in such a simple job as this just because they will not take the necessary trouble to get the metal nice and bright. With a file go over it until the whole of its surfaces resemble new metal. Then heat it to what is known as a dull red, quickly rub it over again with a file, and apply some " Tinol " to it, rubbing the bit on a piece of clean tinplate, so that the solder flows all over it. If using stick solder, dip the bit, after heating and cleaning, in the flux, and then rub the solder on it ; or, better still, get a small block of sal-ammoniac from the oilshop, and, after heating the bit, rub it on the block (Fig. 6), touch the bit with the solder, and you will see it immediately flow over the surface of the metal. You will not care for the smell of the fumes that will arise from the sal-ammoniac.

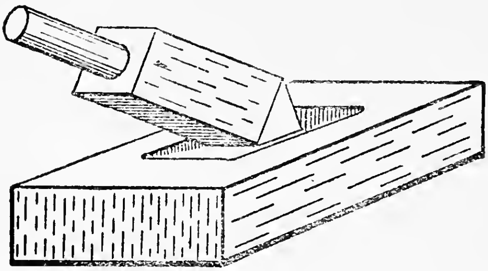


Fig. 6.—Tinning a Soldering Bit in block of Sal-ammoniac

Patching a Vessel.—Now we have tinned our bit and are ready to do some useful work. It is more than likely that the lady of the house has a tin-plate saucepan, kettle or dish that is in need of repair, and will be only too delighted to allow you to try your "'prentice" hand upon it. As a typical soldering job, let me assume that you are going to cover a hole in a tin-plate vessel (*see* A, Fig. 7) with a neat little patch which we can readily cut with some stout scissors from a new coffee tin or anything else of the sort. Scrape around the hole in the vessel and make it nice and bright (*see* B). Then place the little piece of tin plate so as fairly to cover the hole (C), and with the point of a nail scratch the outline of the patch upon the work (*see* D); remove the patch, and by means of a bit of wood or the point of a bradawl apply some "Tinol" thinly all over the place and slightly beyond where the patch is to go. Then replace the patch as at C.

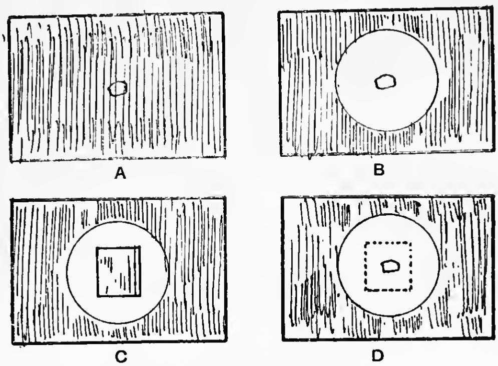


Fig. 7.—Stages in preparing a Soldered or Sweated-on Patch

In the meantime the soldering bit has been getting nicely hot in some one of the ways I have already described. Let it rest well on the patch with the object of transmitting as much heat as possible, and move the bit about so that every part of the patch comes under the influence of the heat.

The job is done. The patch has been "sweated" on and with reasonable care the result is a good one. But probably you will not be satisfied. You will want to *see* the solder in a nice ring all round the patch. There is no reason why you should not, and the extra solder will be extra security. See that the bit is nicely hot, but not so hot that the tin upon it has been badly discoloured and burnt. If it has been, give it a touch with the file, rub it on the sal-ammoniac, and apply a little solder to its face, thus re-tinning it. Then transfer the bit to the

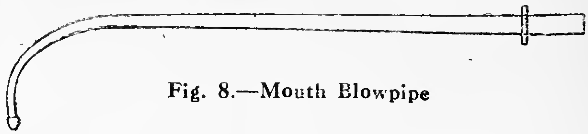


Fig. 8.—Mouth Blowpipe

edge of the patch, and apply a ring of "Tinol," and with the soldering bit in perfect condition gently wipe it round the edge of the patch. If you are using stick solder, you will need first to ring the patch with "killed spirit," and then apply bit and solder together. When you are a little more experienced you can experiment with the object of lifting up a bead of molten solder on the point or edge of the bit and transferring it to the work exactly where it is wanted. It is all-important when using stick solder to hold the work in such a way that the solder can run downhill to the spot where it is wanted. Many a boy has tried to make the solder climb the handle of a kettle, whereas if he had remembered that water always runs downhill he would have saved himself some

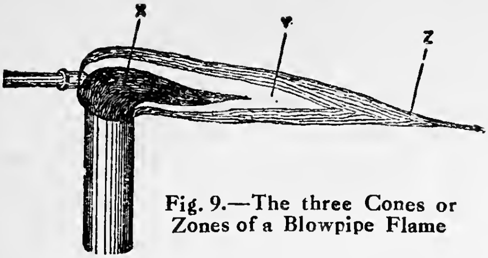


Fig. 9.—The three Cones or Zones of a Blowpipe Flame

annoyance and have had the pleasure of producing a result of which he could have been proud.

Soldering with the Blowpipe.—Not all soldering is done with a soldering bit. Some of the neatest and cleverest work is executed by means of the mouth blowpipe which is simply a bent tube of glass or metal shaped as in Fig. 8. This blowpipe is used for directing a tiny jet of flame upon a speck of solder resting on the spot that has to be soldered. The flame of a candle or spirit-lamp when directed and assisted by the mouth blowpipe becomes hot enough to melt solder most readily, as a single experiment would prove. In using the blowpipe (*see* Fig. 10) a good breath is taken in, so filling the lungs with air. The blowpipe is applied to the base of the flame, and a gentle but constant current of air blown through it. It will be seen that the candle flame has three parts or zones (*see* Fig. 9). That at the base marked x is the coolest of them all, and in a dark room would be almost invisible.

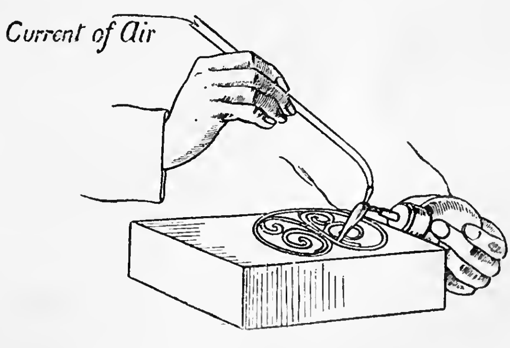


Fig. 10.—Using Mouth Blowpipe with Spirit-lamp Flame

The next zone marked Y gives forth more light than either of the others. The tip of the flame marked Z is the hottest of the three, and it is this part of the flame that does the work. You must try in using the mouth blowpipe to breathe through the nose, and at the same time keep the cheeks full of air, and a steady current passing through the blowpipe. A good flame will be of a bluish colour with a yellowish or brownish tip. Blowpipe soldering comes in so useful when the job is too small for the soldering bit. Say, for example, you wish to attach the head of a pin to a coin. Clean the spot on the coin where the junction will come, and also the head of the pin. Touch both of them with the "Tinol," and, supporting them on a piece of charcoal or brick, direct the flame on to them with a blowpipe one at a time. This "tins" them, that is, it coats them with solder. Leaving the coin where it is, hold the pin on the end of a strip of wood, and place its head in position on the coin exactly as it is to be when soldered. Then a touch with the blowpipe flame will unite the two.

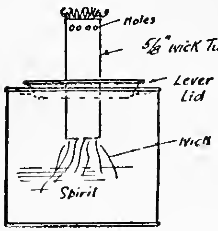


Fig. 11.—An easily-made Spirit Lamp

Fig. 11 shows how easily a spirit lamp for blowpipe soldering can be made. The wick tube is any small piece of tube available, and it slides fairly tightly through a hole cut in the lever lid of a small "self-opening" tin box. The wick is of loose threads. Note the small holes at the top of the wick tube; they considerably improve the action of the lamp. Methylated spirit is the fuel. Lamps on this principle can be bought ready made.

Silver Soldering.—So far, I have talked about soft soldering only, that is, about solders that melt at the comparatively low temperature of a black-hot iron, but there is such a thing as hard soldering. The joints in a really good piece of silver-work or in a well-made model engine or boiler are hard-soldered, for which purpose an alloy of tin and lead would be of no use whatever, and recourse must be had to an alloy of silver and brass. Take my advice and if you use silver solder at all buy it ready made. Such a little bit will go such a long way. Buy it in the form of very thin sheet and with a pair of very strong scissors, or, if you have them, with a pair of snips, cut the sheet up into tiny squares about $\frac{1}{8}$ in. (*see* Fig. 12).

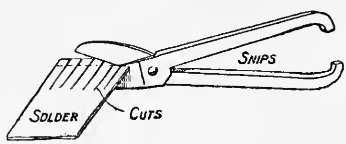


Fig. 12.—Cutting up Silver Solder into Paillons

These are known as "paillons," which you may care to know is a French term. The flux for silver soldering is quite different from that you have already used. It is made by taking a piece of lump borax, moistening it with water, and rubbing it on a piece of slate until a thin paste is formed. Fig. 13 (p. 136) shows the outfit.

If you ever try to build a model boiler or engine, you may need to make a joint in a tube or to solder the end into a tube (*see* Fig. 14). The surfaces having been scraped perfectly clean should have some of the borax paste applied to them with a brush, and then, with the same brush, the tiny paillons of silver solder are placed in position all along the joint. Now slowly heat the work in the blowpipe flame, but do not at first let the flame fall upon the solder. The latter should not be melted until the metal all round it reaches the temperature at which the solder becomes liquid. This course will serve to dry the borax, and the bubbling up may move some of the solder which will need to be pushed back into place. As the bubbling of the borax ceases, slightly advance the flame, and in due course the solder will melt and run into the joint, providing the work is held at such an angle that it is natural for the solder to run that way. Do not immediately remove the flame, but let it remain for a few

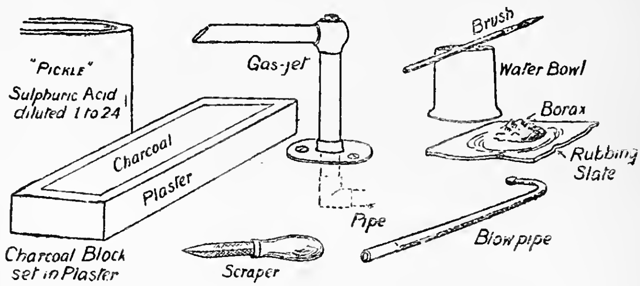


Fig. 13.—Outfit for Silver Soldering

seconds so as to cause the solder to sink right into the joint.

Let the job get cold slowly, and then clean off the borax by placing it in a pickle made by pouring a tiny glass measureful of sulphuric acid into twenty times the quantity of water. By the way, never pour water into sulphuric acid, or the acid will spurt, and if it falls upon your hands or face you won't forget it in a hurry, and should it fall upon your clothes you can depend upon it that it won't do them any good; probably some of your experiences in the chemistry lab. will be fresh in your memory, and my warning may be unnecessary.

I have described only one of the methods of hard or silver soldering because the process is well-nigh essential in serious model building, but I think I ought to warn you that it has difficulties all its own, and that to become an expert silver-solderer demands a lot of practice, and

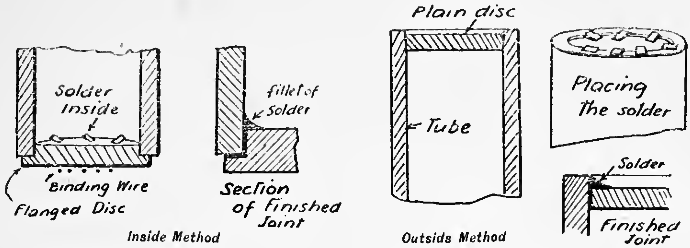


Fig. 14.—Silver Soldering ends into Tubes, especially applicable to Model Boiler Building

there is a great deal more to be said about it than I have ventured to bother you with in this chapter. I prefer to occupy my spacc with information on work that is within nearly every boy's capacity, as measured in equipment and skill.

MAKING SIMPLE WOODEN TOYS

I WANT to show you in this chapter how to make three wooden toys (all of them designed by Mr. I. Atkinson, to whom I am much indebted), which should be well within your capabilities. There is not a really difficult bit of work in any one of them.

A Toy Gymnast.—One of the happiest toys I have seen for a long time is the toy gymnast, a photograph of which is given in one of the plates accompanying this book. Turn to that plate for a moment, and I will show you how the gymnast works. The figure or puppet is of thin, flat wood, normally hanging with his hands above his head, and the string which supports him is arranged as shown in the plan and elevation, Figs. 1 and 2 herewith. Normally the string is crossed, but when the lower ends of the levers are squeezed together by the fingers the upper ends are forced apart, the string is pulled taut, and the figure is jerked upwards in a most realistic manner. There is no end to the contortions and amusing positions of which the gymnast is capable, and when the maker of the toy here described sent it to me I very soon discovered that both juniors and seniors took a huge interest in its antics. The toy, which seems to be still a novelty, although a very old one, consists of a base, a post, a cross-piece, two upright levers, the string, and the figure.

Figs. 3 and 4 are front and side elevations of the woodwork, the levers being shown broken to economise space. We will deal with the parts separately, and make all clear as we go.

In the first case, a fairly hard wood should be used. The levers need to be of tough stuff, or some careless body will sooner or later break them. For the base A, post and cross-piece, you had better use mahogany, oak, walnut, or other hard well-seasoned furniture wood. The base should not be less than $\frac{3}{4}$ in. thick, and $4\frac{1}{2}$ in. or 5 in. long by $3\frac{1}{2}$ in. or 4 in. wide. A hole is bored in its exact centre to take a dowel (shown in dotted lines at the bottom of Fig. 3), which runs up into the post or pillar B.

This post is about $\frac{3}{4}$ in. square and about $5\frac{1}{2}$ in. high, and it carries at its top a cross-piece C shaped as in the detail plan (Fig. 5), where full dimensions are given. The connection here, also, is by means of a dowel, as shown, for which a hole will need to be bored with a twist bit and a suitable piece of round rod prepared and well glued in. An excellent alternative to the dowel would be a stub-tenon at each end of the pillar, with a mortise in base and cross-piece to correspond.

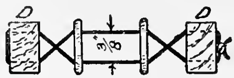


Fig. 1.—Plan showing how Toy Gymnast is suspended

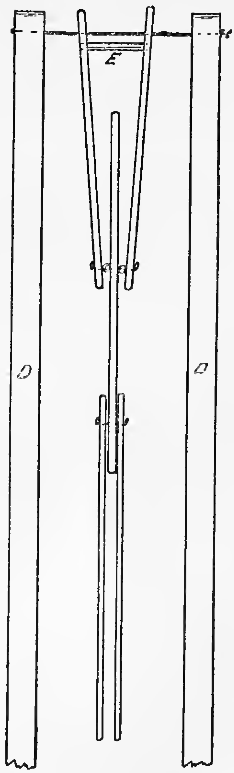
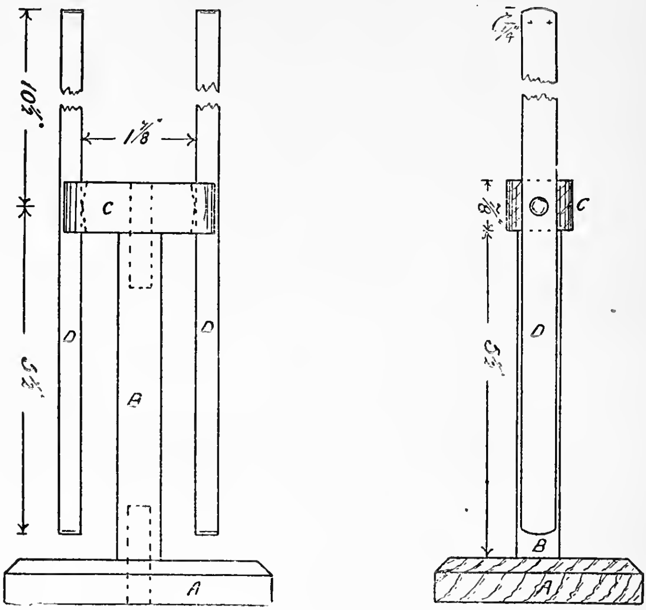


Fig. 2.—Front Elevation of Toy Gymnast

The exact shape of the cross-piece is of importance, inasmuch as this part is a fulcrum on which the levers work. You will recognise the levers as belonging to the "first order." The horns of the recesses in the cross-piece keep the levers upright, but you will note that the



Figs. 3 and 4.—Two Elevations of Gymnast's Stand

bases of the recesses are not quite flat, but there is a little projection in the centre on which the levers can be rocked a trifle. You will understand this more clearly from Fig. 6, which is a large-scale detail section from which it will be apparent that the lever D is free to rock a little on the cross-piece C.

The levers D are shown in a number of the views.

They are 16 in. long, $\frac{5}{8}$ in. wide, and $\frac{3}{8}$ in. thick. At a distance of $5\frac{1}{2}$ in. from the lower end a hole is bored through the thickness to take a wire nail—a fairly stout one, about $1\frac{1}{4}$ in. long. The nails must not fit the holes in the levers tightly, and the holes must be countersunk to take the heads of the nails. Preferably, also, the holes should widen out towards the heads of the nail so that the lever can rock easily. At $\frac{1}{4}$ in. from the top of the lever are two fine holes $\frac{3}{8}$ in. apart to take the string, as shown by the dotted lines in the detail plan (Fig. 1).

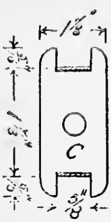


Fig. 5.—Plan of Crossbar for Toy Gymnast

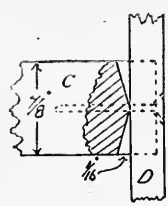


Fig. 6.—Diagram showing how Levers rock on Crossbar

The figure or puppet must be made of tough wood, preferably not more than $\frac{1}{8}$ in. thick. The kind of pear-wood used frequently for cheap set squares is one of the best materials for the purpose. The figure is in five parts—the head and body, two legs, and two arms, and it can be ornamented with ink or stain or with a touch or two of paint. The pattern for body, leg, and arm respectively are given by Figs. 7, 8 and 9. There are two holes in the body, one hole in each leg, one in each shoulder, and three in each hand. The leg and shoulder holes take the wire pivots.

The largest of the three holes in the hand—that shown by the little circle in Fig. 9—takes a tiny piece of matchstick (*see* E, Fig. 2), which keeps the hands apart and assists the action of the toy. The two fine holes in the hands take the string, which actually is a piece of fine, but thoroughly good catgut (an " A " violin string a few inches long), which should be threaded through and tied exactly as shown in the detail plan, Fig. 1. It is wise to drill all the holes before cutting the pieces to shape.

There is one point of particular importance in assembling the figure. Fig. 7 shows in dotted lines the exact positions of the arms. Their length and position on the body should be such that when the gymnast is raised above the catgut his body can come forward over the string and between his hands, trailing his legs after him.

The parts of the body can be shaped with fretsaw and knife, and cleaned up with glasspaper.

The pivots are pieces of wire, such as fine hairpin, on which " heads " have been formed by making tiny loops by means of fine-pointed pliers, these loops being bent at right angles to the wire and flat against the body of the puppet. In making these pivots, the head, as described, would be formed on one end of the wire, the leg, body, and second leg threaded up, the wire cut off to within about $\frac{3}{8}$ in. or so, and a second head formed and bent over. The arms are put on in the same way, but between each arm and the body is a small bead (slightly thicker than the wood of which the puppet is made) threaded on the wire as indicated in Fig. 2. If these beads are omitted, it will be found that the legs will be continually getting jammed between the arms and the body. The distance piece E (Fig. 2) will not be glued in until the arms have been threaded to the body.

You will need a little help in the suspension of the puppet. Holding it upside down with the holes in the hands opposite those in the levers, thread the two ends of the gut straight through lever, hand, hand and lever, without any crossing, and tie the ends together; then,

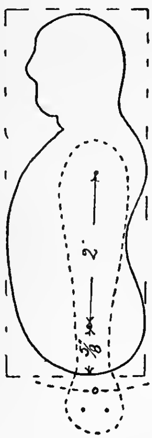


Fig. 7.—Body Pattern

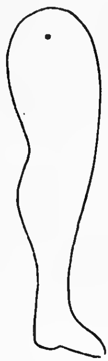


Fig. 8.—Leg Pattern

Fig. 9.—Arm Pattern

when the figure is allowed to drop, the gut will cross exactly as shown in the detail (Fig. 1).

The best finish for the toy is a good coat of varnish, but there is no reason why you should not paint it in some attractive colours if you so wish. Varnish or painting should be done before threading together the parts of the figure or suspending it in place.

A Toy Aeroplane.—You will realise at once that the aeroplane shown in the plate already referred to and in side elevation and plan by Figs. 10 and 11 is not a model but merely a toy, which, by means of a string tied to a ring in front of the propeller, can be pulled about by your small brother and sister, who will occasionally have the joy, should the speed be great enough or a wind be blowing, of seeing the propeller revolve. The toy consists chiefly of the body A with rudder B, propeller F (we ought

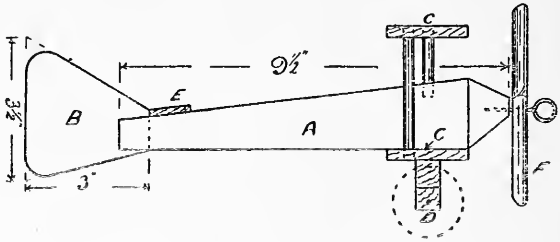


Fig. 10.—Elevation of Toy Aeroplane

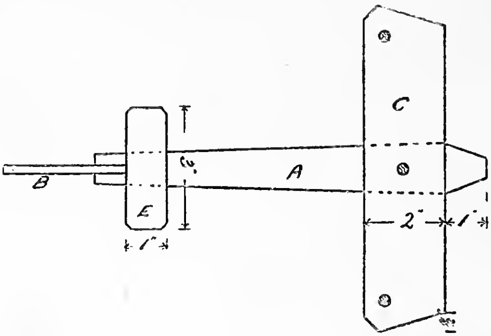
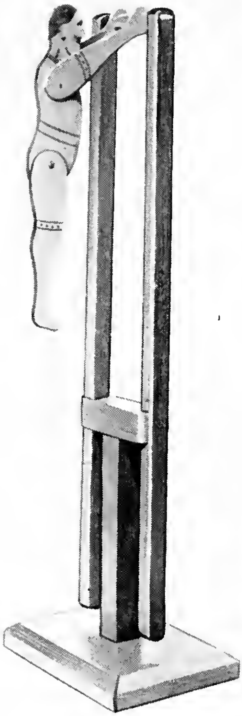


Fig. 11.—Plan of Toy Aeroplane

really to call it a tractor, I suppose), with planes C and E mounted on an axle D to the ends of which are screwed wheels. I show how the whole of the toy can be made in wood, which will look all the better and be all the more pleasing to its owner if brightly painted.

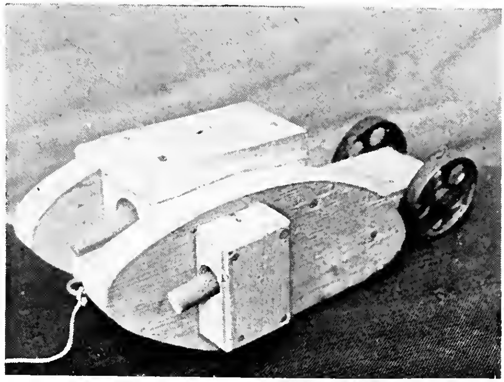
Let us take the body first. It is $9\frac{1}{2}$ in. long, $1\frac{3}{4}$ in. high, and its greatest thickness is $1\frac{1}{4}$ in. It is shaped with

EASY TOY MAKING



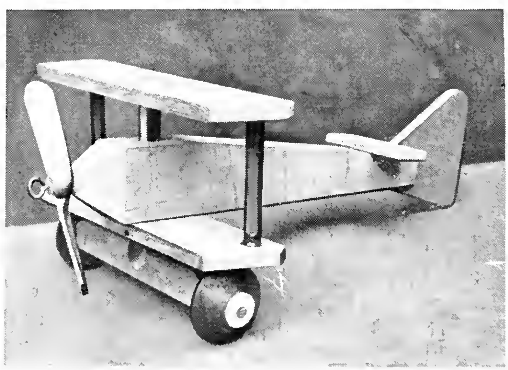
A Toy Gymnast

(*See pages* 139 *to* 143 *for Working Drawings*)



A Toy Tank

(*See pages* 148 *to* 151 *for Working Drawings*)



A Toy Aeroplane

(*See pages* 144 *to* 147 *for Working Drawings*)

For information on making these toys, see pages 138 *to* 152

saw and plane or knife. You will see that, as illustrated, it tapers at the tail end, where it is only ¾ in. square. At its front or nose, where the propeller is attached, it is about ½ in. square. These dimensions will be found to give a good effect, but if you can improve upon them, or if you have some stuff at hand of other and equally convenient size, I see no objection to your making any reasonable modifications that occur to you.


Fig. 12.—Cutting two Aeroplane Bodies from one piece

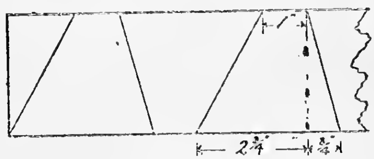


Fig. 13.—Setting out Rudders

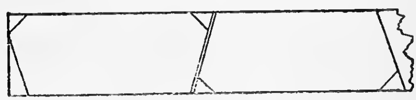


Fig. 14.—Setting out Planes

For example, if you were making two or three toys of this sort, you might wish to save time by keeping the body of the same width from front to back, and you could easily cut two bodies out of a piece of ¾-in. stuff, roughly 10 in. long, and 2¾ in. wide. A slanting cut, as shown in Fig. 12, would make two bodies from such a piece. Similarly a strip of three-ply stuff, 3 in. wide, could be divided up, as shown in Fig. 13, and cut up without wasting a bit of it into rudders, which could be left pointed or could be easily rounded with a knife.

The rudder is only such in name. As shown at B, it is simply a piece of flat wood (three-ply is the strongest for the purpose) glued and nailed into a slot or notch sawn in the body. Suitable dimensions are shown in the illustration (Fig. 10). Note that the fish-tail shape keeps the rear of the body off the ground. Just in front of the rudder B is the elevator plane E, about 3 in. long and 1 in. wide, made of three-ply stuff, and glued and nailed to the body.

As for the front planes C, these are 8 in. long and 2 in. wide, and the thickness can be about $\frac{1}{4}$ in., but any three-ply stuff can be used, and a strip of it, 2 in. wide, can be economically set out and sawn up, as in Fig. 14. System in setting out means economy when you are making two or three toys of the same pattern at one time. The lower plane is nailed to the axle below it, and also to the under-side of the body above it. But before the nailing is done, holes need to be bored through both planes to receive the vertical struts which support the upper plane. I show only three such struts, but more would look better. They may consist of wooden rods about $\frac{1}{4}$ in. thick and about 3 in. or $3\frac{1}{4}$ in. in total length. They should fit the holes in the top and bottom planes tightly, and be glued in place.

The axle should be about 5 in. long and $\frac{1}{4}$ in. deep. The shape and thickness do not matter, but the shape given in Fig. 15 may be adopted if you like. At each end of the axle is a wheel which may be of cast iron—a type that can be bought at many ironmonger's shops very cheaply indeed—or the wheels may be cut from cotton reels or from any cylindrical wood.

The propeller F (Fig. 10) should be set out on a piece of three-ply to a length of 5 in. (*see* the pattern, Fig. 16), and width of $\frac{3}{4}$ in., and cut to shape with saw, afterwards cleaning up with glasspaper. Two pieces of wood or metal of the shape shown in Fig. 17 can be joined together at right angles to give a good effect.

We must remember that, as I said before, this aeroplane is merely a toy, not a model, and therefore should not be finished model-fashion. It is for the use of a little child, and the grey paint which in your eyes would make it so much the more professional is not to be thought of. Rub over all rough edges and surfaces with glasspaper, give it a second rubbing with a finer paper, dust it, and then paint it in some attractive colours, making the rudder, the axle, and the propeller of different colours from the body. Two or three sample tins of the well-known enamels which can be bought very cheaply will enable you to arrive at some startling effects, which will give great joy to the small person for whom the model is intended.

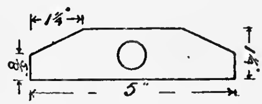


Fig. 15.—Front Elevation of Toy Aeroplane Axle

Fig. 16.—Wooden Propeller

Fig. 17.—Pattern for Metal Propeller

A Toy "Tank."—A substantial, if by no means pretty, toy is shown in the third photograph on the plate already referred to. This toy is as close a representation of its dreaded original as an article constructed almost wholly of wood, and intended merely as a plaything, can be made. There are no travelling belts which would render the toy more realistic, but these belts would be only in the way on a toy for a little boy's use, and had best be omitted. However, you can exercise your ingenuity if you so wish, and easily devise an arrangement for carrying the belts if you think the trouble and expense are worth it.

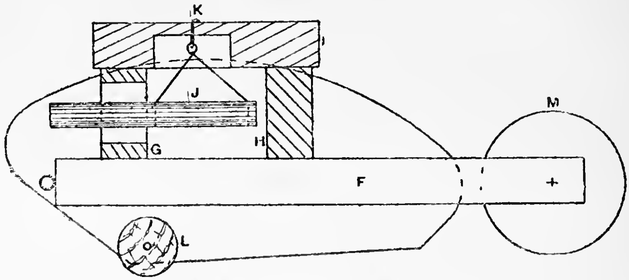


Fig. 18.—Part Elevation and Part Section of Toy "Tank"

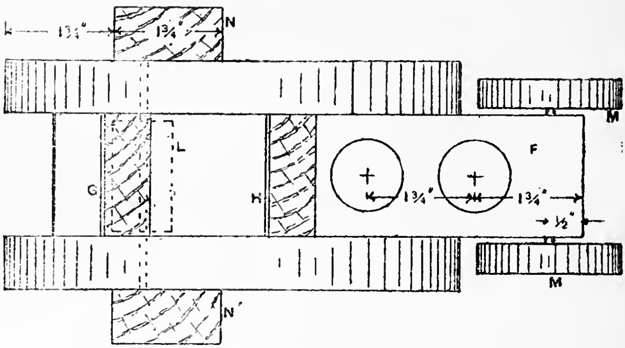


Fig. 19.—Plan of Toy "Tank" with Cover of Middle Cabin removed

You will be able to get all details of the construction of the toy from the part elevation and part section (Fig. 18), and from the plan (Fig. 19). In the first of these diagrams it is assumed that the front side has been removed, and in the second that the cover of the middle cabin has been taken off. The actual centres and dimensions for setting out the sides are given in Fig. 20.

Let us consider the sides first. Each is a piece of stuff at least $\frac{7}{8}$ in. thick (it might be even thicker), not less than $3\frac{1}{2}$ in. wide or less than $7\frac{1}{2}$ in. long. As the exact shape or contour is such a big factor in the toy, you had better take the trouble of setting it out on a piece of cardboard first, and you can then cut the cardboard carefully to the outline and use it as a pattern or template for laying down on the wood. Some boys are remarkably good at catching the proportions and general

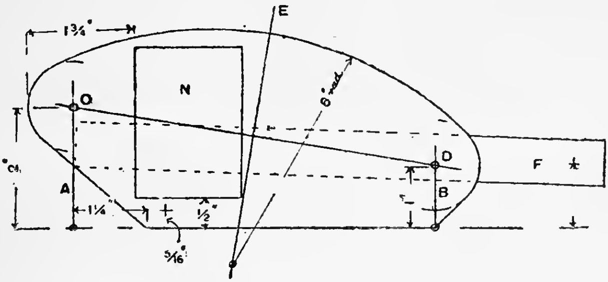


Fig. 20.—Setting out Sides, etc., of Toy "Tank"

shape of an outline, but most readers will need the assistance of the diagram given in Fig. 20. Draw the base line, and then set up the perpendiculars A and B, which are 6 in. apart. The centre C is 2 in., and D is 1 in., from the base line. Join C and D. Setting your compasses to a radius of $\frac{3}{4}$ in., strike arcs from D and C, and from these draw slanting lines to the base line as shown. Bisect the line C D by means of the line E, which, of course, will be at right angles to it, and continue E right through the base line and mark a point at a distance of $4\frac{1}{4}$ in. below C D. This is the centre for the top curve, which should be drawn in so as to connect up the circular ends. The oblong piece shown in Fig. 20 is one of the side cabins.

The pattern or template should be laid down upon the planed wood, and a line pencilled round. A bow saw would cut the curve quite well, but if you do not possess one you must do the best you can by nibbling off bits here and there with an ordinary saw and afterwards shaping with knife and chisel, finishing with coarse, medium and fine glasspaper in the order given. One face of the wood you are using is probably better than the other, and it will be well to lay the pattern on upside down when marking out the second side, so as to ensure that the parts of the sides that show have the best possible appearance.

On each side is nailed a little cabin, of which Fig. 21 is the inner elevation and Fig. 22 the cross-section. You will note that the gun is suspended so as to move slightly when the "tank" is pulled along. Each side cabin consists of one piece of wood, $2\frac{1}{2}$ in. by $1\frac{3}{4}$ in. by $\frac{7}{8}$ in. thick, and in each are bored two holes. One of these holes is bored from the inside face, and has a diameter of 2 in. Really it is a recess going only about three-quarters of the way through. The other hole is simply a gun port through the front of the cabin to connect with the recess. I have mentioned the two holes in this order, but, as a matter of fact, in boring it would be better to make the small hole ($\frac{1}{2}$ in. or $\frac{5}{8}$ in. in diameter) first, and then cut the recess with a big centrebit. The precise size of the recess is of no importance. Of course, in making the two side cabins you will recognise that they must be a pair; in other words, one must be made on a different "hand" from the other.

The dummy guns are pieces of round rod suspended by a wire in such a way that they can roll quite freely. Tiny screw-eyes can support the wires, or small holes can be drilled and a looped wire inserted and clenched over on the top. The side cabins should not be nailed on until the inside cabin and the bottom have been fixed.

The " tank " is held together by means of a bottom F and centre cabin G H, to which the sides are nailed. The bottom F is 2 in. wide, from ½ in. to ¾ in. thick, and about 9 in. long. Two holes can be bored through the back

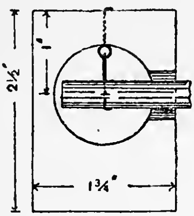


Fig. 21.—Elevation of " Tank's " Side Cabin, showing Inner Side

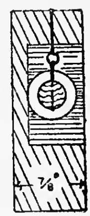


Fig. 22.—Cross Section through " Tank's " Side Cabin

part as shown, but their only purpose is to lighten the appearance. On the bottom are nailed back and front walls G and H to the centre cabin. Their height is 1¾ in. or 2 in., and the width must agree with that of the bottom. In the front wall is bored a hole through which the dummy gun projects. The top or cover to the cabin is a piece of similar stuff to the walls, 4 in. long, and a recess is bored in its underside to give play or freedom to the dummy gun J, which swings to and fro. The gun is of round rod, and suspended on wires in the manner illustrated. The cover is nailed down on the cabin walls.

You will take great care that in putting together the " tank " you get the bottom slightly on the slope. The amount of the slope will largely depend on the size of the rear wheels you are using, and it should be sufficient to give clearance to the wooden roller L, which works between the sides, and is pivoted on two wire nails. The back wheels are mounted on a stout wire, roughly 3 in. long, or a wooden axle may be nailed or screwed to the bottom if preferred.

PAINTING, ENAMELLING, AND STAINING

Painting.—Most things that you make in wood need to be finished with a coat of paint or varnish. Anybody can put on paint, say you. Yes, I think anybody can, but what is necessary is to use the right kind of paint and put it on properly. Now, the first essential is a good brush. A little more money spent on the brush at the start and a little more care taken with it in use will mean far better work than can be done with a poor brush, which will lose its hairs continually as the painting progresses and will leave the painted surface covered with ugly brush marks. What the painter calls a "fitch" with hog-hair bristles, a flat brush of the same material, a good-quality sash tool—that is, a brush specially shaped for painting narrow sash bars, etc.—an oval brush or either of the last-named "ground," that is, bevelled to an edge—any of these is an excellent paint brush for general use, and you can work wonders with a small and a large sash tool.

When you get a new brush, and you have some rough-and-ready work waiting to be done, you can go straight ahead with it, because the rough painting will do the brush a lot of good, and get it into condition for better jobs. Workmen often get a new brush into condition by using it for a day or two for painting brick walls.

Do not forget that when the job is over and if the brush is not to be used again for some time, it should be rinsed out in turpentine to remove the paint and then thoroughly well washed with soap and water—very little water at first, but plenty of soap, afterwards increasing the water until the soap lathers freely. Next, the brush should be rinsed out under the water tap, shaken free of water, allowed to dry, wrapped up in paper, and put away till wanted. If, on the other hand, the brush will be wanted for use next day, keep it with just its bristles, and only the bristles, immersed in linseed oil or in a mixture of linseed oil and turpentine, tying a string round the handle and so suspending the brush that the weight does not come on the bristles. Should the bristles be mounted in tin or other metal, always keep the metal out of the liquid.

A new brush of the quality used by a workman is too long in the bristle for use, and it is customary to tie string round the bristles at the part where they are secured to the handle so as, in effect, to make them shorter. Then, as they wear down, the string is undone turn by turn. I do not suppose, though, that you will take the trouble to do this, but always remember that the professional painter gets his good results very largely because he is willing to spend time on such details.

Any pot will do to hold the paint, and nowadays the best oilshops, and, of course, the decorators' supply houses, sell paint put up in cans having very convenient handles so that the can itself acts as a paint pot.

Mixing up your own paint is probably out of the question. You will buy a good quality ready-prepared paint, which, believe me, is far superior to anything you can make at home. But as I like to explain the why and wherefore of things as I go along, I may explain what an oil paint actually is. It is a pigment—what you may know as a " colour "—or a mixture of pigments worked up with a suitable liquid so that it can be spread over the work to be painted. Very frequently the pigment has a metallic base, for examples, white lead, red lead, zinc white, red oxide of iron, etc., or it may be a coloured earth, such as ochre, umber, etc. The principal liquid in the paint is linseed oil, or similar oil, which, when drying, forms a tough elastic coat which protects everything it covers from the effects of the atmosphere. The pigment gives some protection also and supplies the colour. To make the paint workable and to give it a nice consistency, turpentine is added. A further ingredient—the driers—may be added to assist the paint to dry quickly, but you will remember that the drying of paint is not like the drying of a wet coat. It is simply the combining of the oil of the paint with the oxygen of the air, and not a simple evaporation.

On new wood paint has a way of sinking in, and leaving a very unsatisfactory surface, and no amount of daubing on the paint at the outset will get a really good effect if only one coat is used. If you have made a kennel, a cupboard, or a boat, and have put some weeks, or perhaps months, of work into it, surely it is worth while putting in a few extra hours in order to execute the painting properly, and so I advise you not to be content with just one coat. For the first coat, use the prepared paint just as you receive it, having previously rubbed down all the surfaces with glasspaper. Allow at least twenty-four hours for the paint to dry (it will not be really dry, but will be sufficiently hard for the purpose), and then go over the work with some putty or painter's stopping, and fill in all little holes made by punching in the heads of nails, etc. etc., using for the purpose an old blunt table-knife. The stopping is made by mixing $\frac{1}{4}$ lb. of putty with 2 oz. of paste white lead (white lead ground in oil). Now putty, which is only whiting or ground chalk and oil, can be safely held in the hand, as it is quite harmless, but white lead, or any mixture of it, should always be held on a little board of wood, as all the lead compounds affect the human body injuriously.

If you have had to do much stopping up of crevices, you had better leave the work another twenty-four hours. But if only an occasional nail-hole has had to be filled up, you can go ahead at once. Gently rub the whole job down with a piece of worn glasspaper and apply a second coat of paint, this time mixing a little turpentine with it. This thinning will make the paint flow more easily, and will assist it in combining with the first coat. Allow another twenty-four hours at least, and you can then give the third and final coat, this time using the paint as it is, and without any extra turpentine.

Enamelling.—Some of the nicest paint on the market goes by the name of enamel. This is really a very fine pigment or colour ground up with a suitable varnish, and I know that its use will appeal to you. Unfortunately, people suppose that enamelling is childishly easy, and they proceed to daub the stuff on where it is wanted, and often where it is not wanted, so generously that it runs down in " tears " like so much treacle. Such sloppy work is unworthy of the boy mechanic. It is not difficult, I admit, to get a showy effect with enamel paint, but please take the trouble of preparing the work properly and of applying the enamel carefully. If your pocket affords, get a really good brush for the job, or use one that has been well broken in. Sometimes at a second-hand shop I have seen good paint brushes, one-third or one-half worn, to be had for just about the same proportion of their original price. Such a brush thoroughly well washed with soap and water, rinsed and dried, would make a first-rate enamel brush. If you buy a new one, get a brush especially made for varnish. Thoroughly prepare the work in the first place with worn glasspaper, and if you are intent upon getting a result of which you may well be proud you will need to buy at the same time as you purchase the enamel a tin of the special " undercoating " made by the enamel manufacturer especially for use with his enamel. Apply two or three coats of this special preparation, allowing full time for each coat to get hard, and gently rubbing each down with worn glasspaper and wiping over with a duster before proceeding farther. On such a basis as this you will get a very fine finish, and if you are out for something very special, you can apply a second coat of the enamel.

Perhaps you do know that not all enamel is glossy. Some of it dries with what is known as a " flat," that is, a lustreless finish, or with the very slightest shine resembling that on a new-laid egg. The use of a flat enamel on a piece of furniture is generally preferable to that of the glossy kind.

Always, in enamelling, avoid dust. Don't do the work in a dusty room, and don't let the brushes and enamel lie about and get gritty. Keep everything as clean as you can. Pour a little of the enamel out into a small vessel, and use it all up before taking more from the tin. Another important point is, try to strike the happy medium by applying not so much as will run down in tears or form wavy lines, and not so little as to cause the brush marks to show and give a patchy effect. The advice is quite easily given, but there is more in putting it into practice than you might suppose. Finally, don't brush or work the enamel too much in applying it. The fewer the strokes of the brush the better.

Staining.—Now this is a very different process of colouring wood. It adds nothing to the surface, but is simply a method of dyeing the outer skin of the wood. The old-time craftsmen were very clever in concocting vegetable stains, and the beauty of their effects has never been surpassed, but nowadays only the few still go to the trouble of making their own stains, and most people rely upon various forms of aniline colours, a variety of which can be bought in cheap packet form. As a rule, directions are printed on the packets, and they amount to little more than adding hot or cold water, with perhaps a little vinegar, to the powder, although many of them (those known as "spirit soluble") require the addition of spirits of wine or the far cheaper methylated spirit, which is practically the same thing with the addition of some nasty-tasting mineral spirit to render it objectionable to the palate. Aniline dyes can be applied with brush, or sponge, and will be found excellent for general use, although the brighter colours, particularly the reds, are fugitive—in other words, they bleach—in direct sunlight.

Bichromate of potash and permanganate of potash, respectively, dissolved in hot water make fine rich stains, and coat after coat can be applied until the right tone is reached.

An excellent walnut stain is made by stewing some green walnut peel in water and applying two or three coats of the liquid to the wood in a warm room. When nearly dry, give it a coat of bichromate of potash solution.

To make wood resemble the tone of dark oak, apply some brunswick black considerably thinned with turpentine.

For a mahogany stain dissolve 1 oz. of dragon's blood (a gum you can buy at an oilshop) in 1 pint of turpentine. Stand the bottle in a warm place and shake it frequently.

Most of you know the term "fumed oak." The fuming or fumigation of oak is an interesting process, but not all oak is susceptible to the action of the ammonia used for the purpose. Some varieties of mahogany also can be treated in this way. To find out whether a piece of wood can be darkened by fuming, place a portion of it over the mouth of a bottle containing liquor ammoniæ (the so-called "liquid ammonia"), the stopper having been removed. If the wood is susceptible, its colour will soon darken. The work must be quite clean from grease or the marks of the hands. If you are using a good-sized packing case as the fumigating apartment, place a saucerful of liquor ammoniæ on the floor of the case, then insert the articles, but not so that they touch the liquid, close the lid, and stop the joints by pasting on strips of brown paper. The longer the wood is left in the case the darker will it become. Wiping over with diluted liquor ammoniæ will have a darkening effect upon any wood that is susceptible of the other treatment, but the true fuming method has one great advantage over the use of liquid stains—it does not raise the grain of the wood. Generally, after the use of a liquid stain, it is necessary, if a good finish is required, to go all over the work with glasspaper to remove the portions of the wood fibres swollen and raised by the liquid.

The oilshops sell a mixture known as "combined stain and varnish," and you may be tempted to use it. It may do for a common job, but not for anything which you prize, as the effect is rather cheap and nasty. The boy mechanic may be entrusted with the job of staining a floor margin, and may resort to the stuff as being the easiest and quickest for his purpose, but he will get a far better effect and a more lasting one by getting some oak, walnut, or mahogany stain in liquid or powder form, giving it twenty-four or forty-eight hours after application to get dry, then applying a coat of size, and finally a good flowing coat of oil varnish purchased from a reliable firm.

FRETWORK IN WOOD

Most people associate fretwork with those fantastic and often fragile articles which sometimes ornament cottage parlours—photograph frames that dwarf the photographs, model "tanks" and locomotives grotesque to the point of absurdity, clock cases and brackets that nobody dare dust, and so on. Fretwork has suffered from two causes—poor designs and their wrong application. It is restricted in its scope, but the zealous fretcutter has not recognised any limitations and has applied his ornament to anything and everything that can be made of wood. Fretwork can be made very beautiful and can be extended to ivory, celluloid and various metals. I shall give in this chapter a few designs (*see* Figs. 2, 6, 7, 8 and 10) that, in my opinion, will occasion but little reproach. Let me first talk of fretwork in wood, and leave the finer work in metal to a later chapter.

