BUREAU OF EDUCATION

WOODWORKING FOR BEGINNERS

A TEXTBOOK FOR USE IN
THE TRADE SCHOOLS AND SCHOOL SHOPS
OF THE PHILIPPINES

COMPILED BY
FRANK W. CHENEY

MANILA
BUREAU OF PRINTING
1915

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BUREAU OF EDUCATION PUBLICATIONS.

[Abbreviated list.]

ANNUAL REPORTS:

First to Tenth Annual Reports of the Director of Education. 1901–1910. (Supply exhausted.)
Eleventh Annual Report of the Director of Education. 1911.
Twelfth Annual Report of the Director of Education. 1912. (Supply limited.)
Thirteenth Annual Report of the Director of Education. 1913.
Fourteenth Annual Report of the Director of Education. 1914. (Not published.)
Fifteenth Annual Report of the Director of Education. 1915.

BULLETINS:

1 to 8 and 10 to 30, inclusive. Various subjects relating to the early activities of the Bureau. Editions for the most part exhausted and material obsolete.
9. List of Philippine Baptismal Names. 1905. (Revised, 1915.)
31. School and Home Gardening. 1910. (Revised, 1913.)
32. Courses in Mechanical and Free-hand Drawing. 1910. (Edition exhausted.)
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35. Housekeeping and Household Arts—A Manual for Work with the Girls in the Elementary Schools of the Philippine Islands. 1911. (Edition exhausted.)
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37. School Buildings and Grounds. 1912.
38. School Buildings—Plans, Specifications, and Bills of Material. 1912.
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40. Athletic Handbook for the Philippine Public Schools. 1911. (Revised, 1913.)
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Volume VI. 1913. (Supply limited.).

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FOREWORD.

Since woodworking became a part of the plan of manual instruction in Philippine public schools, the need has been felt for a text suitable to the conditions under which this work is being carried on. The standard American text-books contain much material, particularly as to woods and their treatment, that does not apply here; also, the English in them is too advanced for most Filipino pupils.

The Bureau of Education has previously issued two publications dealing with woodworking—one, a Manual of Elementary Carpentry for Philippine Public Schools, and the other a printed circular (No. 97, s. 1912) outlining the Courses in Woodwork for Primary and Intermediate School Shops. These publications, while serving the purpose for which they were intended, presented very little subject matter that a pupil could study; furthermore, they do not meet the requirements of the present day. A new Manual in Woodworking for the guidance of teachers has recently been published in Volume III of the Philippine Craftsman and has also been issued as a reprint. This manual is to be used in connection with the text which follows, the two providing both teachers and pupils with a set of directions and instructions for this form of handwork.

The text here given is not original. To the contrary, it has been adapted from several approved publications and has been reviewed by a committee of teachers in the Philippine service who have an intimate knowledge of this phase of school work in both trade schools and school shops. In addition to this, the text has been read and discussed by a representative committee of seventh-grade boys. Words and phrases which they could not understand have been either eliminated or substituted by others, except those found necessary to express the meaning satisfactorily. Every effort has been made to keep the English so simple that the average seventh-grade boy can read and understand it without the aid of a dictionary. This object has been pursued throughout, and, if at a sacrifice of literary merit, it is believed with a consequent gain along practical lines.

Parts I and II have been adapted from Goss's "Bench Work in Wood" and changed to suit local conditions. Part III was taken largely from Bulletin No. 10 of the Bureau of Forestry, was reviewed by Mr. E. E. Schneider, wood expert of that Bureau, and was corrected to meet his approval. In preparing Part IV use was made of an American textbook, "Wood Finishing," by LeMair, and of notes furnished by Mr. Bartolome Pascual, of the Philippine School of Arts and Trades. This part was approved for use and published in The Philippine Craftsman (Vol. I, No. 8). Part V was compiled from information furnished by local authorities, while the questions in Part VI have been taken from the text matter herein. Part VII was adapted from an American textbook, "Wood Turning," by Ross.

The judicious selection of this material, as well as its subsequent adaptation and arrangement in suitable form, was made by Mr. Frank W. Cheney, acting superintendent Philippine School of Arts and Trades, for which reason the name of Mr. Cheney may not inappropriately figure as the author-compiler of this work.

This text, together with the Manual in Woodworking now current, shall be considered as official; the former was authorized for use as soon as published. Woodworking for Beginners and A Manual in Woodworking for Philippine Public Schools will supersede all other publications and circulars on the subject heretofore issued by the Bureau of Education.

FRANK L. CRONE,
Director of Education.

MANILA, *January 1, 1916.*

TABLE OF CONTENTS.

PART I.

PART II.

WOODWORKING FOR BEGINNERS.

Part I.—BENCH TOOLS.[1]

Bench.—A simple form of bench is shown in figure 1; its length may vary from 6 feet upward, depending upon the size of the shop or the needs of the workman. In a school shop the usual bench space allowed for each pupil is 18 inches wide and 4 feet long. For a single bench, to be used by one workman, 6 feet is a good length. The height is regulated by the height of the person who uses the bench. A good height for the average schoolboy is 30 inches. If the bench is built for private use, the owner can decide what height he wants. Benches are made both single and double. To save space, school benches are usually made double—that is, they are made wide enough so that two or more boys can work on opposite sides of the bench. A single bench should be at least 2 feet wide, while a double bench should be 3 feet wide. The drawing shows a double bench intended for use in a school shop. Six boys can work at this bench at one time. The top is made of two thick planks with a tray in the middle for holding tools. If the bench is to be placed against the wall, where only one side will be used, it can be narrowed by leaving off one of the thick boards. Care should be taken to keep the bench top in good condition. It should never be scarred by the chisel or cut by the saw. Nails should never be driven in its surface.

The bench stop (fig. 1a) is intended to hold work while it is being planed. It may be simply a square piece of wood fitting tightly into a mortise in the bench top, which may be driven up for use or driven flush with the top of

[1] The material appearing under this heading has been adapted from Goss's "Bench Work in Wood."

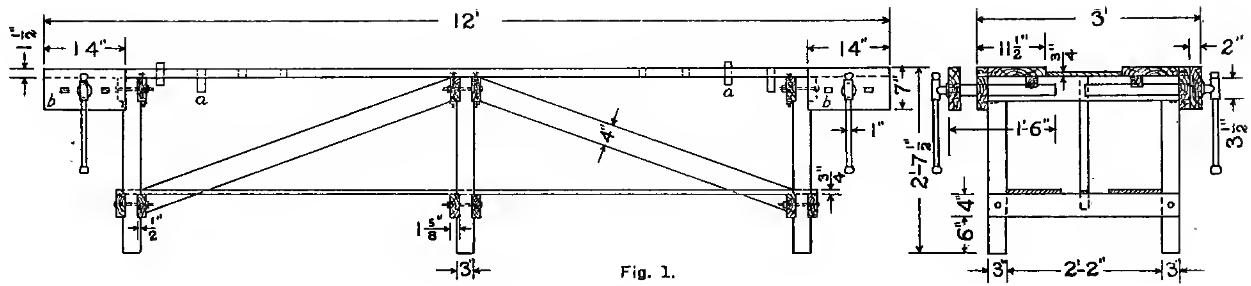


Fig. 1.

BILL OF MATERIALS FOR ONE WORKBENCH.

Finished dimensions:

- 6 pieces 3 by 3 by 30 inches; legs.
- 6 pieces 1⅝ by 4 by 32 inches; crosspieces, bottom.
- 6 pieces 1⅝ by 4 by 36 inches; crosspieces, top.
- 2 pieces 1⅝ by 4 by 60 inches; braces.
- 2 pieces 1½ by 11½ inches by 12 feet; top boards.
- 1 piece ¾ by 13 inches by 12 feet; tray.
- 2 pieces ¾ by 9 inches by 10 feet; shelves at bottom.

Mill order:

- 1 piece 3 by 3 inches by 12 feet, surfaced 4 sides (full dimensions); lauan or some similar soft wood.
- 3 pieces 2 by 4 inches by 16 feet, surfaced four sides; lauan or some similar soft wood.

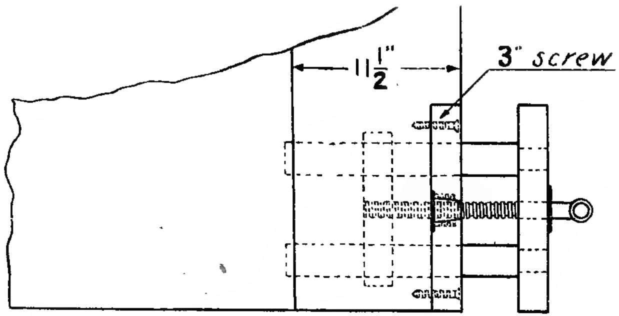
Mill order—Continued.

- 2 pieces 2 by 12 inches by 12 feet, surfaced 2 sides; guijo, ipil, molave, or other hard wood.
- 1 piece 1 by 14 inches by 12 feet, surfaced 2 sides; lauan or some similar soft wood.
- 2 pieces 1 by 10 inches by 12 feet, surfaced 2 sides; lauan or some similar soft wood.

Hardware order:

- 24 bolts, carriage, ⅜ by 6 inches with washers.
- ½ kilo nails, common wire, 2½-inch.

NOTE.—The dimensions of the pieces in the above list can be varied to suit materials at hand, observing the following rules: The legs should not be less than 3 by 3 inches; the top boards should not be less than 1½ inches thick and 11 inches wide; the crosspieces and braces should not be less than 1⅝ inches thick and 3½ inches wide; the tray should fill the space between the top boards; the bottom shelves may be any width desired.



SPECIFICATIONS FOR VISE.

Bill of materials.

Finished dimensions:

- 2 pieces 2 by 7 by 14 inches; jaws.
- 2 pieces 2 by 2 by 18 inches; guides.
- 1 piece 1½ by 2 by 10½ inches; guide block.

Hardware:

- 5 screws, flathead, bright, 3-inch, No. 16.
- 4 screws, flathead, bright, 1¼-inch, No. 12.
- 1 bench screw, iron, 1½ by 18-inch.

NOTE.—The thickness of the vise jaws may be varied to suit materials at hand, but should not be less than 1¾ inches. The most valuable feature of this vise is that its weakest point is in the woodwork. If the vise is misused, the wooden jaws will break, not the bench screw.