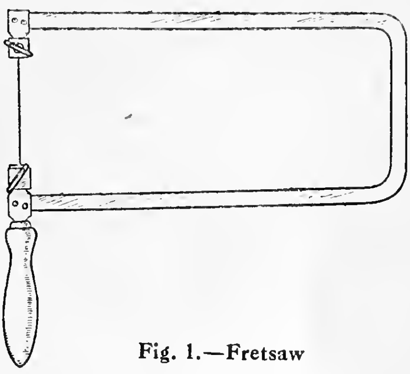


Fig. 1.—Fretsaw

Saws.—The saw may be hand or machine, the advantages of the latter being greater speed of cutting, less fatigue, and freedom of both hands to guide and control the work. Suitable machines are shown in variety in any dealer's catalogue. In use keep the machine clean and oil all the bearings often but sparingly; a suitable lubricant is cycle oil of a thick variety.

The hand saw may resemble Figs. 1 and 3, or may be one of the many other patterns available. The sweep of the frame should not be less than 12 in. or more than 18 in. In selecting a frame, see that the clamps which hold the blade in tension are good and work well. The best type of clamping arrangement is that in which the blade is simply inserted and then tightened up by giving the handle a turn. Something quick and easy is required because the saw has frequently to be threaded through holes drilled in the work, for which reason the blade has to be unclamped every time. Remember one point: so thread the blade that the teeth cut on the downstroke, otherwise the sawdust will obscure the lines of the pattern, and a swarf be raised on the paper which will make it difficult to follow the lines; this means that the working stroke is the pull and not the push, as the controlling hand is underneath the work. When a fretsaw, usually a machine saw, cuts on the upstroke, a blowing device is employed to keep the pattern free of sawdust.

With regard to saw-blades, buy the best. The difference in price between the good and the bad is so little as not to be worth considering, whilst a poor, slow-cutting soft blade which soon bends or an over-hardened one that soon breaks when in use is a nuisance and may mean the

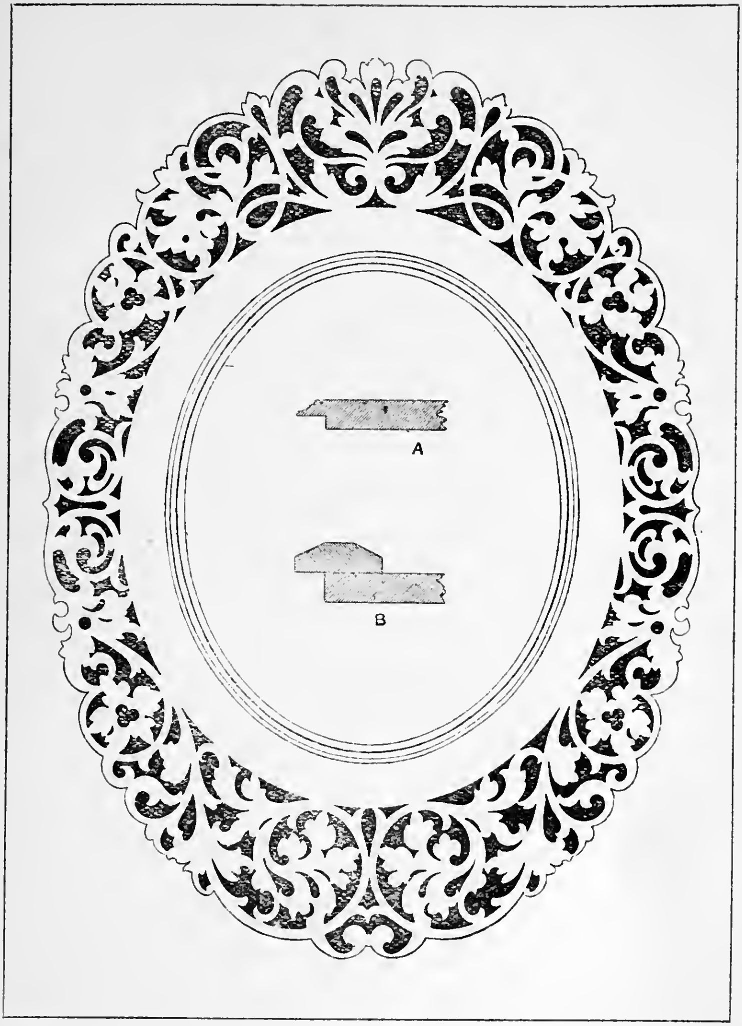


Fig. 2.—Design for "Oval" Frame in Fretwork

(A and B show respectively a difficult and comparatively easy detail of forming the rebated edge)

fracture of delicate detail. Rounded-back blades of the best quality will give the greatest satisfaction.

Other Equipment.—Work is held for sawing by means of a cutting board, which is either permanently screwed to the bench or fitted with a clamp for attachment to bench or table. The usual shape is shown in Fig. 4, the V-notch accommodating the saw blade when at work. This figure shows a table or bench especially designed for fretworkers' use. Perhaps you can pick up a light table for a few shillings and screw on a notched cutting-board, and, if necessary, shorten the legs by an inch or two so that as you sit at your work the table-top is at such a height that your left hand easily rests upon it, while your right works the saw from underneath. Then, if a small vice (as in Fig. 4) can be attached at one end, you will have a serviceable and comfortable bench for fretwork and similar light operations; but don't attempt to use it for carpentry work, as it will not be solid or heavy enough for planing upon.

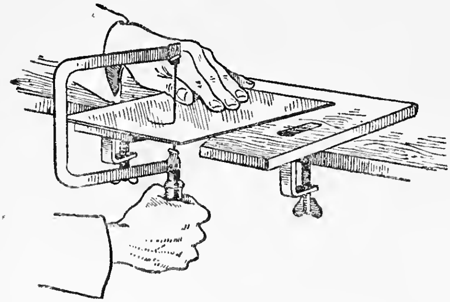


Fig. 3.—How to Hold a Fretsaw

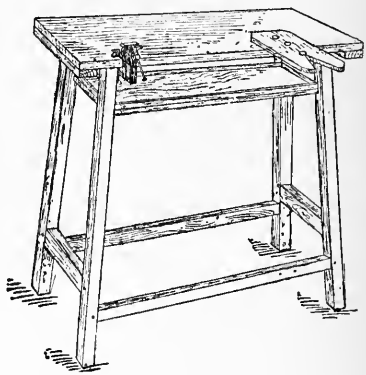


Fig. 4.—Fretworker's Table with Cutting-board and Vice

Besides the usual tools and accessories—hammer, fine-toothed ordinary saw, pincers, small screwdriver, chisel, small nails or "pins," seccotine, gluepot, etc.—which most boy mechanics are almost certain to possess, you will need a special tool for drilling or boring holes in the work to give a start for the saw in enclosed parts of the design. A bradawl or even a gimlet—anything with a wedge-shaped point—will only split the work as a rule. The proper tool is the drill named after your dear old class-room friend Archimedes, its twisted stem resembling the famous hollow screw which the ancient Greek invented (about 260 years B.C.) for the purpose of raising water. The twisted stem rotates in a bearing formed in the handle (*see* Fig. 5), and is given motion by pressing down the bobbin through which the stem is threaded. The bottom end of the stem carries a chuck (vice) to hold a drill-bit. A good type of archimedean drill has a small spring in the handle to assist the withdrawal of the bit; another improved pattern facilitates speedy work—it carries balance weights just above the chuck, the momentum which they gain on the down stroke of the bobbin being sufficient to keep the drill rotating on the idle upstroke.

Fig. 5.—Archimedean Drill with Chuck or Holder to take Drills or Boring Bits

Another necessity is glasspaper of three grades, Nos. 2, 1½ and 1, used respectively for rubbing off pasted-down designs, cleaning up the surface and finishing the job, the higher the number of the glasspaper the coarser being its grade. The trouble in using glasspaper is that without great care you find yourself rubbing away the sharp edges of the wood and losing the effect of good workmanship. Therefore to obviate this always use the glasspaper wrapped tightly round a block of wood or cork.

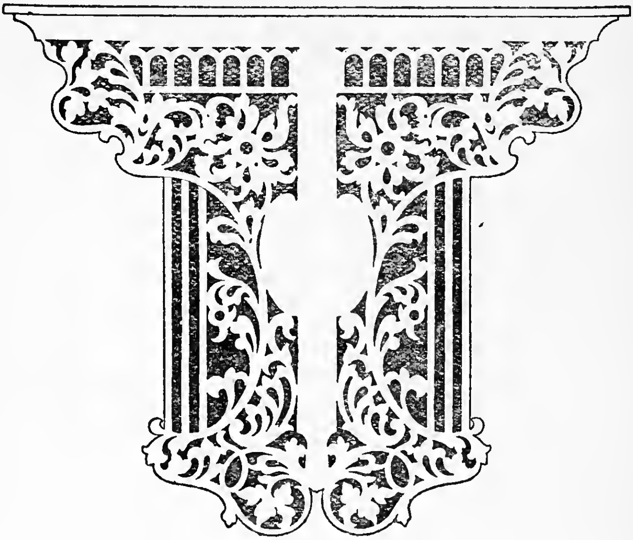


Fig. 6.—Design for Wall Bracket in Fretwork
(The centre support is a repeat of half the back)

Fretwood.—So far I have not mentioned the material. Many firms now make a speciality of fretwood, and you can order from them exactly what you want, so avoiding waste pieces. Almost every cabinet-making wood is obtainable in suitable thickness—in the neighbourhood of $\frac{1}{16}$ in.—for fretwork, and the unit of measurement is the square foot. Thus, a piece of wood 7 in. wide by 29 in. long will contain $7 \times 29 = 203$ sq. in., nearly $1\frac{1}{2}$ sq. ft., and would be charged for on that basis.

All fretwork is liable to warp and twist. Wood is constantly absorbing or giving off moisture according to the condition of the surrounding atmosphere, and unless it is suitably secured at the sides or held down by weights warping is inevitable when the fibres swell. Two-ply and three-ply wood has two or three layers of thin wood glued together under great pressure, one of them being at right angles to the other or others as regards the direction of the grain, so that the grain of one layer counteracts any tendency of the other layer to twist out of shape. Some good pieces of three-ply material can often be obtained from tea-chests, but the faces of the stuff need to be glasspapered into condition.

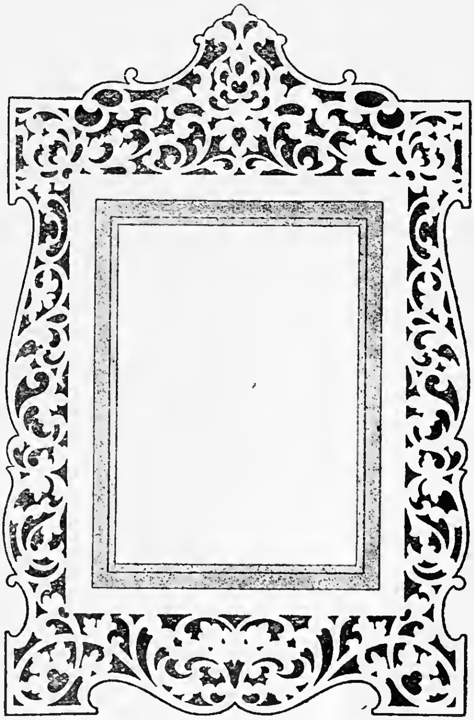


Fig. 7.—Design for Frame in Fretwork

The Design or Pattern.—Fretwork designs of the printed kind are obtainable on thin paper and need to be pasted down on the wood (but if they can be easily transferred by means of carbon paper and a hard pencil, so much the better, and there will then be no paper needing to be rubbed off at a later stage). Let the length of the design run in the direction of the grain. Apply the paste to the design only, and use either boiled starch or an office paste of the "Fixol" or "Stickphast" types, but in any case *use as little as will effect the purpose.* Applying the paste to the wood itself or an excess of paste on the paper will raise the grain and possibly warp the wood. Let the pasted paper get *thoroughly dry* before starting to use the saw.

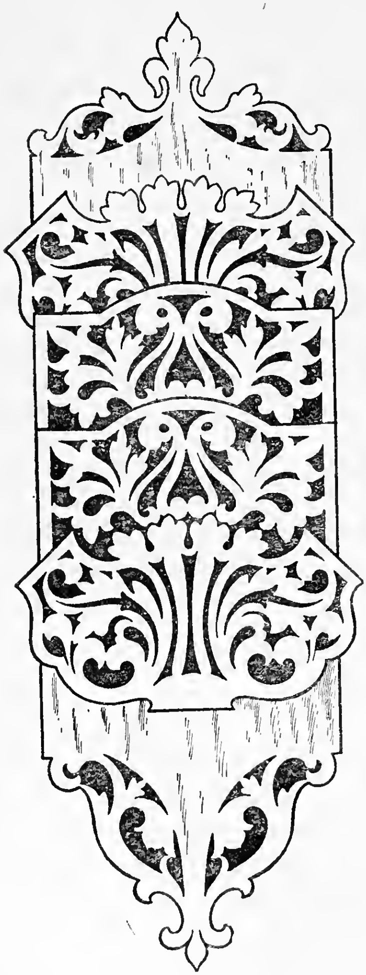


Fig. 8.—Design for Letter Rack in Fretwork

Using the Fretsaw.—The actual fretsawing is a matter of infinite care and practice, and not much need be said concerning it. Hold down the work firmly with the left hand, see that the blade is held taut in its frame, and firmly grip the handle in the right hand, always keeping the blade perfectly upright and making uniform, steady strokes. The right hand simply works the saw up and down, and does not advance the saw into the wood. The feeding of the work to the saw is a matter for the left hand, and this is where most people find the machine saw to have a great advantage. It is usual to saw out the inside parts of the pattern before attempting the edges, because the work is then more easily and safely handled up to the final stages.

The turning of both inside and outside corners is a matter for practice. Use fine good saws and plenty of common sense.

Overlays, Marquetry, etc.—The modern fretworker is fond of overlays—fret-cut patterns in thin stuff glued down on the face of the work. Very thin stuff should be placed between waste stuff, nailed together at the edges, and the pattern laid down on the top piece of waste. This leads to double and treble cutting—known as plural cutting—only to be attempted when you have mastered the correct use of the saw—and to marquetry, which is a system of ornamentation by which very interesting effects can be obtained. Two pieces of wood of different colours, say holly and rosewood, are cut at the same time, care being taken to keep the sawn edges perfectly square, and to avoid spoiling any cut-out pieces as might be perfectly legitimate in ordinary fretwork. Then the parts of the two designs are interchanged (*see* Fig. 9) to give good

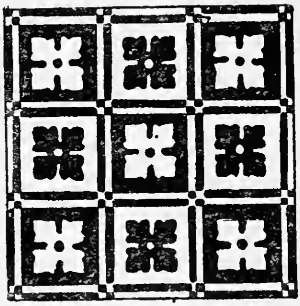


Fig. 9.—Marquetry Interchange Pattern

effects, and glued down on the surfaces to be ornamented, thus forming two companion ornaments in reverse colours.

Finishing.—For removing the pasted-down design do not attempt to soak it off. Fretted woodwork cannot stand water. Instead, place it on a perfectly smooth flat surface and rub it off with No. 2 glasspaper held round a block, finishing with Nos. $1\frac{1}{2}$ and 1 applied successively.

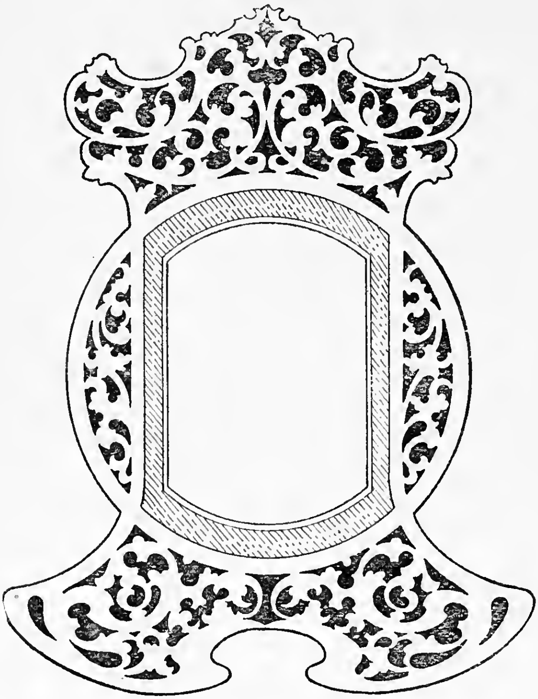


Fig. 10.—Design for Frame in Fretwork

By inclining the saw-blade inwards when cutting out a piece (a circle, say, or other simple figure), the area of the bottom face of the cut-out part will be made greater than that of the top of the hole from which it came (*see* the section, Fig. 11), and by seccotining the edges and possibly further securing the part from the back it will be possible to mount the cut-out part as a bevelled-edge overlay entirely covering the hole. But good workmanship is absolutely essential, as the bevel must be uniform. In straight-sided patterns, some workers obtain a uniform bevel by wedging up the fretwork slightly

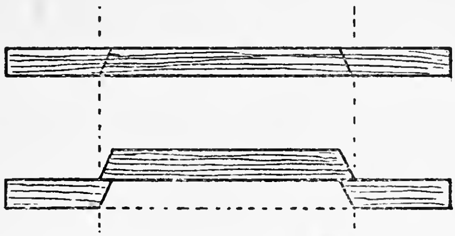


Fig. 11.—Diagram showing the Use of Bevel-cutting in Appliqué or Overlay Work

at one side, the saw blade being kept perfectly upright, but should the wedges slip the bevel alters. Some fret-cutting machines have a tilting table which facilitates the cutting of bevels. Fire-screens can be well decorated in this manner.

CLEANING AND ADJUSTING A BICYCLE

I TAKE it for granted that nearly every boy knows a great deal about his bicycle, and that in a chapter under the above heading he will look for information only on those points in which his acquaintance with his machine is not likely to have afforded him experience. Still, there are one or two matters, such as the repairing of a puncture, which I must dwell briefly upon, although to many my readers instruction on that point will be superfluous. I shall take the case of a bicycle that has been running two or three years, or which has come secondhand into your possession, and which would be all the better for a complete overhauling. True, the professional cycle repairer could probably do the work better than you can, but in taking your machine to bits, its mechanical anatomy will be impressed on your mind in a way you will never forget, and you will the better be enabled to remedy any trouble that might occur on the open road.

The Parts of a Bicycle.—Every part of a bicycle has its own particular name. Look at Fig. 1, and you will at once identify the chief of its components—the top tube 1, the down tube or seat tube 2, the bottom tube 4, and the head tube 3. In addition, there are the front fork blades 23 and the back fork blades 15. There are the front and rear wheels with rims 19, tyres 18,

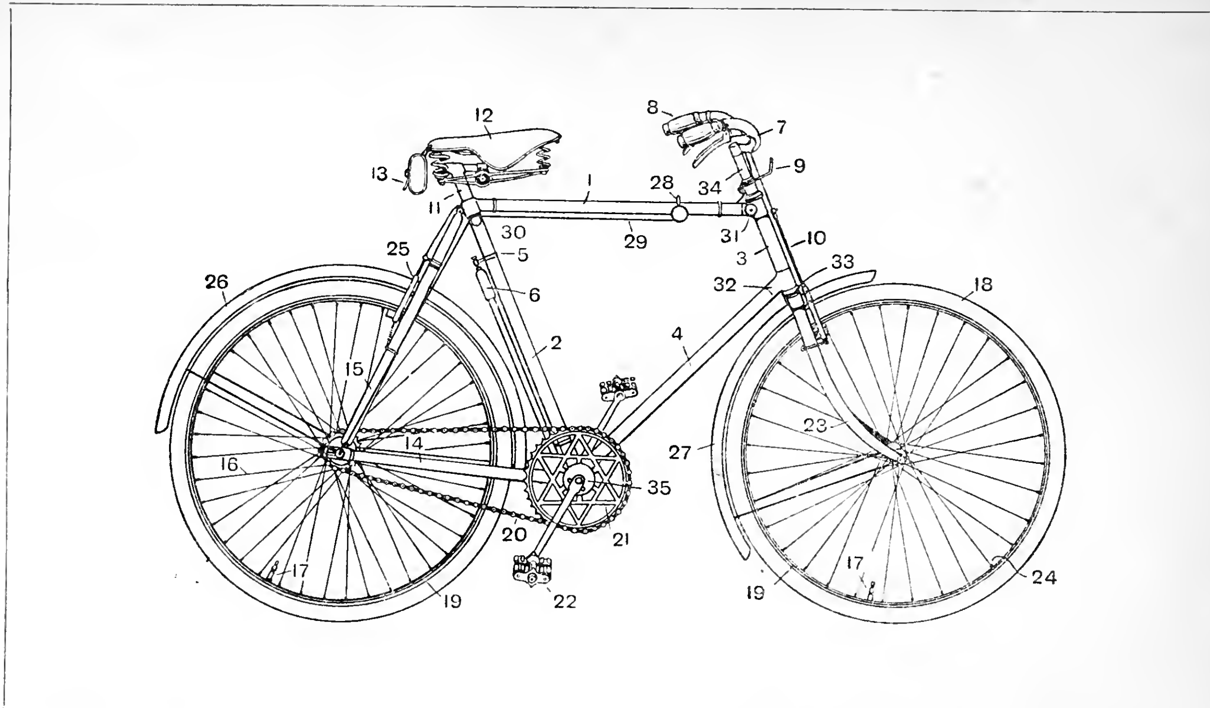


Fig. 1.—Diagram of Bicycle, with Chief Parts Numbered for Reference

spokes 16, valves 17, and spoke nipples 24. To protect the rider from mud and dust, there are the front mudguard 27, with its extension, and the rear mudguard 26. In the bottom bracket (at the junction of the seat tube and bottom tube) is the spindle, behind 35, carrying the chain wheel 21, the chain 20 transmitting the drive to the chain ring on the hub of the rear wheel. The handlebars 7, with handles 8, are one with the steering tube which is clamped into the fork stem, this being a tube passing through the head tube 3; the lower end of the fork stem carries the fork crown and fork blades. The saddle 12, and tool wallet 13 are supported by the seat pillar 11, which enters and is clamped within the seat tube 2. In the bicycle illustrated are two rim brakes, both operated by hand; 10 is the front brake forket and 25 the back brake forket, but, as you know, some bicycles have only one rim brake, and in addition a brake working within the rear hub and actuated by the chain when back pressure is applied to the pedals 22. In my opinion, no safer system of brakes has yet been devised than the hub-contained type, but there should always be a front rim brake as well.

"Gear."—Most boys will recognise the gear change control lever 28, and its cable 29, but I find that the general idea of what is meant by the "gear" of a bicycle is a very vague one, as well it might be. It is a term that dates back to those days when our fathers—in some cases our grandfathers—rode the "ordinary" machine with a big front wheel and a small back one. If that front wheel was 60 in. or 56 in. or 64 in. in diameter, then the gear of the machine was said to be "60-in.," "56-in.," or "64-in."

respectively. The distance travelled in one revolution of the pedals in those old front-driver machines was $3\frac{1}{7}$ times the diameter of the front wheel; thus a 56-in. wheel travelled about 176 in. for every complete revolution of the pedals. Now, if you have a bicycle and by careful experiment find that one complete revolution of the pedals drives the machine forward 176 inches, you will know that your bicycle has a "gear" of 56, but it is an awkward experiment to carry out, and it is much more simple to work a little sum instead. Fig. 2 will show you how to set about it. First count the number of teeth on the chain wheel. Say it is 50. Take the diameter in inches of the back wheel; say this is 22. Multiply the two together, $50 \times 22 = 1100$. Divide this by the number of teeth in the chain ring or sprocket on the back hub; assume this to be 18. Then $1100 \div 18 = 61$ and a fraction, and the machine is said to have a gear of 61.

The higher the gear, the greater the strength required to push the machine up-hill or against the wind, and that is why boys' and ladies' machines are always geared lower than a man's. But the higher the gear, also, the greater the speed of the machine per revolution of the pedals, and the more convenient for running on a slight down-hill, or with the wind behind you. So it comes to this. Up-hill you want a low gear. Down-hill you can do with a high one. And it is this pleasant alternative which you get by installing a variable gear device or "change-speed gear," which is a box of cog-wheels built into the back hub, by means of which the leverage or mechanical advantage is increased or decreased. Whereas on a fixed gear machine you must negotiate all conditions of road and wind at the same gear ratio, on a variable gear machine you can select one of three (sometimes two) gear ratios to suit the circumstances of the moment. Now to the actual business of the overhauling.

The Frame.—If the frame is dirty and mud has dried on it, don't rub it off violently or you will scratch the enamel. Sponge it off gently, wipe over with a cloth, and if you want to improve the appearance of the enamel,

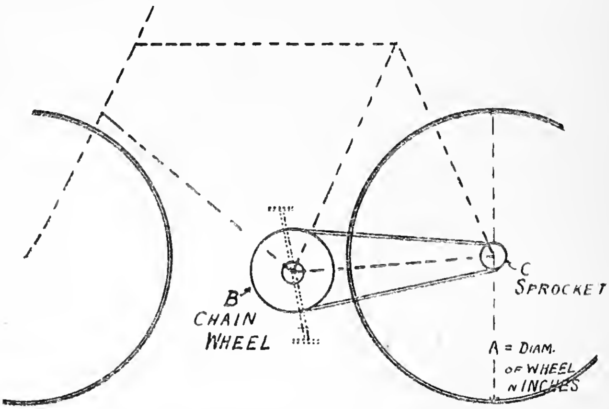
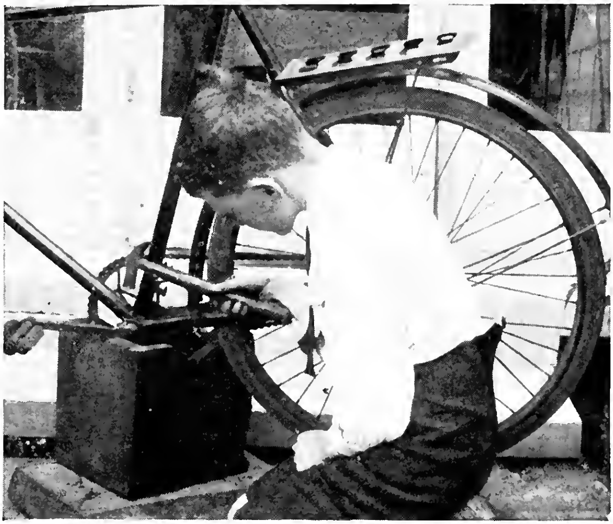


Fig. 2.—Diagram showing how to obtain "Gear" of Bicycle. Multiply Teeth in B by A, and divide by Teeth in C

rub over with some good furniture cream. If the enamel is very badly chipped, you may decide to have the frame re-enamelled, or to give it a coat of air-drying enamel yourself. Several good makes are sold at any cycle shop, but you need a superior brush to get a good result, and more than one coat is advisable. If you have the time, it pays to rub over the first coat when it is thoroughly dry and hard with a felt pad sprinkled with fine pumice powder and moistened with water or oil. The result will be all the better too, if before the enamelling is

BICYCLE CLEANING AND ADJUSTING



Bottom Bracket supported on box for the hammering out of Cotter Bolt

Bicycle Suspended by Rope for ease in Oiling and Adjustment

started you go over the old enamel with some fine emery paper. The use of some good oil-colour specially mixed up for you by a coach-painter and followed by a coat of the best oil varnish would give a better result than shop-bought " cycle enamel."

Bearings.—For cleaning out the bearings, stand the machine on the saddle and handle-bar, or suspend it by a couple of ropes from two hooks fixed in the shed roof, and squirt petrol or paraffin oil into all the bearings repeatedly, and revolve the wheels so that the cleansing

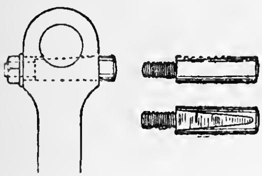


Fig. 3.—Crank End and Cotter Bolt

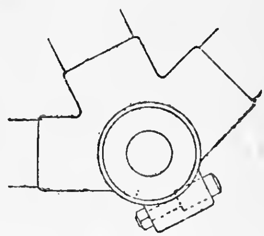


Fig. 4.—Bottom Bracket with Cotter Bolt

liquid can get everywhere. Paraffin and petrol do not improve rubber tyres, and if you propose a very copious application, you had better first remove the tyres. Work the pedals till all the paraffin, etc., is out, and then lubricate with good quality cycle oil or pure sperm oil alone.

Test the bearings to see if there is any shake or play in them, and if there is tighten them up by means of the thin cone spanner. If you suspect a broken ball in any of them, listen carefully while the spindle revolves. There ought to be only the regular noise of the balls touching one another as they revolve, but if occasionally you hear a sharp click, you will know that one of the balls is fractured or the cone or cup is faulty. Then you must undo the bearing with a spanner, but look out for trouble, and don't do the work on the lawn; remember that the steel balls are liable to drop out quite suddenly, and it's an awful business finding them all. You can get new steel balls at a cycle shop or even a new ball-bearing cup in the unlikely event of one being needed, and if you have trouble—as you are sure to do—in keeping the balls in position when replacing them, try the effect of smearing them with plenty of vaseline, which will prevent their running about, but if you use much vaseline, wash it out

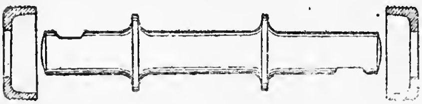


Fig. 5.—Bottom-bracket Axle or Spindle and the Cups

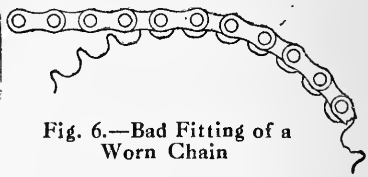


Fig. 6.—Bad Fitting of a Worn Chain

afterwards with paraffin oil or petrol, as otherwise in cold weather the vaseline will be a clog on your progress.

Adjusting the Bottom Bracket.—To make any adjustment of the bottom-bracket bearing, it will first be necessary to take off the crank opposite to the chain side. Remove the nut (*see* Fig. 3) with a spanner, support the end of the crank on a block or anything solid, and drive out the wedged-in cotter bolt (shown separately) with a blow or two from a heavy hammer. (In replacing afterwards, note, of course, that the flat on the cotter will come against the flat on the axle or spindle, Fig. 5, which illustration shows the axle and the cups that keep the balls in place.) The crank having been removed, the cups are adjusted or removed by first loosening the nut of the bottom bracket cotter bolt (shown underneath in Fig. 4), and then turning the cup with a pin or peg spanner if there are two holes in the cup for the purpose, or with an ordinary spanner if there is a raised part with parallel edges. In taking out and replacing the balls and axle, carefully observe the precautions given in the preceding paragraph.

The Chain.—Removing the chain is a simple proceeding. Close examination will show that one or two of the pins consist really of a small screw-bolt and nut, and one of these may be removed by means of screwdriver and spanner. Replace the pin and nut in the loose end of the chain immediately after removal, as otherwise they are easily lost, and it is better to have at hand a tray in which to place the various screws and nuts as they are taken from the machine. All naked chains (those run without a gear-case) need occasional cleaning. Coil up the chain, place it in a dish, and pour over it paraffin, or a mixture of paraffin and petrol, leave it for twenty-four hours, and then hang up to drain. It is not easy, except by some such method as the following, to lubricate a chain thoroughly, oiling in the ordinary way or the rubbing on of chain greases being too superficial a treatment. It is better to make the cleaned chain thoroughly dry and place it in a dish containing Russian tallow or vaseline, or, instead, either of these mixed with graphite, which has been melted by heat. If the chain has been made warm, almost hot before immersion, the tallow will find its way to its internals. After immersion, hang up the chain to dry, and wipe off the superfluous fat.

A chain runs far better in a gear-case than it does naked, and lasts much longer; when the gear-case is an oil-bath, the chain will very rarely require any treatment whatever. Very occasionally, indeed, a wash-out with paraffin and the replenishing of the lubricating oil are all that is necessary. Fig. 6 shows how to recognise signs of wear in a chain.

Wheels out of Truth.—A frequent fault in a bicycle that has been in use for a long time is a lack of truth in the wheel rims. A fall may have loosened or broken a spoke, so upsetting the balance of tension. You have only to screw up some of the spokes a little tighter than those on the opposite side of the hub to destroy the balance of .. wheel and

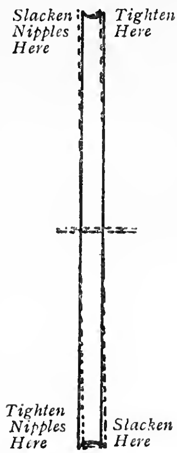


Fig. 7.—Diagram indicating in Dotted Lines the Sideways Bulging of a Cycle Wheel

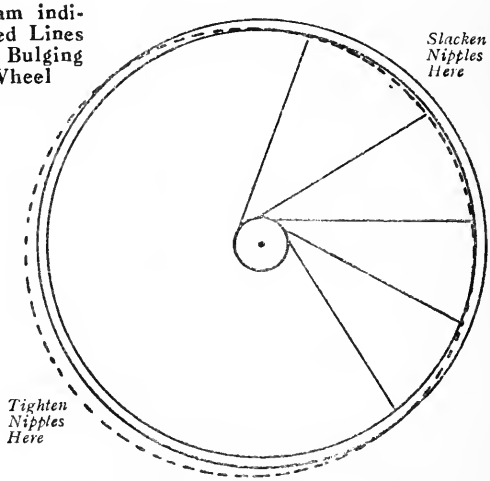


Fig. 8.—Diagram indicating in Dotted Lines a Lack of Circularity

distort the shape of the rim. Rims go out of shape in two ways—they may cease to be circular (Fig. 8), or they may bulge sideways (Fig. 7). The last trouble can be detected by rotating the wheel and supporting a piece of chalk at the side on one of the chain stays quite close to the rim. Then any bulgy part will be marked by the chalk. By means of a spoke nipple key costing a trifle, slacken the nipples in the rim at the side marked by the chalk, and on the opposite side of the rim tighten up the spokes. *Adjust a little at a time only*, and test constantly until truth is restored. It is a job necessitating care and a nice judgment.

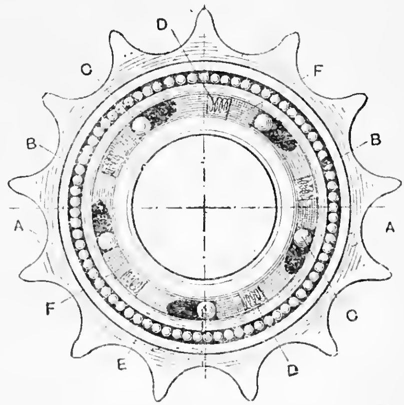


Fig. 9.—Roller or Friction-type Free-wheel Clutch: A, chain ring; B, balls; C, rollers; D, springs; F, followers

To test whether a wheel has lost its circularity—that is, whether it is out of the round — having first removed the tyre, rotate the wheel, and fasten a piece of wire across the forks close to the rim, and mark high places with chalk. At the parts where the rim bulges tighten up the spokes on both sides of the rim. Where the rim is low, slacken them, but be very careful and proceed with the utmost caution. Should an accident have smashed a spoke, a new one must be inserted before any tuning up is attempted. Take the old spoke with you when you buy the new one, so as to ensure getting the proper length and thickness.

In ordering new chain wheels, hubs, etc., it is necessary to give the "chain line" of the machine. You measure this from the centre of the rear wheel hub to the centre of the chain-wheel teeth. Thus a $1\frac{1}{2}$-in. chain-line hub measures that dimension from midway (generally the centre of the lubricator cap) between the flanges to the centre of the thickness of the chain-ring or sprocket.

The "tread" of a bicycle is the overall length of the bottom - bracket axle. The "wheel base" is the length of the bicycle between the centres of the two road wheels. The dimension of frame is the length of the down tube from its top to the centre of the bottom bracket, thus, "20 - in. frame," "24-in. frame," etc.

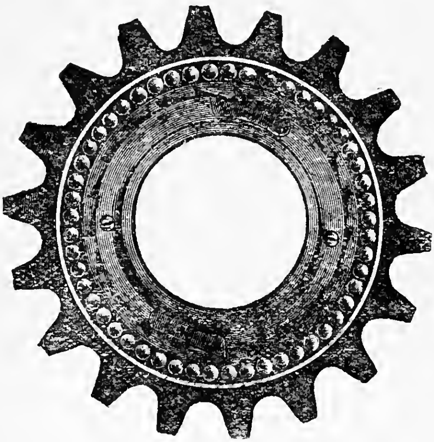


Fig. 10.—Pawl and Ratchet Free-wheel Clutch

Pedals.—The replacement of an old pedal by a new one may prove to be a very puzzling business unless you remember the following: To remove the right-hand pedal turn the spanner to the left, anti-clockwise. To remove the left-hand pedal turn the spanner to the right, clockwise. You can easily see the reason why this should be so; the screw-threads in each case are so arranged that the pressure of the foot tends to tighten the pedal, which would not be the case if the left-hand pedal had the ordinary right-hand thread. This hint does not apply to *very* old machines.

Pedals are quite easily taken to pieces, as their construction is obvious, and parts for replacement may be bought.

Free-wheel Clutches. — Sometimes the free-wheel clutch in the back hub gives trouble. This may simply mean that it is choked up with old and dirty oil, but as a rule, it is a sign that something has worn out. Don't take it to pieces until you have satisfied yourself by squirting in plenty of paraffin or petrol that the failure is not due to dirt or gummed-up oil. Often the trouble is simply a matter of weak springs, which can be replaced at trifling cost; or the friction rollers (*see* Fig. 9) may have worn badly, necessitating the purchase of new ones. In the more modern pawl and ratchet type (Fig. 10), there are few springs and no rollers, and nothing is likely to go wrong if kept clean and well oiled.

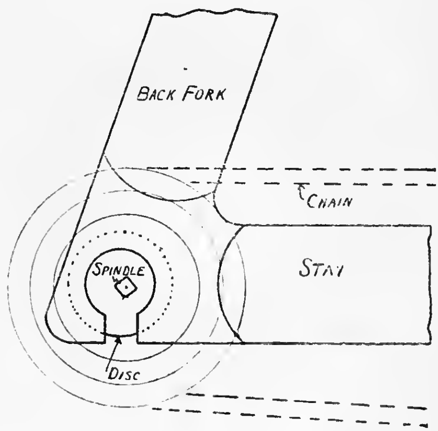


Fig. 11.—Eccentric-disc Chain Adjustment

If you have a coaster hub on your machine, and we know of no more convenient brake, clean it out occasionally in the way described for the free-wheel clutch, and when all the liquid has drained off, apply plenty of lubricating oil. If you want to make a really good job of it, you will need to take the hub apart and see that the whole of the brake surfaces are amply treated with a very thick lubricant such as motor cylinder oil, stauffer grease, or some similar heavy lubricant.

Chain Adjustment.—In putting the machine together again, see that the chain is correctly adjusted. There should be a *very slight* sag both top and bottom, and on no account should the chain be so loose that it can work off the sprockets or so tight that it makes the machine run hard. The method of setting the back wheel farther away from the bottom bracket is self-explanatory in most machines, but when for the first time you seek to adjust a machine having eccentric-disc adjustment (*see* Fig. 11) instead of the time-honoured screw-bolt and nut adjusters, you may be pardoned if you don't understand it at a glance. Two pairs of eccentric discs, one on each side are carried on the spindle of the rear wheel, and all that is necessary to advance the wheel slightly towards the chain wheel, or to push it farther away, is to loosen the nuts which hold the rear wheel in place and give the flattened end of the spindle a slight turn with a spanner. Not many bicycles have been fitted with this device in the past, but it possesses many advantages over the old system.

The Plating.—What is to be done if the plating has got very rusty ? Not much, I am afraid, but you might try rubbing the plating with a rag made wet with sweet oil followed with metal polish. Of course, emery powder and paraffin oil rubbed on with a rag will remove the rust, but the plating will not be worth much afterwards, and then you can do one of three things: (1) Coat the plating with a cold lacquer such as Zapon, which is one of the celluloid varnishes; this won't renew the plating, but it will prevent its getting much worse. (2) Give it a couple of coats of one of the metallic paints, such as aluminium paint, which is a mixture of aluminium bronze and celluloid varnish. (3) Go over the whole of the plating with black enamel, and then pretend that yours is a "special all-weather" machine! If not one of these three appeals to you, then I can only suggest that you have all the bright parts re-plated, which is altogether too big a job to be done at home, and must be entrusted to a tradesman.

If you are putting your bicycle away for any length of time, it is wise to smear the plated parts with vaseline, or, better still, to coat them with cold lacquer, which you can buy ready-made, or may prepare yourself by mixing ½ gill of acetone with ½ pint of amyl acetate, and in the mixture dissolving about ½ oz. of celluloid. Any colourless scraps from broken toys, celluloid combs, etc., can be used. Keep the lacquer tightly stoppered when not in use.

Removing Tyres.—Finally a brief explanation of tyre-repairing, a job, I suppose, to which almost every cyclist has been introduced. A common trouble is for the tyre to get soft within a few hours of pumping up. The job is first to remove the outer cover, next to find the puncture, then to repair it, and finally to replace the cover. But first make certain the valve is not at fault. Rotate the wheel until the valve is at the top, and then lift a wineglass or egg-cup nearly full of water so that the valve is immersed. Bubbles of air immediately betray a leaky valve, and a new valve rubber will then be necessary.

You will know that some covers have wire edges

(Fig. 12) whilst others are simply thickened up or beaded (Fig. 13), the second being more easily removed and replaced than the first. Remove the valve stem by unscrewing the nut so as to empty the tyre. The tools for removing the cover may be a set of special tyre levers bent and notched, which are very convenient, or may be the handles of two old tooth brushes. Starting at a point diametrically opposite the valve, insert two levers about 4 or 5 in. apart under the tyre edges, and apply leverage so that the edge is lifted off the rim. Then by holding

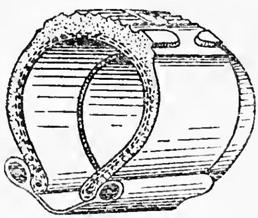


Fig. 12.—Wired-edge Tyre

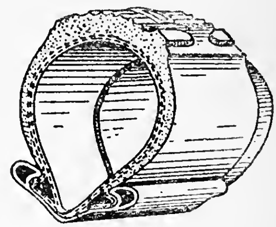


Fig. 13.—Beaded-edge Tyre

down one lever or catching a notched lever on a spoke, the other can be slid along and the edge released all the way round. The job is sometimes very much more difficult than the above explanation might suggest, very much depending upon the fit of the tyre and how long it takes you to acquire the knack. Some people can use smooth pennies as tyre removers, and others can do the work without any tools at all except their fingers. Others again, use screw-drivers and cut up the outer cover, and stab holes in the tube !

Patching the Tubes.—Now pull out the inner tube. Replace the valve stem and nut, and partly inflate. Have at hand a bowl of water on a stool, and pass the tube a few inches at a time through the water, slightly stretching the rubber as you go. There will be no doubt as to whether there is a puncture when you arrive at it. There will be a stream of bubbles rising from the tyre to the surface of the water. Sometimes a tyre is punctured in two distinct places at the same time, and it is generally wise to test the whole of it. Mark the puncture when found with chalk or pencil, and wipe dry.

We are now going to cement on a little patch, but there is a white powdery stuff on the surface of the rubber to which the cement or solution does not readily adhere, so the first thing to do is to dress round the puncture with glasspaper or emery paper until good solid rubber is reached. From a tube of solution (pure unvulcanised rubber shredded and dissolved in pure benzine), squeeze out a blob, and rub it thinly over the dressed surface with a match-stick. Have at hand a piece of old rubber tyre, or, better still, a piece of patching rubber, which is a reasonably cheap material. Coat this with solution thinly in the same way; first, in the case of old rubber, working over it with glasspaper or emery paper as before.

The whole point of the operation is contained in the next instruction. Do not bring the patch into its position yet awhile. *Let it wait until the solution is almost dry.* Actually, it will be what is known as "tacky," that is, although it will appear to be dry, it will adhere to the thumb-nail rather forcibly. Not until this stage is reached should the patch be put on, and if you are doing the work for the first time you will be surprised at the way in which the two solutioned surfaces cling together. It is with difficulty that they can be torn apart. Press the two to expel any bubbles of air, and dust all over plentifully with french chalk so as to destroy the adhesiveness of any solution remaining at the margin of the patch.

Cover Repairing.—Next work the fingers all round the inside of the outer cover slowly and carefully to try to find any nail, sharp flint, etc., that may have caused the puncture. Failure to do this is simply to run the risk of another puncture almost immediately.

If the cover is faulty, with a nasty cut on the outside where a flint or piece of glass has entered, it, too, should be repaired thoroughly. Clean it with a rag or old toothbrush dipped in petrol or benzine (avoid the use of paraffin on tyres), and then work into the cut one, two or three coats of solution, allowing about a quarter of an hour between them, so that one may dry before the next is applied. At the cycle depot, you can purchase some soft prepared rubber known as "tyre stopping," and a little of this can be well pressed into the prepared cut, and left for at least a day or two before the tyre is used. If you cannot get tyre stopping, you can make a fair substitute by mixing some cotton wool with rubber solution.

If the fabric on the underside of the cover has rotted or been badly damaged, it will be only a waste of time to stop the cut unless you also go to the trouble of cementing some new canvas in position at the back. Use a fairly large piece of the specially proofed canvas obtainable at a cycle depot, clean the place with petrol, apply a coat of solution to cover the proofed side of the canvas, and allow to dry. Then apply a second coat, and when the right condition of tackiness is reached, bring the two together and firmly press. Use plenty of french chalk to kill any surplus solution, as otherwise when the cover is replaced the tyre might stick to it and cause a burst.

Replacing the Tyre.—Tube and cover having been thoroughly overhauled, we have next to get the tube back into its position. First place the valve tube through the hole in the rim and carefully work the tube into position. Tuck in the cover at the valve, and for a foot each side of it, and slightly screw up the lock-nut on the valve so that the cover can move only slightly.