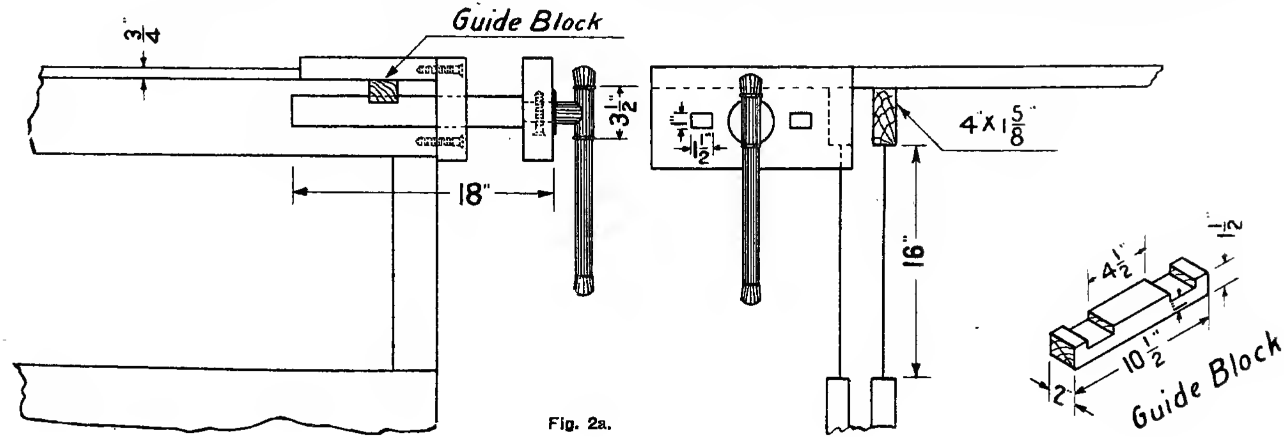
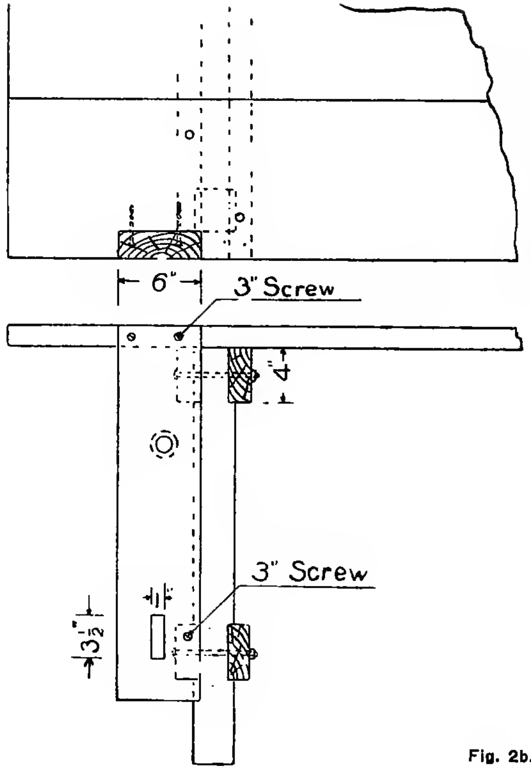


Fig. 2a.



SPECIFICATIONS FOR VISE.

Bill of materials.

Finished dimensions:
- 2 pieces 2 by 6 by 27 inches; jaws.
- 1 piece ⅞ by 3 by 16 inches; guide.

Hardware:
- 1 bench screw, iron, 1¼ by 18 inches.
- 3 screws, flathead, bright, 3-inch, No. 16.
- 4 screws, flathead, bright, 1¼-inch, No. 12.

NOTE.—When using this vise great care must be taken to adjust it to each piece of work. This is done by shifting the pin in the bottom guide. The weak point in this vise is in the bench screw which will break if the vise is misused. The thickness of the jaws may be varied to suit materials at hand but should not be less than 1¾ inches.

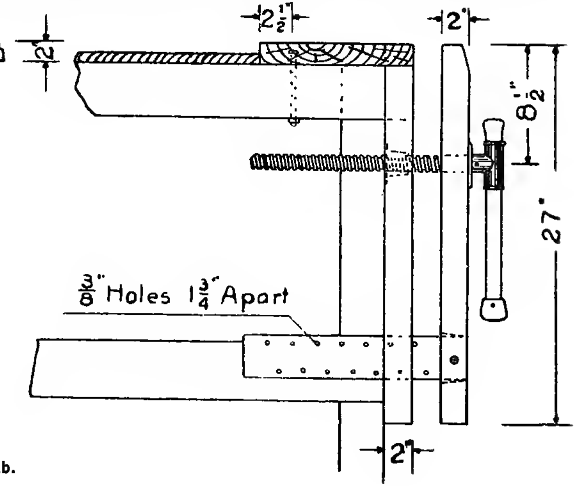


Fig. 2b.

the bench when not in use, or it may be an iron fitting made for this special purpose. The bench stop is used chiefly for holding work that cannot be placed in the vise.

The vise (fig. 2a) is of a form that has been found to give good service. The iron part of it is called commercially the "bench screw," and the wooden jaws are usually made in the shop. In use, the work should be placed as near the middle of the vise as possible. Several other forms of vise which use the bench screw are made but the one shown has one feature that makes it better than the others—when the vise is screwed up too tightly, the wood will break, not the iron screw. Figure 2b shows another very common method of making a vise. This is a very good vise for an experienced workman, but is easily broken by an amateur. It must be adjusted to fit each piece of work. This is done by moving the pin at the bottom from one hole to another until the jaws are parallel.

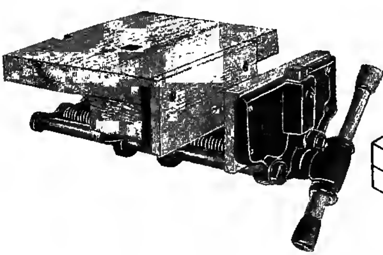


Fig. 3

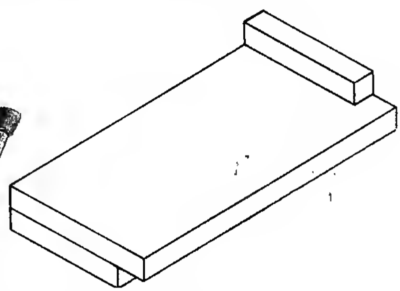


Fig. 4.

Iron vises of the kind known as "rapid acting" are in use in some schools. They are so made that by turning the vise handle to a certain point, the vise will slide in or out to fit the work. They are expensive as compared with the bench screw and are not to be considered in the ordinary shop equipment. Figure 3 shows a common form.

The bench hook (fig. 4) is used as a stop to prevent work from sliding across the bench. Its name is taken from its use—that is, it hooks over the edge of the bench. The flat faces which receive the work and rest on the bench should be true and parallel. Bench hooks are made in several

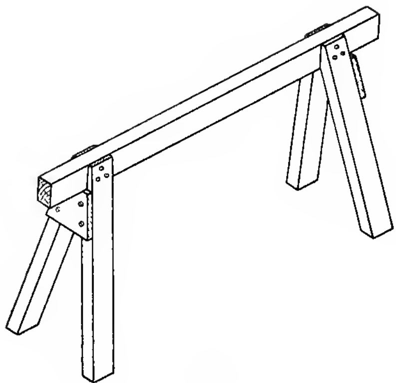


Fig. 5.

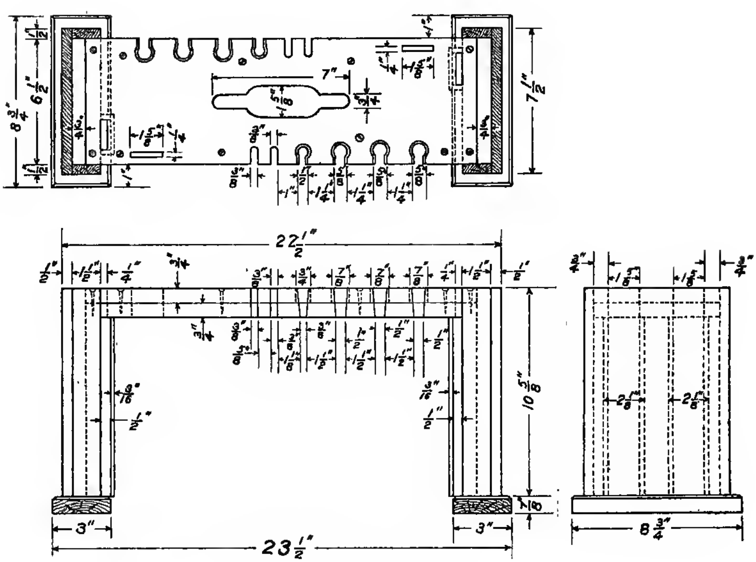


Fig. 6.

forms; the best is that made from one piece of wood. This method removes the danger of nails and screws which, sooner or later, are likely to come into contact with the saw. The simplest form is made by fastening a strip of wood across each end of a board on the opposite sides, by means of screws or nails.

The bench hook is chiefly used when sawing with the backsaw and for holding small work to be chiseled.

Trestles or "sawhorses," as they are commonly called, are used in various ways to support material and to take the place of the bench on very large work. A common form is shown in figure 5.

Tool racks are often made to protect the tools when not in use. Figure 6 shows a good model. This will hold a set of the commonest tools sufficient for two boys, with the exception of the planes and can be easily carried about.

MEASURING AND LINING APPLIANCES.

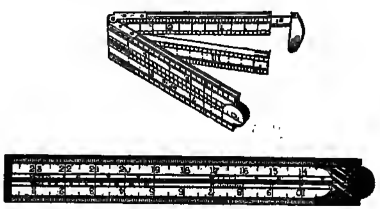


Fig. 7.

Rules (fig. 7) are measuring strips and are usually made of boxwood, a yellowish, close-grained wood somewhat like molave. Their size is expressed by their length in inches, yards, centimeters, or meters, etc., as a "meter stick," a "2-foot rule," or, a "30-centimeter rule."

For convenience, they are often made to fold, and a rule is said to be "two-fold" when it is made of two pieces, "four-fold" when it is made in four pieces, etc. The edges of a rule are often "bound" with strips of brass to protect them.

The English rule is usually divided into inches and fractions of inches: halves, fourths, eighths, sixteenths, and, sometimes, thirty-seconds. The metric rule is usually divided into meters, decimeters, centimeters, and millimeters. The best rule for use in the woodworking shop has both English and metric scales.

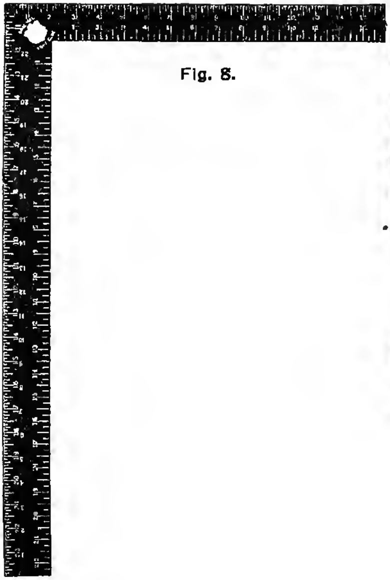


Fig. 8.

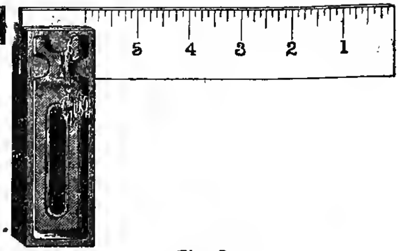


Fig. 9.

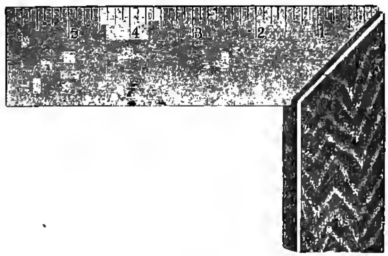


Fig. 10.

The framing square (fig. 8) is often called the *carpenter's square* or *steel square.* It is a tool that belongs to the builder rather than to the bench worker, but its many uses make it a valuable tool to any worker in wood. It is made of steel, having two flat blades at right angles to each other and having scales on every edge. The short blade is usually 16 and the long blade 24 inches long. On the long blade is a table of board measure and on the short blade a brace-measure table. The chief value of this tool to the bench worker lies in the fact that it is much better than a try-square for use on large work. The edges also are often used as "straight-edges" in laying out work. The builder has many

Fig. 11.

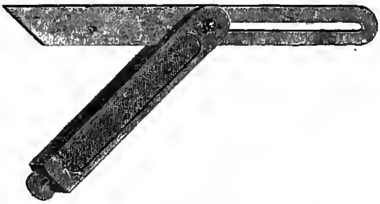


Fig. 12.

uses for the steel square, but they will be omitted as this book deals only with bench work.

A try-square is shown in figure 9. The handle is made of metal or wood. The blade, which is at right angles to the handle, is made of steel. The blade usually has a scale, either English or metric, on its edge, which makes it a useful tool for short measurements. Try-squares are measured by the length of their blades. They are made from 3 to 18 inches long.

A combination try and miter square is shown in figure 10. It can be used as a try-square and also to obtain angles of 45 degrees.

A miter square is named from its use. A miter, in woodworking, is one-half of a right angle, or 45 degrees. In a miter square the blade is set at an angle of 45 degrees to the handle as shown in figure 11.

The bevel, often improperly called "bevel square," is made with an adjustable blade which can be set at any desired angle by means of a thumbscrew. The size of the bevel is measured by the length of the blade in inches. Figure 12 shows a common style of bevel.

Dividers are much used in spacing and in laying off circles and arcs of circles. The form shown in figure 13 is a common kind. The two points are held at any desired radius by tightening a thumbscrew. Very delicate adjustments can be made by turning a screw which is held tight by a spring on one leg of the dividers.

Fig. 13.

Dividers have many uses, not only in drawing circles, but in measuring of all kinds. In wood turning they are used to mark divisions on the work. They are set to the desired measurement and held against the wood while it is in motion. In laying out geometric designs on wood, they take the place of the compass used in mechanical drawing. Their sharp points cut the surface like the point of a knife. They are very useful in trans-

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ferring measurements from one piece to another, or in repeating the same measurement a large number of times.

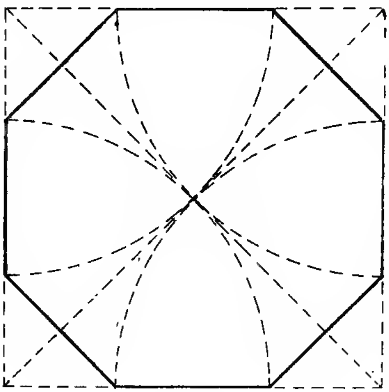


Fig. 14.

Following is an example showing the use of dividers: *To construct an octagon within a square.* It is a very simple problem to draw an octagon in a circle, but very often in the shop it is necessary to construct an octagon by cutting off the corners of a square piece of lumber. Draw the diagonals of the square with a straightedge. Holding one point of the dividers against one corner of the piece, draw an arc which passes through the center of the square. Repeat this process from each corner. With a straightedge, connect the points cut off on the edges by the divider and an octagon is formed. Figure 14 illustrates this problem.

Combining measuring tools.—*To find the hypotenuse of a rightangled triangle when the other two sides are known.*

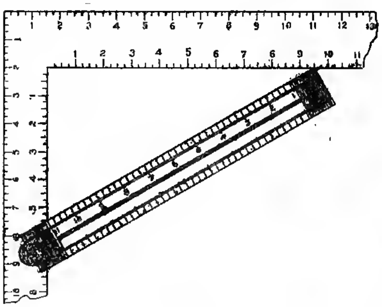


Fig. 15.

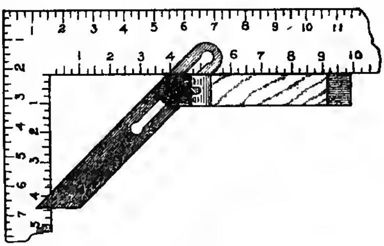


Fig. 16.

The rule and framing square are used as shown in figure 15. Suppose the length of one side to be $5\frac{1}{2}$ inches and the other side to be $9\frac{1}{2}$ inches. The ruler is applied from the $9\frac{1}{2}$ inch mark on one arm of the square to the $5\frac{1}{2}$ inch mark on the other arm. The distance between the two marks is found to be approximately 11 inches. If the distance to be measured is in feet, each inch can be called 1 foot, and the answer is then read in feet. If the triangle is very large, the figure can be drawn full size on the shop floor and the length of each part found by direct measurement.

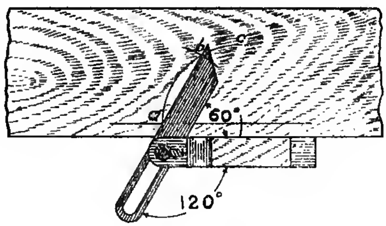


Fig. 17.

To set the bevel at an angle of 45 degrees, the beam is placed against one arm of the square and the blade is adjusted so that it will coincide with equal distances on both arms. Figure 16 illustrates this problem.

To set the bevel at an angle of 60 degrees. Figure 17 illustrates this problem. A piece of wood is prepared having a flat, clean surface and a jointed edge. A light line is drawn with the gauge close to the edge. Next, the dividers are set to any convenient radius and the arc *a–c* is drawn. With the dividers still at the same radius, the distance *a–b* is spaced off. A line is then drawn through

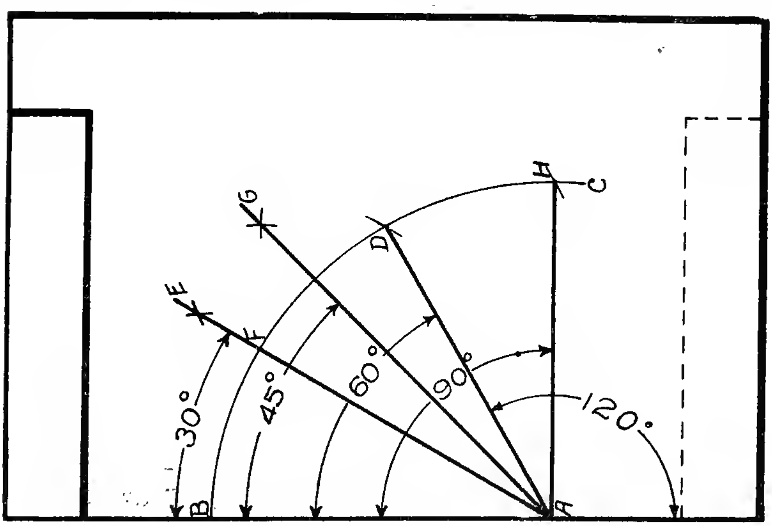


Fig. 18.

the points *a–b* and the desired angle is constructed. By placing the handle of the bevel against the jointed edge and making the blade coincide with the line *a–b*, the bevel will be set at an angle of 60 degrees.

A very useful arrangement for setting the bevel can be made by constructing a set of angles on the surface of the bench hook. If they are drawn deeply with the knife, they will last until the bench hook is worn out. Such an arrangement is shown in figure 18.

Marking gauge.—Figure 19 shows a common form of marking gauge. The steel point or spur should be filed to an edge which will cut, not scratch, when the gauge is used. Most marking gauges are provided with a scale for setting them, but it is always best to prove the gauge by measuring with a ruler before using the gauge. When the head of the gauge is set at the proper place, it is fastened with a set screw.

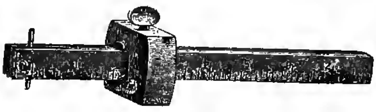


Fig. 19.

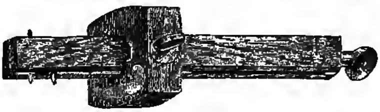


Fig. 20.

A mortise gauge has two points, one of which is fastened to the beam and the other to a brass strip which slides in a groove in the beam and is adjusted by means of a screw at the end of the beam. This gauge may be set to line both sides of a mortise at the same time; its name comes from its use. Figure 20 shows a common form of this tool.

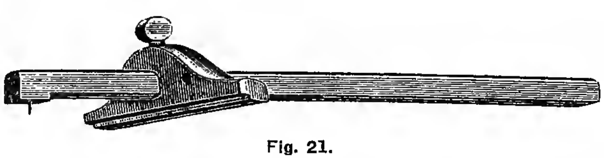


Fig. 21.

The panel gauge (fig. 21) is used for making lines at a greater distance from the working edge. The head and beam are longer than those of the marking gauge. The action is the same.

Cutting gauges, having a long thin blade in place of a point, are sometimes used for splitting thin lumber. They are made in the same form as the marking gauge.

Chalk lines are seldom used in bench work. They belong rather to the builder, though they are sometimes used in the shop when making long lines for ripping rough stock. The cord used in lining should be as small as possible. On most surfaces, blue chalk is more easily seen that white. The marking line used in the Philippines is drawn through a liquid similar to ink, which takes the place of the chalk.

The scratch awl (fig. 22) is a tool used for a great many different purposes. It is a useful tool for drawing lines, marking off points in measuring, and for lining in rough construction.

Fig. 22.

The knife.—Knives for use in bench work are made in several forms. An ordinary pocket knife is the commonest. Special knives for bench work, called "Sloyd knives," are manufactured and sold under that name.

The pencil used for lining the surface of boards should be hard and kept well pointed. The carpenter's pencil is rectangular in section and can be sharpened to an edge which will last much longer than the point of a common round pencil.

PLANES AND PLANE-LIKE TOOLS.

The essential parts of all planes are the same. Every plane has a *stock* or body, a *plane iron* or cutter, a *sole* or surface which touches the work, and some method of adjustment to regulate the amount of cut. Different planes have different uses, shapes, and sizes. They are usually named from their use, such as jointer plane, smoothing plane, beading plane, etc.

Four common planes found in every well-equipped shop are exactly alike except in size and are distinguished from each other by their dimensions. They are as follows:

The jointer plane is from 22 to 30 inches long.

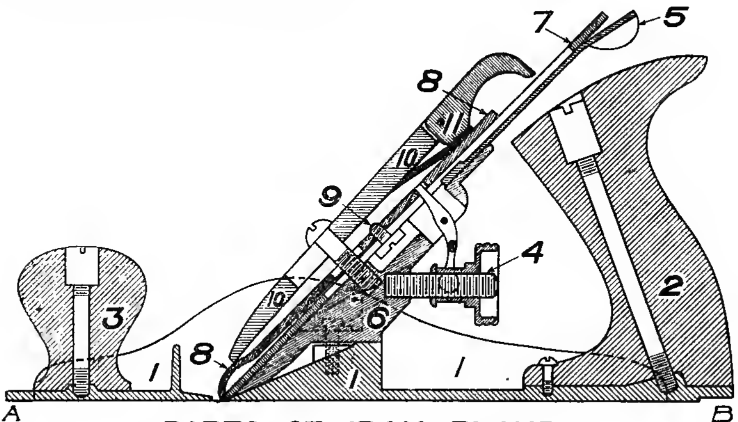
The fore plane is from 18 to 20 inches long.

The jack plane is from 14 to 16 inches long.

The smoothing plane is from 8 to 12 inches long.

Figure 23 shows a sectional view of an iron plane. It may be used in describing the construction and names of parts for all four of the planes named.