In putting a new rubber sleeve on a valve stem, slightly wet the metal and insert it into the sleeve with a twisting motion. Screw up the valve nuts tight.

The one thing to be watched for in replacing the cover is to avoid pinching the tube. Pinches mean ugly gashes and repeated exasperation

With the fingers work the cover into position alternately on each side of the valve until only a few inches remain to be got into place. Sometimes the fingers are alone sufficient to finish the job, but generally some amount of persuasion with a smooth lever is necessary to get the edge over the rim. Fit up the valve completely, tighten the lock-nut, and give a few strokes to the pump so as very slightly to inflate the tyre. Now go carefully round the rim with the fingers and make certain that the tube is not nipped anywhere. Thus assured, you can give a few more strokes to the pump or even inflate fully.

New tape should be put round the rim over the spoke heads when necessary, as this is a great protection to the rubber tube, iron rust having a bad effect on rubber.

GILDING WITH GOLD LEAF AND GOLD PAINT

In the decoration of picture frames and other work not many boy mechanics will aspire to real gilding, so I propose to touch upon it only briefly. The gold in a variety of colours is obtainable in the form of leaf. As you know, gold can be beaten out so finely that 280,000 leaves will be required to make a thickness of 1 in. Gold leaf is obtained in books each about 3 in. square, containing 25 leaves of gold, which can be transferred to a washleather pad (Fig. 1) by means of a little flat brush known as a tip (Fig. 2), which is passed once or twice over the hair of the head to give it the mere suspicion of greasiness. The gold leaf as it lies on the washleather pad is cut into strips, etc., by means of a long flexible blunt-edged knife (Fig. 3), and is transferred from the cushion by means of the tip to the work, which previously has been specially prepared. Surfaces to be gilded need to be coated with oil paint,

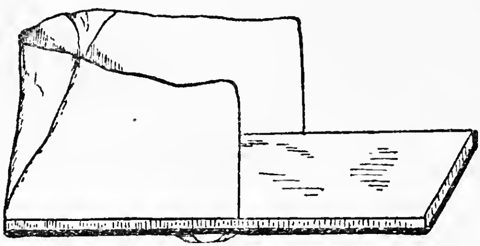


Fig. 1.—Cushion for Holding Gold Leaf

preferably of a yellow colour, or with size containing chrome pigment, the object being to build up a solid surface and to stop the suction of the material. Before laying the gold leaf the work must be given a coat of gilder's oil gold size, which must be bought ready made. Every part of the surface must be gone over sparingly and evenly, but the gold leaf should not be applied until after several hours have elapsed, the actual period varying with the temperature and with the grade of size used. Probably at the end of twelve hours, if not long before, the size will be ready to receive the gold leaf. To test it, touch it with the ball of the thumb. If it prove to be "tacky," the thumb is not wetted by the size, and the surface is not disturbed by the thumb, you may regard the size as being in the correct condition, and the gold may be laid upon it, each strip slightly overlapping the earlier one, and the whole being afterwards lightly gone over with a pad of cotton wool covered with soft clean muslin. Afterwards brush over with a soft brush and a bright appearance will indicate a satisfactory job; but if the

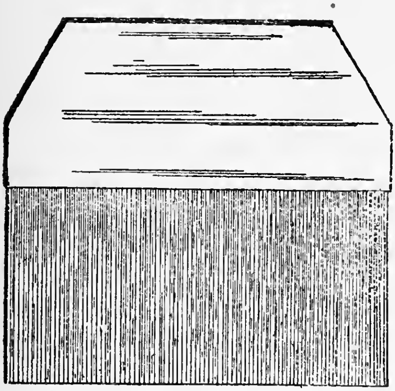


Fig. 2.—Tip for Lifting and Applying Gold Leaf

Fig. 3.—Knife for Cutting Gold Leaf

gold is lustreless and smeary the size was not tacky enough and the job must be left for many hours longer, and, if necessary, coated again with size, left for a period of time as to which you will be guided by your first experience, and the whole given a second coat of gold leaf. Two-coat work has a more solid appearance than the one-coat, of course.

The above process has its many difficulties. Gold leaf is most difficult stuff to handle, the slightest breath of air disturbs it, and it is easily damaged in course of laying. It is much easier to use gold transfer paper, which is sold in the form of books of beeswaxed paper, to which the gold leaf is adhering. The work is prepared by painting or sizing and finally gold-sizing exactly as before, and the transfer paper is applied face downwards and rubbed on the back to cause the gold to leave the waxed paper and cling to the sized surface.

Probably you will come to the conclusion that if you want a gilt effect on woodwork, plaster, etc., you will use the far cheaper and easier gold paint, which is simply a finely powdered metallic alloy of golden colour mixed with a suitable liquid. The bought gold paints used to be far superior to anything that could be mixed up at home. The difficulty was the liquid or medium. I used to experiment with thin french polish, but the result was very "brassy." All sorts of things have been tried, but the vehicle or medium used nowadays and certainly the most successful of all is celluloid varnish made by dissolving ½ oz. of finely shredded transparent celluloid in 9 or 10 oz. of amyl acetate, a liquid you will recognise by its "pear-drop" odour; indeed, it is used as jargonelle-pear essence.

Gilding with Gold Leaf and Gold Paint

Ask for the best "French flake gold bronze powder." You will find $\frac{1}{2}$ oz. of it go a long way, and you will simply mix it with the celluloid varnish as you need the paint, because the varnish (highly inflammable) is useful for lots of other things. Just as in gold leaf gilding, the effect of gold paint is very much enhanced if the work has been properly prepared beforehand. A dark ground will rob the paint of its solid appearance, and if there is much gold painting to be done, say a set of picture frames, it would be best to get from a coach painter a small quantity of a varnish paint made up with orange or middle chrome pigment. Coach painters are clever people at mixing paint and will be able to give you just what you want, but if you have any difficulty, get from a decorator's supply store a small tube of orange or middle chrome paste paint, and mix this to a suitable consistency with a medium or vehicle consisting of boiled linseed oil 4 parts, best oak varnish 2 parts, and genuine turpentine 1 part. Apply this to the glass-papered surface, and allow at least a day for drying, Rub out brush marks with worn glass-paper used lightly, and if you think it necessary give it another coat of paint, allowing the same time to dry, and smoothing out any brush marks as before. Dust the work, and then apply the gold paint with a camel-hair or sable brush.

Silver and aluminium bronze powders for making silver and aluminium paints can also be bought.

MAKING MORTISE-AND-TENON JOINTS

An "Open" Mortise.—I cannot hope to show you in this chapter how to make all the various kinds of mortise-and-tenon joints. There are actually scores of varieties, and I can afford space to deal with only two or three of the commonest but, at the same time, most important kinds. A mortise-and-tenon joint connecting the ends of two pieces of framework (*see* Fig. 1) is known as an open joint, the end grain of both of the pieces being visible, as shown. The mortise itself is open, and does not constitute a box, as it does in the closed type, which I shall take as my second example.

I must assume that you have planed up the work parallel and trued the ends. With a square carry round on all four sides of the stuff and on both members of the joint the shoulder lines which will indicate in one case the depth of the mortise and in the other case the length of the tenon. Now, with a gauge set to one-third the thickness of the stuff, mark the two sides and ends, as shown in Fig. 2, and before proceeding further, mark with a pencil cross those parts that are to be removed—the middle part of the mortise piece, the two outer parts of the tenon piece. I attach great importance to indicating the waste in this way. May I confess that I have attached that importance ever since the day when I spoiled a table framework by thoughtlessly cutting through a tenon instead of through the waste at the side of it. It taught me a lesson which I should like you to learn at less expense than my mistake meant to me.

First let us make the mortise, which is in this case

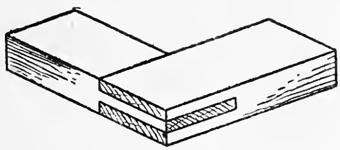


Fig. 1.—"Open" Mortise-and-tenon Joint

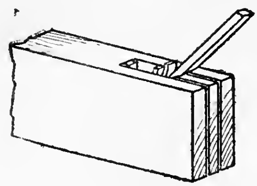


Fig. 4.—Second Position of Chisel in Removing Waste.

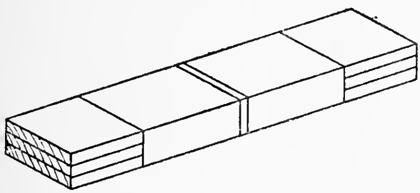


Fig. 2.—Model Joint Set Out

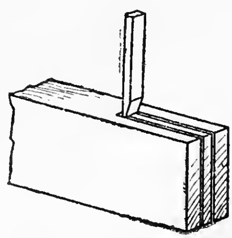


Fig 3.—Starting to Remove Waste of Mortise

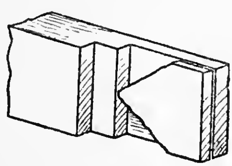


Fig. 5.—Effect of Taking Chips from Both Sides

merely an open slot. Place the work upright in the bench vice, and with extreme care run in a fine saw on the waste side—the inside—of the setting out lines. We are going to remove the piece of waste with a chisel. Placing it in the position shown in Fig. 3, but not quite as far back as the shoulder line, drive it in with a hammer or mallet for ½ in. or so. Then withdraw it, and re-insert in such a way as to cut a V-shaped chip from the waste. Drive in the chisel still farther vertically, and take another slanting cut so as to remove more waste. Repeat until a V-shaped slot half the depth of the stuff has been formed. Turn the piece over and do the same from the other edge, thus detaching a piece of waste of the shape shown in the cut-away view, Fig. 5. Next, with a chisel in perfectly keen condition, pare the bottom of the slot right up to the shoulder line.

The above is the slowest method of doing the work. It is much quicker to use a brace and twist-bit, running the bit into the work close to the shoulder line as illustrated in Fig. 6, but note that the bit must be slightly less in diameter than the width of the mortise, and the slot must be finished with a keen chisel as before.

As it is not every boy mechanic who possesses a mortise gauge, I have described in the foregoing a method of setting out a joint with an ordinary marking gauge, which gauge, by the way, must be used from the same face of the work all the time; otherwise, if the wood varies in thickness the tenon will not fit the mortise. The use of a mortise gauge makes for better and more accurate results and it is usual to set its two marking points to the width of the chisel that will be used for cutting the mortise, particularly in making a closed mortise, where, of course the saw cannot be used. Fig. 7 shows how the mortise gauge is set to the width of the chisel, the gauge being altered by turning the thumb-screw shown at the end of the stem. One of the two points is fixed, and the other is controlled by the thumb-screw but the screw in the square part (the stock) must first be loosened. The stock is then slid into its proper position, according to the dimensions of the stuff, and secured there by tightening its screw.

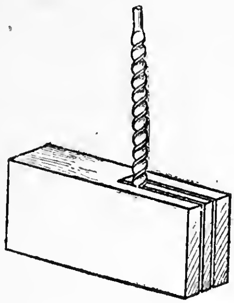


Fig. 6.—Removing Mortise Waste with Twist-bit

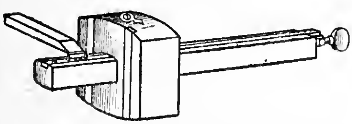


Fig. 7.—Setting Points of Mortise Gauge to width of Chisel

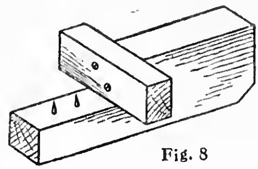


Fig. 8

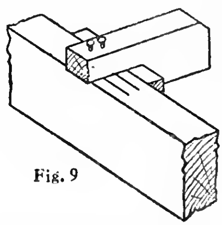


Fig. 9

Figs. 8 and 9.—Home-made Mortise Gauge

A substitute for the mortise gauge is the little home-made device shown in Figs. 8 and 9, which scarcely needs description. It costs nothing except the trouble of making, but the two sharp nails constitute fixed points, and you will need to make a separate gauge for every different thickness of stuff worked or width of mortise required.

Next we will proceed with the shaping of the tenon on the end of the other piece of stuff. It has already been set out with marking gauge, mortise gauge, or a home-made scratch gauge as above described. Fix the piece in the bench screw, and saw down on or slightly outside the lines drawn on the end grain, and then cut on the shoulder lines from opposite faces so as to detach two pieces of waste.

A "Closed" Mortise.—The closed form of mortise-and-tenon joint is shown in Fig. 10. Some readers might think that the name ought more properly to be applied to a joint in which the tenon does not go right through the mortised member, but a joint of that particular kind would be known as a shouldered, stump or stub mortise-and-tenon.

The setting out of the open joint is practically as

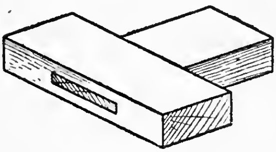


Fig. 10.—"Closed" Mortise-and-Tenon Joint

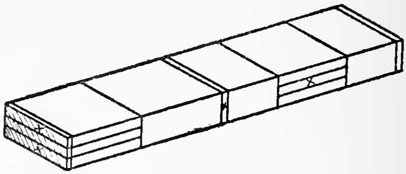


Fig. 10A.—Model Joint Set Out

before described, and in the case of the tenon the setting out and cutting are exactly so. The extent of the mortise will be set out on all four sides of the work, but its actua opening will be set out on the two edges only. Note that the gauge must be used from the same face of the work all the time. Fig. 10A shows a model joint set out.

A quick method of cutting the mortise is to make with brace and twist-bit a series of holes close together or slightly overlapping, so removing the bulk of the waste and leaving the mortise to be finally trimmed by means of a keen chisel ; but this is not the time-honoured method employed in general joinery work, and it needs to be pointed out that unless the boring be done absolutely at right angles to the edge there is a grave risk of spoiling the job. The usual method, therefore, is to cut out the mortise by means of a series of chips, the work being held down firmly on the bench, for which purpose the work is placed on the edge of the bench alongside the bench vice C (Fig. 11), and held tightly down by means of an L-shaped piece A, which presses upon a packing piece B, and is itself held tightly by the vice. By adopting some such arrangement as this both hands are free to hold the tools and there is no risk of a sudden movement of the work.

The cutting out of the mortise is started by making a little V-shaped notch with a chisel right in the middle of the waste. (Note the exact position of the chisel in Fig. 11A.) This is enlarged at every chip (*see* Figs. 12 and 13, which, of course are cut-away views) until the mortise has been cut out clean and square. The whole of the cutting cannot be conveniently done from one edge, so when half the waste has been removed it is well to turn the work over and repeat the process from the other. It will be found in practice that a series of wedge-shaped chips are formed, and these will be required to be levered

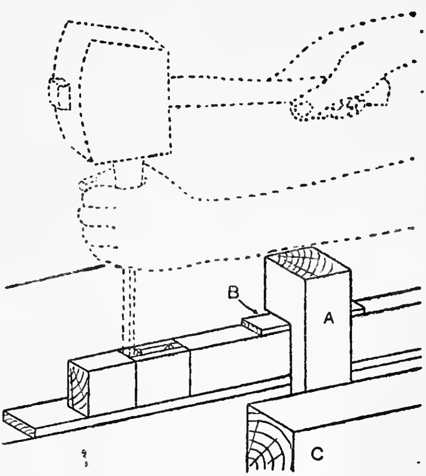


Fig. 11.—Cutting Closed Mortise in Wood held down by L-piece

out. The proper tool for this work is a mortise chisel, which is a thicker, stronger tool than the ordinary firmer chisel. Take particular note that the ends of the mortise are finished with the bevel of the chisel directed toward the mortise so as to produce a clean vertical cut, as in Fig. 14.

The above instructions will answer quite well, if in-

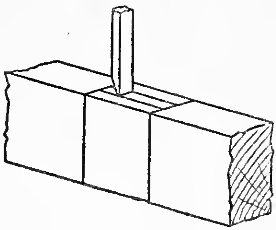


Fig. 11A.—Starting to Remove Waste of Mortise

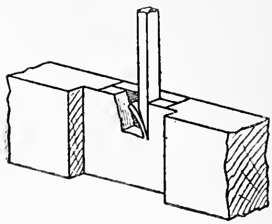


Fig. 13.—Taking the Next Cut

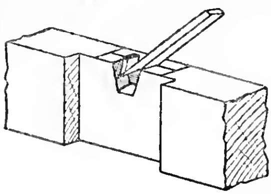


Fig. 12.—Method of Removing Chips from Mortise

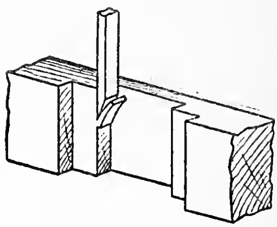


Fig. 14. — Finishing Mortise Vertically

terpreted with reasonable intelligence, for the making of shouldered tenons (*see* Fig. 15); generally the mortise will go about half-way through the work, and the length of the tenon will correspond, but make the tenon just a shade shorter than the hole is deep.

Wedging Joints.—Very frequently mortises are slightly under-cut, so as to produce a dovetail effect, and the ends of the tenon are sawn down with the grain, and wedges are inserted, as shown in Figs. 16 and 17. The

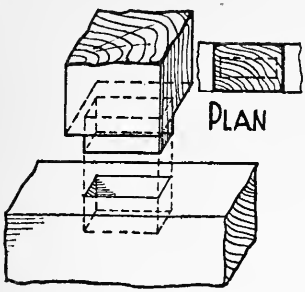


Fig. 15.—Shouldered Tenon

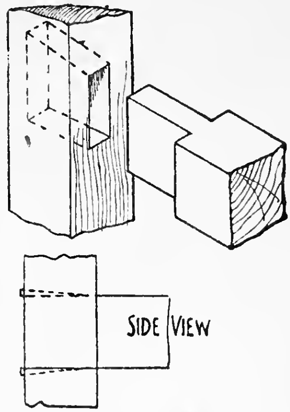


Fig. 15A.—Wedged Tenon

combined thickness of these wedges must not exceed the amount by which the mortise has been under-cut. Then on inserting just the points of the wedges in the saw-cuts the two parts of the joint can be driven together forcibly, with the result that the wedges will spread the tenon in the mortise and form a dovetail. This is known as "fox-wedging," but the usual method of wedging the ordinary "closed" joint in which the mortise goes right through the work is to drive in wedges from

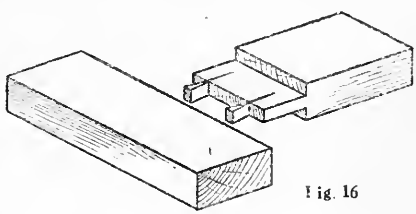


Fig. 16

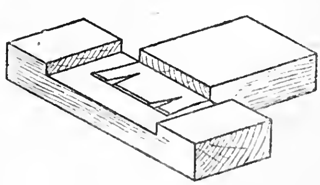


Fig. 17

Figs. 16 and 17.—Fox-wedged Tenon

the opposite side over and under the tenon, the wedges being as wide as the tenon is thick, as shown in Fig. 15A.

Pinning Joints.—When wedging is not adopted, the ordinary way of securing a mortise-and-tenon joint is with a wooden pin, and there is a particular method of inserting this to ensure that the tenon is drawn well home. It is known as "draw-boring." The joint having been made and fitted, it is taken apart and a twist-bit is passed right through the cheeks of the mortise; the tenon is re-inserted, the bit replaced, and its point allowed to make a mark on the tenon, as suggested in the cut-away view (Fig. 18). Next the tenon is removed, and the twist-bit placed very slightly nearer the shoulder, as in Fig. 19, and a hole bored through. When the joint is again put together there will be a hole through the two cheeks of the mortise and also through the tenon, but it will not be a straight one (*see* Fig. 20). By

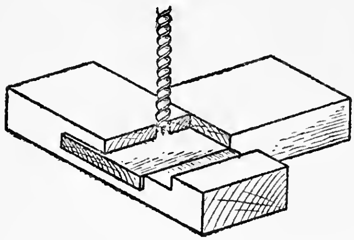


Fig. 18.—Marking Tenon for Draw-boring

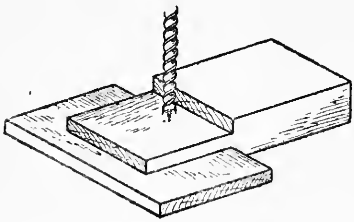


Fig. 19.—The Boring Bit Placed Slightly Nearer Shoulder

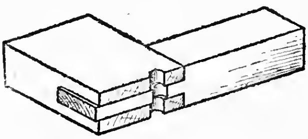


Fig. 20.—Draw-bore Holes not in Line

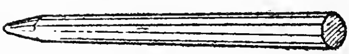


Fig. 21.—Pin for Joint

driving in an oak pin (Fig. 21) from one side of the mortise, the tenon will be tightly cramped up, but it may first be necessary to draw the joint together with a steel pin, afterwards replacing it with the wooden one.

If you try this method, do not forget the following precautions: Don't overdo it by making the distance by which the hole in the tenon is out of alignment too great, or, instead of cramping up the joint, the forcible driving home of the pin may split a piece from the tenon, or at any rate spoil the pin. Secondly, see that when you shift the bit for boring you place it *nearer* the shoulder and not *farther away* from it, as has been done many hundreds of times.

BUILDING A CARDBOARD MODEL L. & S.W.R. EXPRESS LOCOMOTIVE

By Henry Greenly

Before the boy mechanic essays to build a model locomotive he should know something of the various types from which he may choose. All the larger railway companies possess characteristic designs of locomotives each suited to the work allotted to it. They are classified by the wheel arrangement, as indicated in the diagram (Fig. 1), the numeral system being adopted to distinguish

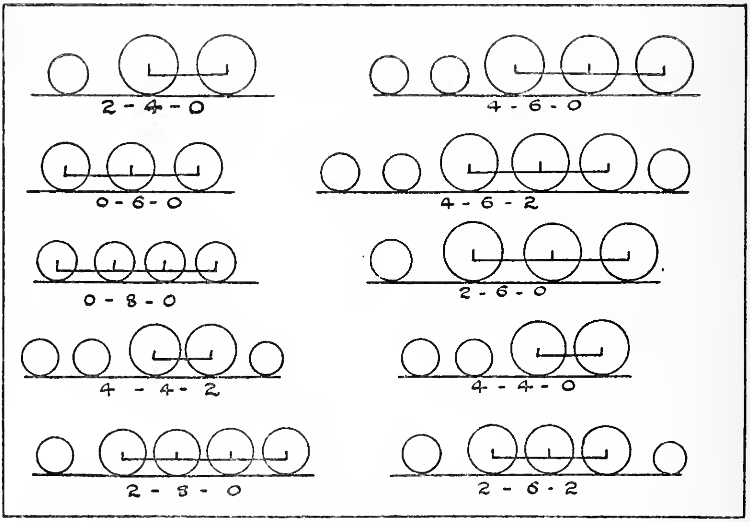


Fig. 1.—Diagram Explaining Wheel Classification of Locomotives

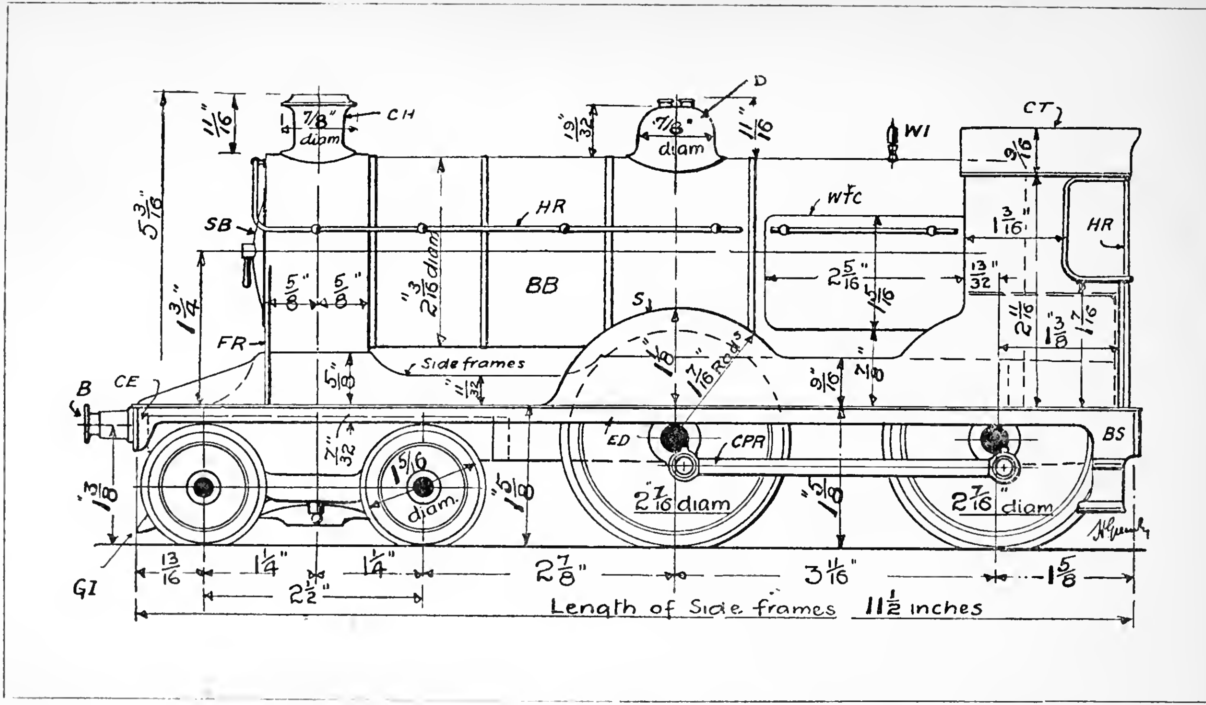


Fig. 2.—Side Elevation of Model L. & S.W.R. "4-4-0" Express Locomotive

the types. The most common for express trains is the four-coupled bogie engine termed the " 4—4—0 " type and for the subject matter of this chapter a model of one of this class has been chosen. A " 4—4—0 " arrangement is included in the diagram (Fig. 1) and a picture of a model locomotive of this identical class is presented in one of the photographic plates.

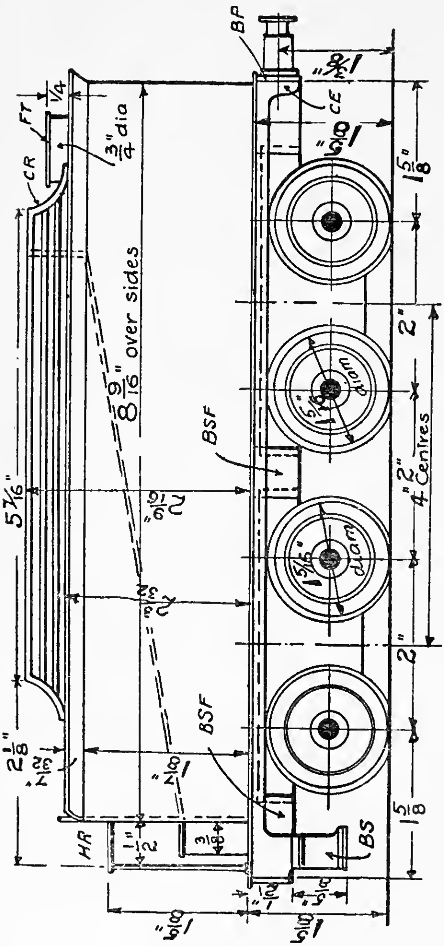


Fig. 3.—Side Elevation of Model L. & S.W.R. Double-bogie Tender

In model work there are several standard gauges. Model locomotives in the smaller gauges are, of course, the least expensive, and require simpler tools to make. The gauges (always measured *between* the rails) vary between No. 0 ($1\frac{1}{4}$ in.) and 15 in. for garden and estate models, the four smaller sizes having the designating numeral (Nos. 0, 1, 2 or 3 as the case may be) in addition to the dimensions. The following table will be helpful in understanding and in choosing among model locomotives in all the more common dimensions.

TABLE OF GAUGES AND SCALES FOR MODEL LOCOMOTIVES

Gauge	*Scale*	
No. 0 (1¼ in.)	7 mm. to 1 ft. (about $\frac{1}{44}$th full size)	Eminently suitable for indoor railways where space is limited or where a big railway scheme is intended. Locomotives can be driven by clockwork or electricity. A few steam models have been made for this gauge.
No. 1 (1¾ in.)	10 mm. to 1 ft. (about $\frac{1}{30}$th full size)	The best gauge for electrical, steam and clockwork locomotives for indoor model railways.
No. 2 (2 in.)	11¼ mm. to 1 ft. or $\frac{7}{16}$ in. to 1 ft. (about $\frac{1}{27}$th full size)	The largest size advisable for an indoor railway. Most suitable small size for steam and electric locomotives. The smallest outdoor size advisable. This gauge is not being developed very much for indoor lines or for clockwork locomotives.
No. 3 (2½ in.)	13 mm. to 1 ft. ½ in. to 1 ft. ($\frac{1}{24}$th full size)	The amateur steam locomotive builders' favourite gauge, especially where the railway portion of the equipment is of secondary importance. The best small outdoor size.
3¼ in. gauge 3½ in. gauge 4¾ in. gauge	$\frac{11}{16}$ in. to 1 ft. ¾ in. to 1 ft. 1 in. to 1 ft.	These sizes are suited to exhibition models, made by skilled mechanics.
6 in. gauge 7¼ in. gauge 9½ in. gauge 15 in. gauge	1¼ in. to 1 ft. 1½ in. to 1 ft. 2 in. to 1 ft. 3 in. to 1 ft.	For garden and estate model railways carrying passengers and goods. A full engineering equipment is required to produce models in these scales.

The foregoing table is not only useful in preventing an inexperienced worker from making a locomotive to some odd scale and gauge, but will enable him to fix upon a size to which he can construct locomotives of progressive degrees of completeness and workmanship. For instance, should the No. 3 ($2\frac{1}{2}$ in.) gauge be decided upon, the first locomotive may be a simple shunting engine running on four or six wheels. When successfully finished and more

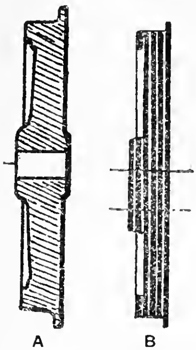


Fig. 4.—Wooden Wheel (A) and Cardboard Wheel (B)

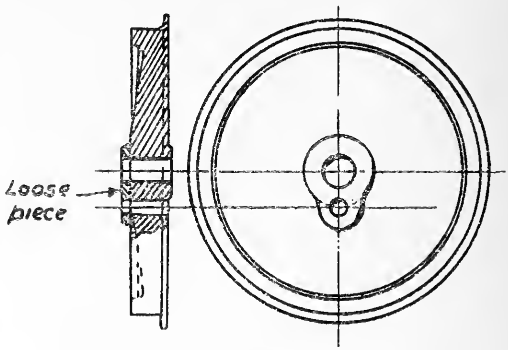
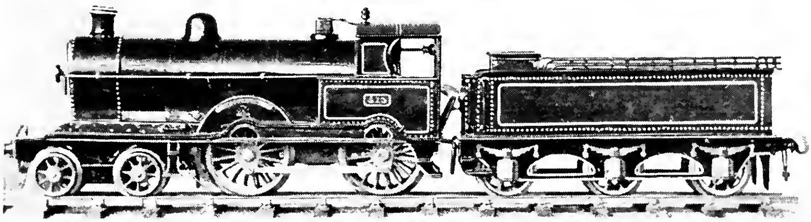


Fig. 5.—Driving and Coupled Wheel, with Boss

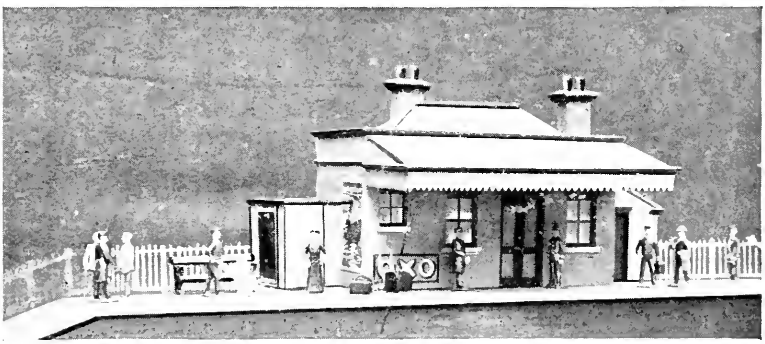
skill and further tools have been acquired, an express engine of more complicated character may be attempted, and both of the engines will be available on the same track. Once the locomotive hobby is started there is little or no finality in it, and therefore the basis of the work—namely the size of the line of railway—needs to be earnestly considered at the outset.

For the average novice the indoor railway is usually the least difficult proposition, and while the smallest gauge (No. 0) may be adopted, No. 1 ($1\frac{3}{4}$ in.) gauge will be found to provide a size which is not expensive in the

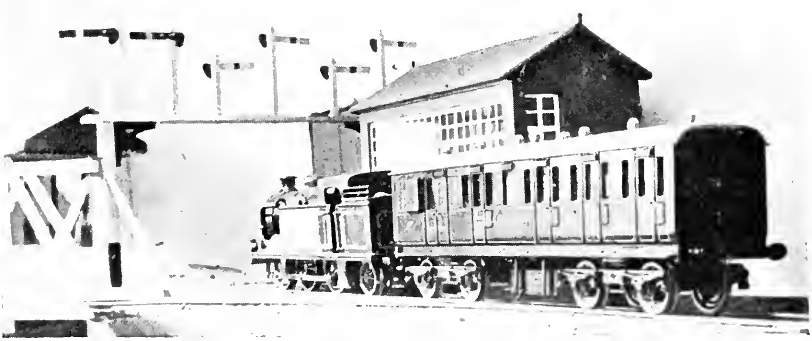
MODEL LOCOMOTIVE, STATION AND SIGNALS



Model L. & S.W. Express Locomotive



Model Railway Station



Model Locomotive, Rolling Stock, Signals, etc.

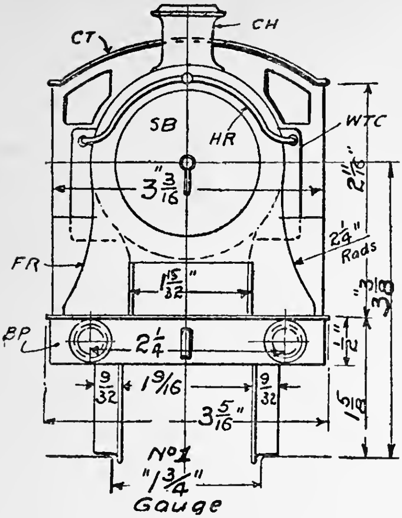


Fig. 6.—Front Elevation of Model Locomotive

matter of materials and not too small to be difficult to construct. We will therefore consider first the building of a model cardboard locomotive. Such a model may afterwards be altered to run by clockwork or electricity if a suitable motor is obtained.

The drawings are sufficiently correct in detail to be used for an all-metal clockwork or electric locomotive, in which case tin plate, strip metal, and solder would take the place of cardboard, wood strips, and glue.

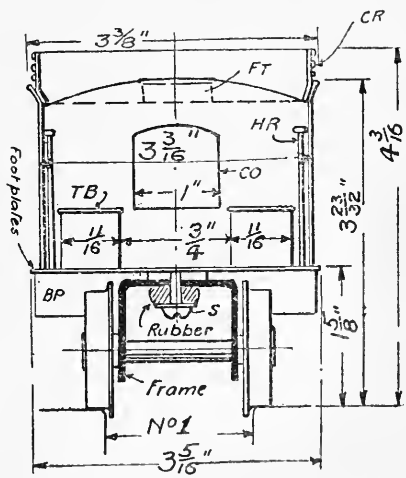


Fig. 7.—Front Elevation of Model Tender

Figs. 2, 3, 6, 7, and 8 show dimensioned the leading features of a No. 1 ($1\frac{3}{4}$ in.) gauge model L. & S. W. R. "4—4—0" type express locomotive with a double - bogie tender. The engine is extremely

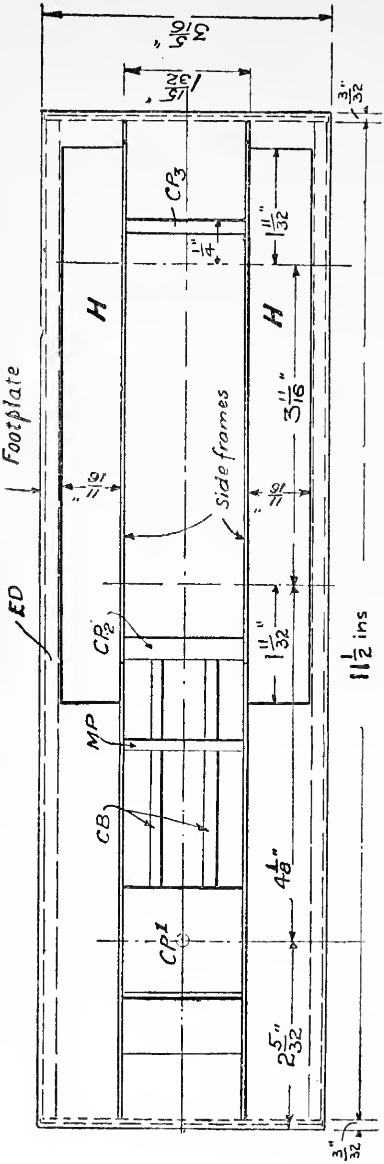


Fig. 8.—Plan showing Frames of Model Locomotive

neat and simple in outline. There are no outside cylinders or valve motions to model, and supplied with a clockwork motor a very successful locomotive should result. Only two diameters of wheels are employed on the whole machine, which fact also simplifies the work.

Wheels. — For a cardboard model the first and most important consideration is the making of the wheels. Suitable metal wheels with proper spokes and coupling-rod boxes may, in normal times, be obtained, but, failing these, there are two good methods of making wheels. They may be turned in hard wood as at A (Fig. 4); box or beech wood will give the best results. Or the wheels may be built up out of discs of cardboard glued together as shown in the section B (Fig. 4). In either arrangement the spokes, of course, will be absent. In the case of cardboard wheels, to provide for the flange the disc at the back should be nearly $\frac{1}{4}$ in. bigger in diameter than the diameter of the wheel on the tread. For the driving and coupled wheels the pear-shaped bosses which embrace the coupling-rod pins will require to be added; these may be cut out and applied to the face of the wheel. Even with the wooden wheels this will have to be done (*see* Fig. 5), as it is impossible to turn bosses of this shape.

Main Frames.—The main frames are shown in Figs. 8 and 8A, those of the bogies being separate structures. To reduce work, the engine and tender bogies have been made of similar construction, the wheel-base (distance between the wheels, centre to centre) being smaller in the case of the tender bogies; the long slot for the bogie pin and the dummy equalising spring gear are omitted. The side frames of the engine are rather complicated by the fact that at the front bogie the underside of the foot-plate is quite clear except for the edging. This is to give room for the bogie to rotate and swing.

The footplates and panels should be made of stout Bristol board or other close-grained white card. The only slots in the footplates are those required to clear the coupled wheels (*see* H, Fig. 8). Some strip wood, $\frac{3}{16}$ in. by $\frac{1}{8}$ in. section, is required for the edging (E D), and $\frac{1}{8}$ in. by $\frac{3}{16}$ in. stuff for the crosspieces (C P) and other stiffening blocks. The outlines of all these blocks and all centre lines should be drawn on the pieces of card used

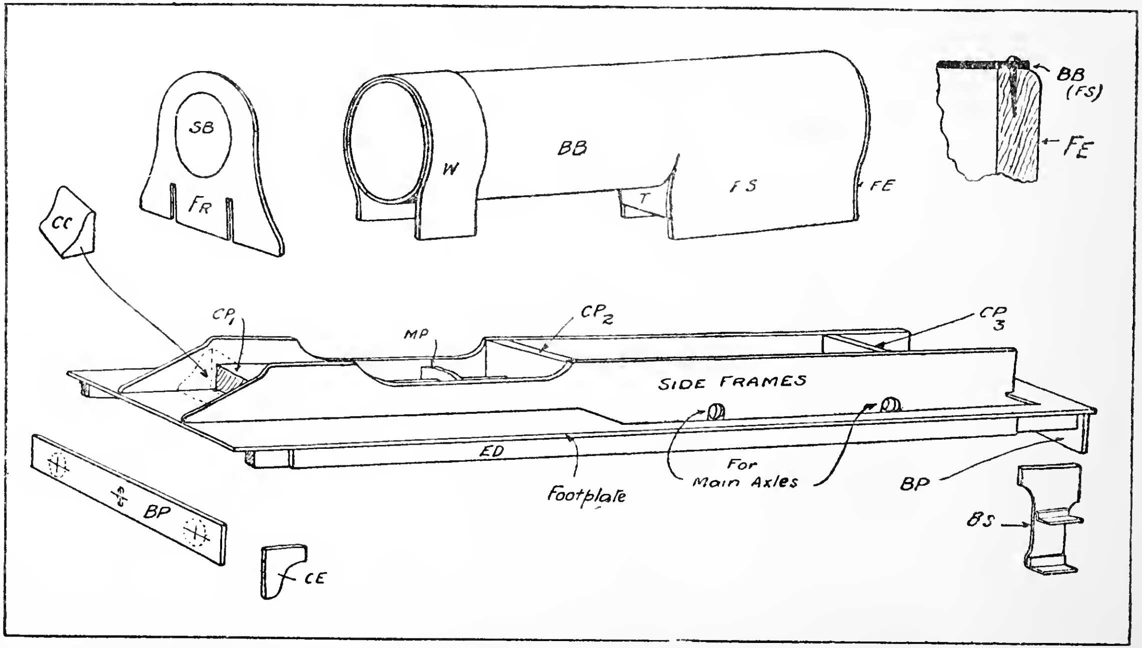


Fig. 8A.—General View, showing Side Frames, Cross-pieces, Boiler Barrel, Smokebox Door, etc., of Model L. & S.W.R. Locomotive. *(See list of letter references on p. 218)* for the frames and footplating. Between the crosspieces C P and C P_2 the strip work shown at M P and C B (Figs. 8 and 8A) may be added to stiffen up the footplate and also to represent the motion-plate and slide bars of the real engine.

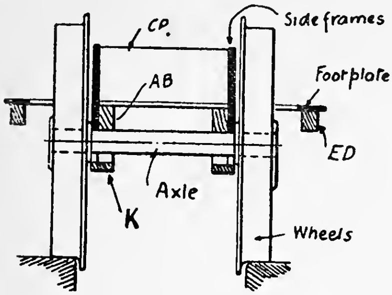


Fig. 9.—Section showing Details of Axleboxes, Frames, etc.

Coupled Wheels, Bogie, etc.—The detail drawings of main axle-boxes (Figs. 9 and 10) show the arrangement of the coupled wheels in the frame. By using slotted axleboxes instead of plain drilled holes it is possible to fit up the wheels on their axles and then put them into place complete, securing them by a "keep" plate (strip wood, metal or card), as shown at K.

Fig. 10 is a view of the back of the engine from the

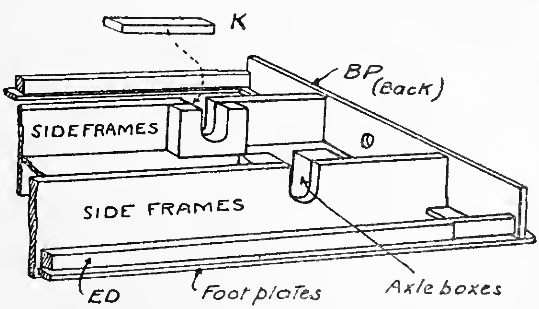


Fig. 10.—View of Rear End of Engine from Underside, showing Axleboxes, etc.

underside. Fig. 9 is a sectional view of the frames and front main axlebox, showing how the side frames are continued below the footplate level to a point which just overlaps the frame of the leading bogie. The latter structure is illustrated by Fig. 11. The framing consists of three pieces of card secured together by angle-blocks in the inside top corners. The spring work (equalisers, etc.) is, in this case, mere ornament applied to the outside. To obtain the relief, the parts may be built up in layers; for instance, three layers would make the equalisers and one and two the springs underneath. For the axle-

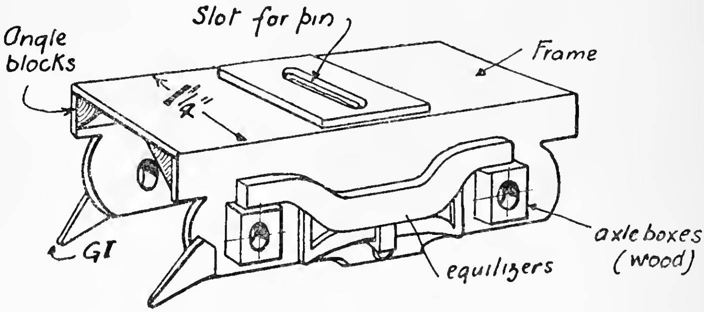


Fig. 11.—Details of Leading Bogie

boxes wood blocks are suggested, but, of course, four or more layers of card may be employed.

Boiler.—The boiler barrel may be made out of a piece of flat card over a good round postal tube, curtain-pole or anything similar. The diameter of the boiler barrel is given as $2\frac{3}{16}$ in., so that the tube bar or pole chosen should measure as nearly as possible $2\frac{1}{8}$ in. diameter outside. If a postal tube is employed it may, of course, be cut to length and left inside the boiler barrel to stiffen the whole structure. The front end of the barrel has an additional wrapper strip w (Fig. 8A) the width of the smokebox glued on to it. The firebox end is opened out as indicated ; the rear end of the firebox sides F S being retained to the shape required by a flat piece of wood about $\frac{1}{4}$ in. thick, cut out to fit inside. This piece of wood F E (firebox end) should project slightly, and the outer edge should be rounded as shown in Fig. 8A.