The skilled workman has no definite rule for the use of any of these planes, but selects the one most suitable for the work to be done. He uses the smoothing plane not only for smoothing surfaces, but for any purpose where he needs a short plane of light weight.



PARTS OF IRON PLANE

1-Body A-Toe B-Heel 2-Handle 3-Knob 4-Adjusting Screw 5-Adjusting Lever 6-Frog 7-Plane Iron 8-Iron Cap 9-Cap Screw 10-Cap 11-Cam

Fig. 23.

In choosing his plane, a good workman selects it by its length. The length of the plane body has an important bearing on the straigthness of the work. The smoothing plane, if used on a long uneven edge will rise over the high places and settle in the low places, taking a shaving from the whole length and not changing the outline. (See fig. 24.)

A fore plane or jointer plane used on the same surface will hit only the high places at first, cutting them down and making a straight edge as the planing is continued. The fore plane or jointer will smooth as well as the smoothing plane, but not until the edge is straight. Figure 25 illustrates the action just explained.

Planes have various methods of adjustment. The common iron plane has a screw which regulates the depth of the cut, and a lever which is used in truing up the edge. The lever is used principally after sharpening, to allow for uneven or imperfect grinding. Planes having wooden bodies, with the same method of adjustment, are very common. They are not so strong as iron planes and wear out very rapidly when used on Philippine woods.

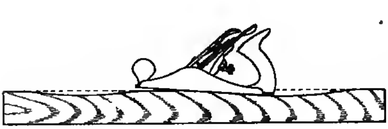


Fig. 24.

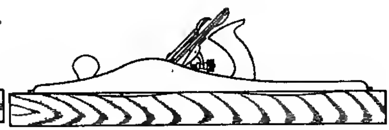


Fig. 25.

A **circular plane** has a thin steel face which is straight when free, but which can be drawn up or forced down by turning a screw, making its face either concave or convex, so that this tool may be used to plane inside or outside curves. Figure 26 shows a common type of this plane.

The **scraper plane** (fig. 27) is a plane body which holds a common cabinet scraper in place of the plane iron. The scraper is adjusted to the proper angle by means of a set screw.

Block planes are made in many forms, of which a common type is shown in figure 28. They are chiefly intended for use in planing across end grain. They generally have a single plane iron, turned with the beveled side up. This construction makes them unsuitable for planing with the grain, as their action is more like that of a scraper than a plane. In the model shown, the opening may be made narrow or wide, as desired. The depth of the cut is regulated by a set screw.

The **rabbeting plane** is so constructed that the cutting edge is the full width of the plane body. This allows the plane to be used in cutting into a corner, where the angle is not less than 90 degrees. The rabbeting plane is adjusted in exactly the same manner as the jack plane. Figure 29 shows a standard type of rabbeting plane; many other forms of this plane are made.

The **universal plane** is a combination of several planes. Before the universal plane was invented, separate planes were made for each purpose. It is supplied with a large

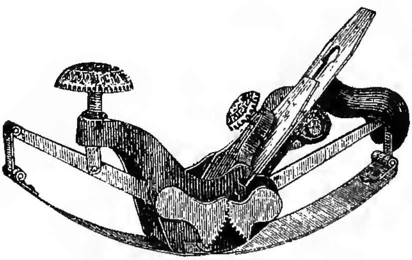


Fig. 26.

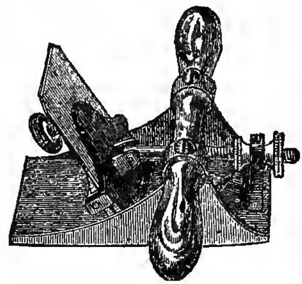


Fig. 27.

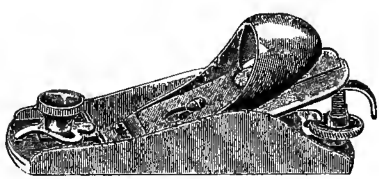


Fig. 28.

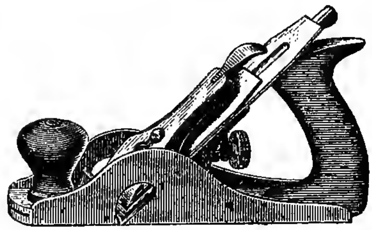


Fig. 29.

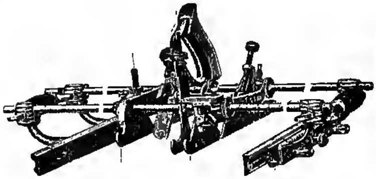


Fig. 30.

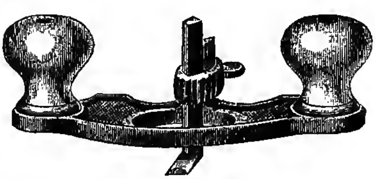


Fig. 31.

variety of cutters.. Figure 30 shows a common type of this plane.

The **router plane** is a special plane used for removing the waste material between two saw cuts across the grain. The cutter is made in the form of a hook which drops below the guiding surfaces of the plane to any desired depth. The router plane is pushed by two handles. Figure 31 shows a common form of this plane.

The **cabinet scraper** is a rectangular piece of steel made of saw plate. It is sharpened by grinding or filing the edge to a right angle. If smooth work is to be done, the sharpening may be finished by whetting on the oilstone or by rubbing with another piece of steel, such as the side of a chisel, until the edge is turned over. The latter is the common practice in working with soft or medium-hard woods. Two cutting edges are produced at once when it is sharpened at a right angle. When a sharper cutting edge is desired, the angle is changed as shown in figure 32, but this requires more work to keep the scraper in order and has no special advantage.

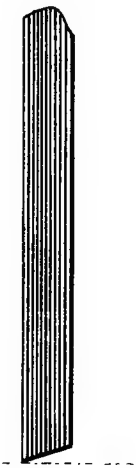


Fig. 32.

The **spokeshave** has the same action as the plane, although it is not usually classified with planes. Figure 33 shows a common form of this tool. It has a very small guiding surface, and a cutter which is regulated by a set screw. The spokeshave belongs to the wheelright shop, but it is a handy tool for smoothing irregular surfaces on all kinds of work. In use it is pulled or pushed by the workman by means of two handles.

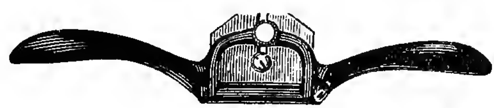


Fig. 33.

Sandpaper, while not usually spoken of as a tool, is somewhat like a plane in its action and is used after the plane or scraper to remove rough spots that still remain on the surface. It is made of very hard, fine sand glued on a sheet of paper and will cut a small amount of wood if used long enough. The most important thing to remember about sandpaper is when *not* to use it. Since it is composed of very hard sand, it should never be applied to work until all tool work has been finished, for the fine particles of sand stick to the surface of the wood and dull very rapidly any tool that is used on it. Sandpaper should always be folded tightly over a block of wood which fits the surface to be sanded and should be passed over the wood in the direction of the grain.

Fig. 34.

CHISELS AND CHISEL-LIKE TOOLS.

Chisels are made in two general forms; e. g., one in which the chisel is driven into the handle and one in which the chisel is provided with a socket for holding the handle. They are called by the manufacturers *firmer* chisels, and the two varieties are called *tanged firmer* and *socket firmer,* respectively. The tanged-firmer chisel (fig. 34) is intended for light work only and should not be used with the mallet as repeated blows on the handle will force the tang further into the handle and cause it to split. Socket-firmer chisels

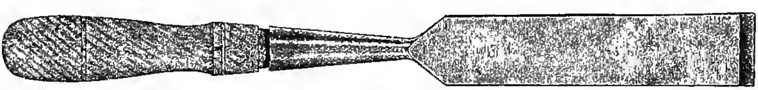


Fig. 35.

(fig. 35) are made with a hollow socket which fits the handle and are better suited for heavy work, as the steel socket keeps the handle from splitting.

Chisels are measured by their width and are made in sizes from $\frac{1}{8}$ to 1 inch, by sixteenths, and from $1\frac{1}{4}$ to 2 inches, by fourths. A chisel is commonly described by its size as, a "$\frac{1}{2}$-inch chisel" or a "2-inch chisel."

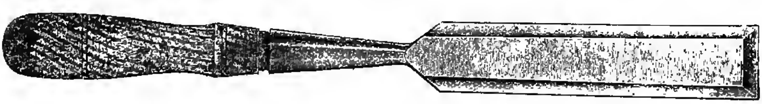


Fig. 36.

Chisels made with the back edges beveled (fig. 36) have no special name, but are described as bevel-edge chisels to indicate this feature.

Framing chisels have heavy iron blades overlaid with steel. The handles are strong and are protected at the end by ferrules or leather caps to prevent splitting when struck

Fig. 37.

a heavy blow with the mallet. These chisels are used in the heavy mortising and framing of building construction. Figure 37 shows a common form.

A **corner chisel** is shown in figure 38. Its two cutting edges are at right angles to each other which form makes it a useful tool in cutting inside angles like the corners of a mortise. The size is measured by the length of one cutting edge.

Fig. 38.

Gouges [1] have blades that are curved in section throughout their length, as shown by figure 39. When the bevel is on the concave side, they are called "inside gouges;" when it is on the convex side, they are called "outside gouges." For general use the outside gouge is the better, as it is the easier to keep in order. Gouges, like chisels, are made both

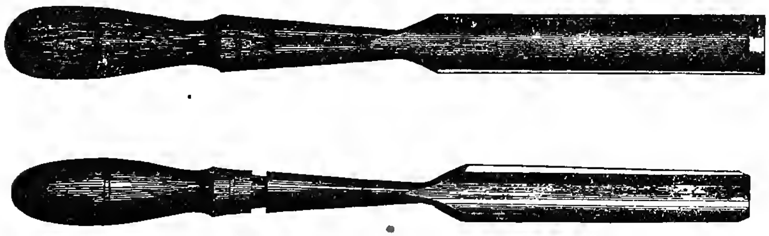


Fig. 39.

tanged and socket. The size of a gouge is measured on a straight line from one corner to the other.

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[1] When chisels are ordered, the word "tanged" or "socket" should be used to show what kind is wanted as: Socket firmer, socket framing, tanged firmer. If handles are wanted, the word "handled" should also be given.

Handles for chisels, gouges, and similar tools are of two general classes—light and heavy. The former are intended for hand use and are shown in connection with the firmer chisels, tanged chisels, and gouges. The latter are strengthened at the end by a ferrule or cap, as shown in connection with the framing chisel. In cutting Philippine woods it is nearly always necessary to use a mallet to help out the hands. This means a constant wearing out of chisel handles, and, therefore, only the hardest, toughest woods should be used. The better class of chisels and gouges have the socket-fitted handles.

The drawknife, shown in figure 40, is really a wide chisel, although it is very different from the chisel in form. The handles are so attached to the blade that it is drawn into the work instead of being pushed, as in the case of the chisel. The drawknife is very useful when a large amount of waste material is to be removed, as its action is much faster than that of the plane. Drawknives are measured by the length of their cutting edge.

Fig. 40.

SHARPENING "EDGE TOOLS."

The term "edge tool" is applied to any kind of a tool that is sharpened to an edge. This edge is made by cutting or grinding away the steel until the stock tapers from full thickness to a cutting edge. There is no fixed rule as to the angle at which a cutting edge shall be sharpened. The quality of steel from which the tool is made and the kind of wood on which it is to be used have a great deal to do with the angle. A sharper angle can be used on soft wood than on hard wood. A skillful workman will study his tools and material and decide at what angle to grind. The sharper the angle is, the faster the tools will cut, so this is an important question.

As the details of sharpening planes and chisels are about the same, the directions which follow may be used for either.

Grinding.—A new plane iron or chisel, or one that has become very dull, must be ground. Holding the tool firmly with the right hand, with the fingers of the left hand resting on the blade near its cutting edge, apply it to the grind-

Fig. 41.

stone as shown by the dotted lines *a* in figure 41. Raise the right hand until the correct angle is reached, as shown by the full outline *b*. See that there is a good supply of water, and, as the grinding proceeds, move the tool slowly from one side of the stone to the other. If the stone is in good order, the tool should be applied on the surface that is "coming toward" the workman. If the stone is not round, or does not run true, it is better to grind on the opposite side, as the grinding will be slower and there is less danger of the tool catching and "digging" into the stone, which is very bad for both stone and tool.

When the grinding is finished, the ground surface reaches the cutting edge. This can easily be decided by holding the tool to the light. If it is still dull there will be a bright line along the edge where it was rounded and worn away by use. When this line has disappeared the tool is as sharp as it can be made by grinding. More grinding will result in a "wire edge," which is a useless waste of steel.

Whetting.—The next step in the process of sharpening is called *whetting*. The work of the grindstone is too rough to produce a fine cutting edge, so, after the chisel is ground, it must be whetted.

To whet a chisel, apply it to the oilstone in the position shown by the dotted lines *a* in figure 42. As it moves back and forth across the surface of the stone, gradually raise it until the cutting edge comes against the stone. This

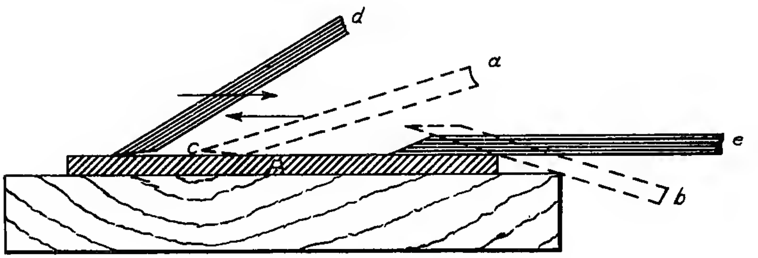


Fig. 42.

position can be easily found by the workman, as the feeling of the edge on the stone will be noticed at once. In whetting, the angle of the bevel is changed slightly at the edge, because it would take too much time to follow the exact angle made in grinding. The unskilled workman must take great care to avoid giving the tool a rocking motion on the stone; for that will round the edge, as shown in figure 43, and it will be no sharper than if it had the form indicated by the dotted line *a b c*.

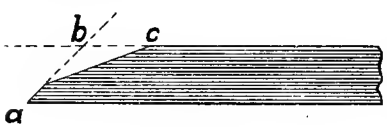


Fig. 43.

The whetting turns a light wire edge over on the flat surface of the chisel as shown by figure 44. This cannot always be seen, but it can be discovered by feeling the edge with the finger. This wire edge is removed by whetting a very little on the flat face. It is necessary to be very careful to avoid beveling the flat face. To guard against this, the chisel should be applied to the stone as illustrated by the outline *b* shown in figure 42 and slowly raised until it is flat on the surface of the stone. If the wire edge is not entirely removed by this process, the tool is turned over and whetted, first on the flat and then on the beveled face until the edge is perfectly sharp. To

Fig. 44.

still further perfect the edge, it is sometimes finished by "stropping" on a soft piece of leather or on the surface of a clean, smooth piece of soft wood.

A tool properly ground can be whetted many times before it needs to be ground again. A common mistake made by a beginner is that of grinding too often. There is always a temptation to go to the grindstone, because it is faster; but grinding also wears out the tool much more rapidly. A good workman will grind only when it is really necessary.

Grindstones are made in many sizes and varieties; a common form is shown in figure 45. A grindstone is usually ordered "unmounted, with fixtures," and the wooden frame is made for it in the shop. The power may be furnished with a crank which is turned by hand, with a treadle which is worked with the foot, or by a pulley and belt from the engine if the shop has one. The power system is, of course, the best. If the shop has no engine, the next best arrangement is the treadle, as this makes it possible for one person to turn the stone and grind at the same time.

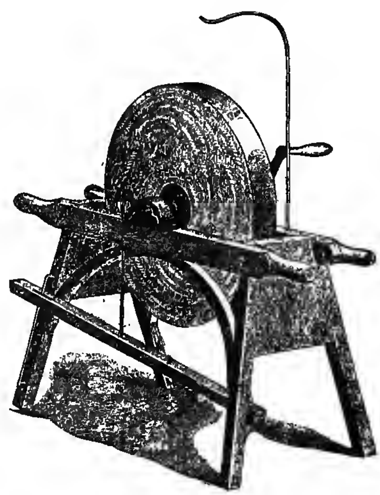


Fig. 45.

The stone should be kept wet while grinding, but it should be kept dry while it is standing still. It is a very bad practice to have the grindstone stand in a box of water, as the part which stands in the water will become soft and will grind away so that the stone will not be round. If this system is used, the water must be drawn off every night. A simpler and safer way is to hang a can of water over the stone. A small hole is made in the bottom of the can and the water drips on the surface of the stone.

Oilstones are flat, rectangular blocks of stone used for the finishing work of tool sharpening. The best kind are made from a natural rock found near Hot Springs, Arkansas, in the United States. They are described as coarse or fine, depending on the quality of the stone. As they are easily broken by dropping on the floor, it is customary to mount them in a block of wood, wedging them tightly so they cannot fall out. A beginner will usually spoil his first oilstone by doing all his sharpening in one small spot at the middle. In a very short time the stone becomes concave and cannot be used safely for sharpening flat tools. A good workman will work all over the stone, so as to keep the surface flat and even. Figure 46 shows an oil stone mounted in the proper manner.

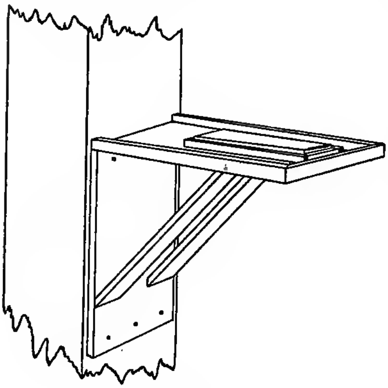


Fig. 46.

Slip stones are made from the same material as oilstones, but are made in many different sizes and shapes to fit the curved surfaces of gouges and turning tools. Figure 47 shows a common form.

Fig. 47.

Oil.—The best oil to use on an oilstone is petroleum. It keeps the stone moist and clean and in condition to do rapid work. If petroleum cannot be obtained, water is the best substitute.

To true an oilstone.—After an oilstone has been used until its surface is concave, it can be trued or flattened by grinding it on a flat piece of stone, such as the side surface of the grindstone. To do this properly, keep the surface wet and rub the oilstone on it with a rotary motion until flat. This should be done before the oilstone has been badly worn, as it is a long, tiresome job if very much grinding is needed. Any flat, hard stone can be used, but the grindstone is suggested as there is usually nothing better at hand.

To true a grindstone.—Like with the oilstone, this should be done often, so that the stone will not get in bad shape. A piece of wood to serve as a rest is clamped on the frame very close to the stone. A piece of pipe makes the best cutting tool. This is held firmly on the rest and rolled slowly across as the stone turns toward it. The stone should be kept very wet and the grinding should be very slow.

Various appliances are made for truing grindstones, but most of them require the use of power to work well. The means described is very simple and effective.

SAWS.

The term *handsaw* is a name used by manufacturers to distinguish between saws that are operated by a single workman and those operated by more than one workman or by machine. Since we are describing only the kind of tools used in handwork, the saws of that type will be discussed.

In describing a saw, three things must be specified—the use of the saw, whether crosscut or rip; the length of the blade, measured on the cutting edge; and the number of points to the inch.

Handsaws are classified by the manufacturers under three headings—rip, hand, and panel. In the shop the term "crosscut" is usually substituted for handsaw, as it indicates the use of the saw and is less likely to cause mistakes.

FIG. 48.

The shape of our saws has been developed after a careful study of the conditions under which they have to work. A saw must be thick enough and strong enough to stand without bending the force of pushing it, but there must be no unnecessary material. The blade tapers from the handle to the tip as shown in figure 48. The blade is thicker, also, at the handle than at the point and, to help the saw to run easily in the cut, it is made thicker at the teeth than at the back.

Set.—Although the saw is thicker at the edge than at the back, this taper is not enough to keep the sides of the saw cut from pressing against the blade. To prevent this trouble, the teeth of the saw are bent or set—one to one side and the next to the other side—so as to make the width of the cut greater than the thickness of the saw blade. The amount of such bending or set can be seen by holding the saw toward the light with the edge in line with the eye; the set will appear as shown in figure 49.

Fig. 49.

In very hard wood the saw leaves the sides of the cut smooth and even and very little set is needed, sometimes not any. If the wood is soft and wet, as in green lumber, the wood fibers spring away from the teeth and then come back on the blade after the teeth have passed, therefore a large amount of set is needed so that the saw will make a wide cut. For most purposes in bench work the set is sufficient if it can be plainly seen.

Size of saw teeth.—If a saw is working properly, each tooth begins to cut when it enters the work and continues to cut until it passes out on the other side. The space in front of each tooth must contain the material removed by the tooth, therefore a saw with large teeth must be used if a thick piece is to be cut. On the small saws used in bench work the space between teeth is of the same size and form as the tooth. On the "two-man" saws used for cutting logs, the teeth are large and widely spaced.

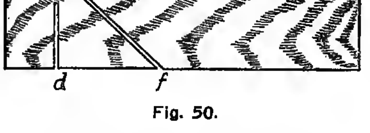


Fig. 50.

The size of saw teeth is expressed by the number of teeth, or points, contained in 1 inch. Thus, 8 points means that the distance from one point to another is $\frac{1}{8}$ of an inch.