Funnel and Dome.—The funnel and dome (*see* Fig. 12) are best turned out of beech or box wood to the shape as shown, and if no lathe is available the builder must rely on the help of a pattern-maker or wood turner. If turned in box or other similar close-grained wood the

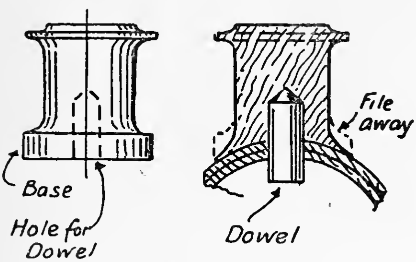


Fig. 12.—Funnel Turned from Wood

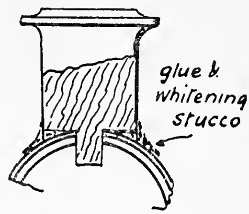


Fig. 13.—Funnel Shaped from Composition

saddling of the underside of these mountings may be done with the file, the base curves at the sides being modified with the same tool. The other alternative is to turn them straight down with a dowel pin out of the solid, and then to form the base curves with a stucco made of whitening and hot glue (*see* Fig. 13). When dry, this mixture, if there is enough whitening in it, can be carved with a penknife or filed to shape. The safety valves on the top of the dome should be of bright brass, also the whistle. Oddments may be worked up into these, or cheap dummy fittings may perhaps be bought. In referring to scrap it is always advisable for the amateur model maker to collect odd fittings, old clocks, instruments, bits of other small machinery, etc., for future use.

Tender.—The tender is a simple box structure, which is strong in itself, the side framing B S F (Fig. 3 and 14) underneath being necessary only to overlap the bogie frames and give the undergear a solid appearance. The bogie frames are shown in Fig. 15, and their attachment is indicated in the sectional drawing (Fig. 3). A plain pivot hole only (instead of the slot necessary in an

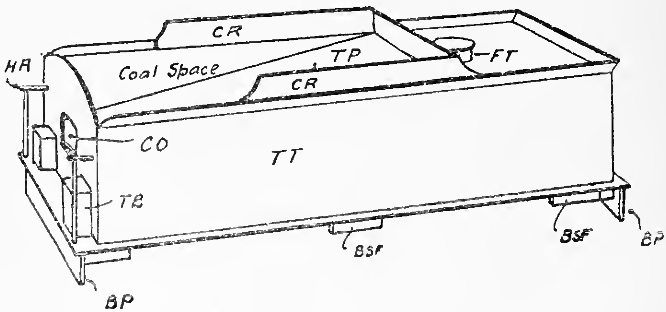


Fig. 14.—Details of Model Tender

engine bogie) is required in the case of a double-bogie vehicle. The pivot is a screw which engages in a block of wood inside the tender body. In building up the body, angle blocks of wood may be freely used to unite the cardboard "plates" forming the sides, ends, etc. The coal space has a sloping bottom, and the coal rail may be built up out of wire or a strip of card may be glued on the top edge, and the rails represented by drawing wide black lines on the card to represent the spaces between the rails.

Completion of Model.—When complete any rough edges on the joints should be trimmed up with glasspaper and the whole locomotive and tender coated with size. This is a necessary preliminary to the coating of paper with oil paint, and any loose parts such as bogies should be removed.

The coupling-rods may be made of wood or metal and " screwed " into the wheels; the screws are secured by seccotine or a shellac cement. The coupling-rods on each side of the locomotive are arranged at 90 deg. to each other, not opposite.

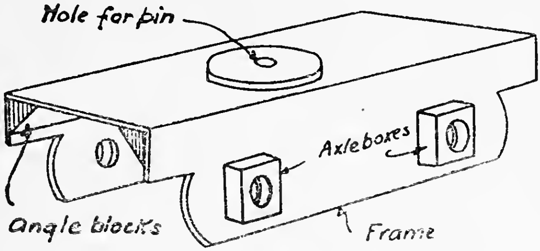


Fig. 15.—Bogie Frames of Tender

The hand-rails (Fig. 16) should be made of stiff wire, the rail along the boiler being fitted into standards made of split pins. The boiler bands should be strips of card carefully cut out with a sharp knife and glued on to the boiler, the joints being on the underside. Buffers may be made of wood, small drawing pins, polished bright, forming the heads. The hooks are best made of two or three thicknesses of strong card glued together.

One or two elementary hints may be given for the benefit of readers who have not attempted such an ambitious model before. The parts should be drawn out on the card before cutting them up; care being exercised to see that the setting out is correct. This will ensure an accurate result and good fitting of the parts. The glue should not be too thin or too lavishly used. One professional expert in cardboard modelling known to the writer strongly advocated gum arabic as an adhesive, saying that with this substance and by building up layer on layer, models would last at least a hundred years. The gum arabic needs to be dissolved in water. Except where wood parts are employed good gum may be used in place of glue.

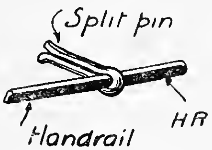


Fig. 16.—Details of Handrail

Some of the letter references in the illustrations given in this chapter have already been explained. The following is a complete list :—

LOCOMOTIVE : A B, axleboxes ; B B, boiler barrel ; K, keep for axleboxes ; W, wrapper for smokebox ; S B, smokebox door ; F R, smokebox front plate ; W T C, water-tube cover ; C P R, coupling-rods ; C T, cab top ; W I, whistle ; C H, chimney ; D, dome ; G I, guard irons ; C E, corner frame edging ; E D, edging of frames ; C C, cylinder cover piece ; B, buffers ; B P, buffer planks ; C P, cross pieces ; B S, back step (and front step of tender) ; M P, motion plate ; F S, firebox sides ; F E, firebox end.

TENDER : B S F, bogie stop frames ; C R, coal rails ; T P, tank top ; H R, hand rails ; T T, tender tanks ; T B, tool boxes ; F T, tank filler ; B P, buffer planks.

TURNING WOOD IN THE LATHE

By A. Millward

The Lathe.—A boy who owns (or can get the use of) a lathe, however simple its form, will find it invaluable not only for making any number of useful things, but also as a great help in many other hobbies. Any object having a circular form can be readily and truly shaped in a lathe, which comprises essentially a pair of "centres" between which the work is revolved against the action of a cutting tool. In order to make the instructions which follow more easily understood it is proposed to give first a brief description of the component parts of a lathe with their proper names.

In Fig. 1 is shown a front view of a simple form of lathe, in which *a* is a foundation plate or bed carried on a bench or legs a^1. On the bed *a* is fixed the headstock *b*, which carries a revolving spindle or mandrel *c*, which is rotated by pulleys *d* fixed thereon. The pulleys *d* are driven by a belt *e* passing over one of the pulleys *d* and over another pulley of a series of pulleys *f*, which are driven or rotated by a treadle *g* through the medium of a crank pin *h* on the pulley and a connecting rod or pitman *i*. The variation in the sizes of the pulleys *d* and *f* is to provide a simple form of gear for varying the speed of the mandrel. It will be apparent that if the belt *c* is placed on the first or outer pulleys (that is, on the smallest one of the pulleys *d* and on the largest one of the pulleys *f*), then the mandrel *c* will be rotated at a greater speed than would be the case were the belt placed as shown in the illustration, but the speed of treadling would remain constant.

On the opposite end of the bed *a*, is arranged the loose headstock, tailstock, or back poppet *k*, which is free to

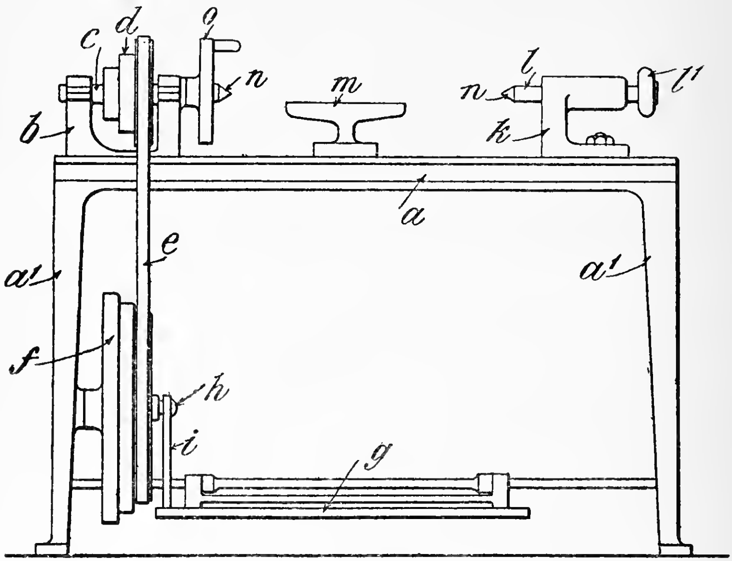
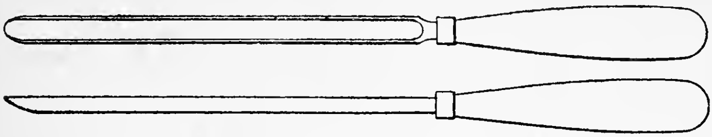


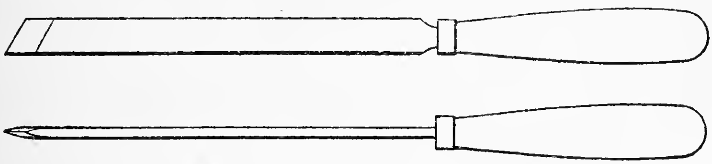
Fig. 1.—Diagram of Simple Lathe with Parts Lettered for Reference

move on the bed *a* until clamped in position. The back poppet *k* carries a spindle *l* which, on turning the wheel l^1, is moved through it by a screw. A tool rest *m* is clamped to the bed in any desired position. The mandrel *c* and the spindle *l* are each provided with centres *n*, which must be exactly opposite one another in order to produce perfectly round work. Fig. 1 must be looked upon not as being the drawing of any particular form of lathe, but merely typical of a simple form, as almost any lathe, however complicated, will comprise the above described essential parts.



Figs. 2 and 3.—Wood-turning Gouge

Tools.—With regard to the tools required for wood turning it will be sufficient to start with a wood-turning gouge (*see* Figs. 2 and 3, which are plan and side views



Figs. 4 and 5.—Wood-turning Chisel

respectively) and a chisel (*see* Figs. 4 and 5, which are also plan and side views). It will be seen that the chisel, unlike an ordinary wood chisel, is bevelled or sharpened

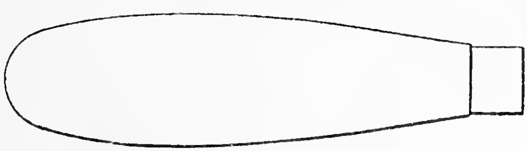


Fig. 6.—Tool Handle to be Turned in Wood

from both sides, and its edge is inclined instead of being square with its sides.

Making a Tool Handle.—As a first attempt at wood-turning it is proposed to make a tool handle, as shown by

Fig. 6. Get a piece of square wood (the most suitable will be beech, which is inexpensive and fairly hard and close-grained) an inch or two longer than the handle when finished is required to be, and of a thickness slightly

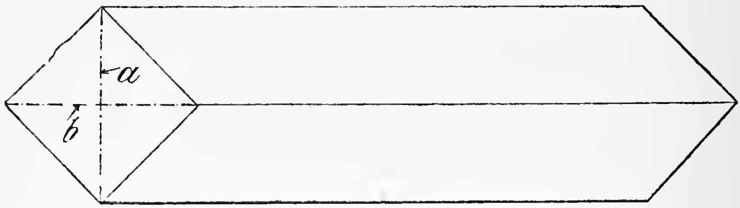


Fig. 7.—Square Piece of Wood for Tool Handle

greater than the largest diameter of the finished handle. Square the ends and mark diagonal lines *a b* from each corner, as shown on Fig. 7. At the point where the two lines cross each other—which will be the axial centre of the wood—make holes with a centre punch. Now chisel or plane away the corners *c* of the wood shown in dotted lines on Fig. 8, and make a saw cut *d* along one of the

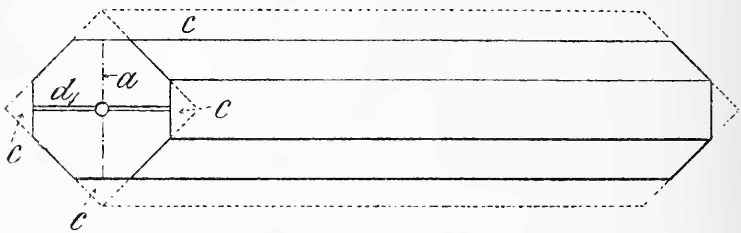


Fig. 8.—Wood for Turning Tool Handle prepared for the Prong Chuck

diagonal lines on the end to take a " prong " or " horn " chuck (*see* Figs. 9 and 10) which is inserted in the nose of the mandrel *c* (*see* Fig. 1) in place of the plain centre *n*. The prong or horn chuck, of which a side view is shown on Fig. 9 and an end view on Fig. 10, is for the purpose of causing the wood to turn with the mandrel whilst being cut.

Be careful to see that the centre prong of the chuck enters the centre hole of the saw cut. Fix the chuck in the wood by giving the end of the wood or the end of the chuck a smart blow with a hammer. Adjust the back poppet *k* (*see* Fig. 1), and then screw in the spindle *l* so that its centre *n* enters the hole at the other end of the wood, first putting a little grease, oil or black lead in the centre hole.

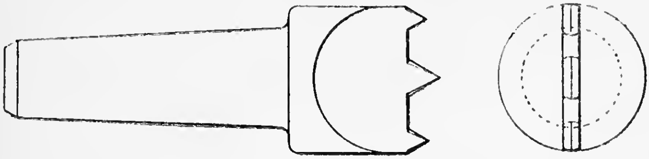


Fig. 9. Fig. 10.

Figs. 9 and 10.—Two Views of Prong Chuck

It is advisable to screw up the spindle *l* fairly tightly at first; any binding resulting therefrom will disappear after a few revolutions. Now adjust the tool rest *m* (Fig. 1) until its top edge is below the centre of the work, and so that the wood when revolving is just clear of the front edge of the rest. Take the gouge and work the treadle to cause the top of the work to turn towards you at a fairly high speed. Rest the rounded side of the gouge on the top side of the rest *m* with the hands well down so that the cutting edge will be higher than the hands. It is essential to hold the gouge very firmly, the right hand grasping the handle with thumb uppermost and the left hand grasping the tool with the knuckles uppermost a few inches from the rest *m*. Now press the tool forwards towards the work until it begins to cut, and then move it along until a few inches are reduced to the same diameter. Then press the tool farther, and move it back again until the beginning of the cut is reached, and so on until the desired diameter is obtained, adjusting the height of the tool rest as required.

It is always advisable to turn the larger diameters first before turning the smaller ones. In the present case the main portions of the handle will first be turned, then the ends reduced ; the one end *a* (*see* Fig. 11) nearest the fixed centre should be turned down to fit into a short

Fig. 11.—Turning the Tool Handle

length of brass tube to form a ferrule so as to prevent the handle splitting when the tool is driven into it.

A pair of outside callipers (Fig. 12) will be required to gauge the diameter of the work, and since it will be necessary hereafter to have means for measuring internal diameters such as holes, hollows or insides of boxes, etc., it will be as well to get a pair of inside callipers also (*see* Fig. 13).

To use callipers, first set them to the desired diameter by placing the end of one of the legs against the end of a rule, and extending them until the end of the other leg coincides with the required measurement on the rule. *Always bring the work to rest* in the lathe before attempting to calliper or gauge it.

If the cut is not satisfactory or the wood is torn rather than cut the fault will be found to be: (1) Speed not high enough. (2) Tool not sharp enough. (3) Wrong position of the cutting edge. The third fault is the most common. The remedies for the first two faults are obvious, while the third can usually be put right by dropping the hands a little so as to raise the cutting edge of the tool; but see that the tool rest is at the correct height.

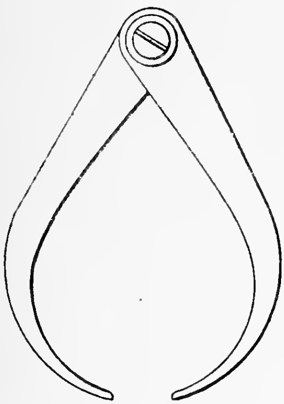


Fig. 12.—Outside Calipers

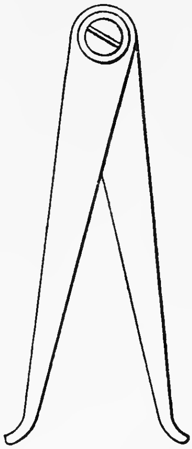


Fig. 13.—Inside Calipers

After the whole surface has been turned or "roughed out" with the gouge to the desired size, it will be found that the surface consists of a series of ridges instead of being smooth. To obtain a smooth surface, the chisel must be used. This tool, like all cutting tools, must be kept absolutely sharp, and a good oilstone is therefore a very necessary item.

To use a chisel properly is very much more difficult than the use of the gouge. It must be so held in relation to the work that only the middle part of the edge does the cutting. It must not be used, as is so often the case with amateurs, as a scraping tool. Fig. 14 shows the proper way of using the chisel, *a* being the cutting part of the edge, the highest point or edge a^1 being above and out of contact with the work *x*, whilst the lower point a^2 is below and also out of contact with the work. In such a position a smooth, even surface will be produced as the tool is moved along the rest *m* from right to left, but considerable practice will be required to prevent the edges a^1 or a^2 digging into the work.

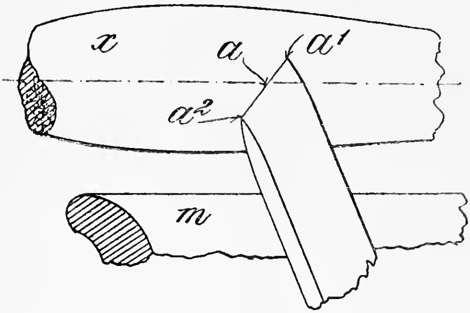


Fig. 14.—Using Chisel in Wood Turning

An easier way of obtaining a smooth surface is to use an ordinary carpenter's chisel sharpened to a truly square edge on one side only. The bevel of the chisel should be underneath and the top side of the chisel should be in line with the centre of the work. As a chisel so held scrapes rather than cuts, it will be necessary to sharpen it continually.

When the surface has been gone over and reduced to the desired size with the chisel it should be perfectly smooth, but this is seldom obtained at a first attempt. To make it quite smooth, take a piece of fine glasspaper and press it lightly on the surface backwards and forwards whilst revolving the work at a high speed. To polish the work, press against it whilst it revolves in the lathe a rag dipped in linseed oil or smeared with beeswax and turpentine.

The end a^1 (Fig. 11) of the handle must now be cut off. To cut off a piece of work in the lathe a parting

Fig. 15.—Cutting-off Tool

tool, illustrated by Fig. 15, is employed, and must be held at right angles to the axis of the work and advanced into the work in that position without moving it to the right or left. It is not advisable to cut right through with the parting tool owing to the liability of the work to break and perhaps be spoilt ; it is better to turn down as much as possible without breaking, remove the work from the lathe, and to cut off with a fine saw.

In the present case it will not be necessary to use a parting tool, as the end to be cut off will already be turned down to a fine neck, which can be easily sawn through, and the saw marks removed by means of glasspaper.

Having turned the handle satisfactorily it will be an easy matter to use the knowledge so gained in doing more ambitious work.

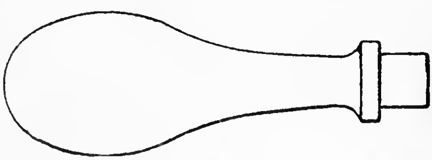


Fig. 16.—Another Tool Handle

Fig. 16 shows a slightly different form of handle, Fig. 17 a bail or spindle, Fig. 18 a chair or stool leg, and Fig. 19 a drawer knob or handle, all of which can be turned after some practice.

Screw Chuck.—It is not always convenient or even possible to turn some work between centres; take, for instance, a powder box (shown in section in Fig. 20) or an egg-cup (*see* Fig. 21) or other articles requiring to be hollowed out. In such cases the block of wood must be held on to the mandrel by some other means than the prong chuck already described.

Fig. 22 shows a screw chuck which will be found very useful; this, as shown, comprises a shank *a* fitting into the end of the mandrel (or in some cases it may be provided with a socket to screw on to the mandrel nose), a plate *b* and a tapered wood screw *c* projecting centrally

Fig. 17.—Bail or Spindle

Fig. 18.—Leg of Chair or Stool

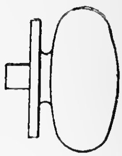


Fig. 19.—Drawer Knob or Handle

from the face of the plate *b*. In use, a centre hole is first made in the wood, and then the wood is screwed on to the screw *c* until its back surface (which should be first planed true) butts against the plate *b*. The taper screw chuck can be employed only when the diameter of the work is fairly small and is not of great length; if it is required to turn a disc or a wheel or a circular picture frame (*see* Figs. 23 and 24, which are a front view and side section respectively) it is better to screw the wood either directly on to the face plate *o* (*see* Fig. 1) (a slotted disc fixing on to the mandrel; it is part of the furniture provided with most lathes, even of the simplest form) with wood screws passing through the slots from the back of the plate into the wood held flat against the face or by screwing the wood from the front face on to a piece of wood previously secured on the front surface of the face plate.

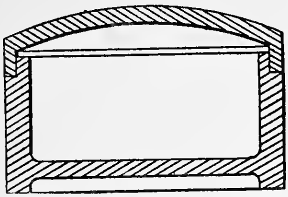


Fig. 20.—Section through Powder Box

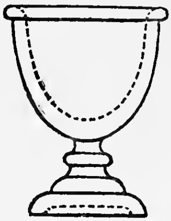


Fig. 21.—Wooden Egg-cup

When it is necessary to turn one part to fit within another, such as the lid to fit on the box (*see* Fig. 20), it is advisable to turn the hollow part of the joint first and then turn the outer part to fit within the hollow part, because it is easier to turn an outside part to an exact size than it is to turn an inner surface to a precise dimension.

Woods for Turning.—As a general rule, hard and close-grained woods, such as box, rosewood, holly, lime, ebony, teak, beech, ash, apple and pear, are better suited for turning than the more open-grained hard woods, such as oak, walnut, elm and mahogany, or the common soft woods, such as pine, yellow pine, spruce, poplar and sycamore.

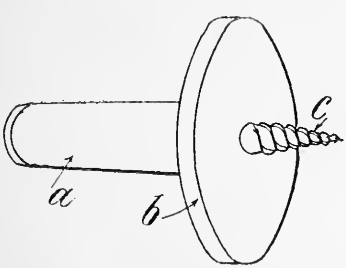
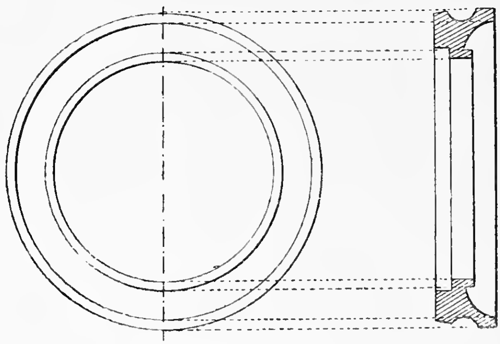


Fig. 22.—Screw Chuck

Turning Tapered Work.—Occasion may arise when it may be necessary to turn a tapered pin or spindle, the taper to be gradual and even from a larger end to a smaller one. This may, of course, be accomplished by carefully advancing the tool nearer the centre as it approaches the smaller end of the work, but such an operation requires much skill and practice to be performed successfully. A much easier way is to "set over" the tailstock, that is, to move it in such a way that the centre carried by it is not in line with the centre carried by the headstock.



Figs. 23 and 24.—Elevation and Section of Wooden Wheel, Picture Frame, etc.

Most lathes will allow of the tailstock being set over, in which case turning a gradually tapering article presents no more difficulty than turning an article with parallel sides. The amount of eccentricity given to the back centre (in other words, the distance which the back centre is put out of line with the front centre) governs the amount of taper produced.

HOW TO MOUNT PICTURES

I WILL not trouble you with many particulars with regard to the mounting of pictures. Engravings and similar pictures of value are rarely mounted, but are inserted in the frame just as they are; but presentation plates, cheap prints in general, and often water-colour drawings and the like, require to be mounted on stiff paper boards, which are obtainable in all the regular sizes, such as 24 in. by 19 in., 30 in. by 21 in. or 22 in., 33 in. by 26 in., and several larger sizes. The picture, etc., having been carefully trimmed up with sharp knife or scissors to lines previously drawn by means of T-square and pencil, is laid face downwards upon a piece of clean newspaper and brushed all over with flour paste, made by mixing a tablespoonful of flour with a cup of cold water, and boiling until the paste becomes more or less translucent; or a starch paste, made in a similar way, may be used. After a few minutes' interval, brush on lightly a second coat of paste. What is wanted is not a thick coat of paste, as that would squeeze out and prove a nuisance, but a well-worked-in thin coat, the moisture in which will make every part of the paper amenable to pressure.

See that your fingers are perfectly clean, lift up the pasted print, turn it over, and lower one edge of it into the position already marked with faint lines on the mount. Then let the rest of the print come into contact, cover the whole with a piece of perfectly clean paper, and rub with a clean handkerchief or duster from the centre so as to expel all air and make the print lie perfectly flat. If any paste oozes out at the edges of the print, wipe it off rapidly with a perfectly clean sponge or cloth and clean water. Cover the print with a fresh piece of paper (the old piece probably has some paste on it which might spoil the picture), and place under a pile of books or in a press to dry.

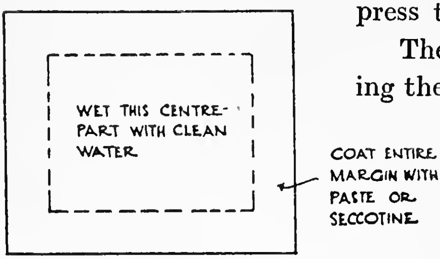


Fig. 1.—Stretching Print on Mount (also applicable to Straining Drawing-paper on Board)

There is a trick of stretching the print when laying it on a mount. I have frequently adopted it, and find it to answer very well, but the mount needs to be stout to resist the pull of the print. With a brush or pad of clean cloth, rub some water over the back of the print, but leave perfectly dry a margin about 1 in. wide at all four edges (*see* Fig. 1). Allow two or three minutes for the moisture to expand the paper. Apply some really strong paste (seccotine or a similar cement is better) to the dry margin, and very carefully lay the print on its mount. Gently smooth out any wrinkles on the margin of the print, but do not touch the centre part, however hopeless at this stage the job may look. Put it away for a few hours to dry, at the end of which time it will be found that the paper has considerably contracted, and the print is now as taut as a drumhead. As a matter of fact, the parchment heads

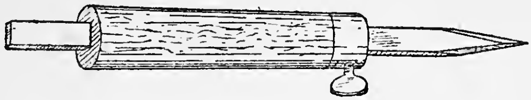


Fig. 2.—Mount-cutter's Knife

of certain instruments are stretched taut by a similar method.

Mount Cutting.—Cut mounts of many different materials, sizes and shapes can be had from picture-framing shops. A touch of seccotine is the best means of securing prints to the backs of such mounts. Should you be sufficiently ambitious to attempt to cut out a sunk mount for yourself, you will need a very thinly ground penknife, and had better spend ten minutes in making it extremely keen on a knife-polishing board, wiping it on a duster when finished. The proper tool is the mount-cutter's knife shown in Fig. 2; the steel blade has a very keen edge, and slides in and out of a wooden handle, at one end of which is a brass ferrule which takes the clamping screw. For straight mounts, the knife is guided along in contact with a straightedge; for curved mounts

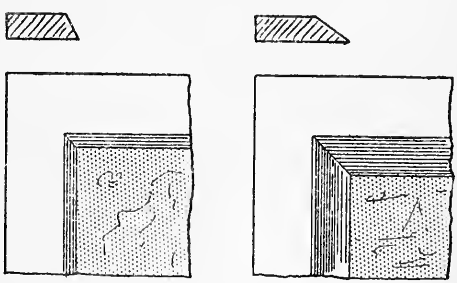


Fig. 3.—Diagrams showing how Bevel of Sunk Mount affects the Apparent Thickness

everything depends upon the worker's skill, and I do not advise you to try, as the result is not worth the expenditure of time and material in practising. According to the angle at which the knife is held the sinking is given an effect of thinness or thickness (*see* Fig. 3).

Setting Out an Ellipse.—Oval mounts need to be set out with pencil before attempting to cut them; in my opinion they are best avoided, but as I know many people like them, and as ellipses are often wanted in mechanical work, I will show the most practicable method of setting them out ("oval" means really egg-shaped, whereas what are known as "oval" mounts are truly elliptical). Place the mount on a drawing board and draw a horizontal pencil line about midway between the top and bottom edges. Mark off on this two points A and B (Fig. 4) to represent the length of the oval (the "major axis" in geometry). Mark a centre point between A and B as at C, and with the T-square or set-square drop a line at right angles to the point D. Now C D will be exactly half the depth of the opening required (by the

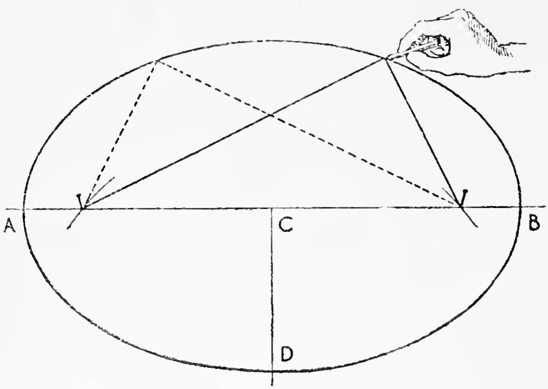


Fig. 4.—Drawing an Ellipse with Pins, Thread and Pencil

way, I advise you to cut the opening first on common white paper, and place it over the photograph or picture to see whether you have struck the right proportion). With compasses measure from C to B, and, without altering them, with D as centre, make two marks on the major axis as shown, and drive in a pin or needle at each of the intersecting points. Pass over the pins a loop of thread, of such a length that when it is stretched downwards by means of a pencil the latter just touches D. There will now be a triangle of thread, and by using the pencil to keep the loop taut and at the same time moving it about round the pins it will be found to trace an ellipse, as shown. Probably many of you are quite familiar with the method, but I have often found that boys when attempting it do not know how to go to work when given definite lengths for the major and minor axes. On a large scale, the method can be used to set out garden beds, using posts instead of needles, string or rope instead of thread, and a dibber or poker instead of the pencil. The illustration (Fig. 4) shows a thread not looped but secured at its ends to the pins. Some experienced draughtsmen prefer this method.

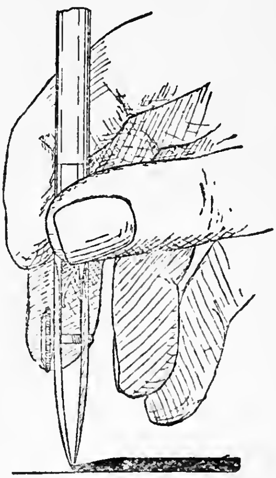


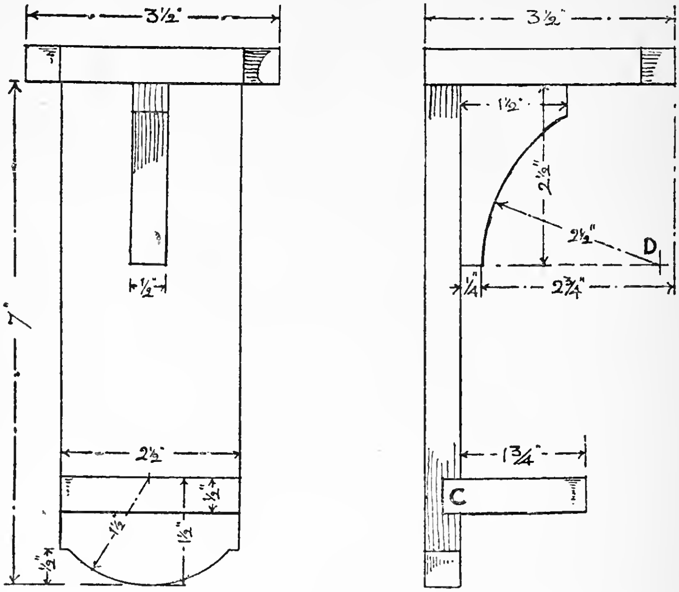
Fig. 5.—Using a Draughtsman's Ruling Pen

White and Gold Lines on Mounts.—Good effects are sometimes obtained by mounting prints and water-colours on brown mounts, a simple line of white being run round on the mount half an inch or more from the picture. Such lines can be drawn with diluted chinese white used in a draughtsman's ruling pen (Fig. 5), but the job needs to be done quickly, as the white soon clogs the pen and frequent cleaning out will be necessary. An ordinary writing-pen nib may also be used. For gold lines on picture mounts, rule the lines with gum water, allow to set, but not to dry, breathe on them, and at once dust over them some gold bronze powder; a better and more permanent effect is obtained by dabbing gold leaf on the gum lines, in which case the gum needs to be strong and to have a little sugar dissolved in it. Edges of mounts can be gilt in the same way, or strips of gold paper may be gummed on.

SOME EASY THINGS TO MAKE IN WOOD

A Lamp Bracket.—A simple but solid lamp-bracket is shown on the next page. It is made wholly of ½-in. material, which, naturally, will be a trifle thinner than this when finished. There are four pieces. The long wall piece is 7 in. long and 2½ in. wide; it will require to be cut a little larger than the dimensions here given to allow of planing up. The top shelf is 3½ in. square, and its shape is shown in detail in the plan (Fig. 3), while Figs. 1 and 2 are two elevations in which the shelf is shown simply in edge view. The lower shelf should be made originally as a part of the back piece so that it will be exactly the same width. It is 2 in. from back edge to front edge, but ¼ in. of it is housed into the back piece, and its outer corners are rounded off (*see* Fig. 4). The bracket piece under the top shelf will be cut from a piece measuring 1½ in. by 2½ in., and the method of striking the curve to which it requires to be cut is given in Fig. 2, where D is the centre for the compasses.

First plane up all the stuff and get it true and square. Dealing with the back piece first, Fig. 1 shows how the foot of it is struck to a curve, the centre for the compass being 1½ in. up and 1¼ in. from either side. The curve can be worked with a saw if the wood is left originally a trifle long, or perhaps it will be easier to execute it with a sharp chisel, but the square shoulders ½ in. from the bottom could be cut in with a fine saw. A groove should be cut for the bottom shelf exactly as shown, its depth being half the thickness of the material. Nothing need be said about the bottom shelf c—its shape is quite clear



Figs. 1 and 2.—Front and Side Elevations of Lamp Bracket

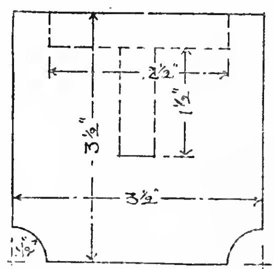


Fig. 3.—Plan of Top Shelf

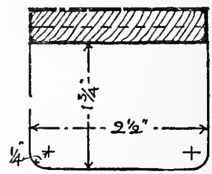
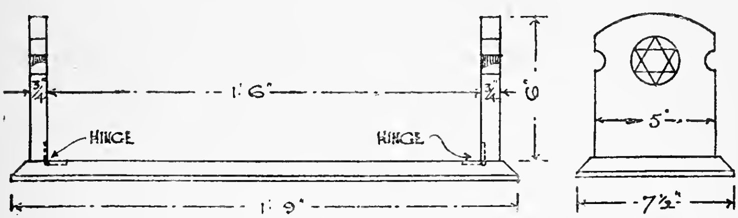


Fig. 4.—Section through Back piece, showing Plan of Under Shelf

from what has been said already. The top piece is perfectly square except for the hollowing out of the two front corners executed with saw or gouge. It is simply laid on the top of the back piece squarely, and nailed or screwed on. The bracket piece is cut to the curve shown, and should be screwed on, there being, say, one screw through the top and two inserted from the back.

Folding Book Rack.—The book rack shown in Fig. 5 is a base with plain or bevelled edges and two hinged ends. If desired these ends can be permanently fixed upright by means of screws inserted from underneath. Fig. 5 is



Figs. 5 and 6.—Two Elevations of Folding Book Rack

a front elevation, and Fig. 6 an end elevation, while Fig. 7 is an enlarged end elevation giving the construction lines by means of which the end pieces are correctly set out. The base is 1 ft. 9 in. by 7½ in. (finished sides). The bevel, or straight chamfer, is worked on it with a plane. Each end piece is 6 in. high by 5 in. wide (finished), and very little need be said about its shape, because Fig. 7 gives full particulars.

The perforated star adds considerably to the effect. It is set out as shown in Fig. 6, a circle being drawn and the radius stepped round with the compasses to give six points, the alternate points being then connected as shown. A hole could be bored in the middle of the star, and the points then cut out with saw or chisel.

The end pieces are each connected to the base piece by one brass hinge, although two hinges each would be an improvement. The hinges are carefully laid in position marked round with a sharp knife, and recesses carefully chiselled out to receive them. Drive in the screws straight so that their heads come perfectly flush.

Stool and Doll's Carriage.—Fig. 8 shows just the sort of article in wood the boy mechanic can make and at the same time give much pleasure to a young brother or sister. It is a stool 11 in. high, having a top 16 in. long by 9 in. wide, the end pieces being cut from pieces approximately 11 in. long and 8 in. wide (*see* Figs. 9 to 11). To give the whole thing strength the sides are preferably dovetailed in, and they will require to be cut to the shape and dimensions given by a full-size drawing; they can be got out of pieces each about 1 ft. 3 in. long and 5 in. wide. I shall not anticipate the information on dovetailing given in a later chapter, but may remark that the dimensions given in Fig. 12 will assist you in making a good job of it. If you do not feel up to the dovetailing, simply notch out the end pieces with a saw to receive the sides, and connect all together with screws or nails.

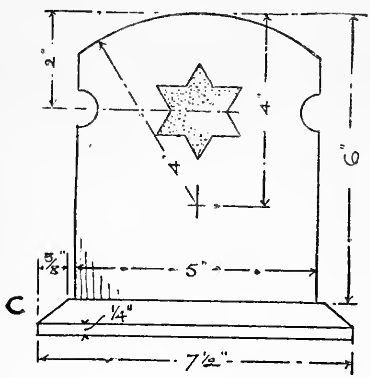
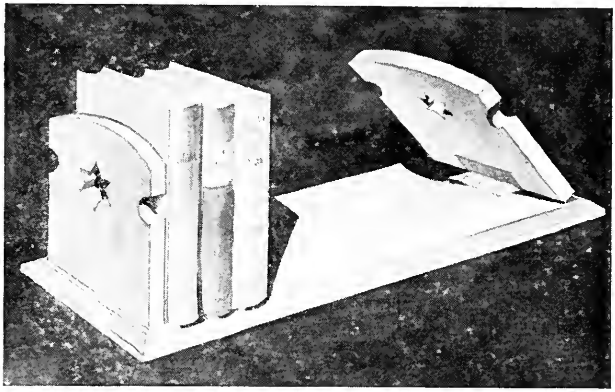


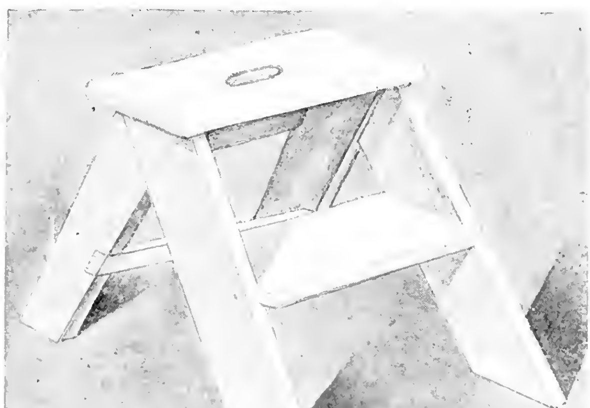
Fig. 7.—End of Book Rack

SOME EASY THINGS TO MAKE IN WOOD



Simple Bookrack with Hinged Ends

(*For Working Drawings, see page* 239)



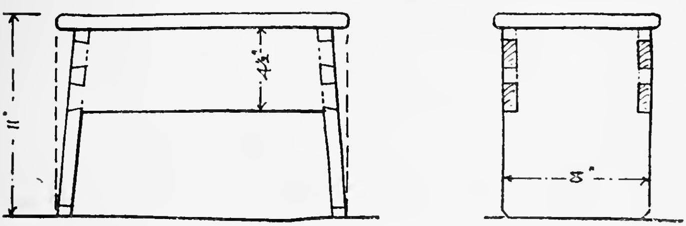
Pair of Dwarf Steps

(*For Working Drawings, see page* 243)

Some Easy Things to Make in Wood

A Pair of Dwarf Steps.—A pair of dwarf steps is very useful in a study or hall or workshop where articles just out of ordinary reach are continually being wanted. The steps shown on p. 243 stand about 18 in. high, and the two elevations given in Figs. 13 and 14 give most, if not all, of the essential dimensions. The steps will be made wholly of 1-in. pine, which, when planed up, will be $\frac{7}{8}$ in. thick. The front legs are $4\frac{1}{2}$ in. wide, and have a total length of about 22 in. Therefore, at least 3 ft. 8 in. of this width of stuff will be required. The back legs are about 1 ft. 6 in. long, tapering from $3\frac{1}{2}$ in. at the

Fig. 8.—Stool and Doll's Carriage



Figs. 9 and 10.—Two Elevations of Stool

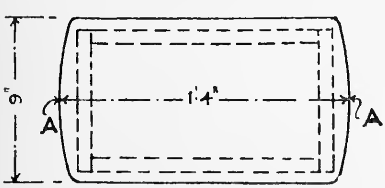


Fig. 11.—Plan of Stool

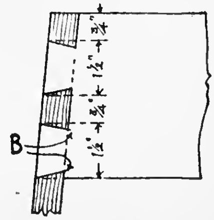
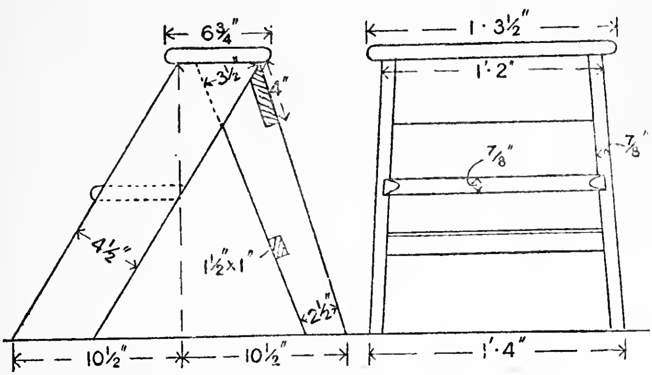


Fig. 12.—Side of Stool Dovetailed to Leg

top to 2½ in. at the bottom, as shown in the side elevation, and both of them can be cut from a piece 18 in. long and 6 in. wide. The one step and the top may be about 6¾ in. or 7 in. wide, although the step can be 1 in. narrower if desired. The top will be about 1 ft. 4 in. long, whilst the step will need to be accurately fitted in place, and will be about 1½ in. shorter than the top piece.

To get the various bevels correctly marked out, the best plan would be to draw the side and front elevations on a floor or on a table top with a stout pencil or crayon; or perhaps a piece of packing paper large enough for the purpose can be found. From the full-size drawing all the bevels can be transferred by means of the tool known as the sliding bevel, or even by means of a 2-ft. folding rule as long as the joint is not too easy. First draw a rectangle, letting the top and bottom lines fall on the ground line and upper surface of the top step in Fig. 13; then by measurement along both the horizontal lines, the points where the sloping sides start and finish can be easily ascertained and the correct angles determined. The wood can be actually applied to the full-size drawing, and risk of error in transferring measurements thereby reduced considerably. The side pieces must be cut to shape and "housed," that is, grooved to receive the ends of the steps.

There is more than one point in the construction in which you can please yourself. Where the front legs overlap the back ones just under the top, the two may be halved together, or halving may be dispensed with, and the two simply nailed or screwed together. The halving should be done after the back legs have been connected together. The steps are given rigidity by two rails which connect the back legs together—a top rail 14 in. by 4 in. and a lower rail 14 in. long by $1\frac{1}{2}$ in. by 1 in. Both these back rails are notched in, as clearly shown in Fig. 13, and nailed or screwed on. The top notch may, if you like, be wholly removed with the saw, whereas the bottom one requires two saw cuts and careful paring with a chisel.



Figs. 13 and 14.—Two Elevations of Dwarf Steps

There is no need to go into every detail of the construction. It is a simple article, which there will be no difficulty in making, and which can be modified to suit your own particular requirements. Only two parts are rounded or chamfered on the edges, namely, the top and the step. There is a hand hole in the top piece, the position of which requires to be set out before cutting. The simplest way of making the hole is to bore a centrebit hole at each end and connect the two holes with a fine saw, or to bore a row of centrebit holes, and complete the slot by paring with a chisel. It makes a good job to house or groove the underside of the top to receive the ends of the sides.

Bathroom Shelf.—Figs. 15 and 16 are almost self-explanatory. The article has two ends (for economy in cutting out, reverse the pattern of one as at B) with the shelf tenoned into them (*see* Fig. 17). In the fitment

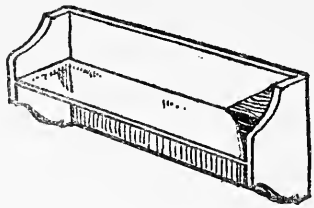


Fig. 18.—Bathroom Fitment with Glass Shelf

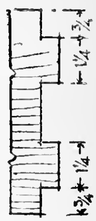
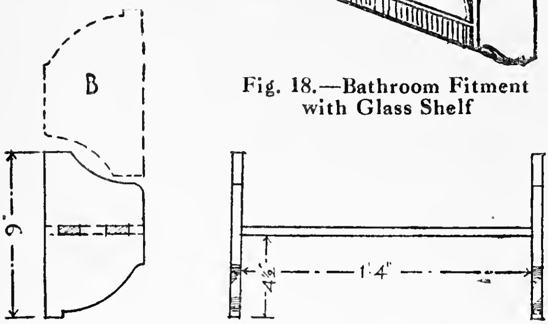


Fig. 17.—Tenoned End of Shelf



Figs. 15 and 16.—Two Elevations of Bathroom Shelf

shown by Fig. 18, the two ends are nailed or screwed to the back piece, and the actual shelf is a plate of glass with its front edges rounded off, supported in grooves in the two ends or on little ledges or fillets nailed or screwed to them.

ETCHING A NAME ON METAL

It is a very simple matter to etch your name on a knife-blade, and I used to find the job great fun. The principle is very simple. The blade is to be treated with a chemical that will act upon the steel, and those parts of the metal that are to remain as they are must be coated with something that will resist the action of the chemical. Now there are many chemicals that act upon steel, copper and brass, and among them are the following: (1) equal parts of pyroligneous acid, nitric acid, and water. (2) diluted nitrous acid. (3) 2 oz. of copper sulphate, ½ oz. of alum, ½ oz. of salt, ½ pint of vinegar, and 40 drops of nitric acid. These are among the simplest mixtures used for the purpose, and there are many more complicated ones; but the substance I used when I was a boy was something very much more simple. It was ordinary bluestone (sulphate of copper), a big lump of which can be bought from a chemist or an oilman for a trifle. It is made ready for use by crushing a little bit of it to powder, adding a tiny pinch of salt and moistening with water; or you can dissolve a larger quantity of the bluestone crushed fine with a little salt in a bottle with hot water. If you continue to add crushed bluestone until the water will not dissolve any more you will form a saturated solution, and this will be excellent stuff for etching knives, steel tools or anything else made of iron or steel.

Etching acids and solutions can be applied with a tiny bit of sponge or tissue paper tied to the end of a thin piece of stick, or, if it happens to be convenient, the article to be etched may, after careful preparation, be dipped into the solution. Of course, the longer the time for which it is dipped the deeper will the etching be. It is not usual to have the etching acids very strong unless particularly quick results are required. It is generally better to dilute them with water so that the effect of the corrosion may be carefully watched and stayed just at the right moment. Plunging into water and stirring round vigorously immediately stops the action.

If the whole of a knife-blade or tool unprepared in any way were immersed, the whole of its surface would be etched or corroded, and one result would be that the keen edge would disappear. Before dipping the blade every part that is not to be touched by the acid must be covered with something (known as the resist) which is not affected by the acid. In roughly etching a name on a knife-blade with powdered bluestone and salt, all that most boys do is to rub a thick film of soap over the blade, scratch the name in the soap right through to the steel beneath, fill up the grooves so made with the powder slightly moistened, and leave the whole for a few minutes. This is a rough and ready method, and not one which is likely to lead to a particularly neat result.

Say, for example, there is a steel, copper or brass plate to bear your name which it is proposed to screw down on the lid of a tool-box or school locker (*see* Figs. 1 and 2), you will want the effect to be as artistic and the workman ship as neat as possible. The soap method would be a trifle too rough, and, instead, you had better coat the whole

Fig. 1.—Etched Name-plate

of the plate (back and front and edges) with japan black, a small quantity of which you can obtain very cheaply at an oilshop. This should have several hours in which to dry hard. The name will be written by means of an etching needle, a piece of knitting needle held in a suitable handle, and finely but roundly pointed, or an old bradawl or anything similar can be sharpened up on a stone flag to answer the purpose. A sharp point is not necessary, as the object is not to scratch the metal, but simply to remove the resist and lay the metal bare. Having written

Fig. 2.—Etched Name-plate

the name, brush over the letters to remove any loose particles of the resist that might be clinging to the plate, and the latter might then simply be placed in a saucer and the etching solution poured on until the plate is covered. It is impossible to say how long the plates should be left in the acid, but if you make the solution

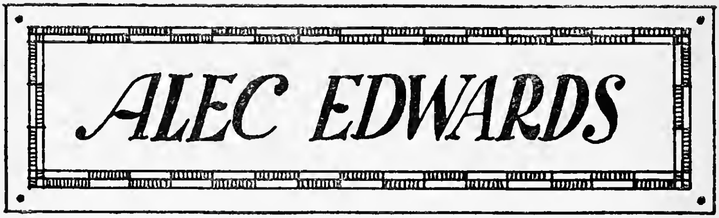


Fig. 3.—Etched Name-plate with "Stopped-out" Border

fairly weak, you can leave it in for ten minutes and still be on the safe side. If you don't wish to immerse the whole plate, you can dab on the acid with the little device already mentioned, or you can build a wall of modelling wax or candle wax around the edge of the plate and pour in the acid into the shallow recess so formed. Obviously, there will be no need to coat the edges and back of the plate unless the whole-immersion method is preferred.

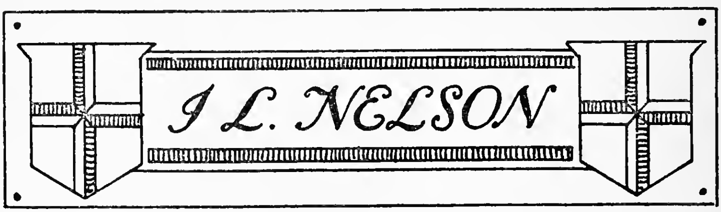


Fig. 4.—Etched Name-plate with "Stopped-out" Ornament

It is an easy matter to sponge off the acid and renew the treatment if the biting in is not sufficiently deep.

Rinse with water when the right depth of etching is reached.

Finally, you can wash off the japan black with some turpentine or paraffin oil, and the etched work be revealed in its finished state.

You can try all kinds of fanciful effects by etching some parts of the design more deeply than others ; for example, you could have a border line very slightly etched with your name more deeply etched inside the line. To get this effect, you would proceed in the ordinary way, and after a slight action had taken place, you could wipe out the acid from the border line, and coat the line with wax or japan black, allowing it then an hour or two in which to dry and afterwards renewing the etching action on the name. This method is known as " stopping-out " (Figs. 3 and 4 illustrate examples), and is very generally practised in commercial etching.

VARNISHING AND POLISHING

Varnishing.—I do not propose to say much about varnish. You will not be making your own varnishes, but will use what you buy ready made; indeed, oil varnishes cannot be made at home, as the linseed oil needs to be made hot before the varnish gums are introduced, and that is much too risky a game to be tried at home; besides, the making of oil varnish is an art beyond the amateur. All sorts of names are given to oil varnishes, but they mean very little. There is only one course if you want good varnish; go to a reliable dealer in decorators' supplies and pay a fair price. Tell him what you want the varnish for, and leave the choice to him.

In applying oil varnish, avoid dust. Do not work the stuff too much with the brush, and do not attempt the job in a room that is either cold or damp. If you think that the varnish is too thick, try standing it in a slightly warm place to see whether it gets a trifle more workable, but do not add any turpentine or oil to it or you will probably spoil it. If you think that two coats will make a better job than one, allow the first to get hard, and before applying the next, rub over with worn glasspaper or with a piece of wet felt or cloth on which has been sprinkled some pumice powder. As in the case of the enamel paint previously mentioned, apply neither too much nor too little.

Oil varnish can withstand a lot of wear and weather; on the other hand, spirit varnish, which is generally a simple solution of shellac, etc., in methylated spirit, and can either be bought ready made or prepared at home, can seldom resist either, and is, therefore, used chiefly on small articles where a bright finish is desired, but which will not be liable to rough usage or come much in contact with water. It needs to be applied quickly, and it dries very often almost as soon as it is on. The coat of shellac or other gum or resin which it leaves on the work is often rather brittle, but for all that spirit varnish answers excellently for small and fancy articles of a great many kinds. Following are two or three recipes which you may find useful. If you try them, see that the gum, etc., is quite dry, is crushed up fairly fine, and that the bottle containing the ingredients is kept in a nice warm place such as near a chimney breast, near a hot-water pipe or in a heated linen-cupboard. Give the bottle a shake up every day, and finally leave it for as long as possible for any impurities to sink to the bottom.

A favourite spirit varnish is "brown hard varnish." The name means anything or nothing, and I expect there are scores of different recipes for it. Here is one of the best: Dissolve 4 oz. of orange shellac, 1 oz. of resin, and ½ oz. of gum benzoin in 1 pint of methylated spirit. An excellent reddish-coloured varnish is made by adding a touch of bismarck brown to the above, or 1 oz. of dragon's blood. You can get a yellow tinge by adding a little piece of gamboge, a lump of which can be got from the chemist very cheaply.

There is also a "white hard varnish," and for this you can dissolve 4 oz. of gum sandarach and 2 oz. of gum-thus or Venice turpentine in 1 pint of methylated spirit.

The following is a bright varnish which is not so brittle as the usual spirit varnish :—Dissolve 1 oz. of resin, 2 oz. of gum sandarach, 6 oz. of shellac, and 1 oz. of Venice turpentine in from 1 to 1½ pints of methylated spirit.

An everyday spirit varnish is simply a solution of a few ounces of shellac in 1 pint of methylated spirit.

Polishing.—I wonder how many of my readers will be ambitious enough to attempt what is known as french polishing. I shall merely outline the process here. It gives a much more beautiful finish than varnishing, and consists of applying a coat of shellac to the work and then bringing this to a lustrous polish by means of friction. You must first prepare the surface with glasspaper and then fill up the grain by rubbing over it a rag dipped into a creamy paste consisting of whiting and turpentine. Rub away the surplus "filler," and see if there are any nail holes or defects that require to be made good. If there are, you can fill them with melted shellac, although the proper material to use is a hard stopping known as beaumontage, and containing shellac, resin, beeswax, and colouring matter. This can be bought ready-made, and is run into the defects by means of a hot iron, cleaning off the surplus when cold with a scraper and glasspaper.

The job is first to give the work a sound, even coating of shellac. This is done by going over it many times with french polish, which can be bought ready-made or prepared at home by dissolving 6 oz. of shellac in 1 pint of methylated spirit. The polish is kept in a bottle, and when required for use is allowed to drip into a little pad of wadding, which should then be covered with a piece of clean dry rag, previously thoroughly well washed free from dirt and dressing. By having the rag of ample size and giving it a twist occasionally, the polish can be squeezed out of the rubber on to the work. The rubber meets with some resistance in use, and, to lessen it, you may apply just a spot of raw linseed oil to its face, but the less oil you use the better. Work the rubber in a series of overlapping circles or figure eights, and when you have got on as much shellac as you can, let the work rest for a day in a situation protected from dust, cold and damp. Give it another coat and yet another, observing the precautions before mentioned, and when you are satisfied that you have obtained a good body of shellac, you can start the particular stage of the process in which trouble, if not already met, makes its entry !

Now what you have to do is to wash the film of shellac with spirit and polish it by the passage of the rubber, but you must avoid washing it all away. You will need a clean outer rag—or two or three rags one over the other—on the polish rubber, but do not add any more polish. Add, instead, a little methylated spirit, and, as it dries out, add a little more, and continue in this way until, as the job nears its end, there will be very little polish left in the rubber, the spirit having taken its place. The rubbing continues until the polish is attained. I doubt whether a long chapter on the subject would succeed in teaching you the polisher's art. I shall make no attempt to do that, however; I have simply outlined the process, and you can experiment to your heart's content if you so wish. French polishing is one of those jobs that ought to be easy from the description of how it is done, but—wait and see.

There is one little trick (it is not used by the best polishers) by which you can avoid some of the risky later stage—the spiriting-out—and yet get a passable effect. Having progressed a little in the polishing of the shellac film, do not continue with the rubber, but brush on a coat, or even two, of a glaze or varnish made by dissolving 6 oz. of gum benzoin in 1 pint of methylated spirit. Of course the result is not so good as that given by the true french polish.

Dull Polishes.—French polishing is often garish in its effect, but can be made to look very good by dulling it with friction from a pad of felt made wet with linseed oil and sprinkled with pumice powder or the finest emery.

Probably the best dull polish is also the simplest, and is obtained by rubbing on, with a rag or a brush, some beeswax dissolved in turpentine. You simply rub it on, and then with a cloth or another brush do your best to rub it off again. Repeat the process as many times as you like, and with every repetition the quality of the polish will improve. After a time you need not apply more wax, but simply more friction.

Rubbing with linseed oil, either raw or boiled, in much the same way as wax polishing is done, will, in course of time, produce a dull polish; but the work is laborious, and will require many applications and plenty of elbow grease. It is the ideal polish for finishing the woodwork of tools, particularly plane stocks.

MAKING HUTCHES

Most boy carpenters try their hand some time or other at making a rabbit hutch, which occasionally is nothing better than a lidless box placed on its side with the opening covered in partly by wire netting and partly by a wooden door, there being a partition to separate the "living-

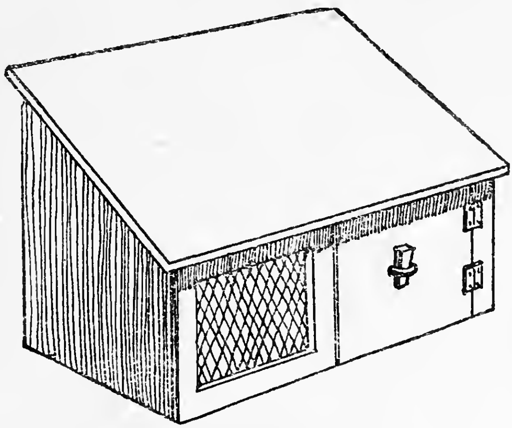


Fig. 1.—Rabbit Hutch

room" from the "bedroom." In Fig. 1 is shown something a trifle more ambitious, although, of course, it is little more than a box divided up as above explained. Fig. 1 is a view of the hutch complete; Fig. 2, a front elevation; Fig. 3, a cross section; Fig. 4, a horizontal section showing the dividing up of the hutch into two apartments ; and Fig. 5 is another front elevation of the hutch with the outer door open or removed to show the inner door, to which reference will be made in due course. The remaining illustration (Fig. 6) shows exactly how the hutch is arranged internally.

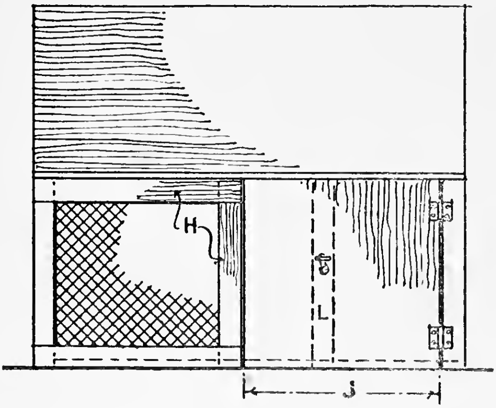


Fig. 2.—Front Elevation of Hutch

You can either build up the box from any material you happen to have at hand, say $\frac{1}{2}$ in., $\frac{5}{8}$ in., or $\frac{3}{4}$ in. thick, or you can adapt a box or packing case to your needs. Assuming the latter, remove the lid, and very carefully prise off one of the sides by means of an old chisel or screwdriver. The lid and side will help to make the roof and to increase the height, if necessary, by adding triangular side pieces C (Fig. 6) and back piece B. To hold these in place, two strips D at each of the internal corners will be necessary, nailing these with fine wire nails to the lower part of the box, as will be readily understood from the illustration. You can please yourself whether you

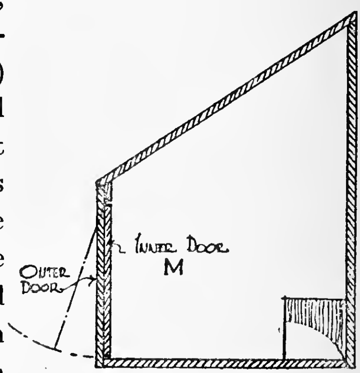


Fig. 3.—Cross Section through Hutch.

use another strip near the front or whether you secure C to the piece underneath by driving a nail down through C from the top edge.

The partition F should be in one piece if possible, but if obliged to make it in two, you can connect them together with a couple of strips at right angles to the joint. The partition will be secured with two or three nails driven through from the back of A and B and with a couple of nails driven through from underneath. Before securing the partition, however, it is necessary to cut out a square of 4 in. or more, as indicated at G, to give access from one apartment to the other.

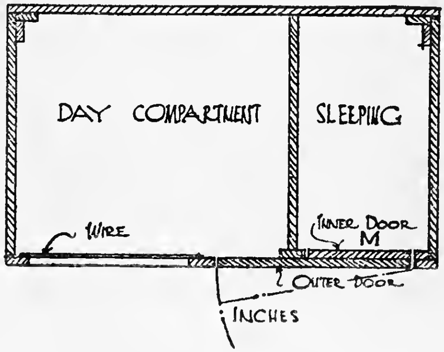


Fig. 4.—Horizontal Section through Hutch

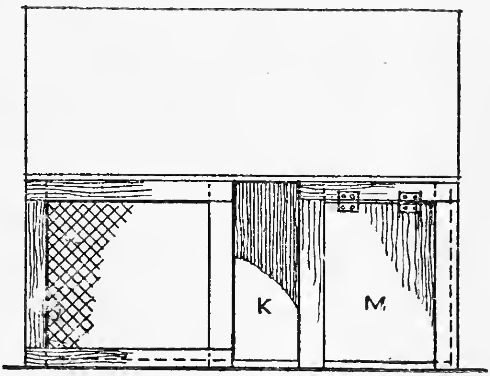


Fig. 5.—Front Elevation of Hutch, with Outer Door Removed

You can next proceed with the lid, and as you are unlikely to be able to find a board sufficiently wide, you will need to build it up of two or three widths and nail them down to a couple of fillets which will come on the underside of the roof, and be, therefore, hidden. In the section (Fig. 3) the roof is shown as being flush at back and front, but a better idea is to make it as shown in the general view (Fig. 1), that is, with a projection at front and back and also at sides. Always remember that damp is the great enemy of the domestic pet. Poultry, rabbits, dogs and even bees soon lose their health if obliged to exist in damp surroundings, and it is therefore an advantage to carry out a roof as shown for the purpose of throwing off rain. You can fit the roof, but do not fix it yet awhile, and remember to take care in deciding the height and arrangements of the outer door that it is not prevented from opening by the front over-hang of the roof. I mention this point because you are not likely to carry out the design in every detail as it is here shown; you should study the requirements for yourselves, and make the instructions and illustrations here given merely a basis for your own particular adaptation.

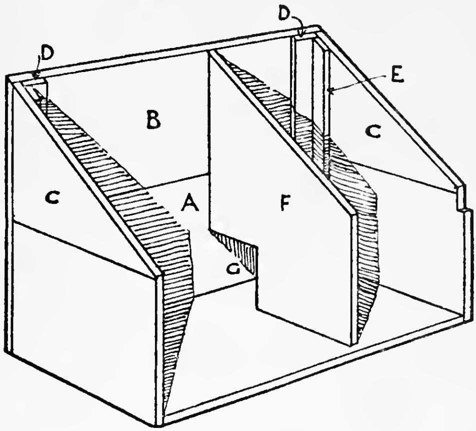


Fig. 6.—Internal Arrangements of Hutch

The front of the hutch consists of two parts: (1) a frame H with wire netting, or even straight vertical wires about 1 in. apart, and (2) a wooden door which covers just about half the entire width of the front. The frame on which the wire netting is stretched is simply four pieces of $\frac{5}{8}$-in. or $\frac{3}{4}$-in. stuff, halved at the ends to make good joints. It is either nailed in or hinged on.

Make the frame and attach the wires or netting before building the frame into the hutch; it is secured with nails to the edge of the bottom board and to the edge of the side piece. A couple of nails through the roof when this is finally fixed will strengthen the job.

You will note in the illustrations that there are two doors, an outer door L, and an inner door M. The outer door is hung from a post or strip and nailed to the front edge of the side piece. It should close flush with the frame H, and when it is open, there will, of course, be discernible a space between the right hand edge of H and the partition. You can quite see that in frequently opening the door to handle the rabbits or for purposes of cleaning the hutch, you would disturb any occupant of the sleeping apartment were it not for the inner door. A doe with new-born rabbits must not be disturbed.

The inner door opens vertically, and is simply a piece of board hinged to a horizontal strip which fits in the notch shown to the extreme right of Fig. 6, and is nailed to the front edges of side and partition. At the front edge of the partition underneath the strip last mentioned is nailed a vertical strip flush with the front face of the door M.

Little more need be said, but you will notice in Fig. 1 a wedge through a staple, and in Fig. 2 a small padlock through a staple. You will please yourself which of these you adopt. The staple is driven into the strip on the front of partition F and a hole or slit is cut in the outer door to receive it, all being fastened up by means of a wedge or padlock as shown.

All the woodwork being finished, you can paint the outside of the hutch if you so wish, and cover the roof with some tarred felt, which should project slightly from the boarding to which it is tacked down. See that ventilation holes are bored high up in the back and side of the hutch. I have not shown any dimensions, because these will, of course, depend upon the box which you propose to adapt; but you will scarcely wish to make a hutch from a box smaller than 3 ft. long, and about 2 ft. deep.

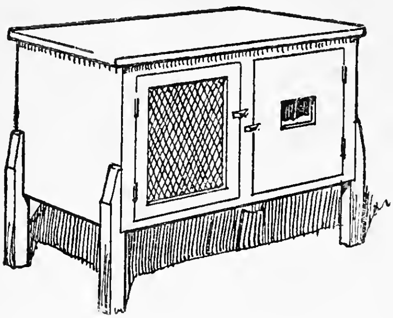


Fig. 7.—Ferret Hutch

Another Hutch.—The hutch which I show in Fig. 7 was specially designed for use as a ferret hutch, but is generally applicable to many different uses. Fig. 8 is the front elevation, and Fig. 9 is a cross section. The hutch can easily be converted from a box or packing case, or can be built up of $\frac{5}{8}$-in. or $\frac{3}{4}$ in. boards. A few suitable dimensions are suggested in the illustrations, but they can be varied to any extent. Four legs will be required, and these may be of square or rectangular section and of any suitable thickness, 2 in. by $1\frac{1}{4}$ in. being suggested in the illustrations.

You will note that these legs require to be notched out so as to give better and stronger support to the hutch. They are secured by a couple of screws or nails inserted from the outside of the legs into the side of the hutch.

A strong packing case, 3 ft. long and 18 in. deep, is suggested in the illustrations, but you will use just what you can get as near to these sizes as possible. The front of the box consists, first of all, of a rectangular frame made of ½-in. by 1-in. stuff, and halved at the four corners as shown in Fig. 10. At the centre will come an upright

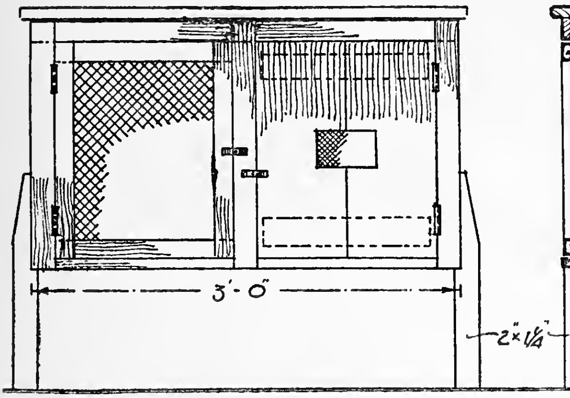


Fig. 8.—Elevation of Ferret Hutch

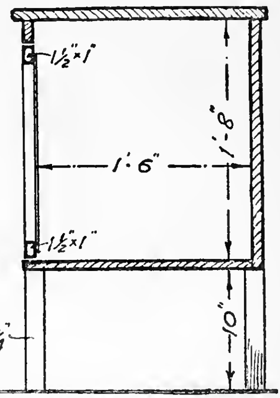


Fig. 9.—Cross Section through Ferret Hutch

piece, which will be halved into the frame at top and bottom, as shown in Fig. 11; it will carry two buttons, one for the wooden door to the right of the hutch, and the other for the frame to the left. The framing is made of 1-in. stuff, lapped at the ends, and covered with quite fine wire mesh. The door to the right will probably have to be built up of two widths, nailed to strips or ledges, which are indicated in dotted lines in Fig. 8. In the middle of the door is a small rectangular opening of any size, but not less than 5 or 6 in. across, and this also should be covered with very fine mesh, or with wire gauze. It will be obvious that the upright in the middle of the front will come on the front edge of a partition piece, which can be secured in position exactly as in the case of the rabbit hutch already described, and in this partition there will need to be made a small hole so that the animals can pass from one compartment to the other. By means of the big doors shown, it will be an easy matter to get at the hutch for cleaning purposes.

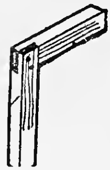


Fig. 10.—Joint in Hutch Framework

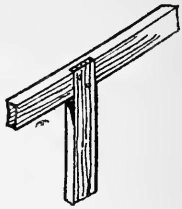


Fig. 11.—Joint of Front Upright to Framework

HOW TO SILVER GLASS FOR MIRROR MAKING

I SUPPOSE most boys have wondered at times how a piece of glass is converted into a looking-glass, and many have got hold of recipes and have tried their hands at the job. A state of "chemical cleanness" is essential at every step and in every one of the materials used, and this is not easy to attain. In the old days, a sheet of lead-foil was laid down on a special bench or table and treated with plenty of mercury, which amalgamated with the lead to produce a bright alloy, on to which the cleaned glass was floated. Glass easily floats in mercury. Next the bench had to be tilted to drain off the superfluous mercury, the degree of the tipping being increased day by day until, in the course of perhaps three or four weeks, the alloy or amalgam was dry. But the boy mechanic is not advised to play about with mercury for any length of time, as its vapour is poisonous. Nowadays, mirrors are made by precipitating silver from a chemical solution upon glass that has been made perfectly clean.

Probably the safest and easiest method is the one here described, for which you must get from the chemist a bottle of distilled water, 180 grains of silver nitrate, 150 grains of caustic potash "pure by alcohol," 75 grains of glucose, and a small quantity each of nitric acid and of liquor ammoniæ. No other method employs cheaper or fewer ingredients. Potash and glucose are too cheap to buy by the grain in the ordinary way, but you need to be correct in your proportions; but if you have a delicate balance you can measure out the ingredients for yourself.

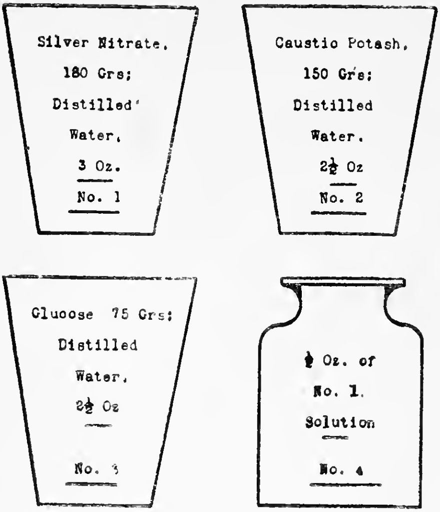


Fig. 1.—The Solutions used in Silvering Glass

First clean three tumblers and a small bottle with dilute nitric acid, which will leave them chemically clean, and then rinse them with distilled water.

In tumbler No. 1 place the silver nitrate and 3 oz. of distilled water (1 pint of water is 20 oz.). See that the nitrate is all dissolved, and then transfer ½ oz. of the solution to the bottle (No. 4.) *Don't let this solution touch the fingers or it will blacken the skin.* The discoloration will wear off in the course of a few days.

Silver nitrate is the "lunar caustic" of the chemist's shop, and is useful in certain cases of skin affection, the blackening being partly due to the formation of metallic silver; in mirror making the glucose solution acts much in the same way as the cuticle of the skin in "reducing" the metallic silver.

In tumbler No. 2 put the potash with 2½ oz. of distilled water.

In tumbler No. 3 put the glucose and add 2½ oz. of distilled water.

The three tumblers and one bottle are shown in Fig. 1.

To tumbler No. 1 add a few drops of the ammonia to cause a muddy brown colour to appear. Then add more ammonia, drop by drop, until once again the solution is clear and bright. For pouring out drops of the liquor ammoniæ loosen the stopper (never use a cork, as it would soon be eaten through) and tilt the bottle to and fro to allow a drop or two to leak out.

You remember that ½ oz. of the silver nitrate solution is in a bottle (No. 4). Add some of the contents of this bottle to tumbler No. 1, drop by drop, until for a second time the solution loses its clearness; when held up to the light it will be of a translucent yellow colour.

Next, to tumbler No. 1 add the potash solution from No. 2, the result being a blackish liquid. Again add ammonia, drop by drop, and stir with a chemically clean glass rod all the time until the liquid is much clearer and the precipitate (a powder falling to the bottom of the vessel) is full of black particles. Strain the whole by pouring it through a chemically cleaned glass funnel in which a piece of fresh cotton-wool has been placed to act as a filter (*see* Fig. 2); or, if this is impossible, allow plenty of time for the precipitate to settle, and then pour off the clear liquid. To this clear liquid add, drop by drop, more of the silver nitrate solution from the bottle until a very slight precipitate appears, when you must instantly stop the addition.

The glass should be "patent" plate, and has two distinct sides—a right and a wrong. These may be distinguished, after chemically cleaning as described, by breathing upon them. The film of condensed moisture will leave the right side rapidly and evenly; this is the best one to be silvered, while on the wrong side the condensed vapour will dissipate slowly and irregularly.

Get a dish—say a photographer's glass developing dish—of such a size that it will easily accommodate the glass to be silvered, both dish and glass being chemically clean, of course. Set the dish level, pour in the solution, and add distilled water to give sufficient depth. But before immersing the glass, pour in the glucose from tumbler No. 3, stir up, and then introduce the glass, slanting it so that it will not carry down air bubbles with it. The glass would ordinarily settle on the bottom of the dish, but this must be prevented, either by two blocks of glass seccotined to the dish at the extreme sides or ends (*see* Fig. 3), or, instead, a piece of wood must be cut out as in the sectional view (Fig. 4), and the glass be cemented to it with pitch. (At the proper time it is easily removed with a thin chisel carefully inserted at the edge.) Whatever arrangement is adopted, there must be a space of about $\frac{1}{4}$ in. between the underneath surface of the glass and the bottom of the dish.

As the glass is lowered into the solution the latter becomes of a purplish-pink colour, becoming gradually darker. In the course of 15 to 30 minutes the silver will have deposited on the glass, which may then be removed, carefully washed, and placed on edge to dry. This accomplished, the silver may be polished for a quarter of an hour with a pad of cotton-wool covered with a soft fine washleather.

A silver film is deposited also on the surface of the dish, but the greatest quantity separates as a fine powder and is lost, from the silverer's standpoint.

The above is particularly adapted for silvering the

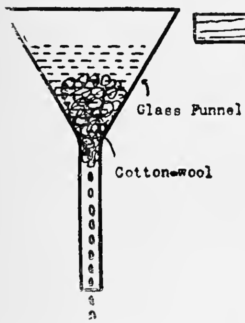
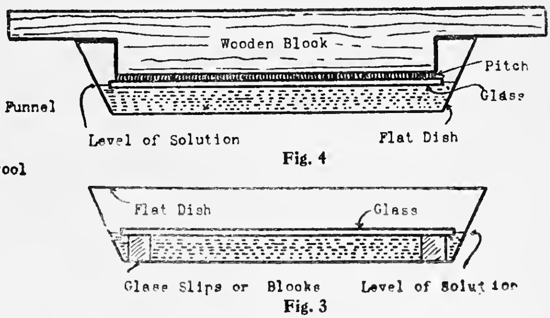


Fig. 2.—Filtering the Solution.



Figs. 3 and 4.—Methods of supporting Glass in the Silvering Dish

speculum of a telescope or microscope, but can be used equally well for small pieces of plate glass.

The silver film when formed must be protected, or it will very quickly lose its colour from contact with impurities in the air, notably sulphur; for this reason the film should be coated twice with good copal varnish, after the silver is quite dry, and when it is slightly warm. Use a very soft brush. The mirror will reflect from both surfaces of the film, and for certain optical work, where the reflection is not through the glass, the film must not, of course, be varnished.

WATERPROOFING TENTS, GROUND SHEETS AND GARMENTS

WATERPROOFS of the oilskin kind are easily made. Most people know that they are cotton, linen or even silk dressed with boiled linseed oil repeatedly, but few are aware that to get the best results only the "double-boiled oil" should be used, this giving the familiar yellow colour, drying better than ordinary boiled oil, and having more marked waterproofing qualities. To get black waterproofs, you merely add to the oil some oil black or vegetable black, but not lampblack.

Let us assume that you are going to waterproof a tent canvas or a number of ground sheets which are to be used on a camping expedition. If you have not the use of a suitable heated kitchen, in which to hang the sheets for drying, do the work on a sunny day and hang them in the open. Spread the canvas, new and unwashed, on a table, or on some clean boards propped up to form a bench, have the oil in a wide vessel close at hand, and mix nothing with it but the colouring matter if this is needed. Apply the oil to the canvas, etc., by means of any suitable bristle brush, such as an old clothes-brush. Don't try to saturate the cloth, but do your best to get a good even coat. As you finish the pieces, lightly fold them and push them out of the way until all have been done. Then pull them out straight and hang them up to dry, a process that will take from one to several days, according to the drying facilities, weather, etc.

When thoroughly dry, the canvas is shaped, sewn and otherwise worked up, and is then given two more coats of the oil, allowing each to get thoroughly dry. If much used, the sheets can be given a reviving coat every summer to keep them in good condition. Of course, if you like, the sheets, garments, etc., can be made up wholly un-oiled, and the oiling done as a finishing process, but there is a great likelihood of wrinkles and puckers if you work on this system, as the first coat of oil shrinks the fabric. You will find that the second and third coats go on much more easily than the first.

Oilskins, however, are not always suitable, and what is known as "chemical" waterproofing, which scarcely affects the appearance of the fabric, is preferred. This, too, is easily executed. In principle it consists in filling up the fibres of the cloth with a soap that will not dissolve in water. You need to prepare two solutions. No. 1 is a solution of 1 lb. of best yellow soap in 1 gal. of water, and No. 2. is, similarly, 1 lb. of alum in 1 gal. of water. You can the more easily prepare the two solutions fairly hot, but use No. 1 warm and No. 2 slightly warm. Put the fabric in No. 1, and allow it to stay for at least half an hour so that the soap gets on every particle of fibre. Then remove it, wring it over the vessel, smooth it out, and transfer to No. 2 (alum) solution for a second half-hour's treatment. Again wring out the cloth, rinse it in clean water, again wring out (or pass it between the rollers of a wringer), and hang up to dry in the open air. That is simple enough, but it is very effective.

MAKING DOVETAIL JOINTS IN WOOD

There can be no satisfaction of the boy mechanic's ambition until he has tried his hand at a dovetail joint. Now, the job is not so difficult as it looks, but for a start make a fairly big joint in stout common wood. It ought to be unnecessary to advise the reader to practise on

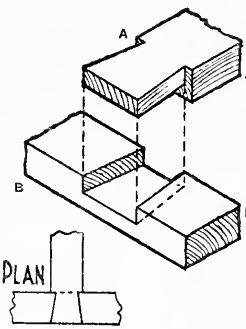


Fig. 1.—Half-lap Dovetail Joint

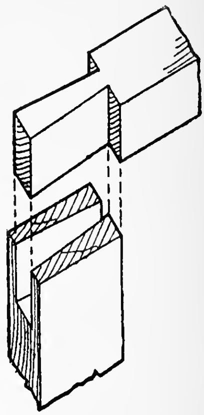


Fig. 2.—Single Dovetail Joint

model joints before attempting to dovetail together the sides of a nice box or drawer, but is it? When ambition and skill run a race, which wins?

Single Dovetails.—First let us make a "single" dovetail—just such a joint as we might use in constructing framework. Both Fig. 1 and Fig. 2 are "single" dovetails, the former being generally given the name of "half-lap dovetail." Bearing in mind the method of making an ordinary half-lap joint (*see* p. 30), this form of dovetail will prove easy enough.

You must not think that the wider you make the outer end of the "tail" the stronger the joint will be. The angle of the sides of the "tail" should not exceed *about* 15°, as shown in the diagram (Fig. 3). In very hard,

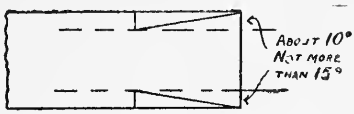


Fig. 3.—Diagram showing Dovetail Angle

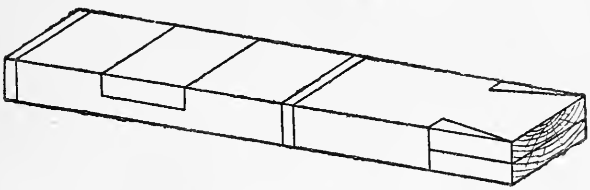


Fig. 4.—Model Half-lap Dovetail Joint set out

tough stuff, the angle may be more, and in soft, weak wood, as little as 10°.

The two parts of a lap dovetail joint are set out as in Fig. 4. The square, gauge and bevel are the setting-out tools required.

But how is the blade of the bevel to be set to the required inclination? Take any planed-up piece of wood and square a line A B (Fig. 5) across it, and divide the line into inches (or other uniform parts). Set off on the edge of the board to one side of the line a space of 1 in. (or one part). On a narrow piece of stuff, make all the distances half-inches; but the larger the unit the greater the accuracy. Number the divisions on the line, say 1 to 5 or 6 (not shown in Fig. 5). Divide space 2-3 into two parts, the space 3-4 into three parts, and number them as indicated, respectively $2\frac{1}{2}$, $3\frac{1}{3}$ and $3\frac{2}{3}$. Place the sliding bevel on the edge of the board with the blade right over the 1-in. mark to the left of the line, and let its point reach the $3\frac{1}{3}$ mark on the line A B. Tighten the clamp of the bevel; it will now be set at 15° to 16°, and with sufficient accuracy for the purpose. Setting the blade to mark 5 gives an angle of approximately 12°, and to mark $2\frac{1}{2}$ an angle of 20° to 22°.

Professional workmen use a little template for marking out dovetails, and I think you will find its use makes for ease and accuracy. You can easily cut one for yourself. Set out a piece of tinplate as in Fig. 6. This can be any length, but 4 in. or 5 in. will do admirably, and the width may be $1\frac{1}{2}$ in., more or less. The dotted line shows where it will be bent at right angles to the shape given in the side view (Fig. 7). You will first have made up your mind as to the angle to which the dovetails are to be cut, and will then set out this angle from the end of the metal to the shoulder line. The shaded parts are now to be cut out with snips, strong heavy scissors, or with hammer and chisel, finishing very carefully to the line with a file. The method of cutting must depend upon the thickness of the metal. After cutting, the piece will be bent as shown, with a hammer, over the square edge of a board. Now if this little template is put on the edge or end of the pieces which are to be jointed, it will be a very simple matter to scratch the correct outline of the dovetail by

DOVETAILING

Cutting Dovetails with Dovetail Saw

Finishing Single Dovetail Socket with Chisel

means of an awl or the point of a knife. The template will last a lifetime.

First we will cut the pin on the piece A (Fig. 1). The shoulder of the joint must be set out with a square or gauge on all four sides of the piece. Across the end grain of the stuff gauge a line at half the thickness, and square this line down on the edges to meet the shoulder lines already set out. Put the stuff in the vice, and saw down with the grain parallel with the face until you reach

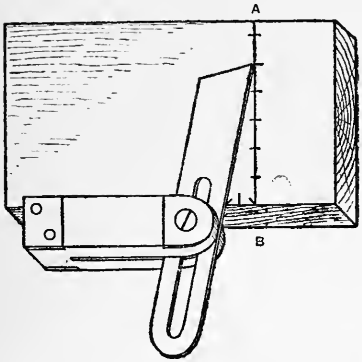


Fig. 5.—Obtaining Dovetail Angle with Sliding Bevel

Fig. 6

Fig. 7

Figs. 6 and 7.—Metal Template before and after Bending

the shoulder lines. You must next remove a half thickness of stuff, so on that face opposite to the one where the dovetail is to be, cut in with a saw to half the thickness, so as to detach a piece of wood. Next with a saw cut in on the shoulder lines on the edges until you reach the slant lines that define the sides of the pin. Then put the work, slightly inclined, into the vice, and remove the waste chip by chip with the chisel, the handle being held in one hand, and the lower part of the blade between the thumb and first finger of the other.

For the setting out of the socket piece B (Fig. 1), either the bevel or the little template can be used, the lines being squared down on the two edges to meet a horizontal line at half the thickness, which will be obtained by means of the gauge. The waste will be removed by sawing down on the slanting lines and then with the chisel taking out the stuff chip by chip, as explained on page 273. A more accurate method of setting out the socket piece is to use the pin already worked as the template or pattern, laying it on the second piece of wood and marking the outline of the socket by means of awl or knife, taking care afterwards to saw down to these lines in the waste, the reason for which precaution I have already remarked on in an earlier chapter (*see* Fig. 8).

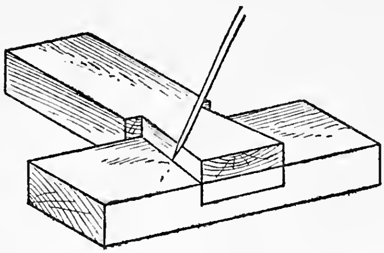


Fig. 8.—Scribing Socket from Half-lap Dovetail

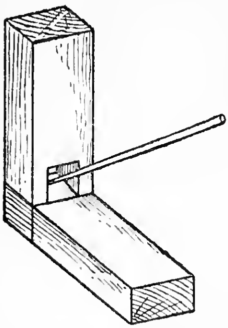


Fig. 10.—Scribing Pin from Socket of Single Dovetail

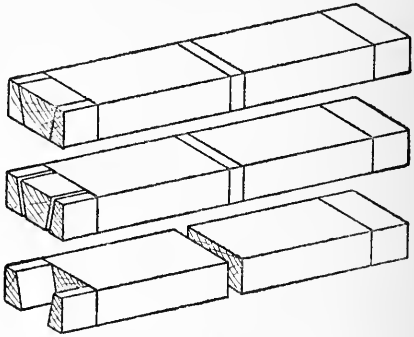


Fig. 9.—Single Dovetail Set Out, and the Socket Sawn and Worked

The form of single dovetail shown in Fig. 2 is excellent for framework. In this case it is better to cut the socket first and to mark out the pin from this. As before, you need to see that the shoulder line is squared on all four faces (Fig. 9), while the slant lines across the end must be set out by means of bevel or template ; lines connecting these slant lines to the shoulder lines on face and back of stuff are then drawn by means of square and pencil. Put the work vertically in a vice, saw down on the slant lines, and remove the waste with a chisel as usual. Place the socket piece on the other member of the joint to form a right angle, and with a slender awl scribe the shape of the pin on the work as shown in Fig. 10. Square the shoulder lines and also the lines across the end, then saw down outside the slant lines, and cut in from the side so as to detach the two small pieces.

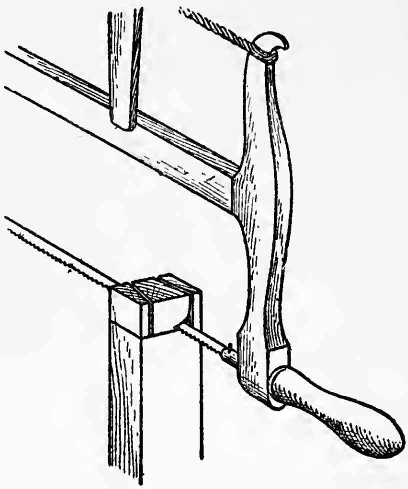


Fig. 11.—Sawing Out Waste of Large Single Dovetail

Often it is possible to save a great deal of time in cutting out a large dovetail socket by using a bow-saw, as in Fig. 11, cleaning out the socket by means of a chisel. The bottom of the socket is finished with the chisel held bevel outwards, the work being laid on the bench with the narrower part of the socket uppermost—a most important point.

The Box Dovetail.—There is a great variety of dovetailed joints, but I propose to explain only one more, and that is the box or common dovetail (Fig. 12). For a start, do not attempt to make a very fine joint, but work in common wood, and make the angle of the dovetail slight. As in all joint making, the setting out is of the greatest importance, and this setting out can only be properly done after the wood has been carefully planed up smooth and parallel, and the edges have been shot true.

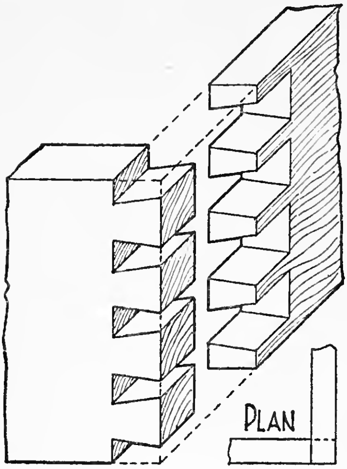


Fig. 12.—Common or Box Dovetail Joint

I have already explained what "shooting" is. The work is held in a shooting board over which its edge very slightly projects, and a keen plane is then "shot" along to take off a very fine shaving or two from the end grain.

Shoulder lines must now be squared or gauged round (*see* Fig. 13) on both pieces, and, as in all joints of this simple kind, these lines will be distant from the ends of the stuff by an amount exactly equal to the thickness of the stuff. In the first place, it is easy to get confused as to which

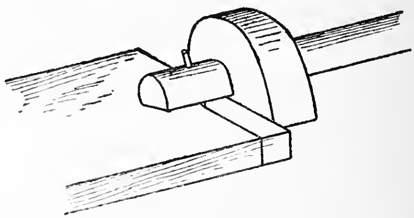


Fig. 13.—Gauging Shoulder Line for Dovetail Joint

piece carries the pins and which piece contains the sockets, because, as a matter of fact, there are pins and sockets on each of them; but in the joint shown by Fig. 15 the part that carries the four thin projections has the "pins" whilst in the other are two complete sockets and two half-sockets. Woodworkers do not agrce among themselves as to whether the pins or the sockets should be cut first, but I am going to describe the "pin first" method, and I think you will find it quite satisfactory.