Ripping saws and crosscut saws.—A ripping saw, or ripsaw, as it is commonly called, is one that is used in cutting with the grain of the wood as on the line *a b* (fig. 50). A cross-cuttting saw, or crosscut saw, is intended for use at right angles to the grain as indicated by the line *c d*. An oblique or slanting cut such as is shown by the line *e f*, can be made best with the ripsaw if it is on soft woods. A crosscut saw,

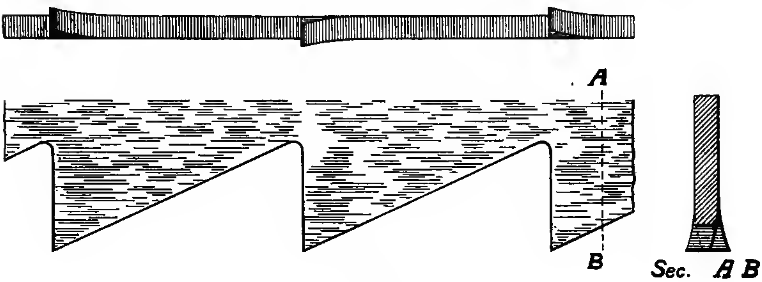


Fig. 51.

however, will do the smoother work. If a large knot comes in the way of the ripsaw, it is better to substitute the crosscut saw until the knot is passed. A cross cut saw for bench work should have a blade from 24 to 26 inches long with 10 points to the inch. A rip saw for bench work

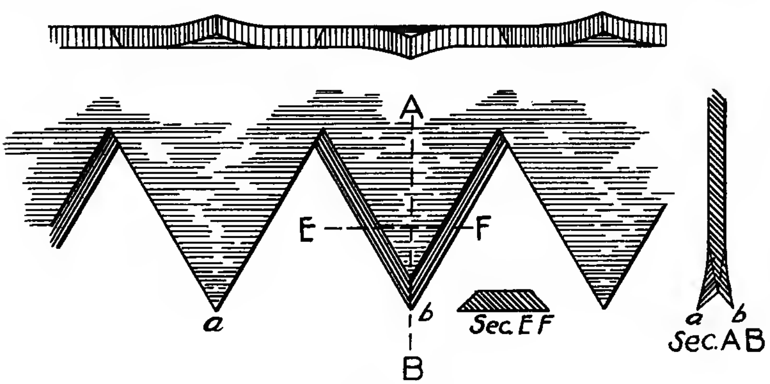


Fig. 52.

should have a blade from 24 to 26 inches long with 8 points to the inch.

The teeth of ripsaws.—Figure 51 shows a plan, elevation, and section of three teeth as they are usually made on a ripsaw. The action of a ripsaw tooth is like that of a chisel. When the saw is pushed through the work one tooth follows another just like a succession of small chisels, each cutting a small shaving which is carried in the space in front of the tooth until it reaches the other side of the work, where it falls out as sawdust.

The teeth of crosscut saws.—Figure 52 shows a plan, elevation, and cross section of three teeth as they are usually made for a crosscut saw. It will be seen in the drawing that each tooth ends in a triangular point; also, that while the point *a* is formed on one side of the blade, the point *b* is formed on the opposite side. This system is followed through the whole length of the saw. This arrangement makes the end view of the blade show two parellel lines of points with a triangular notch between them which is increased by the set. In action, the two rows of points scratch, or score, the wood, and the edges of the triangles break up the wood fibers and carry them out. The same effect could be obtained by drawing two parallel lines across the surface of a board with the point of a knife, and then scratching out the short wood fibers between them. (See fig. 53.)

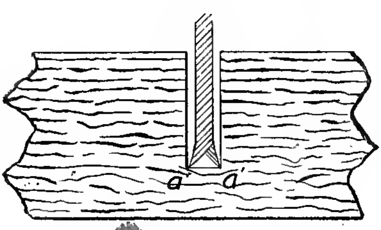


Fig. 53.

By comparing the teeth of a ripsaw and a crosscut saw, it can easily be seen why one saw cannot be used very well in place of the other. The ripsaw, used across the grain, will tear and splinter the wood. The crosscut saw, used with the grain, will hardly cut at all, but will simply wear the wood fibers away after much hard work. No great harm is done to the saw in either case, but a great deal of damage can be done to the work. In cutting small tenons across end grain and in a few other special cases, the backsaw is sometimes used; but as a rule the substituting of one saw for another results in damaged work and wasted time.

Ripsaws are made with blades from 24 to 36 inches long and with teeth varying from 4 to 10 points to the inch.

Hand crosscut saws are made with blades from 24 to 36 inches long and with teeth varying from 5 to 12 points to the inch.

Panel saws are small crosscut saws with blades from 16 to 24 inches long. The teeth are the same as those in a crosscut saw.

Hollow-ground saws.—These saws are made for use on seasoned lumber and do not require setting. Their blades are ground with a concave surface on both sides. They are useful only for fine work.

Backsaws are used only where very accurate cuts are required. Their teeth are similar in form to those of the crosscut saw except that they are filed so that the angle inclines toward the direction in which the saw is pushed. This makes them work better in cutting with the grain. The teeth are much finer than those in the crosscut saw, being made with as many as 16 points to the inch. This saw cuts slowly as compared with a panel saw, but may be used for very delicate work. It can be used in any direction, without regard to the grain. Used in dry, seasoned lumber, and well sharpened, a backsaw does not require setting.

The blade (fig. 54) is too thin to withstand the force necessary to drive it into the work, so it is strengthened by an iron back. This, being thicker than the blade, will not allow the saw to enter the work beyond the width of the blade. For this reason the blade is uniform in width instead of tapering.

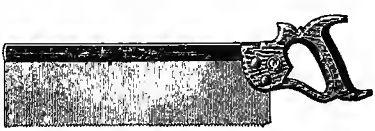


Fig. 54.

The **compass saw** (fig. 55) is intended for sawing in curved lines. Its blade is very thick and tapers to a small point. The teeth are given a large amount of set and are filed, as shown in figure 55, with the square face of the ripsaw and the point of the crosscut saw, thus allowing the saw to be used in any direction of the grain.

The **turning saw** (fig. 56) consists of a narrow blade stretched on a wooden frame and so arranged that the saw blade can be turned at any desired angle. It is used for scrollwork where a machine scroll or "jig saw" is not available. The teeth are filed like those of a crosscut saw.

The bucksaw (fig. 57) is made on the same principle as

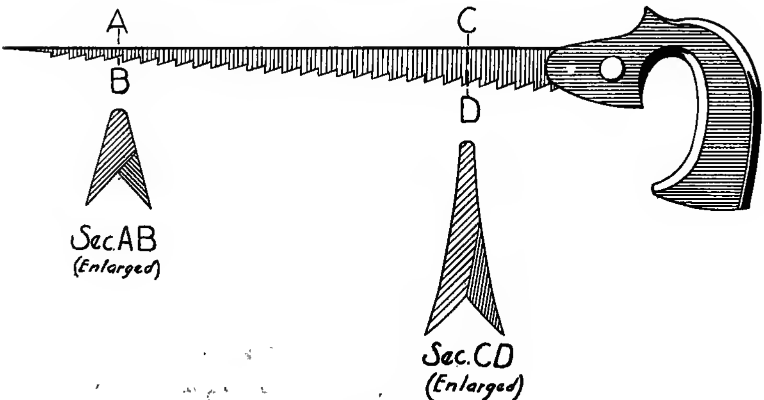


Fig. 55.

the turning saw, but is much larger. It has a wide blade, and is used for rough work, such as sawing firewood.

The crosscut saw (fig. 58).—In commercial usage this name means a large saw used for heavy work, such as for cutting down trees and cutting up logs and heavy timbers

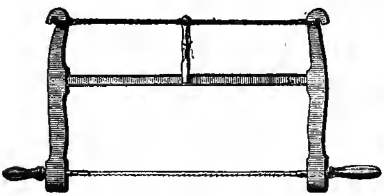


Fig. 56.

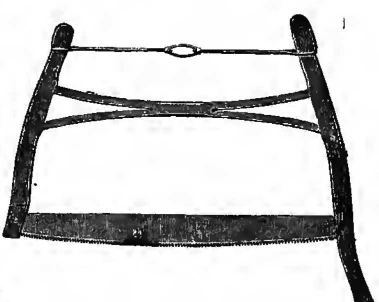


Fig. 57.

Fig. 58.

across the grain. Crosscut saws are made in many sizes, from 3 feet long upward. The larger sizes are provided with two handles, so that they can be operated by two men.

Saw filing and setting appliances.—The common triangular, or "slim-taper," file is used for saw filing. Figure 59 represents this kind of file and figure 60 shows it in cross section. Saw files are measured from the shoulder *s* to the tip *t*. They are made from 3 to 14 inches long, and their diameter increases in proportion to their length. The size of file selected for use depends upon the size of the teeth to be filed.

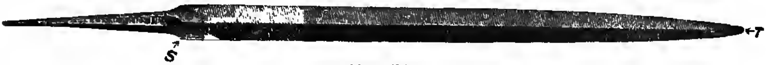


Fig. 59.

Saw sets.—Figure 61 shows a common form of this tool. A small disk, beveled at different angles and numbered to indicate the number of points to the inch, can be adjusted to fit each saw. The number of teeth per inch is usually stamped on the blade of the saw; if not, the edge can be measured. In use, the saw set fits over the edge of the saw and is operated by squeezing the handles together. This presses a small point against the tooth and forces it out until it is stopped by the beveled surface of the disk.

Saw clamps are used to hold saws while they are being filed. Figure 62 shows a common form of the saw clamp.

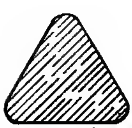


Fig. 60.

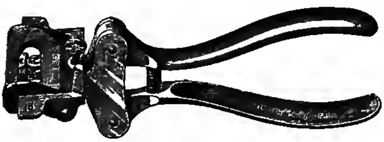


Fig. 61.

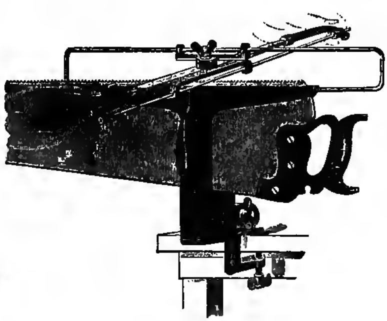


Fig. 62.

This is a manufactured clamp and is sold in every hardware store.

Figure 63 illustrates a very good clamp that can be made in the shop. It consists of two flat pieces of wood faced with narrow strips and fastened together so that the two strips are about ⅛ inch apart. The clamp is placed in the vise and the compression of the vise tightens the two strips

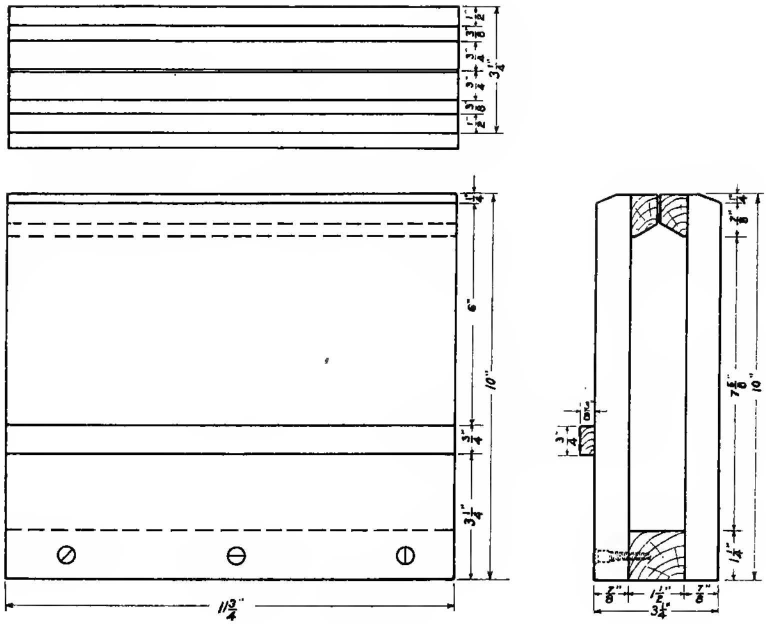


Fig. 63.