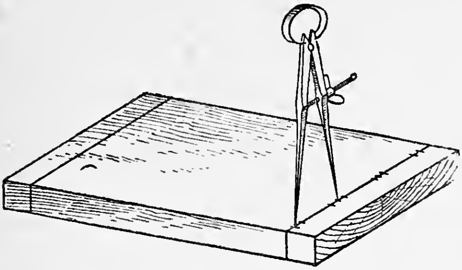


Fig. 14.—Spacing Dovetail Pins with Dividers

We will have chosen two pieces of board in which two complete pins and two end pins can be cut, as in the illustration (Fig. 15). The shoulder lines have been squared round. At the extreme ends mark off on the face from each edge half the thickness of the thinnest part of a pin. This "thinnest part" is shown on the edge of the socket piece, and its dimension varies with the thickness of the stuff that is being joined up. For wood up to $\frac{3}{4}$ in. thick, the thinnest part of the pins may be $\frac{1}{4}$ in. thick, but don't aim at too fine work at the start. With dividers or compasses (*see* Fig. 14)

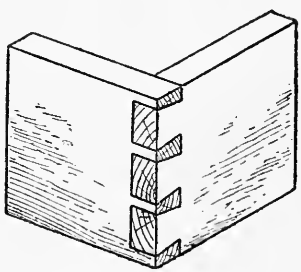


Fig. 15.—Common or Box Dovetail Joint

divide the space between the two points already marked on the shoulder line into three, and set off on each side of these marks half the thickness of the pin. Set off that distance also inside the two end marks already made. Next, with a small try-square and an awl, draw lines from the shoulder line to the end of the work to indicate the sides of the pins (*see* Fig. 16).

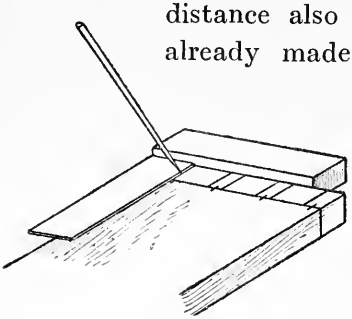


Fig. 16.—Squaring Down Dovetail Pins

The slant of the dovetails will now need to be indicated on the end grain of the piece, for which purpose you must fix the wood vertically in a vice, and by means of a bevel or template (*see* Figs. 17 and 18) mark the ends of the pins across the end grain, continuing the work by means of the square on the back of the work so as to draw the sides

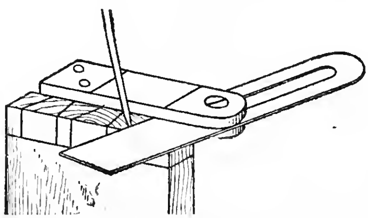


Fig. 17.—Marking Ends of Dovetail Pins from Sliding Bevel

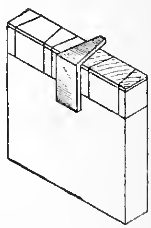


Fig. 18.—Marking Ends of Dovetail Pins from Template

of the pins as far as the shoulder line. The little template illustrated can easily be made by the boy mechanic in wood, or, as already explained, in metal, or it can be bought ready made.

Keeping the wood fixed vertically in the bench vice, cut down with a fine saw on the slant lines which cross the end grain, but see that the saw cuts keep accurately to the parallel lines that have been squared down from the end to the shoulder lines. A chisel is used for cutting out the waste, but, by the way, first make sure which *is* the waste, and to prevent mistakes it is better after setting out to mark with a pencil cross any stuff that is to be removed, as otherwise an accident or mistake is the easiest

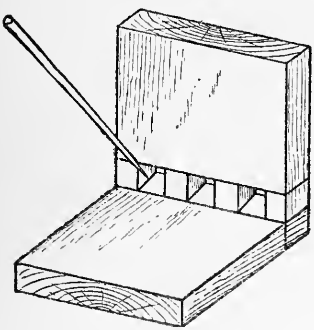


Fig. 19.—Scribing Dovetail Sockets from Pins

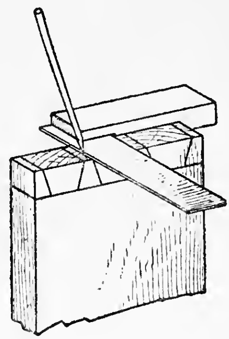


Fig. 20.—Squaring Ends of Dovetail Sockets

thing possible. Your best plan will be to use a fine carving chisel, particularly if the work is rather small. Clean out the recesses between the pins, and do everything you can to produce sharp, true edges, and a perfectly flat bottom to each of the recesses. Of course, each recess is really a socket, but if I label them "sockets," you may easily become confused between the pin piece and the socket piece.

This box dovetail is really, as by this time you will have discovered for yourself, a number of single dovetails cut side by side in the same piece of wood, and you will therefore be prepared to understand that the socket piece is set out by " scribing "—that is, the pin piece is laid on the other member of the joint (on which the shoulder lines have already been squared), and a slender pointed awl is used as in Fig. 19, to " scribe " the shapes of the sockets from the pins.

As all you have so far marked on the socket piece is the shoulder line and the slant lines on one face, you will need to use a square (Fig. 20), and continue the socket lines across the edge of the stuff. The sockets are cut out in exactly the same way as the pins were formed, having previously taken the trouble to mark with a cross the parts that are to be removed.

TURNING METAL IN THE LATHE

By A. Millward

With the lathe as described in the chapter on wood turning it is quite possible to do a limited amount of metal turning of a light and simple character. For instance, it may be desired to turn a small knob or handle in brass, or turn a small rod or spindle, or do a number of small jobs as necessity arises; and these are quite possible in the lathe shown on p. 220.

Metal-turning Tools.—These have quite different cutting edges from those of wood-turning tools, due to

Fig. 1.—Metal-turning Graver

the difference in hardness and character of the material to be turned. Since the lathe is only adapted for very light metal turning it will be better to confine the attempts to turning in brass, and for this purpose a single tool, a "graver," will probably be all that is required. This (*see* Fig. 1) comprises a bar of square steel sharpened at an angle so as to produce a diamond-shaped point; the face of the tool must be kept perfectly flat, and the tool must be kept well sharpened by grinding the flat face only.

Rest and Chucks.—A metal-turning rest is usually flatter on its face and of a greater width but of a less length than one used for wood turning so as to provide a greater width of bearing surface for the tool.

A " chuck " of some kind for holding the metal is a necessity for any work that cannot be held and turned between centres. A " self-centring chuck " will save much time if round or circular work is to be turned. Such a chuck comprises three radially arranged jaws, which can be moved equally towards or away from the centre, and between which the work is gripped. For holding irregular work a chuck having independently movable jaws will be required.

A Simple Metal-turning Job.—In order to turn a bar or spindle between centres proceed as follows :—Having obtained a bar of a suitable length, first square or file the ends so that they are at a right angle to its length. Now find the centre, that is the axial centre, of the bar by marking intersecting lines on its ends. A convenient way of doing this is to mark two lines at an angle to each other by means of a centre square, a little tool somewhat resembling a T-square but having, in some types, two pins in the head of the squares; the edge of its blade intersects at right angles a line connecting the two pins. Another method is to set a pair of dividers to approximately half the diameter and to scribe a series of lines by resting one leg of the dividers on the edge or circumference whilst the other one is used for marking the end face; finally the centre between the marks must be judged. Mark the centres when found with a centre punch, and then, on each end, drill a small hole about $\frac{1}{4}$ in. deep. Now take the centre punch, which should be sharpened to the same angle as the lathe centres (usually 60 deg.), put the point in the hole and hit it smartly until a coned-shaped hole results, which forms a bearing for the lathe centres when the bar is placed between them.

It is now necessary to provide means to cause the bar to rotate with the rotating mandrel of the fixed headstock. For this purpose a "carrier" is used. A simple form of carrier is shown in Fig. 2; the rod *a* is inserted in the hole *b*, and the carrier gripped to the rod by screwing up the screw *c*. The carrier is so fixed on the rod that the end *d* comes into contact with a pin or driver secured on the face-plate.

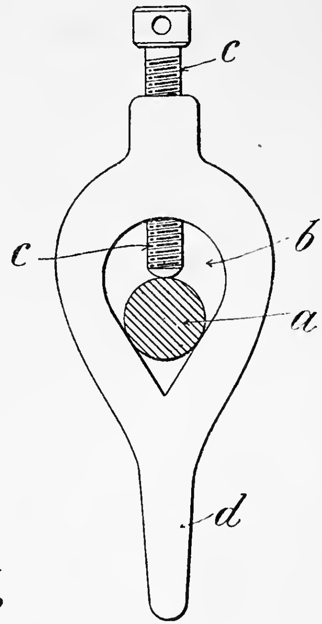


Fig. 2.—Metal-turner's Lathe Dog or Carrier

The graver is now held firmly on the rest, which is so adjusted in height that the point of the tool can be held so that it is in line with the axial centre of the work; the position will be quickly found by experiment, as the tool will not cut properly unless the correct position is found. The tool must only be moved towards the work very gradually so as to remove quite a small amount of metal at a time. When the desired diameter is reached the tool is turned over so as to present one of the sides of the diamond-shaped face to the work, which will remove the irregularities produced by the point of the tool. With a little practice a perfectly bright and smooth surface can be obtained which will not require any further finishing. By altering the angle or position of the "graver" tool it will be found possible to produce rounded surfaces, V-shaped grooves, square recesses or shoulders, but it will not be possible to produce rounded hollows with it, for which purpose a rounded hollow-nose tool will be necessary.

FRETWORK IN METAL AND IVORY

Equipment.—Saw-piercing in metal is a higher stage of the fret-cutter's art. It requires special saw-blades having very much finer teeth—so fine that the unaided eye can scarcely see them. A suitable grade is No. 00, and only the highest quality with rounded-backs should be bought. The woodworker's fretsaw frame can be used if desired, but a smaller frame is more suitable. The type shown in Fig. 1 has the advantage that the handle part slides along the back when the thumbscrew is loosened, thus allowing of broken pieces of saw-blade being accommodated. Fig. 2 compares fretsaw blades for wood and metal.

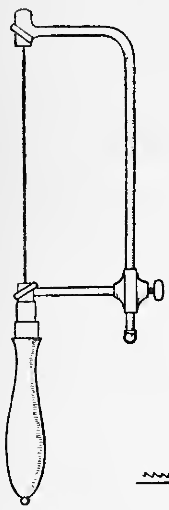


Fig. 1.—Metal Fretsaw or Piercing Saw

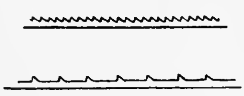


Fig. 2.—Metal and Wood Fretsaw Blades

Ordinary paste does not adhere very well to metal, and it is better to use a mixture of starch, gum arabic, and sugar. The gum arabic can be bought at any oilshop. One ounce of it placed in a piece of muslin and soaked for a few hours in water and then turned out into a jam-jar containing 1 oz. of starch and 4 oz. of sugar with about ½ pint of water will make a good paste for the purpose, the mixture being boiled until it thickens.

Applying the Design.—Let us take a useful little pattern like Fig. 3, a design for a large brooch. Make a tracing of the design on thin paper, and, using only just paste enough, stick it down on the metal. (To get a pair of patterns when the design is reversible, make two tracings on very thin translucent paper, and in pasting them down see that one of them is reversed so that its face is in contact with the metal.) Allow to dry thoroughly before proceeding further. When the fretting is completed, the remains of the paper will need to be soaked off in hot water.

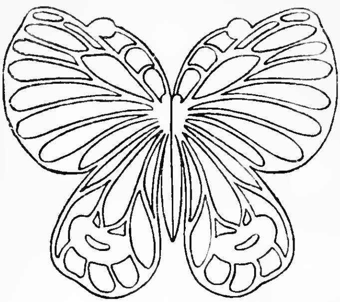


Fig. 3.—Design for Large Brocch or Waistbelt Clasp

Professionals frequently adopt a different method of transferring the design. They use carbon paper and a hard point for transferring it to the metal and then, while the lines are fresh, go over them with a steel point, which gives them an indelible nature. Metal that has been smeared with gamboge (a lump can be bought at a chemist's for a trifle, and most colour-boxes include it) and allowed to dry can be drawn on with an ordinary pencil.

The "pouncing" method is useful in transferring all kinds of designs for all sorts of purposes. The pattern or a tracing of it is converted into a stencil by pricking over its lines with a fine piercer, awl or needle; the coarser the pattern, the wider may the holes be spaced. The stencil is laid down on the metal and rubbed over with a little muslin bag containing fine chalk, the pattern then appearing in dotted lines on the metal, and being easily made permanent by going over them with a fine pen or hair pencil and brunswick black thinned with turpentine, or by scratching over them with a steel point. The stencil can be used scores of times, and the method could be employed for wood fretwork, using, instead of the black, a very dilute mixture of chinese white and water, and applying it in such thin lines that the saw would utterly obliterate them.

Using the Saw on Metal.—The saw should be worked much more slowly and deliberately on metal than on wood, very little pressure should be applied, and the point of cutting should be kept supplied with oil or with turpentine, which, together with an occasional rub of the saw on a piece of beeswax, will make a big difference to the ease and speed of working. The blade soon gets hot with the friction, and must be given a few moments to cool before proceeding. As before, holes must be drilled to take the blade, for which purpose the Archimedean drill stock will come in handy again, but the boring-bit used on wood will not be suitable, and in its place you must get a tiny twist-drill, and keep it lubricated with turpentine, bearing in mind that it is not strong enough to stand much pressure. An alternative method is to prick through with a fine piercer or awl, first placing the metal on a block of hard wood.

Beautiful fretwork can be done in copper, brass, aluminium, ivory, ebonite, and, of course, gold and silver; when working in the precious metals there should be a bag of leather or waterproof material underneath the bench to catch the waste, as this has market value. Silver works out fairly expensively, but for occasional articles, such as pendants, ladies' ornaments, etc., it may be used of No. 23 gauge metal (standard wire gauge), which is ·024 in. thick, and equivalent to about 9 sq. in. to the ounce—enough for, say, two club badges, or for five hatpin heads or charms.

The saw cannot do the whole of the work, and you will soon find that much of the delicate detail must be executed with tiny files, of which two or three selected shapes, including a needle file, should be bought. Files, also, must be used for correcting outlines. A triangular file is best for the sharp angles.

Finishing.—The cutting having been completed, the paper pattern (if used) must be removed with hot water, and the metal laid upon a block of wood or lead and worked over with fine pumice powder and water rubbed vigorously with a large smooth cork. This will remove any swarf at the cut edges and prepare the piece for polishing, which is a matter of time and patience, and is done with a soft leather and tripoli powder and oil, finishing in the same way with jewellers' rouge applied dry.

BUILDING A DOG KENNEL

In this chapter I am giving you drawings for a big kennel. Some of you may think it is far too large, inasmuch as it is 4 ft. long by 3 ft. wide, but I am taking a rather big construction because, as a matter of fact, the actua making is easier in the case of a large kennel than with a small one, and there is no reason whatever why you should not build, from the instructions and drawings here given, a much smaller house should you so wish. For example, if you reduce length and breadth to 2 ft.

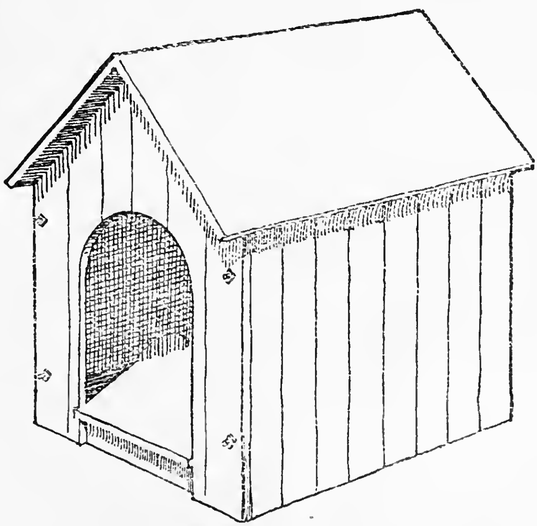


Fig. 1.—Dog Kennel Solidly Built in Sections

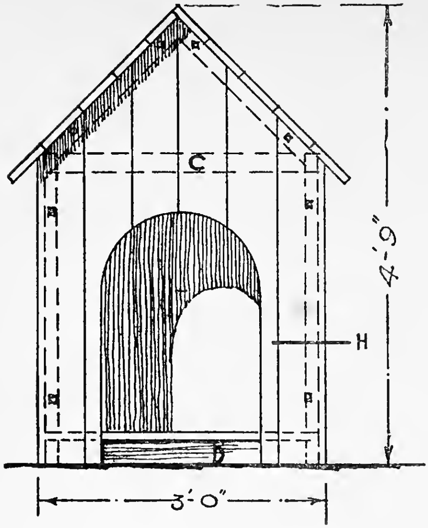


Fig. 2.—Front Elevation of Kennel

and 1 ft. 6 in. respectively, you get a very nice size kennel for a small terrier, and the drawings will still answer exactly as before, except that the bearers and ledges need not be so thick as shown in the illustrations. There are some excellent points about the kennel here shown, not the least of which is that it can be readily taken to pieces and packed flat, while the construction is very solid and good enough for a lifetime's use.

You must study the drawings before you cut a single piece of timber, so as to realise fully what you propose to do. There are seven main pieces in the construction: the floor, four sides, and two roof pieces, and

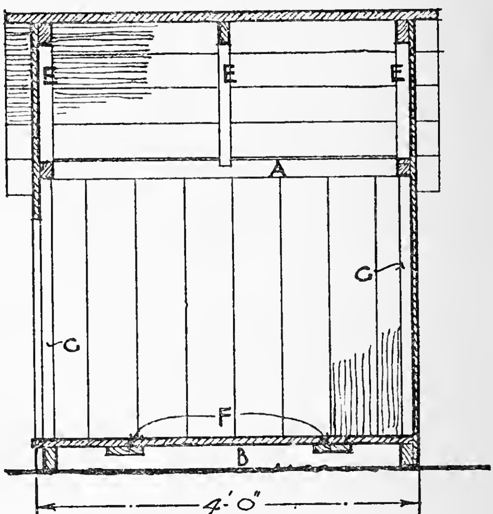


Fig. 3.—Longitudinal Section through Kennel

each of these is built up as a separate unit. You will notice in the illustrations that a number of bolts and nuts are shown. I advocate these if there is any chance that the kennel may not be required for some time, or if it is to be made in one place and transported to another ; but there is not the slightest reason why you should not use $2\frac{1}{2}$-in. or 3-in. brads or nails (to be clenched over) or $2\frac{1}{4}$-in. screws if you so prefer.

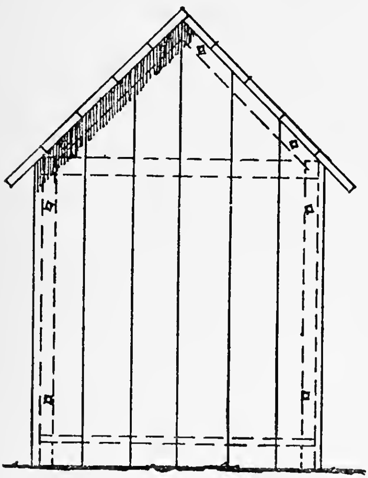


Fig. 4.—End Elevation of Kennel

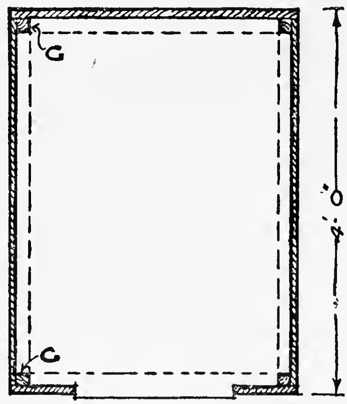


Fig. 5.—Horizontal Section through Kennel

You will realise that the principle of construction is first of all to build up the seven main pieces accurately to size, and then bolt or nail them together. This is a much better plan than building up the kennel as a whole, board by board, and it is a method which you will find always answers best in any work of this kind—poultry houses, beehives, summerhouses, and so on. All portable constructions are best built in sections, as here shown.

You can make a start with the four sides, or rather with the front, end, and two sides. All the boards consist of grooved and tongued stuff 6 in. wide and preferably 1 in. thick, but slightly thinner if you like; $\frac{5}{8}$ in. stuff would do for a small kennel. See that the boarding is planed up and fits well together before it leaves the timber yard (if you are buying it locally). You can take all the dimensions from the drawings, which, except the general view, Fig. 1, are to a scale of $\frac{1}{2}$ in. = 1 ft. Fig. 2 is the front elevation, Fig. 3 the vertical section lengthways of the kennel, Fig. 4 the end elevation, and Fig. 5 a plan or section through the body of the kennel.

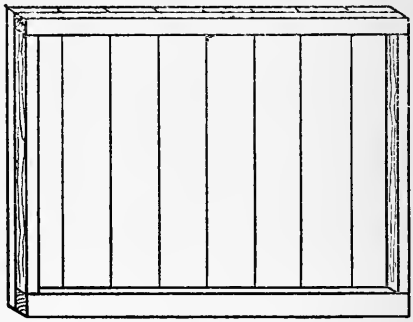


Fig. 6.—Internal View of Side of Kennel

As here shown, the sides are 3 ft. $1\frac{1}{2}$ in. high, but, of course, you are at liberty to vary this by an inch or two as you think proper. Eight widths will be required, and they will be nailed top and bottom to two bearers or ledges, A and B; the top one A is 2 in. deep and $1\frac{1}{2}$ in. thick, and the bottom one B, 3 in. deep and $1\frac{1}{2}$ in. thick. These bearers or ledges will come flush with the top and bottom edges of the boards. At the ends you will nail fillets or angle pieces G, which need to be about $1\frac{1}{2}$ in. square, and the construction when this has been done will resemble Fig. 6, which shows the inside view of one of the sides. It will be necessary to saw off the extreme ends of the fillets or angle pieces to accommodate the top and bottom ledges, as shown in Fig. 6. Both of the sides of the kennel will be the same.

Now for the front and end. All the materials will be of the same thicknesses, etc., as for the sides, and the pieces will be built up by means of two bearers or ledges as before, as shown at C and D. The front and end are 3 ft. 1½ in. high to the top of the sides and about 4 ft. 8 in. high to the apex of the angle or gable. Fig. 7 is the inside view of the front or end, showing the positions of the bearers, and it will be noted that these are cut away at the ends to allow for the ledges A on the sides when the four main pieces come together.

The entrance hole in the front can now be cut. In the illustrations it is assumed to be about 1 ft. 9 in. wide, and about 2 ft. 8 in. high from the ground level, but this will, of course, depend upon the size of the dog, and whether you are working to the dimensions here given or to a much smaller scale. Set out the opening centrally with square, rule, compass, and pencil. Saw down with a hand saw as far as you can, but don't saw through the bearer D (Fig. 2), and finish with a turn or compass saw. Smooth the edges with glasspaper held on a block of wood, using, if possible, a curved block for the glasspapering at the head of the opening. It would strengthen the front if an extra fillet were nailed across (on the inside) under C (Fig. 2), and just over the opening, before cutting.

We can now consider the floor of the kennel. As drawn, it is about 2 ft. 10 in. wide with an extreme length of 4 ft. It will be built up of about the same sort of material as was used for the sides, and nailed to two ledges as shown in section at F in Fig. 3, and also in the general view of the floor shown in Fig. 8. In Figs. 5 and 8, you will note that square notches will have to be made to clear the fillets or angle pieces, and, in addition, the front end of the floor is cut away at the sides so that the centre part projects a trifle past the opening.

We have now to make the two parts of the roof. They will each consist of five widths of 6 in. wide material, of the same thickness as used elsewhere; but one part of the roof will be narrower than the other by an amount equal to the thickness of the stuff used. If you study the front elevation (Fig. 2) you will easily see why. One part of the roof overlaps the other, and if they were of exactly the same width, the eaves at one side would be lower than on the other; so if you are using $\frac{3}{4}$ in. material, saw off a strip $\frac{3}{4}$ in. wide, and you can probably do this more easily from the completed roof part. The bearers or ledges can be of the same material as the bottom ledges of the sides, that is, 3 in. by $1\frac{1}{2}$ in., and it is better to have three bearers for each roof part. You will, of course, note that the roof boarding is longer than the side of the kennel. A length of about 4 ft. 8 in. will give an overhang at each end of about 4 in., and this is advisable inasmuch as it helps to throw off the rain, keeps the dog more comfortable, and preserves the kennel from decay. You need to be very careful in deciding the positions of the end roof bearers, as these must, of course, just clear the inner surfaces of the front and end of the kennel. Study Fig. 3, and this point will be obvious.

We have now the seven main pieces, and before we do anything more we might as well give them all, except the floor, a couple of coats of paint or good outside varnish, but do not paint the inside. A coat of brown or green stain before applying the varnish is not a bad idea.

Let us set about assembling the kennel. We need a good flat, clean floor, or a flat bench top or table top upon which to work. Prop up one of the sides,

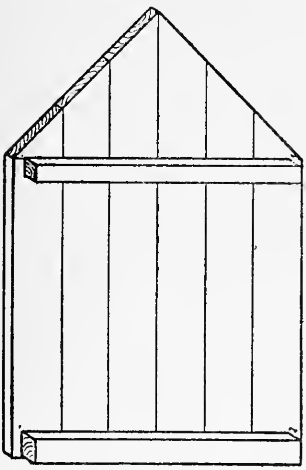


Fig. 7.—Internal View of End or Back of Kennel

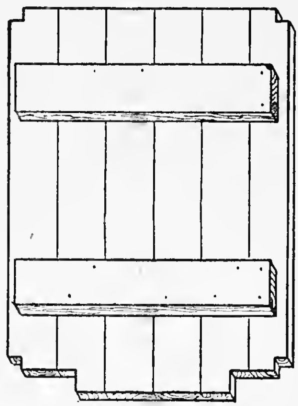


Fig. 8.—Underneath View of Floor of Kennel

and put the end in position against it. Having settled whether you are going to use bolts or screws, the latter being much the easier, it will be necessary in the case of bolts to bore holes from the end right through the angle piece, as fully explained in the detail sectional view (Fig. 9), which shows a section taken on the line H in Fig. 2; on the right is one of the sides to which G is nailed, and at the bottom is either the front or the end, to which G is bolted. One little point: You will notice that in this section the extreme corner of the angle piece has been trimmed off, with the object of not leaving any hard corners for our friend the dog to knock himself against. Having secured the end, place the second side in position and proceed as before, taking great care that all the joints are square, and that there is no tendency for the rectangular construction to go out of shape as indicated by the dotted lines in Fig. 10.

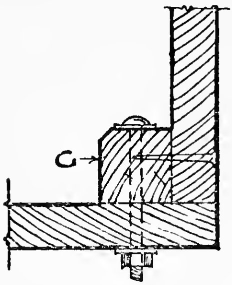


Fig. 9.—Details of Corner Joint of Kennel, showing Bolt and Nut

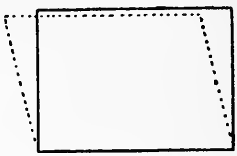


Fig. 10.—Diagram showing Tendency for a Square Construction to go out of shape

Now let us put the floor in. It will easily go into the three-sided box already formed if it is slanted a trifle. There is no real need to nail it down to the bearers, but you can please yourself.

The front can now be added, and all will be ready to receive the roof. Get someone to help you to hold the two parts of the roof in something like their proper positions. You will find that some little adjustment with the plane will probably be necessary on the top edges of the sides, so that the roof boards " sit " well in place. The roof bearers are secured to the front and ends with bolts or screws, exactly as before. You will need altogether eight bolts at each end of the kennel or a dozen screws.

All the woodwork is now completed, but the construction would not be watertight if left in its present state, and it is advisable to get some good-quality tarred felt with which to finish the roof, allowing the felt to project all round for about $\frac{3}{4}$ in. A big kennel like this will of, course, be kept in a yard or garden, and so must be very well protected with paint or varnish against the weather.

LAYING THE RAILS FOR A MODEL RAILWAY

By Henry Greenly

The author's practical experience in this direction dates from the time when an ingenious and skilful friend made him a wooden model locomotive which had flanged wheels for running in the orthodox manner on rails. At the outset the locomotive ran by force of gravity, but later it was improved by the addition of an "elastic" drive such as that now commonly adopted for model aeroplanes. Clockwork motors and electric mechanisms had yet to make their advent for model locomotive work.

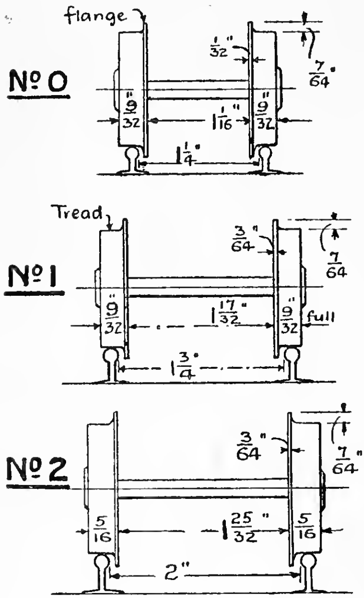


Fig. 1.—Standard Gauges and Wheel Dimensions (Indoor Model Railways)

The rails were hard wood strips of about $\frac{3}{8}$ in. by $\frac{1}{4}$ in. rectangular section glued and pinned down to a baseboard. The points were fashioned with a penknife, and were pivoted at the heel with a fine cabinet-maker's brad. This crude affair, however, was sufficient to make clear the importance of accuracy in the matter of rail gauge and wheel widths.

The "between-tyre dimension" is of the utmost importance in any railway, real or model. The London, Brighton and South Coast Railway suffered a bad accident at Stoat's Nest, due to the wheels of a carriage spreading out. Miniature "Stoat's Nests'" will happen continually on a model railway unless the work in these particulars is done with a reasonable degree of accuracy.

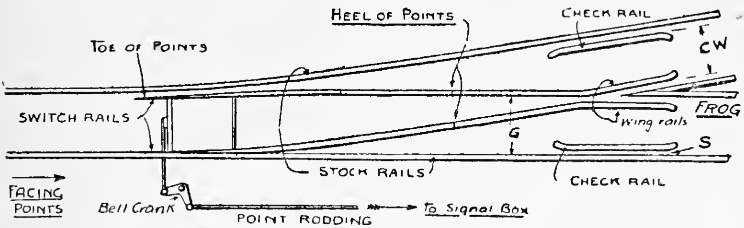
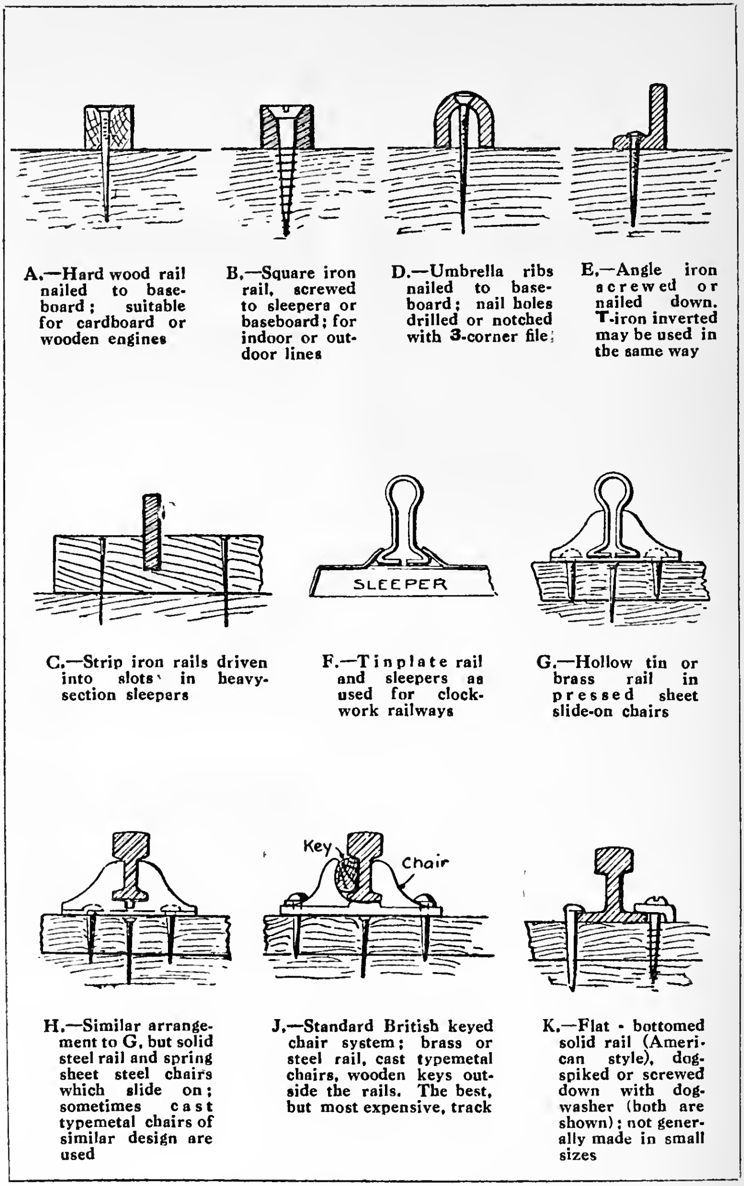


Fig. 2.—Diagram showing Railway Points with all the Parts Named

Fig. 1 shows the standard dimensions for the three smaller model railway gauges, Nos. 0, 1, and 2. It will be noticed that almost the same width of tyre is adopted for all three sizes. This is because the minimum it is practicable to adopt is reached on the No. 1 gauge. The No. 0 gauge cannot be reduced, as the same size rails, etc., are common to both sizes.

Fig. 2 will enable the boy mechanic to identify the essential parts of a standard British arrangement of rails and points. The chairs and sleepers are omitted; in model work the arrangement of these will depend on the material available.

The question of material for rails will naturally



A.—Hard wood rail nailed to baseboard; suitable for cardboard or wooden engines

B.—Square iron rail, screwed to sleepers or baseboard; for indoor or outdoor lines

D.—Umbrella ribs nailed to baseboard; nail holes drilled or notched with 3-corner file

E.—Angle iron screwed or nailed down. T-iron inverted may be used in the same way

C.—Strip iron rails driven into slots in heavy-section sleepers

F.—Tinplate rail and sleepers as used for clockwork railways

G.—Hollow tin or brass rail in pressed sheet slide-on chairs

H.—Similar arrangement to G, but solid steel rail and spring sheet steel chairs which slide on; sometimes cast typemetal chairs of similar design are used

J.—Standard British keyed chair system; brass or steel rail, cast typemetal chairs, wooden keys outside the rails. The best, but most expensive, track

K.—Flat - bottomed solid rail (American style), dog-spiked or screwed down with dog-washer (both are shown); not generally made in small sizes

Fig. 3.—Various Systems of Rail Formation

arise very early. There are innumerable arrangements from which a choice may be made, and therefore a table is given on p. 300 of a selection of various kinds of rail material; the latent sources of

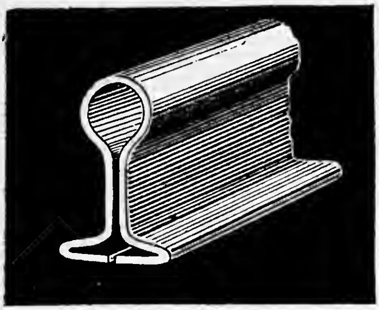


Fig. 4.—Tinplate or Sheet Brass Rail

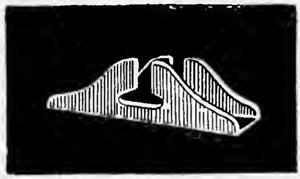


Fig. 5.—Pressed Metal Chair for Hollow or Solid Rails

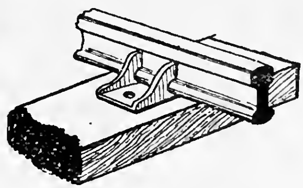


Fig. 6.—Solid Rustless Steel Rail and Pressed Chair

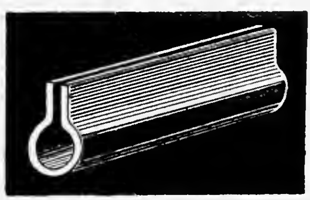


Fig. 6A.—Model Spring Fishplate for Solid Rails H and J (Fig. 3)

supply are, however, not exhausted by this list.

For an indoor line of 1¾ in. (No. 1) gauge, such as would be suitable for the model express engine described in an earlier chapter, the hollow tin or brass rail illustrated at G in Fig. 3 may well be chosen. It is the cheapest of what may be considered the proper thing, whilst the next best is the system using a solid steel rail, as shown in H (Figs. 3 and 6), with similar chairs.

An indoor railway requires some more or less permanent baseboard. The average system is laid down on what are virtually shelves round the walls of the attic or spare room devoted to the railway. The baseboards may, of course, be quite separate from the walls, and may be arranged in sections placed on trestles when it is required to use the line: normally, the sections are stacked away. However they are built up the baseboards should be level. Wooden sleepers may be laid down previous to putting on the rails and chairs, these sleepers being set out in accordance with and to suit the proposed line of railway. The baseboard should be

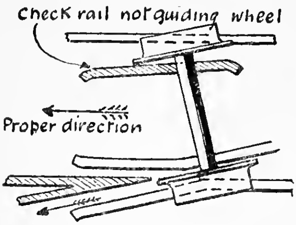


Fig. 7.—No Control over Direction of Wheel if Check Rail is Absent or Misplaced

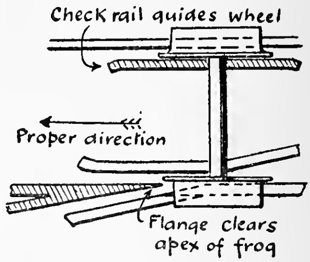
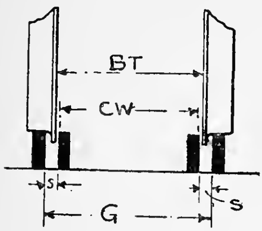


Fig. 8.—Wheel Controlled or Guided by Check Rail in the proper way

marked out with four lines besides the centre line of the track, two outer lines indicating the edges of the sleepers, while the inner lines show the inside edges of the rails.

Sleepers should, of course, be made of equal thickness, as otherwise the track will not be level. They can be stained black, with ebony stain, Stockholm tar, or similar colour or preservative, to make them look like the real thing. They should be spiked down exactly under the centre of the rail, so that the spikes which hold down the chairs do not interfere. The scheme is shown in G to K (Fig. 3).

One of the photographic plates shows the general arrangement of the "frog" portions of a pair of points made up in a chaired road. The frog, as indicated in Fig. 2 in this chapter, is that portion of the points where the one rail crosses the other, and the peculiar arrangement is necessary to allow the flange of the wheel to cross over another line of rail and at the same time to provide a continuous bearing for the tread of the wheel. Obviously the flange could not be expected to jump up



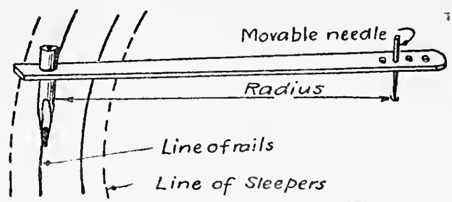


Fig. 10

Fig. 9.—Check and Wing Rail dimensions: BT, between tyres (*see* Fig. 1); G, gauge of rails; S, space between check and running rails; CW, check to wing rail dimension ($\frac{1}{16}''$ less than BT)

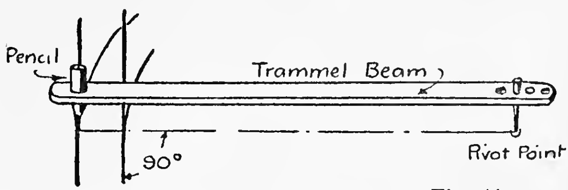


Fig. 11

Figs. 10 and 11.—Setting out Curves and Points with Trammels

over a rail, and while the rail is broken the guiding effect of the flange is preserved by the system of wing and check rails, clearly illustrated in Fig. 2

Figs. 7 and 8 show the necessity of properly fitting up the wing and check rails. In the first sketch it is evident that a wheel will just as easily travel along the line of track if the check rail is either absent or is laid down with too great a space between it and the stock rail opposite the frog Where the check rail and wheels are correctly proportioned and properly fitted, the check rail acting on the opposite wheel to that traversing the frog retains the latter wheel in the straight and correct path. In all the small gauges the distance between the main and the check and wing rails is settled by the all-important " between tyre dimensions," as shown in Fig. 9. The distance over check and wing rails, c w, should be $\frac{1}{16}$th of an in. less in all the three small gauges (Nos. 0, 1 and 2) than the " between-tyre " dimensions given on the diagrams in

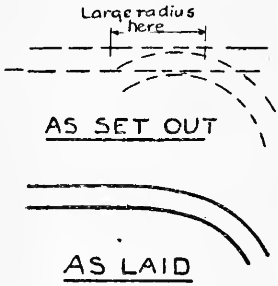


Fig. 12.—Setting out Rails from Straight to Curve

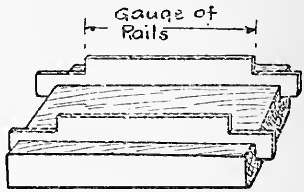
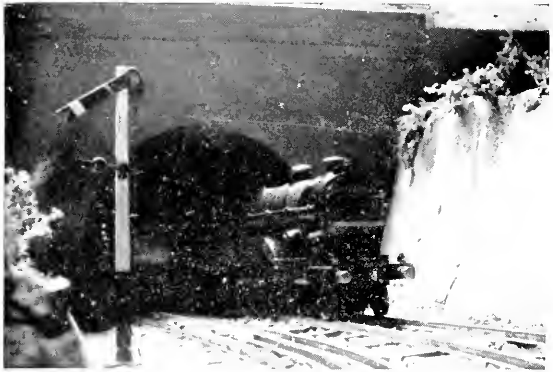
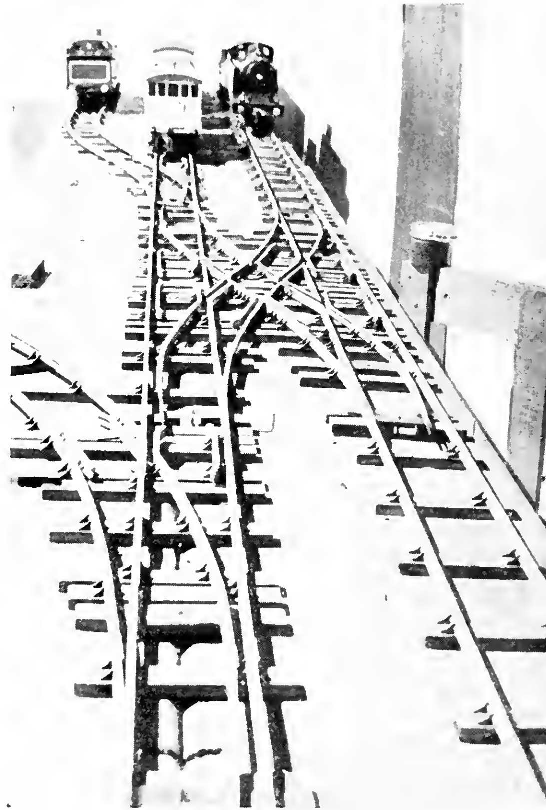


Fig. 13.—Sketch of " Rail-gauge " for Model Railway Work

Fig. 1 (1 in., $1\frac{15}{32}$ in., and $1\frac{23}{32}$ in. each gauge respectively). The space s (Fig. 2) is therefore half the difference between the dimension c w and the gauge G.

In setting out curves and points the use of the " trammel " is strongly recommended. A very simple instrument of this kind is shown in Fig. 10. The centre point may be a stout needle or other stiff steel pivot, and to allow for scribing out the four lines (two for the rails and two for the edges of the sleepers) the pivot end of the wooden lath forming the trammel may be provided with





[illegible]

four holes for the pivot pin, each hole corresponding to the radius to be drawn. In setting out points (Fig. 11) the pivot point at which the trammel swings should be at exactly 90 deg. to the toe of the points (that is, the toe of the switch rail). In the case of ordinary curves which enter straight portions the best scheme is to provide a transitional entrance to the curve. In this case the curve is set out with the trammels as shown in Fig. 12, not exactly at a tangent, and the junction between the curve made with a larger radius curve which can best be judged by eye.

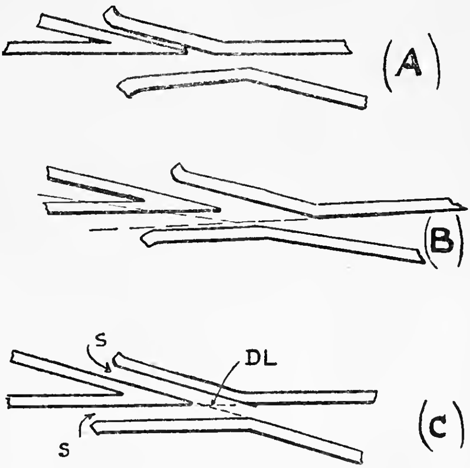


Fig. 14.—How to Lay Frogs: A, Wing rail space inaccurate; B, Rails not in continuous line; C, Correct Spaces (S), Rail line continuous (*see* dotted line D L)

A " rail-gauge " made as shown in Fig. 13 is a simple device for setting the rails true to gauge. It may be made out of sheet metal, the strips being driven into saw cuts in a block of wood, or soldered to a metal base plate.

In laying plain rails one rail should be put down first, tuned up by eye, and then the adjacent rails laid to suit, using the " rail gauge " instrument already described. Much of the final accuracy of the track is obtainable by sighting along the rail. Surface " wind " or " twist " may also be observed by looking across from rail to rail with the eye on a level with the top face of the rail.