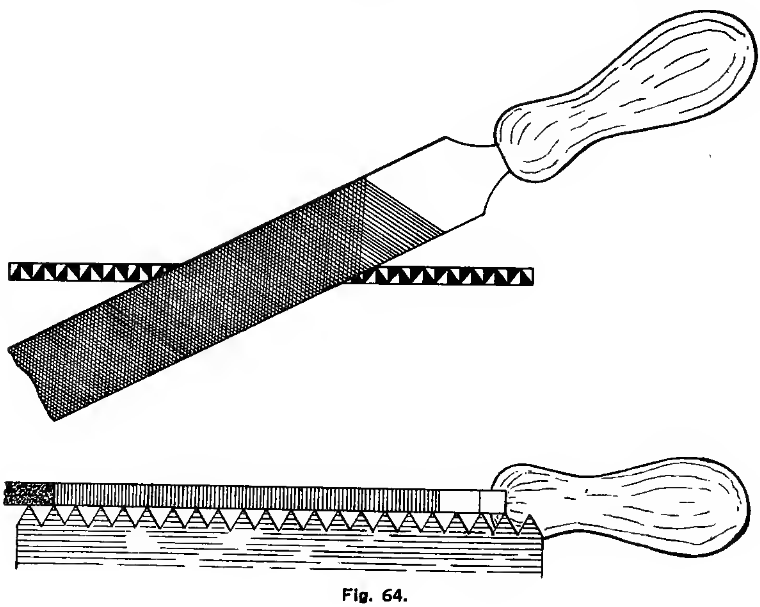


Fig. 64.

against the saw blade, holding it firmly. One half of the saw is filed and then the saw is moved along so that the other half is held in the vise.

TO FILE AND SET A SAW.

Jointing.—The saw is clamped in the vise with the teeth up. It is jointed by running a flat file along the tops of the teeth as shown in figure 64. This is done to bring all the teeth to the same height and to keep the shape of the saw. The line of the teeth should round slightly from one end of the saw to the other. Jointing leaves a small flat surface on the point of each tooth which will be rectangular in a ripsaw and triangular in a crosscut saw. Jointing is not always necessary, and should be done only when a careful examination has proved it to be necessary. If a saw is used properly, it can be filed five or six times before it needs to be jointed.

Filing.—The saw must be held very firmly while it is being filed. An unusual amount of noise proves that the blade is not properly clamped or that the file is not being used properly. It is also a sure sign that time is being wasted and that the file is being injured. If the file is sharp, the pressure should be very light. The file should be carried, across the work with a slow, steady movement. Short, quick strokes of the file do no good and dull the file. In filing a ripsaw, the stroke should be squarely across the blade, as shown in figure 65, and the outline of the teeth preserved by even filing, as shown in the same figure. If the form of the teeth is to be changed, the file must be turned, either in the direction shown by the arrow (fig. 65), or in the opposite direction. The file should be lifted on the return stroke and not allowed to drag across the tooth. A file does not cut backward.

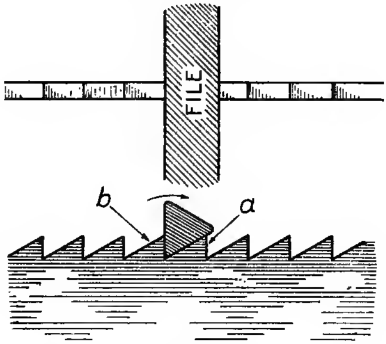
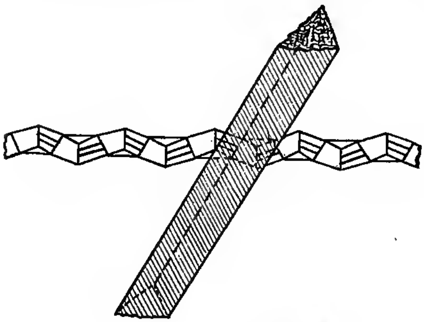


Fig. 65.

In filing a crosscut saw, the angle at which the file is applied to the blade is changed to suit conditions. First, the outline of the teeth may be kept the same, or changed in the same manner as in filing the ripsaw; secondly, the angle of the front of the tooth is regulated by the angle at which the file is placed against it, as shown in figure 66; thirdly, the angle of the point is decided by tipping the file as shown in the same drawing. After the form of the teeth has been decided, the filing may proceed and the correct result will be produced by following the directions carefully. It is a fact worth remembering that a saw comes from the manufacturer in perfect condition for proper use.



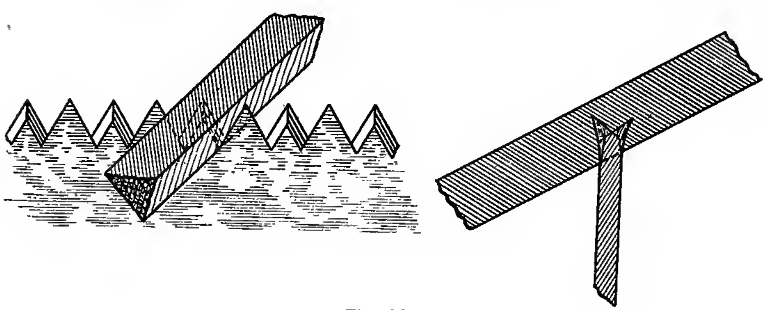


Fig. 66.

A beginner can do no better than to follow the original shape of the teeth when resharpening a saw.

When filing either a crosscut or a rip saw, the file should be touching the face of one tooth very lightly (as *b*, fig. 65) while most of the cutting is done on the back of the next one, *a*. This tooth should be the one which, by its set, bends away from the workman. Beginning at the end of the blade, the workman files every tooth that bends away from him until the other end is reached. The saw is then turned around and the other teeth are filed. No saw, even though its teeth are not set, should be filed wholly from one side. The file turns a slight edge or "burr." This increases the set and it should be evenly divided between the two sides.

The filing of each tooth should be continued until the flat, shiny surface produced by jointing has been removed. After this the filing should stop, as a single extra stroke of the file on any tooth will make it smaller than the others. To avoid this, it is better to leave the teeth which are filed from the first side a little dull; because when the other side is filed, the file will cut a little more from their faces. After every tooth has been filed, if dull points are still seen, they can be filed from either side, as needed, until all the teeth are alike. Regularity in size and form and similarity is appearance when looked at from either side are the tests of good workmanship.

Setting a saw.—Adjust the saw set to fit the saw by setting the small, round plate so that the number corresponding to the saw is opposite the point. For example: If the saw has 8 points to the inch, place the number 8 on the saw set opposite the point which does the setting. Commencing at one end of the saw bend every second tooth outward; then turn the saw around and bend the remaining teeth the opposite direction.

Side jointing a saw.—Usually, when the filing is finished, the saw is ready for use; but it will cut more smoothly if it is jointed on the sides of the teeth. The teeth in figure 67 *b* are side jointed as shown by the dotted lines and in *a* the teeth are not side jointed. Side jointing is done by passing the oilstone lightly along the sides of the teeth.

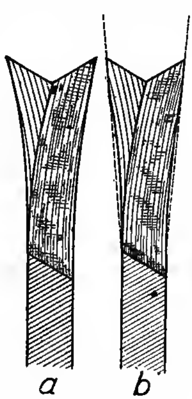


Fig. 67.

BORING TOOLS.

Auger bits.—Figure 68 represents an auger bit of the kind in common use. Auger bits are sold singly, or in sets of 13 each, varying in size by sixteenths from $\frac{1}{4}$ to 1 inch. Each bit is marked by a small figure on the shank which indicates the diameter in sixteenths. Thus, the figure 9 indicates that the bit will bore a hole 9/16 inch in diameter.

Fig. 68.

Figure 69 shows the different parts. The spur *a* is in the form of a tapered screw. Its sharp point makes it easy to start the bit in the right place, and the threads of the screw pull the bit into the wood. The two knife-like edges *b b* cut the wood, and the lips *c c* cut and remove the shavings, which are carried to the surface by the screwlike body of the tool.

Fig. 69.

Sharpening auger bits.—Auger bits are sharpened by filing. The knife points are usually the first parts to become dull and should be filed wholly from the inside. If they are filed the least bit on the outside, the diameter of the cut will be changed. The cutting lips should be filed from the lower side, great care being taken to keep the original angle. The spur, or screw point, can be sharpened a few times with a small, triangular file; but when it becomes badly injured, the tool is worn out. A bit is unlike most of the other cutting tools in that it cannot be repaired. A saw that has been used against a nail can be filed and made as good as new, a chisel that has been broken at the edge can be repaired by grinding, but a badly damaged auger bit cannot be repaired.

Augers.—Figure 70 shows a double twist, spur auger, a form used by carpenters for heavy framing. Augers are made in sizes varying from ½ to 4 inches in diameter, but are seldom employed below 1 inch. These tools are not often used in bench work and are mentioned because they were used before the invention of the modern brace and bit. The auger bit takes its name from the auger. Augers are still used for heavy work, but the brace and bit are much better suited for light bench work.

Center bits.—Figure 71 shows one of these bits. It is a kind of bit that is used very little today. For some classes of work the center bit is superior to the auger bit, as it will bore very thin material without splitting it.

Fig. 70.

Fig. 71.

Expansive bits are so constructed that their sizes can be changed. There are several forms in use, one of which is shown in figure 72. The cutter can be adjusted so that the bit will bore any diameter between 1 and 3 inches. Smaller sizes are made, but they are seldom used, as the common auger bits are made in so many sizes that one can usually be found to do the work. An expansive bit will not stand as long, hard usage as the auger bit, and does not do as satisfactory work.

Fig. 72.

Gimlet bits.—Figure 73 shows a common form of this tool. They are made in small sizes and work very fast in soft wood. Because they are easily broken and difficult to sharpen, they are not generally used.

Fig. 73.

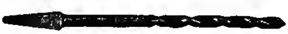


Fig. 74.

Drill bits.—Figure 74 shows the form of drill bit commonly used by woodworkers. It has a square shank to fit the bit brace. The size is indicated by a number which means the diameter measured in thirty-seconds of an inch. This kind of drill is called a "bitstock drill" by

Fig. 75.

the manufacturers. To indicate that it can be used in a woodworker's brace, the words "square shank" are always added to the description. Drill bits have several qualities

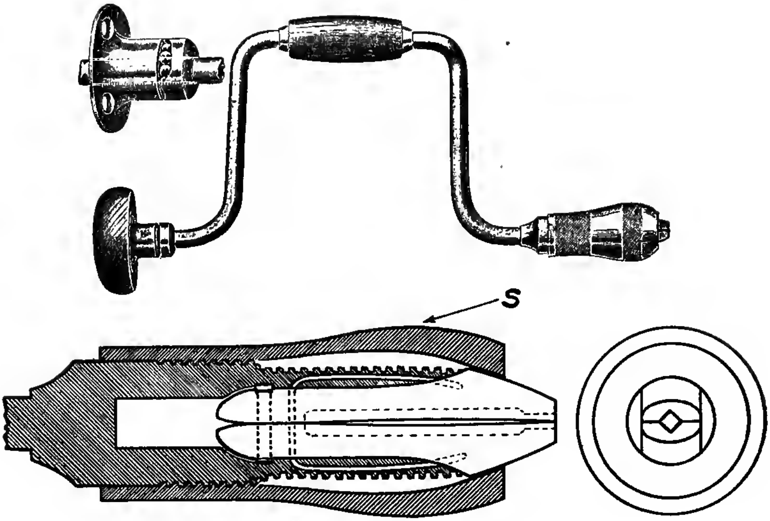


Fig. 76.