When laying down points the lining up of the frogs is an important feature. The diagrams A and B (Fig. 14) are examples of " how not to do it." The inner edges of the running rails should line up accurately so that by a straightedge, or by the eye, it can be observed that the line of the inner edge, against which the flange runs, is continuous, just as though there were no frog there at all. This is shown at C (Fig. 14).

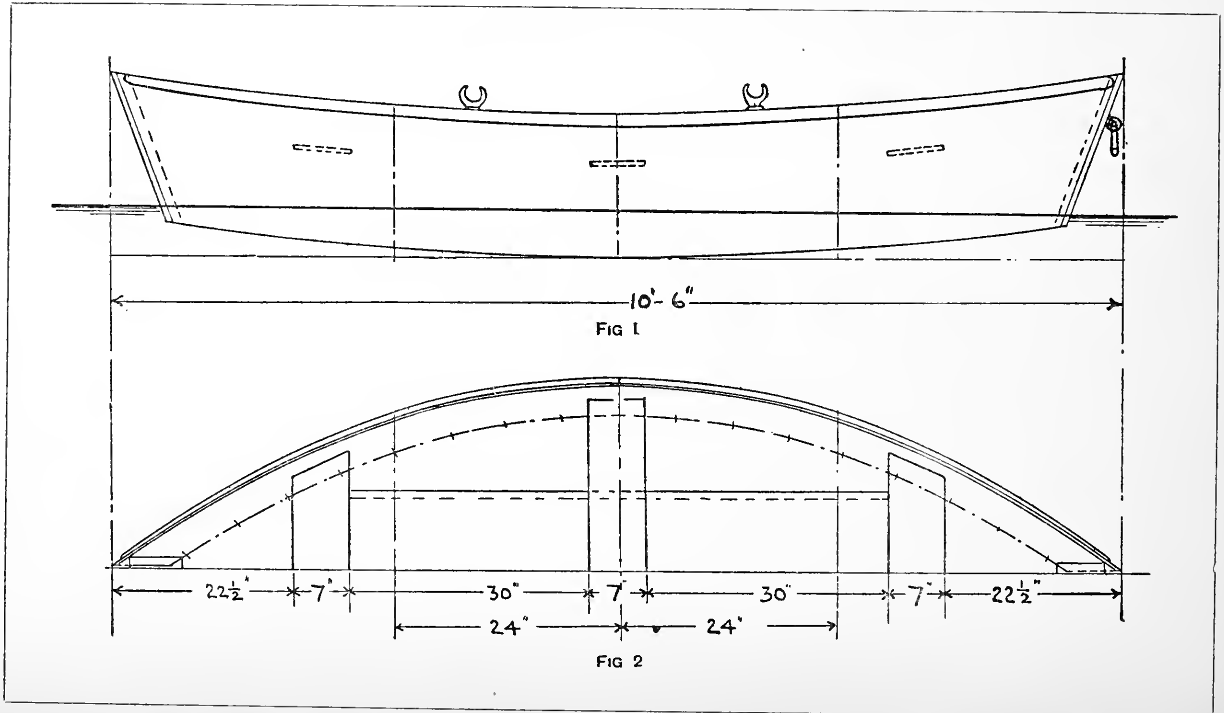
Very much more could be said on this subject, but the variety of materials available is large and the minor features of each create special difficulties and conditions. The broad principle has, however, been covered, and is unalterable whatever kind of track material is used.

BUILDING A 10-FT. FLAT-BOTTOMED ROWING BOAT

THERE are boats and boats, and most of them are beyond the capabilities of the young woodworker. I know, however, what a fascination the building of a knockabout boat has for boys young and old, and I therefore feel obliged to include a chapter giving drawings and instruction on making a boat of a type within the scope of anybody at all handy with woodworking tools. The details of the design here presented are due to Mr. D. Kidd.

Fig. 1 is the sheer draught or elevation of the boat, Fig. 2 is the half-breadth plan, while Fig. 3 is a section "amidships," that is, it is a section right across the centre of the boat. This is an excellent knockabout boat for lakes and rather sluggish rivers, being of comparatively light weight, very stable, and, owing to its design, not dragging water. It tows easily, can carry a big load, and does not require a professional boat-builder to construct it; but like all flat-bottomed boats it is apt to pound in choppy water.

It must be realised that this is a small boat—10 ft. by about 4 ft.—and that any load it carries needs to be distributed properly. One person alone would occupy the central seat. Two people would have an end seat each;



Figs. 1 and 2.—Sheer Draught or Elevation and Half-breadth Plan of 10-ft. Flat-bottomed Rowing Boat three would be distributed over the three seats, while, when there are four people, two would be on the centre seat and one at each end, one of the latter doing the rowing. Keeping to this rule will mean an even keel.

You may care to know that the design has been adapted from that of the American fisherman's dory, the system of construction being practically identical. Briefly, the side planks are secured to a stem or stempost at each end, the inner upright timbers added, and the bottom then put on.

The first thing to do is to prepare the "moulds." As long as they are strong and of the right shape and dimensions it matters not how they are made up. Two "quarter moulds," as Fig. 4, and one "amidship mould," as Fig. 5, will be required; each of these is 18 in. high, and the former is 38¼ in. wide at the top, tapering to 30 in. at the bottom, while the latter is 47 in. and 38¾ in. respectively. As illustrated, they are

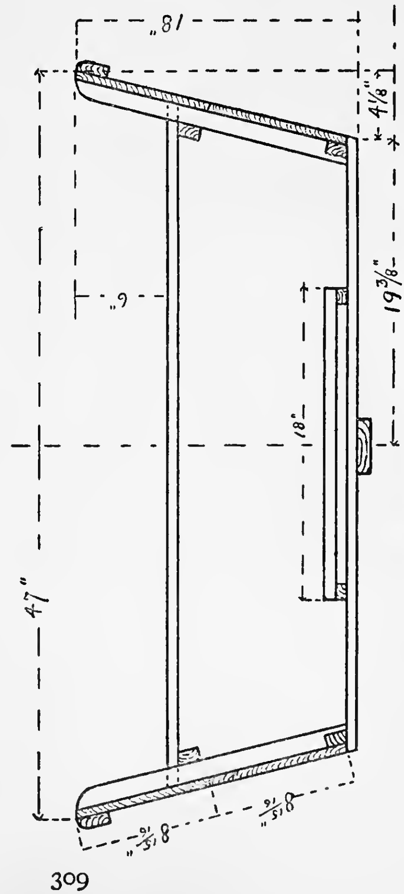


Fig. 3.—Amidship Section of Flat-bottomed Rowing Boat

built up of thick rough stuff 6 in. wide, well nailed at the joints, so that any "giving" at those parts is impossible. A notch 1 in. by $\frac{3}{4}$ in. is cut out at each bottom corner (*see* dotted lines).

The stem or stempost at each end of the boat is the only detail that will tax the skill of the woodworker. You know that the stem is the upright or nearly upright piece at the sharp end of a boat, into which the planks are secured, and as, in this case, both of the ends are sharp, two such pieces will be required. They are about 22 in. long, and after the bottom planking is on they will need to be sawn exactly to size. The section through the stem or stempost is as shown in Fig. 6, which is very fully dimensioned. Probably you can get a joiner to supply you with a piece of oak, mahogany or other hard wood (softer stuff is useless) cut to the section shown, as it will be a rather awkward job to produce such a section at home; but if there is no alternative I suggest that the best method of going to work is to get a piece of stuff 3 in. square and 22 in. long, and make in it a series of cuts with a tenon saw or dovetail saw, as indicated by the dotted lines in Fig. 7. This will have the effect of pro-

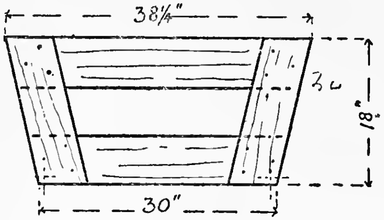


Fig. 4.—Quarter Mould

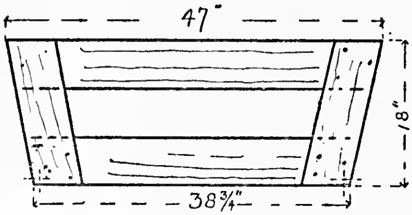


Fig. 5.—Amidship Mould

ducing a piece of the section shown in the hatched lines, and you will then need to divide this into two with a hand saw on the dash-and-dot line shown. Afterwards clean up with glasspaper. Now, I don't recommend this job. It requires a great deal of care, patience and skill, and I think that if you can get the stuff cut for you so much the better.

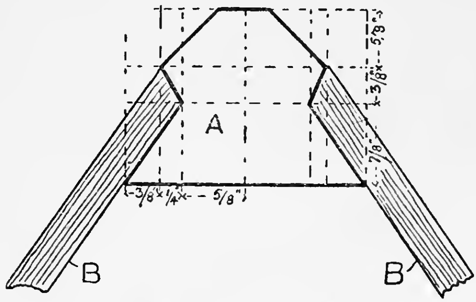


Fig. 6.—Section through Stempiece or Stempost and Sides

The side planking is only $\frac{3}{8}$ in. thick, and should be of good quality. This thin stuff will readily bend to the shape required. Four planks will be required, $8\frac{15}{16}$ in., say 9 in., wide, two for each side, the upper one being 11 ft. $3\frac{1}{4}$ in. long, and the lower one 10 ft. $6\frac{7}{8}$ in. long. They should be placed together as in Fig. 8, and the centre line struck as indicated at A B. Then by setting out the dimensions shown on the diagram and drawing a slanting

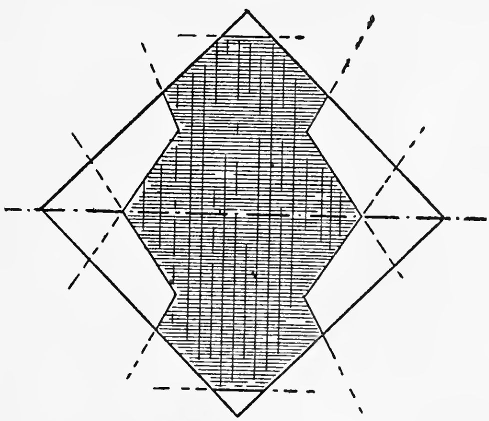


Fig. 7.—Suggested Method of Shaping the Stempost

line at each end right across the two boards the rake for the ends of the planks will be obtained, and the planks can then be cut on those lines. Both sides of the boat are the same, and it will be noticed that although in Fig. 1 a curve is shown, this curve is obtained naturally as a result of the design and system of building and does not need to be imparted to the planks by sawing to a curved line. Indeed, it is of the utmost importance that the top and bottom edges of the planks be planed parallel. Vertical dotted lines will be noted in Fig. 8. These, as indicated, are $7\frac{1}{8}$ in. apart, and they should be transferred to the actual stuff by means of square and pencil before the sides are bent. They indicate the positions of the upright timbers on the inside of the boat, which timbers are not added until after the planks are bent.

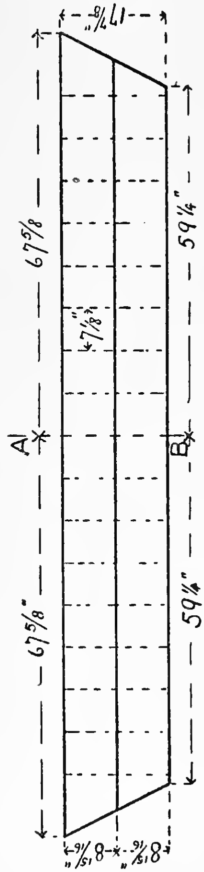


Fig. 8.—Side Planking

A start may be made with the actual building immediately the two stems and four planks are ready. Taking one of the lower planks, place it on the stem in the rebate provided for it, as shown in plan by Fig. 6, the stem projecting by about $\frac{3}{4}$ in. at the bottom. See that the end of the plank is close up in the rebate, and secure it with three 1-in. brass screws. Attach the second lower plank to the same stempiece on the other side.

Take the remaining stem and similarly screw it to the other end of one of the lower planks. Of the two planks there will now be three ends secured and one end free. The next job is to get the amidships mould in place, but before doing this the bottom corners must be notched out, if not already done, to clear the 1-in. by ¾-in. oak strips (known by the boat-builders as " chines ") which will run along the inside of the boat in the angle between sides and bottom. All three moulds need to be notched out in this way. Place the largest mould in position between the bottom planks, and see that it comes exactly central (on the line A B in Fig. 8). Temporarily fix it with a couple of screws through each plank, and you will then be able to bend in the free end of the plank and screw it to the other stempiece.

We can now add the upper planks, first by screwing them to the opposite sides of the same stem, and then drawing the free ends together, tying tightly with a rope and screwing as before. The rope can be tightened to almost any extent by introducing a stick and giving it a twist in the rope. This is a dodge that will come in handy if you are working alone, but boat-building is a job for two people as a rule, and can easily provide employment for three.

The vertical dot-and-dash lines in Figs. 1 and 2 indicate the positions of three moulds, one of which has already been inserted. The two others will now be dealt with. Each of them should be inserted amidships and then forced towards the end until it occupies its proper position, previously decided by exact measurement. The moulds are 24 in. apart, centre to centre, and need to be secured by rough strips nailed across their top edges from the amidships mould, and, in addition, by a screw driven in at each side through the bottom plank. There is a certain amount of wedge action exerted, and were it not for the screws the moulds would be forced upwards.

The chines already mentioned are strips of oak or other hard wood which occupy the angle between the side planking and the bottom. In section they are 1 in. by ¾ in., the 1-in. face being in contact with the sides, while the other face needs to be planed to an exact bevel so that the bottom boards will come flush and in perfect contact. The chines should be attached to the side planks with 1-in. No. 10 brass screws driven from inside and spaced 3 in. apart. The notches cut in the moulds allow of the chines being introduced at this stage of the construction.

The upright oak timbers shown in side view in Fig. 3 are next to be inserted, their positions, 7⅛ in. apart, having been already marked as previously instructed. They will be about 18 in. long, 1 in. by ¾ in., and should be shaped at the top with spokeshave, chisel and glass-paper after they are fixed, with 1-in. galvanised nails 3 in. apart, driven from the outside. These uprights are not bevelled in any way, but require to be notched at the foot where they pass over the chine.

The job is beginning now to look something like a boat, and the attachment of the bottom planking will make a big difference to the appearance. The planks need to be of good stuff, but only those at the ends which are liable to get a lot of rough usage need be of oak. The best stuff to use is about 4½ in. wide and not more than ½ in.

thick, and, of course, the grain will run across the bottom at right angles to the length of the boat. The first bottom plank to go on is amidships, then work towards the ends, and when complete trim off each stempiece, which until now has projected a trifle, so that it comes quite flush with the bottom. The planks are secured to the chines by means of 1¼-in. No. 10 brass screws, three to the end of each plank.

We have now got to the point at which the moulds can be withdrawn, but, before doing so, it is wise to nail a strip across from side to side to the upright timbers near each mould so as to hold the sides of the boat together. Then you can withdraw the screws and remove the moulds. The boat is now in recognisable shape.

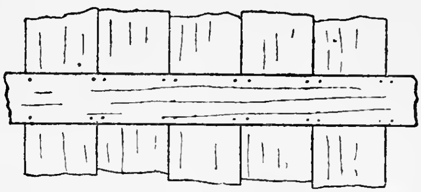


Fig. 9.—Method of Screwing on the Keel Piece

There are two rubbing pieces on the boat—the keel or bottom rubbing piece and the side rubbing pieces round the gunwale, all of which are of oak and are shown in section in Fig. 3 The keel piece is 3 in. wide by not less than ⅝ in. thick, and is the exact length of the boat, it being cut flush with the stempieces at each end. It is fastened by means of ¾-in. brass screws, and these are inserted in the style shown by Fig. 9, there being four screws in each bottom plank, inserted close to the seams as shown.

The side rubbing pieces attached to the upper edge of the top plank are 1½ in. wide, and at amidships ¾ in. thick;

preferably they should taper to $\frac{3}{8}$ in. thick at the ends, where they should be rounded off. They are attached with $1\frac{3}{4}$-in. brass screws which pass right through the plank into the upright timbers. At the extreme ends smaller screws fasten them to the stems.

There must be a floor other than the actual bottom of the boat, but it need not extend the whole length. It is supported on two strips of yellow pine or similar stuff measuring $\frac{3}{4}$ in. by 1 in. in cross section. These strips are 5 ft. 7 in. long, and are laid parallel to support 6 in. widths or $7\frac{1}{2}$ in. widths of $\frac{1}{2}$-in. yellow pine, 18 in. long, as clearly shown in Figs. 3 and 10. The latter shows the floorboards and supporting strips in plan and elevation, and gives all necessary dimensions.

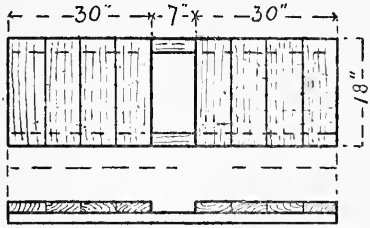


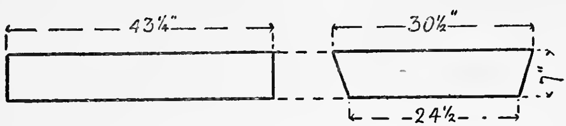
Fig. 10.—Plan and Elevation of Floorboards of Boat

There is a break in the middle as shown, which can take a stretcher for the feet, or the edge of the flooring will act as the stretcher. The strips are fastened to the bottom planking with 1-in. brass nails inserted from the outside.

To support the seats we need to provide oak risings or risers, 1 in. by $\frac{3}{4}$ in., running the whole length of the boat from stem to stem. They should be about 7 in. below the top edge, and their top edges need to be planed to the correct bevel, as will be understood from Fig. 3. They are attached by a $1\frac{1}{2}$-in. No. 8 brass screw in each of the upright timbers. They support three seats, particulars of which are given in Figs. 11 and 12; these are of $\frac{3}{4}$-in. or 1-in. yellow pine, and about 7 in. wide, being secured to the risers with three $1\frac{1}{2}$-in. brass screws at each end; of course, you will notch out the ends of the seats to clear the upright timbers as may be necessary.

The actual construction is now complete, but the caulking and painting remain to be done.

A practical boat-builder provides the following instructions on caulking the seams of a boat. Caulking cotton or cotton wick can be obtained in 1-lb. balls. Two or three strands about 16 ft. long are made fast at one end, and the other end is twisted over the knee by hand,



Figs. 11 and 12.—Centre Seat and End Seat

forming a thick thread, which, when fairly tight, is knotted and rolled into a ball. When caulking, the ball is gradually unrove, and the thread is placed over and driven into the seam with a caulking-iron and mallet. A thin chisel ground to bluntness will answer the purpose of a special caulking-iron. Drive in the thread as far as it will go, care being taken not to burst the edge by too heavy a blow. The next thread, which, if the joints between the planks are a trifle V'd, may be a little thicker, is driven on to this first thread, and so on until the seam is filled to about $\frac{1}{8}$ in. of the outside of the plank; this space is left for a stopping made of white-lead putty. Planking seams are not usually filled with marine glue, as is done to the deck seams of sea-going boats. If the craft is to be varnished, the putty or stopping is coloured to suit the planking. Wide seams are to be avoided, as the caulking and stopping have a tendency to come out when the planking swells.

As regards the painting for the outside, first coat knots with shellac knotting (common shellac varnish), and when this is dry give from two to four coats of reliable paint. It is not usual to paint the rubbing piece at the gunwale, which should be treated exactly the same as the inside and as follows: Coat the knots as before and then give two coats of boiled linseed oil, allowing a day or two between them for drying, and finish with a good flowing coat of good quality oil varnish.

Necessary fittings include two pairs of galvanised-iron rowlocks with side plates, which can be bought ready for attachment. It is desirable to have a ring bolt attached to the stem as shown in Fig. 1, and you will, of course, need a pair of oars and a $1\frac{1}{2}$-in. rope painter.

A MODEL AEROPLANE THAT FLIES

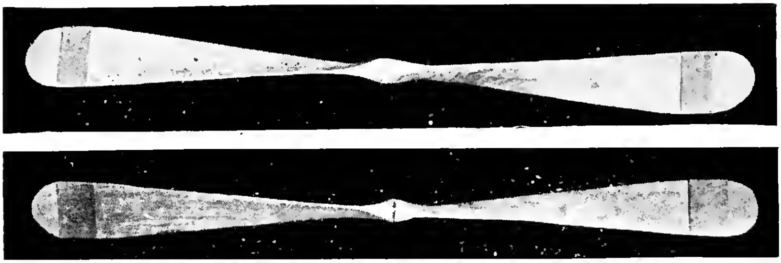
I FEAR that when you look at the illustration given on page 321 you will be tempted to think that such a model is not worth making. It lacks the realism of some of those beautiful structures of canvas and timber which are sold at high prices in the toy shops, but it does one thing that very few of those structures can do—it can fly. It has been designed especially for beginners by Mr. F. J. Camm, and he guarantees that flights of well over a quarter of a mile are easily obtainable with it. It is built for flying and not for looking at. Fig. 1 is a plan of the aeroplane showing the main spar running down the centre strengthened by a bracing with outrigger.

Its technical description is a twin-screw monoplane, propeller or canard type, hand-launched; type formula, "1—1—P2." At the front of the machine is an elevator and at the rear two propellers, while well to the rear, but adjustable as to position, is the main plane.

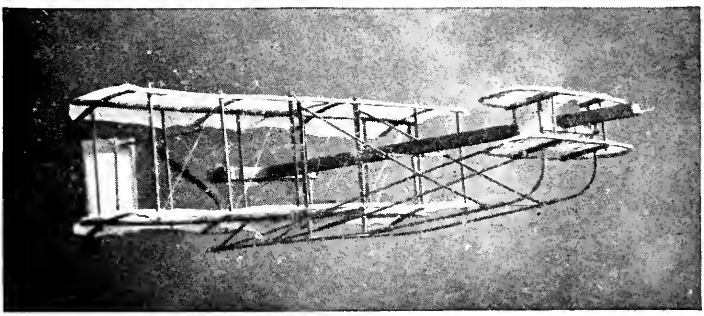
We will talk about the main spar first: it is a piece of straight-grained birch $\frac{1}{4}$ in. wide, $\frac{5}{16}$ in. deep, and $48\frac{1}{2}$ in. long, tapered at the ends to about $\frac{3}{16}$ in. square. At the rear end at right angles to the main spar is a propeller bar, for which the most suitable wood is spruce $\frac{1}{8}$ in. wide, $\frac{3}{8}$ in. deep, and $12\frac{1}{2}$ in. long. In the end of the main spar is a slot to receive the bar, which is held in position by pinning and gluing. Fig. 2 shows how the propeller bar is fastened to the main spar. From each end of the former is a stay, jointed, as shown in Fig. 3, by notching and pinning; and the other end of each stay is connected to the main spar at 6 in. from the end (*see* Fig. 4). A little hole or mortice is cut in the spar to receive tenons cut on the ends of the stays, the tenons abutting in the centre of the mortice as indicated in Fig. 5. The joints may be bound with strong silk or other thread to strengthen them. A suitable binding material is three-cord carpet thread.

At each end of the propeller bar is bound on a little bearing of sheet brass, which receives a wire axle connected to the propeller. Each axle is driven by an elastic motor. The little bearings are cut from scraps of No. 20-gauge brass (·036 in. thick), and in each of them is drilled a hole to allow the propeller shaft to turn quite freely. This hole is indicated in Fig. 6 (which shows the bearing bound to one end of the propeller bar), and should take a shaft of No. 18 gauge, that is, ·048 in. thick. It will be noted that the bearings project from the ends of the bars and are slightly bent so that they come at exactly right angles to the skeins of rubber which drive the propellers; otherwise the propellers will rub on the bearings and power will be lost.

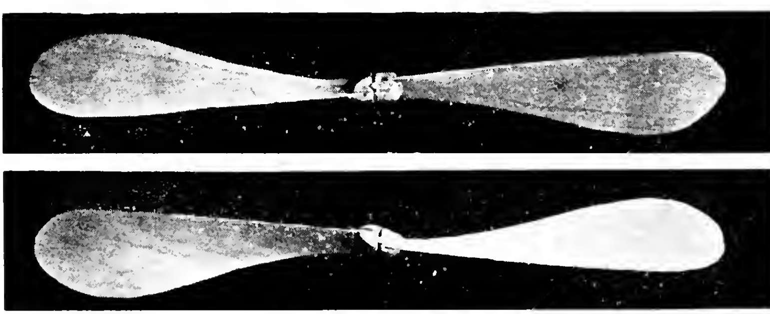
The propellers are 12 in. long and are cut from pieces of white wood $1\frac{1}{2}$ in. wide by $\frac{3}{4}$ in. thick. The general shapes of propellers are given in one of the photographic plates, and it will be understood that one propeller must be right-handed and the other left-handed, and that they will revolve in different directions. There should be no difficulty in shaping them with a good sharp penknife



Carved Propellers for Model Aeroplane



Model of the Historical Wright Biplane



Built-up Propellers for Model Aeroplane

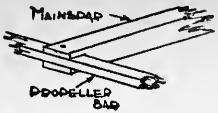


Fig. 2.—Main Spar Jointed to Propeller Bar

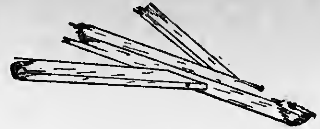


Fig. 4

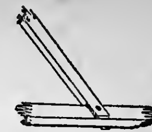


Fig. 3

Figs. 3 and 4.—Propeller-bar Stays Jointed to Bar and Spar

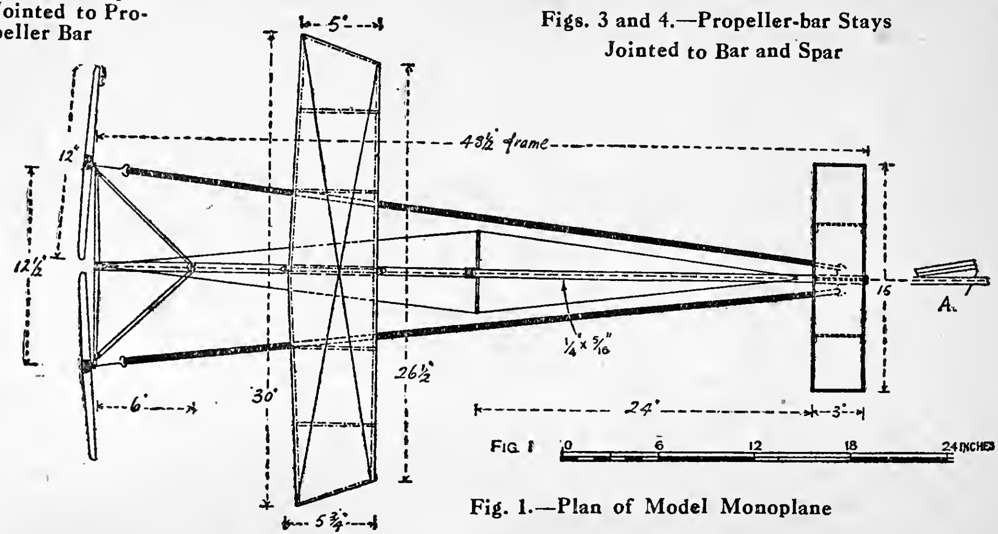


Fig. 1.—Plan of Model Monoplane

whittling them away until a nice smooth outline and an unbroken curve have been obtained. A tiny hole is bored through them centrally to take a wire shaft which should pass through them, and its end be bent flat so that binding with thread will hold the propeller to the shaft; or, preferably, the shafts should be soldered to tin straps, as in Fig. 7. The shaft from propeller to elastic is 4 in. or 5 in. long, and ends in a hook to take the rubber skeins. At the other end of the machine a double hook is bound to the nose of the main spar to receive the front ends of the skeins, as made clear in Fig. 1.

Fig. 7 shows a pair of bent-wood propellers that would be suitable. They are pieces of $\frac{1}{16}$ in. birch, 12 in. long and $1\frac{1}{2}$ in. wide, and may easily be softened for bending by holding them in the steam from a vigorously boiling kettle. Each propeller has a pitch of about 37·5 in.; in other words, each blade tip makes an angle with the spindle of 45°. Thin tin is wrapped round the centres of the propellers so that the shafts can be soldered on.

The spar is considerably strengthened by a wire bracing and outrigger, the latter passing through it, as shown in the detail (Fig. 8), and consisting of a piece of hard-drawn brass wire. A tiny hole is bored to receive it, the wire inserted, bent on both sides of the spar as indicated, and then tightly bound with thread. Fig. 9 shows it more clearly. From spar to the end of each arm measures 2 in., and at each end is a small eye. The fine bracing wire is attached to the spar at the points indicated in Fig. 1 by means of small hooks of No. 20-gauge wire bound on, and the bracing wire will require some amount of adjustment, as there must be exactly the same tension on each side of the spar, otherwise warping is certain.

The elevator must be so made and fitted that its inclination can be altered to control more or less the height attained by the machine when in flight. Its framework is a rectangle, 15 in. long and about 3 in. wide, with three

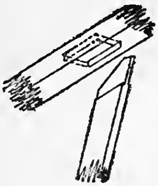


Fig. 5.—Joint of Stay with Main Spar

Fig. 6.—Propeller Bearing Bound to Bar

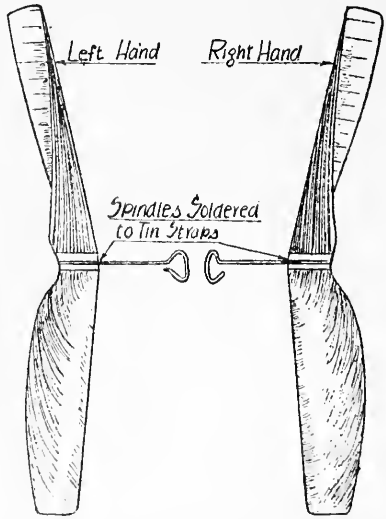


Fig. 7.—Pair of Bent-wood Propellers

cross pieces to strengthen it, made of No. 18-gauge (·048 in. thick) wire. In making this rectangle, the joints need to be bound with fine tying wire and soldered. The elevator's central rib is longer than the others and projects forward and downwards, as shown in the side-view detail A, Fig. 1. The wire passes through a fine hole made in the main spar, the hole being bored in such a way that the wire binds in it with sufficient friction to retain the elevator at any angle to which it may be set, at the same time allowing of its swivelling should it strike any object in the course of its flight. I will deal with the covering of the elevator plane later.

The main plane has a frame roughly rectangular in form, about 30 in. long at the back edge, and $26\frac{1}{2}$ in. at the front edge. The least width is 5 in., and the width along the main spar in the centre is $5\frac{3}{4}$ in. The framework is built up not with wire, but with birch wood $\frac{1}{4}$ in. by

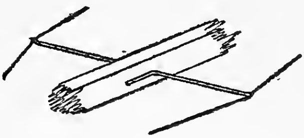


Fig. 8

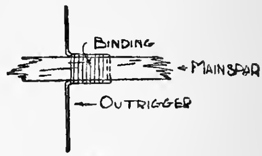


Fig. 9

Figs. 8 and 9.—Outrigger Passing through and Bound to Spar

$\frac{1}{16}$ in. in cross section. Fig. 1 shows that the spar at the back, known as the trailing spar, is curved. The wood can easily be bent in the steam from a kettle, or after soaking for a few moments in hot water, or after wrapping in cloths that have been lightly wrung out in very hot water. There are five ribs as shown in Fig. 1, and they are attached to the frame by pinning and gluing, the pins being clinched on the underside. You will note that the central rib is longer than the others, and slightly projects over both the spars to afford means of securing the main plane to the main spar. These means are very simple, consisting simply of two little strips of thin tin which slide tightly along the spar and clip the projecting ends of rib in place (*see* Figs. 10 and 11). The strips are made by bending up small pieces of thin tin, lapping the ends, and soldering. To shift the main plane fore or aft is thus an easy matter. The main planes have diagonal wing bracing secured as in Fig. 12, and this bracing is put under such tension that there is what is known as a dihedral angle of 1½ in.; in other words, the wing tips of the main plane are 1½ in. above the spar (*see* Fig. 13).

The motor that propels the aeroplane consists of sixteen strands of ¼-in. strip rubber, eight to each propeller, and they should be lubricated with soft soap.

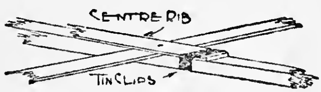


Fig. 10

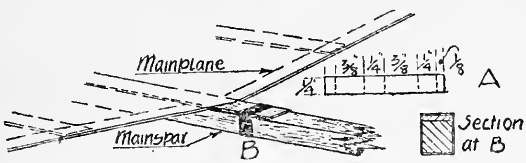


Fig. 11

Figs. 10 and 11.—Adjustable Attachment of Main Plane to Spar; A, Pattern for Clip

All the bindings on the machine should be coated with weak glue or with varnish to strengthen the work.

Mr. W. G. Smith, a very successful builder of aeroplane models, contributed to *Work* the following explanation of his simple method of forming and covering the planes. I reproduce it here because it is essentially practical, and one easily followed by the boy builder. "For the planes of model aeroplanes, steel wire offers exceptional advantages, as it is practically unbreakable, and can be bent to any desired shape. Another advantage is that it offers a minimum resistance when travelling through the air. First obtain a piece of wood about ½ in. thick and slightly larger than the plane to be made, and draw on it a plan of the plane, as in Fig. 14. For example, it will be assumed that a plane 30 in. span and 5 in. wide, having four ribs, is to be made. No. 17 S.W.G. steel wire will be used, and will need to be straightened. Then lay the wire over the plane, beginning at A (Fig. 14), and passing round to B. As the wire is bent to the shape of the plane, it must be fastened down to the board by means of small staples. Then cut four pieces of wire for the ribs C, D, E, and F, allowing ½ in. each end for

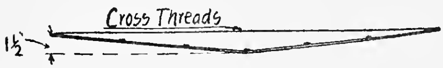


Fig. 13

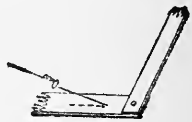


Fig. 12

Figs. 12 and 13.—Wing Bracing to Give Dihedral Angle

turning at right angles as in Fig. 14. The framework is now ready for soldering together. The wire and soldering bit must be perfectly clean. Apply a little 'killed spirits' to the parts to be soldered, and then place a piece of solder in position and touch with the hot bit. Care must be taken to see that the wires lie close together. When the plane is soldered together, remove all the staples and clean up all the joints with a file. The joints must be bound round tightly with clean fine iron wire, the plane fastened to the board again, and all the wired joints re-soldered. Then the plane is once more removed from the board, straightened, the dihedral angle given, and the ribs bent to the desired camber.

" For covering the planes, it is far better to purchase a waterproof silk especially manufactured for the purpose. It weighs about 1½ oz. per square yard. When cutting, about ½ in. must be allowed for turning over for fastening.

At the curved ends of the plane, slits about $\frac{1}{2}$ in. apart must be cut in the edge, as shown in Fig. 15. Apply a thin coating of seccotine to the silk to be turned back, and allow sufficient time for it to get 'tacky.' Then stick over the plane, beginning at A (Fig. 15) and finishing at B. Allow time for the seccotine to set, and fasten the opposite end in the same manner. Care must be taken to stretch the silk tightly, so that it is free from wrinkles. Then fasten first one side of the plane and lastly the other. Another method of covering steel-wire planes

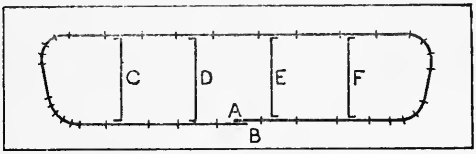


Fig. 14.—Making Frame for Main Plane

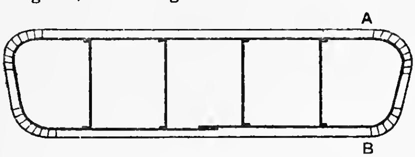


Fig. 15.—Covering Frame of Main Plane

is to sew the silk on the framework. The silk must be cut about $\frac{1}{4}$ in. larger than the framework, and the edges hemmed with a sewing machine. The silk cover when hemmed should be slightly smaller than the framework. First sew the silk roughly into position, and then carefully sew it, beginning at one end, then the other end, and lastly the sides. The stitches, $\frac{1}{4}$ in. apart, should first be passed through the silk, and then round the wire.

The machine should be tried and any necessary adjustments made. Any tendency to dive should be corrected by moving the main plane forward.

NAILS AND SCREWS

SOME amount of care and common sense is necessary in using nails, which must be started in the way in which they are to go. For all rough carpentry the French or wire nail, which is made in a variety of sizes, will be found good enough, but I often prefer the oval steel brad, which is made in a range of sizes, and has to be driven more carefully than the French nail as it is more liable to bend. Panel pins, which are fine wire nails of special manufacture, are useful for good work and in the repair of furniture where the use of thicker nails would probably mean splitting the wood.

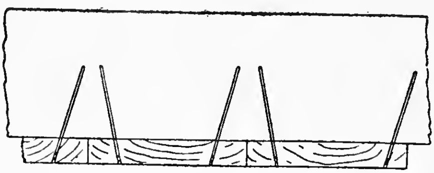


Fig. 1.—Nails Inclined to give Dovetail Effect

Before driving in a nail take a moment to consider the direction of the force which the nail will have to resist. Say, for example, that Fig. 1 represents part of the bottom of the box; the weight inside the box will be pushing down on the boards, and therefore if the nails are driven at exact right angles they will be loosened sooner or later, whereas if they are driven slightly on the slant, and at an opposite slant as illustrated, a dovetail effect is produeed. This is a point worth remembering.

Nails and Screws

A frequent trouble in nailing is the splitting of the work. Thoughtlessness is often a big factor, and you should never insert nails in such a way that their combined effect is to split the board along one line of the grain. Wherever possible, zigzag the nails, so that they cannot help each other to split the wood. A little nail-set, which is a cheap tool, is worth having, as with it the nails can be driven right into the wood without damaging the work—and hammer marks on finished woodwork do not look well. When withdrawing nails do not forget to introduce a bit of scrap wood or something of the sort under the pincers so that in levering out the nail the surface of the work itself is not marked.

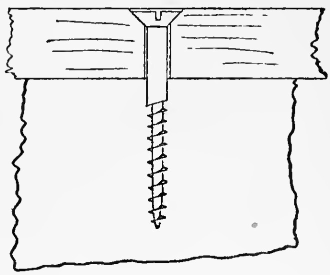


Fig. 2.—Diagram showing Clamping Action of Screw

The screw is, of course, a stronger method of fixing than the nail. It is actually a form of cramp, and one frequently sees it inserted in a very careless manner. In screwing boards together the screw should be a loose fit in the board nearest the head, and a tight fit in the other one; thus you gain the effect of squeezing or cramping the outer board between the head of the screw and the board underneath. Fig. 2 shows what I mean. A touch of fat or oil on the screw helps the insertion and makes withdrawal easier at a later date.

SOME USEFUL JOBS ABOUT THE HOUSE

Erecting a Shelf. — One of the most useful jobs about the house falling to the lot of the boy mechanic is the putting up of a shelf. Now, in the case of a recess in your den or bedroom in which you may wish to erect a bookshelf, the simplest method is to fix wooden bearers, one on each end wall, and support the shelf on them. There is a right way and a sadly wrong way of attaching a bearer to a wall. Most people have tried the wrong one and have found that by hammering big nails through the wooden bearer into the wall they manage without any difficulty to make a mess of the wall, or to arrive at a hard spot in a brick which the nail cannot penetrate. There is no natural hold for a nail in either brick or mortar, and oftentimes a bearer which is simply nailed to a wall will come down when the weight of a heavy bookshelf rests upon it. The right way is to " plug " the wall, and this is done by drilling two or more holes $\frac{1}{2}$ in. to $\frac{3}{4}$ in. in diameter by means of an old chisel; special tools for the purpose can be bought (*see* Figs. 1 to 5), but I have always made do with a blunt wood chisel that was of no further use for its original purpose. Cut the hole about 3 in. deep, shape a plug of hard wood that will make a tight fit in it, and drive it in with a hammer. Two such plugs as this, 1 in. to $1\frac{1}{2}$ in. from the respective ends of the bearer, will support a great weight. Select the screws you are going to use and bore holes through the bearer to take them easily. With a bradawl make a small hole in each

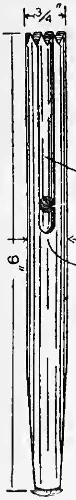


Fig. 1.—Hollow Chisel for Plugging Walls

Fig. 2.—Cutting Edge of Hollow Chisel

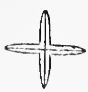


Fig. 3

Fig. 4

Figs. 3 and 4.—Cruciform Chisel for Plugging Walls

Fig. 5.—Flat Chisel for Plugging Walls

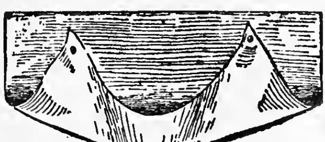


Fig. 6.—Ensuring Tidiness: Paper Pinned up to catch Plaster, etc., when Plugging a Wall

of the plugs, and on driving the screws home you will get a very tight attachment. Be as neat and tidy as you can (*see* Fig. 6).

An excellent way of proceeding is to prepare the bearers and bore the two or three screw holes that will be required. Place the bearer in position on the wall, and mark through the end screw hole with a bradawl. Remove, plug the wall as before explained, and attach the bearer loosely with a screw. Then by means of a spirit level used as in Fig. 7 you can get the bearer truly horizontal, and with a bradawl can mark the positions of the other plug or plugs.

The erection of one bearer should be finished before starting on the other, particularly so if you are in doubt as to whether you can get your shelf horizontal. Support the shelf on the bearer already fixed, place the bearer under the other end, and raise the shelf until the spirit-level indicates that the shelf is horizontal lengthwise; then mark through the screw holes with a bradawl and plug the wall for the second bearer.

Sometimes a recess will not have its end walls at a right angle with the back wall, and it will be necessary to adopt some means of transferring the angle to the shelf so that it can be sawn to shape. Fig. 8 shows how this can be done with an ordinary folding rule that is fairly stiff in the joint. Take the angle of the wall with the rule and transfer the latter to the board so that the part A comes flush with the back edge, and the part B lies over the front corner of the board. Then with a chisel or sharp point mark the angle line and afterwards cut to shape with the saw. The erection of the bearers in a case of this sort is exactly the same as before, but it makes a neater job if their front ends are sawn or chiselled off to be in the same vertical plane as the front edge of the shelf.

When erecting a shelf on the face of a wall where there is no recess, bearers are out of the question, and instead wood or iron brackets must be used. The professional carpenter favours the first, but the boy mechanic saves himself a great deal of labour by using iron brackets, which can be bought quite cheaply. Do not forget that to make a proper job you will need to plug the walls as already described. Possibly you will find that the screw holes in the brackets are just opposite joins between the bricks, and if so, an amount of hard work in drilling will

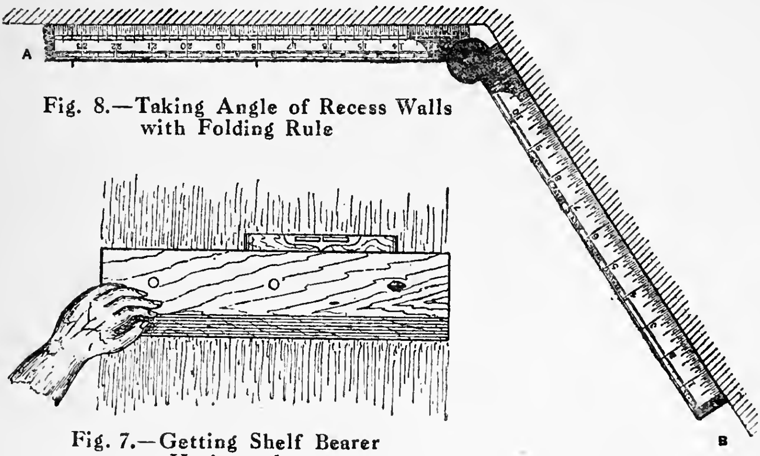


Fig. 8.—Taking Angle of Recess Walls with Folding Rule

Fig. 7.—Getting Shelf Bearer Horizontal

be saved, it being, of course, much easier to plug a joint than a solid brick. Do not forget, either, that a shelf that is not quite horizontal is an offence to a trained eye ; it can easily be made horizontal by means of a spirit level, and I have even known a glass of water used as a testing device. Failing these, get somebody to hold the second bracket, the first having been fixed, and get back a good distance from the wall so that your eye may decide whether the shelf is level.

In many houses, walls in the upstairs rooms are not what they seem ; they look so solid, but are actually only wooden partitions covered with lath and plaster. It is no use plugging these. Instead, find out by tapping with your knuckles where the upright timbers of the partition come. Your ear will soon tell you the difference between the hollow partition and the solid timber. Then you can attach your brackets or bearers with long screws right through the lath and plaster into the timbers.

Sometimes, to minimise the number of wall plugs, shelves and wooden brackets are hung on what are known as "glass plates" or hangers, these being metal plates in which there are generally two screw holes for attachment to the article, the top hole being for the screw which holds the plate to the wall or wall plug.

It very often happens that the screw holes in iron brackets, glass plates, etc., are slightly too small for the screws which you happen to have, but there will be no difficulty in slightly enlarging them with the tang or rat-tail of a file.

By the way, in choosing iron brackets you should give preference to those that are of triangular form rather than to those which are simply pieces of iron bent to L-shape.

Cleaning Locks and Renewing Lock Springs.—I have always taken a great deal of interest in locks, and I expect that you have enjoyed the task of taking one carefully to pieces, noticing the position and the function of each part before you removed it, and doing your best to understand how the lock works. I took to pieces a very complicated lever lock some time ago, and was almost afraid of it when I unscrewed the plate and saw the amount of mechanism in it; but I proceeded carefully, scratching a tiny number on each plate as I removed it so that I could be certain of replacing it in exactly the right order. I made a mental note of the position of every part of the contrivance, and did not remove a single piece until I was quite certain that I should know where it belonged when the time came to put it back again. The lock had probably not been opened for twenty-five years; it was dry and contained a quantity of rusty powder, together with a quantity of old solid oil. The powder and the dry oil had caused the lock to work very stiffly, and I took it apart to see whether I could remedy matters. Having taken all the precautions named, I put the very dirty parts—those covered with the congealed oil—into some boiling water containing a handful of washing soda, and left them there a couple of hours. Then I passed them through some clean boiling water, dried them, and rubbed them up with a rag and some knife polish. I cleaned out the case of the lock and carefully reassembled all the parts in the order in which I had originally found them. As I put the brass levers in place, I tested them with the key to make certain I was not in error. I lubricated all the surfaces that rubbed on one another, tried the action several times to see if everything was right, and put it back in its place on the door. This was a very heavy rim lock, the sort that has an iron or steel box or case visible on the inside of the door, and which could be very easily removed by taking out a few screws in addition to withdrawing the handle stem after removing a tiny set screw in the handle.

Locks that are hidden in the woodwork of the door are known as mortice locks, and they are more trouble to remove; there are generally one or more, frequently two, plates on the edge of the door which have to be unscrewed, but the lock will not move until the handle has been taken out.

I cannot go fully into the mechanism of locks in this chapter, as the subject is a very large one, and I will content myself with just one more hint. A very common trouble in door locks is the failure of the latch to work properly. The handle is turned, the latch recedes into the lock, and when the handle is released it fails to make its appearance; thus the door does not latch when it is slammed, and soon gives annoyance. There is one cause for this—the lock spring is broken. This spring may be of any one of a score of different shapes and sizes. It is made of thin steel, and as this metal is very susceptible to the effects of moisture, it does not take many years for the spring to rust through, or the spring may break simply as the result of wear. I took to pieces a lock the other day suffering from a broken spring, and when I unscrewed the plate the two parts of the spring fell out. You must know that there is a great variety in locks and hundreds of different patterns, and I confess that at first I did not recognise how the spring acted; I found out, though, in a very simple way, and that was by taking off another lock of the self-same pattern, very carefully removing the plate, and studying the internal anatomy.

You can buy lock springs at about one penny each from any ironmonger, and there is no need why, if you are prepared to exercise a little thought and patience, you should not keep in order all the door locks in your house.

Some Useful Jobs about the House

Putting a Washer in a Water Tap.—In every household at some time or other a water tap gets leaky, and however hard the handle may be screwed down there will be a constant stream of water from it. The trouble is that the constant pressure of the water or the screwing-down of the tap has worn away the leather or composition washer, and this requires to be renewed—a very simple job indeed, but one which is very puzzling to some people. First of all get one or two new washers; for ordinary cold-water taps, these washers may be of leather or rubber, but for hot-water taps the best kind is made of red vulcanised fibre. The ironmonger stocks all sizes, and will guide you in the matter.

It is best, wherever possible, to turn off the water at the stopcock, but this sometimes is inconvenient, and frequently also the tap is fed by a pipe from a big cistern, and the cutting-off of the water could not be effective till the cistern were empty. Sometimes a broom handle or a big cork can be used for stopping the outlet from the cistern, but occasionally it happens that the renewal of the washer must take place with the water running until the new washer is in place. Greater care is then necessary, especially if the tap is directly connected to the main water supply, in which case the pressure is so great that on removing the top part of the tap there will be a fountain of water that may reach the ceiling. If the water must run all the while, get somebody to hold a pail upside down immediately over the tap, and be prepared yourself for an occasional squirt of water over you; do not unscrew the tap at c (Fig. 9) or you will be flooded.

With a spanner, such as an adjustable cycle spanner, unscrew the top part (above B), which will bring with it the threaded stem or plunger, in the bottom of which is a jumper (*see* Fig. 10) covered with the old washer. The method of getting off the washer will be self-evident, I expect, but it varies with the kind of tap. Sometimes a little nut or screw has to be removed, but in any case you will find no difficulty here. Put on the new washer, which will, of course, be the same size as the brass plate, and before replacing the top part of the tap loosen the

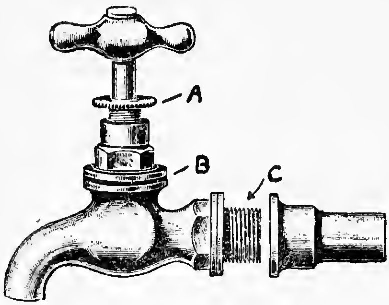


Fig. 9.—Water Tap (Screw-down Bib Cock)

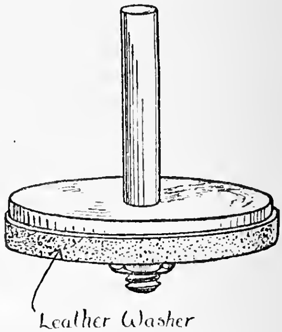


Fig. 10.—Jumper and Washer of Tap

bush or gland A which screws into the body of the tap just against the handle. In the meantime, if the water is running, your assistant must have kept the pail in position all the time so as to throw the water down into the sink.

You now push the stem with its new washer into place. This may require a little force, and occasionally a tap or two with the hammer will help matters considerably. Then tighten up with the spanner and adjust the brass bush A, so that you get a nice easy action.

If the new washer does not wholly cure the trouble it will be found that the metal surface on which the new washer presses down has become roughened or pitted by the water action, and those surfaces will need to be ground, which is a job not usually undertaken at home, but a special tool for the purpose is obtainable. I suggest you can often improve a bad seating by dipping the end of a piece of wood in oil and coarse emery and then revolving it between your hands inside the tap.

Loosening a Stuck Window Sash.—You are fairly certain to be called on to loosen a window that has become stuck, the cause of the trouble possibly being the carelessness of a painter in allowing one sash to become cemented by the paint to the other sash or to the window framing. I strongly recommend you not to use screwdrivers or chisels in your attempt to loosen the frames. It is almost impossible to use edge tools for this purpose without marking the paint, and frequently their use will give no good result. I find there is one method which seldom fails. I place two or three old thick magazines on the woodwork of the stuck frame and give a very sharp, quick blow with a hammer. The paper spreads the blow and prevents any damage to the paint, and, as a rule, the blow breaks the paint contact instantly; if not, the blow can be repeated. Sometimes it may be necessary to lay a block of wood on the bottom rail of the sash and give a smart blow on that, of course taking care and using all your skill to prevent damaging the glass or frame. It is a very simple remedy, which is far to be preferred to the use of sharp tools.

A WORD ON WOOD

Packing cases provide a great deal of useful material for rough carpentry. They should be carefully taken to pieces, preferably by leverage with an old strong screw-driver, and the nails removed one by one, straightened and put aside for use later. Tea chests yield three-ply wood, which is excellent stuff, consisting of three thin pieces of wood glued and pressed together, the grain of the middle one being at right angles to that of the outside pieces. Nowadays, wood can be bought already planed and cut to the exact length required, and this is a great advantage. It is often of interest to know in which direction a board is liable to shrink or warp, and this can generally be determined by the direction of the annual rings, which show so distinctly in the end grain. Take for example, a tree trunk cut into four slices A B C D (*se* Fig. 1, above), and into two square posts E F. As the wood dries, the rings get shorter, with the result that the

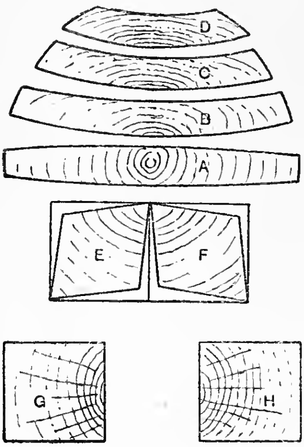


Fig. 1.—How Boards and Posts Shrink and Warp

surface of the wood which is farther from the heart of the tree is inclined to go hollow as shown, whereas a board or slice cut right through the centre gets round and not hollow on both its faces. Square pieces tend to become of a diamond shape, and wherever in special cases it is desirable that the squareness should be maintained they need to be cut so that the end grain shows as in G H.

In buying small quantities of wood the material is sold by the square foot, or by the foot run, the price in the

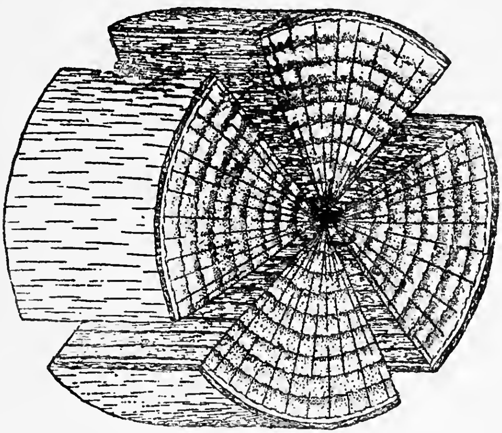


Fig. 2.—How a Log may Split in Drying

first case being based upon 1 in. of thickness; thus per foot run 6 in. wide and 2 in. thick would be the equivalent of 1 sq. ft. at 1 in. thick.

Shrinkage in a felled tree trunk often results in splitting, as shown in Fig. 2.

The woods in general use number some hundreds (as a matter of fact, I give particulars of over three hundred of them in "The Complete Woodworker," a volume in

Cassell's Handcraft Library, which the boy mechanic who has mastered the instruction given in the present book would do well to get). I can afford space for mention of just a few of the best known and most useful.

Ash is close-grained, hard and tough. *Beech,* another excellent wood, is also of close grain; the former is of a light brown colour, and the latter yellowish-red. *Elm* is of a yellowish brown, hard and durable. *Larch,* yellowish to reddish brown, straight grained and tough. *Mahogany* varies considerably, the best being heavy, hard, close grained, and excellent in most ways. *Maple,* reddish white or reddish brown, is tough, hard and fine of grain. *Oak,* generally light brown and very characteristic in its markings, is very strong, tough, and hard. *Pine,* light, durable and easily worked, is among the cheapest class of wood for general use. *Spruce,* another easily worked wood, is of straight and even grain. *Teak,* one of the most durable woods known, is of a brownish red colour. *Walnut* is close grained,durable, of a brownish colour and beautiful in appearance.

A PRACTICAL HOME-MADE TELEPHONE

By B. Clements-Henry

For some years previous to 1914 the constructive instinct and ability inherent in many of us was almost snuffed out because most of the mechanical and electrical things we wished to possess were so cheap that they could be bought ready made. Often the prices quoted were actually below the cost to us of the raw materials, and so we came to think that constructive hobbies were a bit futile. Lots of those cheap things were amazingly good, but some were exasperatingly bad, and the bulk indifferent. Still, we bought the stuff, learned nothing from it, and clean missed all that solid satisfaction that lives for ever in building and contriving and *creating*.

Take the ready-made cheap telephone, for instance. How long did it take to get fed up with ringing and asking "are you there?" Was it really worth the outlay of 15s. to 45s.? Frankly, no. Why? Because our purchase locked us out from all the subtle mysteries of an ever-wonderful instrument (simple though it be), and we had been robbed of all the joy of its making. If it failed to act we discovered that we could not put it right. If it acted perfectly, we took the whole thing for granted and soon became bored. But to build up that same installation oneself in the face of difficulties from the homeliest of raw materials, and at last to have it (in literal fact) voicing our triumph in our eager-listening ears — ah, that is a very different matter !

The writer has been asked to simplify everything in the making of a home telephone down to an irreducible minimum ; and he will do his best ; but he must assume that the boy mechanic knows by this time something of the use of tools. Readers who are better equipped than most with tools and the skill to use them can improve on primitive methods here and there. The whole design is original to this book, and was thought out especially for it with a view of reducing the difficulties of construction to the utmost, yet to retain every essential detail that goes to make up a reliable and efficient installation capable of calling up, speaking and hearing as well as any first-class telephonic apparatus can. Some of the parts have been practically re-invented to attain this end, and the least experienced boy mechanic who cares to follow these instructions to the letter can be definitely and confidently assured of the complete success of his undertaking.

Through want of space the theory of the telephone cannot be discussed here, but those who wish to master its beautiful simplicities can do so by an hour's study of Cassell's "Work" handbook on the subject. In the present chapter points of difficulty or of importance will be emphasised (without explanation) by the use of *italics.* Where these appear the reader is asked to sharpen his wits and exercise special care, adhering closely to the instructions—blindly so, if need be ; and rest assured that they will not "let him down."

A Practical Home-made Telephone

This installation is a "real" one in every respect. It consists of two series-type wall-sets having electric call-bells, hand-combination telephones slung on automatic hook-switches, calling press-buttons and batteries complete. It will speak clearly and distinctly over 150 yards of No. 20 gauge line wire, and farther if thicker line is used.

The Hand-Combination Telephone.—The hand-combination (of transmitter and receiver in one) is familiar to most people, and even in its practical home-made form, shown in Figs, 1, 2 and 3, it will be easily recognisable. This being far the most complicated part should be tackled first, and it would be best to build the necessary pair (one for each station) concurrently.

Fig. 1 shows the front of the instrument—the receiver above and the transmitter below. Fig. 2 is a side half-section showing all the working parts; and Figs. 3 is the back view, in which the wiring connection is seen proceeding from the left-hand terminal screw (at the bottom) to the left bobbin of the receiver, through its winding and that of the right bobbin and back to the metal cover of the transmitter. The other terminal screw is wired direct to the carbon block in the centre of the transmitter. The several wire ends appear also in the side section (Fig. 2).

The woodwork must first be made; it consists of three parts; the body A and the two discs B and C, which are glued to the face of the body. Mahogany, teak and walnut are the most suitable woods; beech and oak will serve admirably, but are harder to work; deal is scarcely good enough.

The body A is 9 in. long over all, by about $2\frac{1}{8}$ in. wide across the circular ends; the exact size of these will depend on the diameter of the two tinplate box-lids used as covers for the transmitter and receiver (*see* Figs. 1 and 2). Tooth-powder or boot-polish tins vary in size, but the lids should be selected of not less than $2\frac{1}{8}$ in. and not more than $2\frac{1}{2}$ in. in diameter, the former size being here illustrated. The wood should be exactly $\frac{3}{8}$ in. thick when planed up and glasspapered smooth and flat.

First cut out the body A with a keyhole saw, and shape it by careful paring with the chisel and by glass-papering. The midway handle part may be $\frac{7}{8}$ in. to 1 in. wide, and should be rounded off neatly to form a convenient grip, as shown, the disc ends being finished quite flat. The discs themselves, B and C, are of the same $\frac{3}{8}$ in. wood; they must be sawn out, pared and glasspapered to make a close and accurate fit for the tinplate box-lids. The transmitter disc (below) has a 1-in. diameter centre-bit hole bored through its centre, and the receiver disc (above) has two $\frac{11}{16}$-in. or $\frac{3}{4}$-in. holes carried through it, side by side, their centres being spaced a shade more than $\frac{5}{8}$ in. apart, say $\frac{21}{32}$ in., which will cause the holes to cut into one another.

If preferred, all these holes can be bored in the board before cutting out the discs therefrom, but the better way will be to attach the finished blank discs to the body and bore them afterwards. A good, durable joint can be made with glue alone, applying it rather thin and very hot, the discs being quickly and firmly pressed and rubbed into close contact with the body, and then put aside under heavy pressure to set for twelve hours; a copying-press

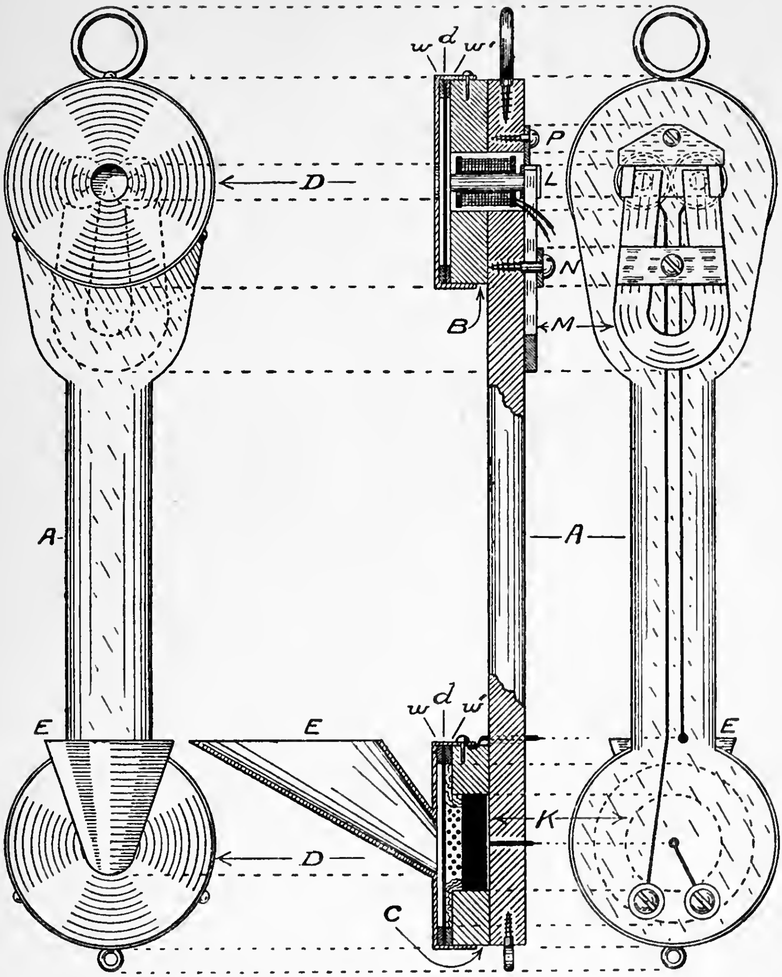


Fig. 1

Fig. 2

Fig. 3

Figs. 1, 2 and 3.—Front Elevation, Vertical Section and Back Elevation of Home-made Hand-combination Telephone. (Scale, 6 in. = 1 ft.)

or a linen-press can be used, or failing these the body may be laid on a flat surface, discs downward, and weights piled on its ends. If preferred, three equally spaced ⅝-in. brass wood-screws can be used additionally to the glue; but care must be taken to place these where they will not interfere with fittings to be subsequently attached, as shown in the illustrations.

After the glue has thoroughly set, the holes must be bored; if any difficulty is anticipated in making them neatly and accurately, any working carpenter will bore them for a trifle. The 1-in. hole at the transmitter end goes through the disc C only, but the two $\frac{11}{16}$-in. holes at the receiver end pass right through B and the body A also. This being done, drill holes for and fit the large screw-eye seen at the top and the small one at the bottom; then remove them again, temporarily. Fit also the two tin-box lids, finally, to the discs, remove them, glasspaper the woodwork all over, and fill the grain thoroughly with a good body of french polish applied with a brush.

The receiver-magnet M is one of the ordinary horseshoe type obtainable at toyshops; the 2 in. size is chosen for illustration, but it may be larger if the woodwork is adapted to suit. It is important that its magnetism be strong, and the two magnets required should be carefully selected from a batch; they should easily support at least four times their own weight suspended from the keeper. The poles of each magnet must be fitted with a stout sheet-brass clip shown at L (Figs. 2 and 3), and on an enlarged scale in Fig. 4. The brass may be $\frac{1}{16}$ in. thick or a trifle less, by about ½ in. wide and 1¾ in. long. Mark the points at which the ends are to be bent by laying the magnet-poles upon the brass, and lightly scribing a line outside each limb. Then bend at right angles in a vice or pair of strong pincers and finish the hooked ends by beating down over a strip of flat metal of similar substance to the magnet. (Do not beat the brass on the magnet itself, because the steel is hard and brittle and may snap). Make the clip a very close push-on fit for the pole ends, and then file to about $\frac{3}{8}$ in. width, as shown, so that, when pushed on as far as the slant of the limbs permits, the upper edge of the brass extends about $\frac{1}{16}$ in. beyond the pole-faces. Now drill two $\frac{3}{16}$-in. holes through the clips a shade more than $\frac{5}{8}$ in. apart.

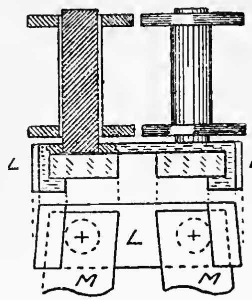


Fig. 4.—Full-size Details of Clip, Cores, Bobbins, and Magnet-poles

Obtain from any ironmonger a piece of $\frac{3}{16}$-in. "nail-rod," which is *ordinary wrought iron*; better qualities of iron such as Bessemer or mild steel will not do so well. From this, cut off $\frac{3}{4}$ in. lengths for the pole-extensions that are to carry the bobbins (all of which are shown in Figs. 2, 3 and 4). File up bright all over, and make all exactly of one length with the ends perfectly flat. Fit these pole pieces into the holes in the brass clips, very tightly and truly upright, with their inner ends very *slightly projecting* through the brass. If they were riveted into the brass the iron would be hardened and rendered less permeable by the magnet-flux of the magnet, so the pole-extensions must be soldered into the holes. If all the parts are quite clean and bright and plenty of zinc chloride soldering fluid ("killed" spirit; *see* p. 126) is applied, together with a few scraps of solder placed round the iron cores, the joints will solder themselves if the brass-clip is held in pincers over a gas flame. Get a good run of solder round the base of each pole-extension, then cool off, quench in water, and wash thoroughly to remove the acrid flux. File the pole-ends bright again, carefully removing every trace of solder from the two inner end-faces, and use every endeavour to make these set flush and hard upon the faces of the steel magnet when the clip is pushed on as hard as it will go. That is why the iron ends must project a trifle through the brass—to make certain that they (and not the brass) are pressed hard and flat against the magnet.

It should now be found that most of the magnet's attractive force is transferred to the tips of the two iron extensions; which is as it should be.

The bobbins are made up of glued paper tubes with wooden or cardboard ends glued on. Cut off a piece of the $\frac{3}{16}$-in. iron rod about 2 in. long and file it bright and smooth. This makes a mandrel, or former, on which to roll a paper cylinder long enough to cut into two bobbin tubes. Cut a strip of medium notepaper about $1\frac{1}{2}$ in. wide by $1\frac{3}{4}$ in. long; roll this lengthwise round the mandrel, which it will be found to lap about three times. Unroll, mark the line of the first overlap and dress the remainder of the strip with thin hot glue; roll up tightly and compress by rolling on a flat surface under a piece of smooth board with considerable pressure. When consolidated the tube can be slipped off the mandrel and dried. Cut out two discs for each bobbin $\frac{5}{8}$ in. in diameter, the central holes being a snug fit for the tube ends. Put the tube on the mandrel, cut it in two, midway, with a sharp knife, glue the discs on the tubes square and true to measure $\frac{5}{8}$ in. long over all exactly. Put aside for at least twelve hours to harden, slip on to the mandrel again, trim off the tube ends flush with the discs, glasspaper smooth all over, and place in a *cool* oven for half an hour.

Meanwhile, melt some paraffin wax (paraffin candle ends will do) in a gallipot stood in the oven. (*Do not overheat the wax*). When this has melted and the bobbins are quite dry and warm, soak them for a few minutes in the wax, then drain, cool them off and polish with a dry cloth.

When the bobbins are in position on the pole-extensions and the brass clip L is pressed on to the magnet-limbs, and the magnet is laid flat upon the back of the wooden body A, the bobbins should pass easily through the $\frac{11}{16}$-in. twin holes bored to receive them, and the end-faces of the pole-extensions should be *exactly level* with the face of the disc B, as clearly shown in Fig. 2. The magnet M is secured to the body A by one mushroom-head brass wood-screw passing through the brass plate N. The triangular-shaped brass plate P is screwed to the body as shown simply to prevent the pole-clip L from slipping off the slanting poles of the magnet, as otherwise it might be prone to do if the combination is roughly handled in use.

Obtain from any photographic stores a sheet of *ferro-type plate* (which is thin Swedish iron sheet coated on both sides with an elastic black enamel). Take a pair of compasses and draw a 2-in. diameter circle on a sheet of paper. Cut this out and gum it lightly to the ferrotype sheet. Cut the ferrotype to match the pattern, then soak off the paper and dry the enamelled disc. (Scissors cut ferrotype very easily.) Compasses must not be used to mark the disc direct because their centre-point would dent or perforate the thin iron, whereas the disc must be kept perfectly plain and flat. If, now, this iron disc were laid on the surface of B it would, of course, touch and cling to the magnetised pole-ends; it must, therefore be raised off the surface of B sufficiently to give it room to vibrate freely (like a drum-head) notwithstanding the strong pull of the magnet-poles. But the air-space separating the disc from the poles must be the least possible that will just keep them from mutual contact. This necessary spacing is effected by a ring or washer of thin card gummed to the face of B; the washer may be of the same diameter as B (say $2\frac{1}{8}$ in.), and $1\frac{3}{4}$ in. inner diameter (which will make it $\frac{3}{16}$ in. wide). The pull of the magnet will bulge inward the elastic iron-disc (or diaphragm, as it must now be called) somewhat, but it must not touch the poles. When testing, press the middle of the disc gently with the finger-tip; it should touch the poles and be felt to cling to them on very light pressure, but be released promptly when the finger is removed. If one thickness of card does not suffice, gum a thin paper washer over the cardboard one; or if the card seems too stout reduce its thickness by glasspapering. The diaphragm is fixed by laying another (and thicker) cardboard (or rubber) ring upon it and then pressing on the tinplate cover tightly. The whole arrangement is clearly seen in Fig. 2, which shows the diaphragm *d* nipped between the washers *w* and w^1, but to make the drawing clear both the diaphragm *d* and the thin inner washer w^1 are shown much thicker than they are in practice.

The aperture D in the centre of the cover is $\frac{3}{8}$ in. in diameter, it can be cut out very neatly with a centrebit of that size, without damaging the tool. Three small equi-spaced holes should be drilled in the rim of the cover to take three small upholstery brass pins for securing the cover to the woodwork when all is finished and the covers finally pressed home.

Having carefully fitted the diaphragm and the magnet M by its two brass plates N and P, all must be taken apart again, temporarily, for the winding of the bobbins with insulated wire. But before this is done the transmitter claims attention. Although the transmitter unit (enclosed in the wood disc C below) is contrived in so simple a way, it is in all respects a reliable instrument of the Hunnings-Deckert granular type in modern use.

The solid carbon block K, shown black, may be a 1 in. square cutting from a broken battery carbon plate $\frac{1}{4}$ in. thick, with its angles removed by rubbing down on a grit-stone doorstep or in a household sink of that material. The rounding off of this block in this way may be rather black and dirty work, but it is soon done, particularly if plenty of water and some sharp sand are used to hasten the grinding. The use of a grindstone much speeds up this uncongenial job. The rounded block should be made a push-in fit for the 1 in. hole in C ; if one of its faces can be roughened by a number of parallel grooves scored across the disc at right angles with each other, latticewise, using an old rasp, file or saw-blade for the job, so much the better; but this is not absolutely necessary. When finished, wash the block free from grit and dry it off thoroughly by heating strongly in the oven.

Cut a 1 in. disc of tinplate or sheet brass, solder a length of covered copper wire to its centre, wash, dry, polish and then pass the wire end through the central hole and push the metal disc to the bottom of the 1 in. cavity in C (*see* Figs. 2 and 3). This is for the smooth side of the carbon block K to bed upon, but to improve the electrical connection between the carbon and metal discs a pad made up of several discs of tinfoil should be compressed between them. Take the carbon block hot from the oven and melt some pitch, marine glue or sealing-wax around its rim (but not on its face or back); then quickly force the hot carbon into the cavity, bedding it firmly on the tinfoil and sheet metal discs and maintaining it under heavy pressure until cold. A cardboard washer w^1 is next gummed to the face of C, just as was done in the case of B (the receiver), but this inner washer of the transmitter must be considerably thicker; about $\frac{1}{8}$ in. or a little less. The transmitter-diaphragm *d* is a 2 in. diameter disc of very thin carbon, which costs a few pence at any electrical stores; it is extremely delicate and brittle, and must be handled daintily.

The space between the carbon disc *d* and the block K is loosely packed with small dustless fragments of granular carbon. This may be ground up from scrap, carefully screened to size and sifted free of dust, but the specially prepared article costs only a few pence per ounce (1 oz. will be sufficient for two instruments), and this had better be purchased along with the diaphragms. To confine the granules to the central areas of the disc and block a circular bedding of soft cotton wool must be lightly disposed over the face of c, within the washer w^1 and extending inwards over the brim of the block-aperture, as suggested by waved lines in Fig. 2, making a soft and yielding nest, as it were, for the granules to lie in. The delicate carbon disc *d*, when placed on the washer *w*, should press down and gently confine the boundaries of this wool nest, but it should bed firmly on the washer, also, and the wool should not be so dense as to endanger the carbon by any excessive strain.

The outer washer *w* may be of cardboard or it may be a stout rubber ring. In either case, this washer must be entirely enclosed in a covering of tinfoil. This is best applied in very narrow strips wound over and under all round the ring with the strip edges overlapping; a mere touch of gum may be used to secure this foil binding, here and there; but not too much, or the conductivity of the metal sheathing will be lessened.

So much for the outer washer *w*, but before the parts are assembled, the face of the inner washer w^1 must also be foil-coated. A plain washer of tinfoil gummed on will do in this case, but it should be rather larger in diameter than w^1 (say $2\frac{1}{4}$ in.), so that its margins will be compressed into close metallic contact with the tinplate cover of the transmitter when the latter is pushed on. Thus the carbon disc *d* will be in good electrical connection with the outer cover when nipped between the foiled washers *w* and w^1, and when all parts are in position the two wires passing out to the back of the body will complete an electrical circuit through the block K, the nested granules, and the carbon disc *d*.

The central hole in the transmitter cover is fitted with a cone of tinplate soldered on skewwise to form a mouthpiece, and requires no further explanation.

To assemble, the granules are lightly strewn over the roughened surface of K, within the wool nest, and the disc *d* placed over them and gently pressed down. The disc should slightly confine the grains, but it should bed on the washer *w* firmly. Several tests must be made (when all is finished) before the best quantity of grains for clear speaking can be decided, and then the covers can be finally pushed on and secured permanently by the three brass pins around the rim.

Winding the receiver bobbins is a delicate job, but perfectly simple if the utmost care be exercised. No attempt should be made to wind by hand as it would prove a waste of time and fruitful source of failure through the tangling and snapping of the very fine-gauge wire necessarily employed (No. 36 gauge). You must, therefore, knock up the little wooden windlass shown at Fig. 5A with an axle $\frac{3}{16}$ in. in diameter to fit the bobbin-bores moderately stiffly; clamp this to the edge of the work bench and mount the store-bobbin of insulated wire on a bent wire " horse," as in Fig. 5B, driven into the same at a convenient point. Turn the crank handle with the right hand and guide on the wire with the left. Wind the wire *quite closely and evenly,* as a reel of cotton thread is wound; do not allow spaces to appear between the coils; do not heap up the wire. As each layer is wound on saturate it with paraffin wax applied in fragments and melted with the warmed blade of a blunted table-knife, palette-knife, or putty-knife. *Do not overheat the knife;* let it be warm enough to melt the wax freely, but not hot enough to cause smoking. A very little wax will be found sufficient to saturate the covering of the wire (turning it to a darker shade of colour). Use no superfluity of wax to cause lumps and irregularities. Interleave every layer of wire with *one lap* of thin paper cut in strips the *exact width* of the winding-spaces. Apply the paper to the wire-layers (already waxed) by rubbing it down gently with the warmed knife. The wax will saturate

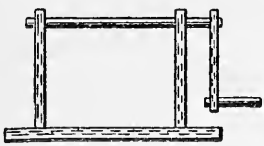


Fig. 5A.—Windlass for Winding Bobbins

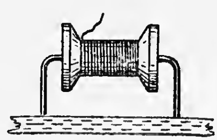


Fig. 5B.—Store-reel mounted on Wire Horse

the thin paper, also, when this is done, and it will adhere closely and leave a smooth surface for the following layer of wire. When the interleaf is taken once round, overlap it very slightly ($\frac{1}{16}$ in. or so), tear off the surplus of the strip, "sleek," down to the seam and proceed patiently winding, waxing and interleaving until the bobbin is nearly full.

In Fig. 2, the section shows the wire conventionally by latticed lines; only four layers are indicated, but in practice there will be about fifteen layers to build up. Every layer should have the same exquisite care bestowed on its winding. It is slow and rather monotonous work, and to hurry it leads to failure. Great patience must be exercised, for there are several hours of work in each bobbin.

Count the layers of the first bobbin and wind the others with the same number. Wind all the bobbins in the *same direction* on the windlass; then, when the pairs are mounted on the cores, it is only necessary to join either *both the outside ends*, or both the *inside ends*, of the windings together to obtain the correct S-wise circulation around the cores. (Carefully note this.) The beginning-end and the finishing-end of each winding may be passed out through holes drilled in the bottom disc to be placed nearest the yoke L. Alternatively, the beginning-end of the wire may be "cemented" to the inner face of one bobbin cheek with wax, and brought out sandwiched between it (the bobbin-cheek) and a washer of waxed card (the latter being cut through to the central hole to allow it to be slipped over the bobbin-tube). The emerging inner wire end will thus be insulated from the succeeding coils by a waxed cardboard wall.

When fully wound, the external layer of wire must be enclosed in a protective sheath of two or three laps of stout waxed paper well consolidated with the warmed knife and smoothed down.

The bobbins may now be pushed on to the cores, their inner winding ends snipped to an equal length, the ends freed of insulation, cleaned, twisted together and soldered. But note that soldering-fluid must *not* be used in this case; *resin* is the only safe flux for soldering electrical wires. The two free wire ends should be similarly cleaned and prepared for jointing, and then all parts of the hand-combination can be put together as in Figs. 2 and 3. The handle connections are clearly shown by the black lines in Fig. 3; these should be made with fairly stout wire, say No. 22 gauge; they may conveniently be laid in grooves cut in the back of the wooden body A. The junction of the thin receiver-wires and the stouter ones may be made by soldered joints, or by looping the ends of both the thin and the thick wires under two brass washers secured by mushroom-head screws at a convenient point, say just within the loop of the magnet. This is not shown in the illustrations, but the current-path is made quite clear.

Starting from the left terminal screw and washer at the lowest point of the transmitter (Fig. 3), one conductor passes to the receiver-magnet and thence returns to the transmitter-casing (*see* also Fig. 2), whence current passes through tinfoiled washers w and w^1 to carbon diaphragm d, the granules (dotted), and the carbon back-block k, to the right-hand terminal. (The grooves containing the conductors can be filled in with shellac applied with a heated iron.) One yard of twin-flexible telephone-cord must be threaded through the small screw-eye, and the bared end of each conductor neatly looped and screwed down firmly under the terminals, left and right. This completes the hand combination. Its total cost for materials should not exceed 2s., or say 50 cents, even at war-time prices. The requirements are 1 oz. of No. 36 gauge silk-covered wire (½ oz. on each bobbin); carbon diaphragm; 2 in. magnet; sundries, 4d., or say 8 cents.

The Wall-Sets.—Fig. 6 shows one of the wall-sets; it is designed to dispense with all ready-made electrical parts, and only the wire for the bell-magnet (2 oz. of

No. 26 gauge, silk-covered) need be purchased. The gong may be taken from a disused cycle-bell, or an efficient substitute can be improvised by use of a wine glass with a broken stem (which emits a clear and musical note).

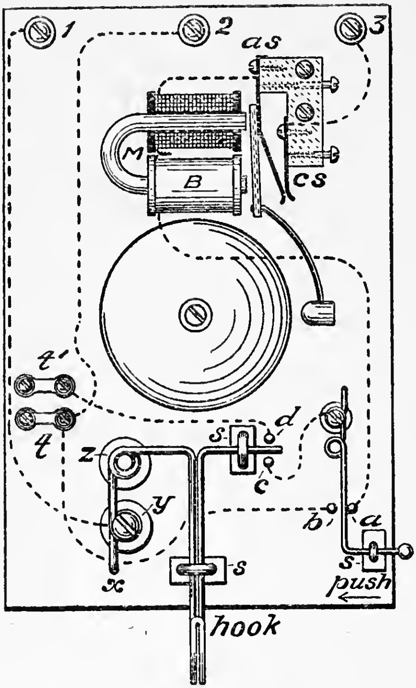


Fig. 6.—Details of Complete Wall-set. (Scale, 6 in. = 1 ft.)

The magnet M is bent up, from a 4-in. length of $\frac{3}{16}$-in. common wrought-iron "nail-rod" and measures $1\frac{1}{4}$ in. from the curve to the pole ends, the latter being spaced about $\frac{11}{16}$ in. to $\frac{3}{4}$ in. apart.

The bobbins B are 1 in. long by $\frac{5}{8}$ in. in diameter, made and wound as already described, but with about 1 oz. each of No. 26 gauge silk-covered wire.

The armature is a piece of strip wrought iron about $\frac{5}{16}$ in. to $\frac{3}{8}$ in. wide by $\frac{1}{16}$ in. to $\frac{3}{32}$ in. thick. The armature-spring *a s* and the contact-spring *c s* are sheet brass hard-beaten with a smooth-face light hammer on the surface of a laundry-iron to make the metal springy, then filed and glasspapered smooth and thin. (To make the drawing clear their thickness is exaggerated.)

The bell hammer is a bit of iron or brass rod filed round-ended and soldered to a wire shaft, itself soldered into the armature; the spring *a s* is also soldered to the armature.

These springs are mounted, by one mushroom-head brass screw each, on a rectangle of tough hardwood (such as oak or beech), which is shown partly shaded. This is drilled to receive two other screws (shown dotted), the upper one 1 in. long and the lower one ½ in. long, with their extreme points filed flat. These screws adjust the stroke of the hammer on the gong; the upper screw advances the armature nearer to the magnet-poles, according to the battery power available; and the lower one advances the contact-spring *c s*, so regulating the rapidity of the hammer strokes. The wooden support of both springs is attached to the baseboard by two more mushroom-head brass wood-screws, the heads of which are shown. Devised especially for this book, this form of contact-breaker is really a better arrangement than the usual one (requiring finished parts), the contact-point of the springs being of the "rubbing" type which is self-cleaning and requires no platinum facing. If, however, some silver scrap is available it will repay the trouble to solder a small cutting of silver to each contact-face.

The magnet is secured to the baseboard by a screw passing through a wooden or metal cross-bar placed across the bobbins, as at N (Fig. 2).

The push and automatic switch-hook movements are also of original design; both are bent up from lengths of wire. That for the switchhook may be No. 12 gauge hard brass, but the push-spring may be thinner. To make them, drive nails or screws into the bench (or an odd piece of board) in the requisite positions and bend the wires round the patterns (" jigs ") thus improvised.

For the switch-hook, take about 1 ft. to 15 in. of the stouter hard brass wire, bend ½ in. of one end at right angles and drive this into a hole in the bench (*see x*) about ½ in. distant from the first jig-screw. Twist the wire round this, one complete turn (*see y*), and round the second jig-screw ⅝ in. farther on, one turn and a quarter (*see z*). Now remove from the bench and bend the wire at right angles about ⅞ in. distant from the *z* twist; and at 3¼ in. from this angle fold the wire closely upon itself (*see hook*); and opposite the last right angle, bend once more at right angles to form the right-hand ⅞-in. extension shown. The doubled portion of the wire may be soldered together or not, at option, and when about 1½ in. of the doubled end is curved forward into a hook of about ¾ in. semi-diameter the fitting is complete. It is mounted by driving its ½-in. spur *x* into the baseboard and securing eyelet *y* down upon a brass washer by a mushroom-head wood-screw. A bone games-counter may be tacked to the baseboard under the spring eyelet *z* and counters (or rectangular cuttings from the same) may be drilled to go under the (easily driven) staples *s*, which keep the hook-switch in position, but allow it free movement up and down between the contact-pegs *c* and *d*. For clearness, the drawing shows the contact end of the switch midway between pegs *c* and *d*; but in practice the spring is given a strong bias upward, so that it always presses hard against the *d* peg until the hand-combination telephone (Figs. 1, 2 and 3) is suspended on the hook, which removes the contact-end from *d* and carries it to rest firmly on *c*.

The push-spring is on identically the same principle as the switch-spring, but simpler and of lighter gauge wire; it is secured by its spur (like *x*), one screw (like *y*), and a staple (*s*). Its permanent spring-bias keeps it hard against peg *a*, but when it is pressed to the left (*see* arrow) it makes contact with *b*.

The two little double-screwed fittings 4, 4^1, on the left side of the board are connections for the ends of the telephone-flexible, and the three terminals, 1, 2 and 3, at the top of the board, are mushroom-head wood-screws passed through brass washers. All the baseboard connections should be of No. 22 gauge copper wire laid in grooves at the back. They need not follow the routes shown by the broken lines, but may take any other direction found to be more convenient, provided that they do not touch each other at any point or crossing.

The contact-pegs *a*, *b*, *c* and *d* may be of stout brass wire with a few inches of No. 22 gauge wire soldered into small holes drilled in their ends; alternatively, the wires may be soldered to flats filed on the peg-stems. (If all the contact points can be sheathed with silver-scraps, soldered on, so much the better; but this is not essential, as the parts are easily accessible for cleaning.) The pegs being driven partly through the baseboard, their thinner wire extensions can be neatly bent down into the grooves, previously cut, and either carried along them and through small holes to the washers, etc., on the front of the board, or soldered (in the grooves) to the ends of other wires brought half-way to meet them. (All joint soldering must be done with *resin* and no other flux.)

The curved broken lines so clearly indicate the baseboard connections that it is necessary only to explain the current paths between the two stations when ringing-calls are sent or conversation is exchanged. As shown, the baseboard measurements are $6\frac{1}{4}$ in. by 4 in.; the completed wall-sets should be provided with outer casings of thin fretwood or of tinplate mounted on wood fillets, to preserve the mechanism from dust and tampering fingers. A central orifice backed by a piece of wire gauze will let out the sound of the gong. This suggestion is embodied in Fig. 7, which shows the external wiring to the batteries and lines complete.

Conclusion.—A complete understanding of the whole installation will best be obtained by a systematic trace-out of the current paths, to which end Figs. 6 and 7 must be studied. Let it be assumed that station A is calling station B (Fig. 7). A's push is pressed to the left and current from the carbon (+) of the A-battery flows by terminal 2 (*see* Fig. 6) to stud *b* of the push (pressed to the left) and through its spring to stud *c* of the switch (which is *down* because the telephone hangs on the hook) and so to screw *y* and terminal 1. Thence (*see* Fig. 7) it travels by *line* to terminal 1 of station B and to screw *y* (*see* Fig. 6) and the switch-hook (*down*), stud *c*, the press-spring (biased to the *right*) and stud *a*, through the magnet-coils B, springs *a s* and *c s* (ringing the bell) to terminal 3 and back to the zinc (—) (Fig. 7) of the sending-battery at the A station, by the *return* line. Thus A can call up B, and B can call up A similarly. A and B now lift their telephones from the hooks, and the switch springs rise breaking contact with studs *c*, and making contact with studs *d*. Current now passes continuously through both telephones and both batteries *in series*, and the bell-circuits are cut out completely. Starting, say, from + of the A battery (Fig. 7), current flows by terminal 2 to con-

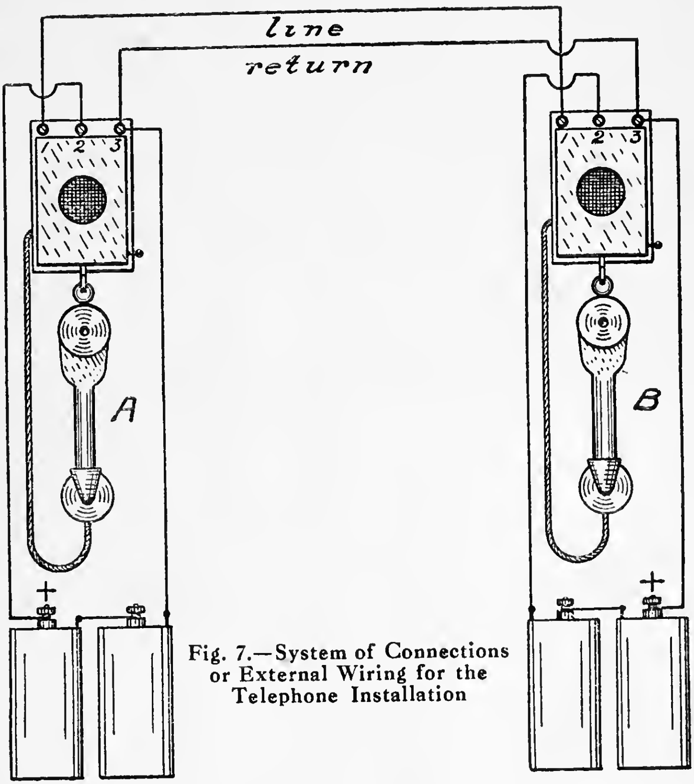


Fig. 7.—System of Connections or External Wiring for the Telephone Installation

nection *t* (*see* Fig. 6) and by one conductor of the twin-flexible through the transmitter and receiver of the hand-telephone (*see* Figs. 1, 2 and 3) and back by the other conductor of the flexible to connection t^1 (Fig. 6), to stud *d*, the switch (*up*), screw *y*, to terminal 1 and thence by *line* to terminal 1 of station B (Fig. 7) to screw *y* (Fig.

6), the switch hook (*up*), stud *d*, connection t^1, the telephone, connection *t*, and terminal 2. Then down to the zinc (—) of the B battery (Fig. 7) through it to +, and (reinforced in power) back by the *return* line to the zinc (—) of the A-battery from which this series-trace commenced.

Well, there you are, dear fellows; the simplest telephone in the world has been designed and described for you. Simple though it be, and within reach of the shallowest purse, it is no toy or makeshift, but the real thing, capable of conveying clearly and reliably the most important conversation that ever passed over wires between the two "biggest pots" on earth. Listen! The writer hails you—"Are you there?"—"Au revoir!"

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