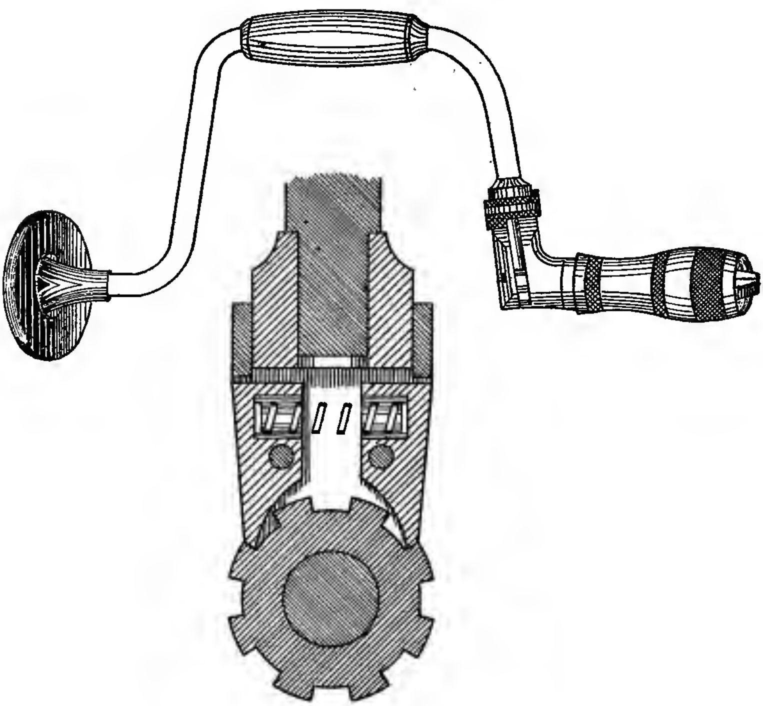


Fig. 77.

which make them superior to auger bits for small work. They are made of harder steel and will cut through soft metal, like a nail, without dulling or breaking; they do not dull as quickly as auger bits and can be sharpened very easily on a grindstone any number of times; they bore without splitting; and they are made in smaller sizes. These qualities make them very useful to the woodworker.

Twist bits, made in the same form as drill bits, but for use in wood only, are now being manufactured. It will be noted in the illustration (fig. 75) that the body of the bit has a greater diameter than the stock, which makes it slightly different from the regular drill bit.

Bit braces.—A simple form of bit brace is shown in figure 76. To put a bit in the brace, the "sleeve" (*s*) is held firmly and the brace is turned until the jaws have separated far enough to make room for the square shank of the bit. The motion is then reversed, and the sleeve is tightened until the bit is held firmly. It is then ready for use.

A ratchet brace is so made that by adjusting it properly, the brace will act only in one direction, slipping in the other. The direction can be reversed so that the brace will turn the bit either in or out, or it can be fixed solid like a common brace. Figure 77 shows a ratchet brace with a sectional view of its mechanism.

Braces are measured by their "swing"—that is, the diameter of the circle made by the outside point when in motion.

Countersink.—Two common forms of this tool are shown in figure 78. The countersink is made with a square shank for use in a brace; it cuts a tapering hole to receive the head of a screw that is to be sunk flush with the surface.

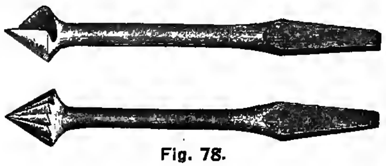


Fig. 78.

MISCELLANEOUS TOOLS.

Screwdriver bits.—A screwdriver bit is shown in figure 79. This tool is made with a square shank for use in a bit brace. It is easier to use than the hand screwdriver, and can be employed, with a ratchet brace in places where handwork would be very difficult. Its only defect is that, in the hands of a beginner, the tool is too strong. He is liable to turn the brace until either the bit or the screw head is broken.

Fig. 79.

Fig. 80.

Hand screwdrivers are made in many styles and sizes. A common one is shown in figure 80. The part which enters the screw should have parallel sides as indicated in figure 81, and should never be wedge-shaped (fig. 82). If the screwdriver tapers to an edge, it will lift itself out of the screw when force is used to turn it.

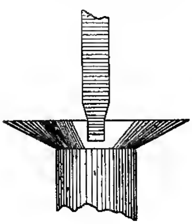


Fig. 81.

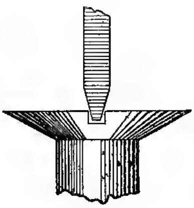


Fig. 82.

A set of three or four screwdrivers of different sizes is necessary in every shop. The screwdriver should always be selected to fit the screw. A beginner will often make the mistake of grinding a screwdriver on the grindstone. This should never be done unless the screwdriver has been actually broken.

Hammers are made in many styles. The "bellfaced" claw hammer (fig. 83) is the best kind for use in the shop. The head is made wholly of steel and the face is hardened so as not to be broken when used in striking heavy blows. The claw is used for pulling nails. A hammer is measured by the weight of its head which is given in ounces, English measure. They vary from 7 to 20 ounces. A well-equipped shop has several sizes, from light to heavy. Twelve ounces is a suitable weight for common use.

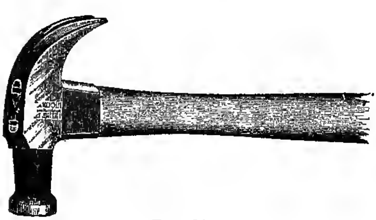


Fig. 83.

Mallets.—The mallet is a tool that is a necessary part of every shop equipment. A good definition of a mallet is "wooden hammer." It has a heavy, wooden head and a handle securely fastened with wedges. Used in chiseling, the mallet strikes a more effective blow than a hammer; it also saves the chisel handles, which would be quickly worn out if struck repeatedly with a steel hammer. It is a

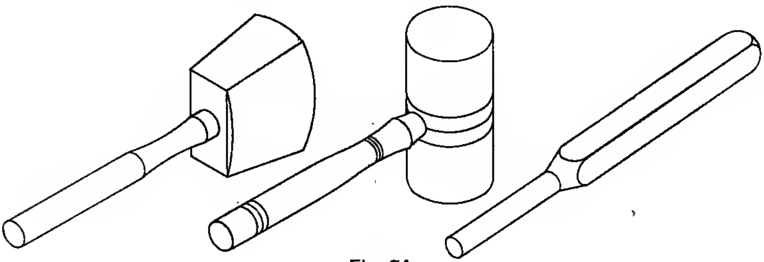


Fig. 84.

common-sense rule of the woodworker that "a wooden hammer should never be used against steel, or a steel hammer against wood." The reason is plain and a careful workman will not often break this rule. Mallets are made in many forms; light-weight mallets with square or round heads are used for bench work, heavy mallets with square heads are used for framing. Three forms of mallets are shown in figure 84.

Hatchets.—The hatchet is a useful tool when a large amount of waste material is to be removed. In construction, a hatchet is somewhat like a hammer, having a knifelike edge instead of a face. A claw is sometimes provided for pulling nails; also a face which makes it useful as a hammer. Hatchets (fig. 85) are made in many forms. They are sharpened by grinding and whetting, the same as chisels. The action of using a hatchet is commonly called "chopping."

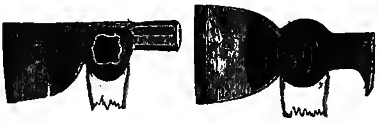


Fig. 85.

The **adze** (fig. 86) is a tool used for dressing large timbers to rough dimensions. It has a long handle with a heavy, steel head, and a broad cutting edge at right angles to the handle. It is used chiefly by lumbermen for squaring or "dressing" logs in the forest; also in bench work for cutting down wide pieces, such as the "one-piece" table tops common in the Philippines.

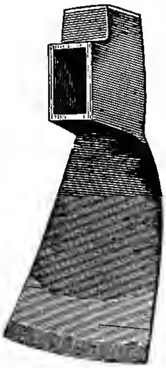


Fig. 86.

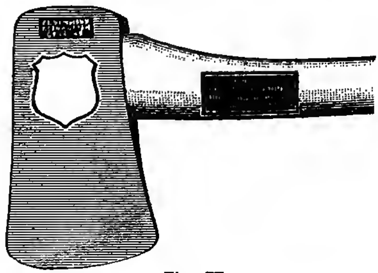


Fig. 87.

The axe (fig. 87) is a tool resembling a hatchet in general construction, having a heavy steel head and a long handle. It is used chiefly by lumbermen for felling trees.

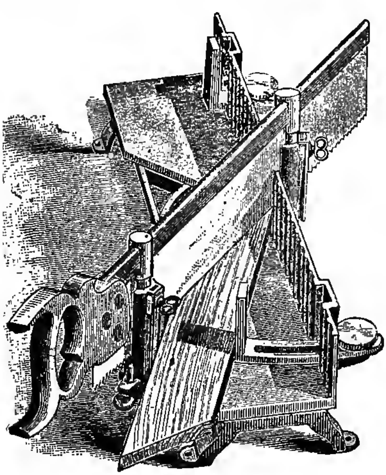


Fig. 88.

Sandpaper.—This material has been mentioned before, in connection with planes. Strictly speaking, it is neither a tool nor an appliance, but on account of its tool-like action it should be mentioned with them. The sand used in making sandpaper is crushed quartz, a very hard rock, and is very angular and sharp. The sand is graded as to coarseness and glued to paper. The finest sandpaper is marked "OO," from which the graduations run 0, ½, 1, 1½, 2, 2½, and 3. The last is the coarsest.

Miter boxes are useful in cutting angles of 45 degrees. They are often made so as to cut other angles. Figure 88 illustrates an adjustable iron miter box of a common make. It can be adjusted to cut different depths, and the angle can be changed from 45 to 135 degrees. Wooden miter boxes are often made by the workman himself. Figure 89 shows a common, homemade miter box.

Clamps are made in many forms, some of the commonest of which will be described.

Figure 90 represents a *"C" clamp*, so called from its shape. The screw works across the open part of the "C" and the size of the clamp is measured by the width of the piece that can be clamped in it. "C" clamps are made in sizes varying from 2 to 20 inches.

Figure 93 shows a cabinetmaker's clamp. These clamps are made in several different forms, but their general parts and uses are the same. The construction consists of a steel or wooden bar having a fixed head and a movable head. The movable head is adjusted to fit the work and is tightened by means of a lever or screw. The clamp illustrated is tightened by means of an eccentric. Cabinetmaker's clamps are measured by the greatest length to which they can be opened and are made in sizes ranging from 18 inches to 12 feet.

Figure 91 illustrates an *eccentric clamp*. This clamp is a cheaper variety of the "C" clamp. It can be adjusted quickly by changing a jaw which slides on the bar of the clamp. Eccentric clamps are measured by their greatest capacity and are made in sizes varying from 3 inches up to 8 feet.

Clamp fixtures can be purchased very cheaply and can be made up to any desired length by the workman himself. The bar of the clamp is made in the shop from hard wood. A common form of clamp fixtures is shown in figure 92.

Wooden clamps.—Figure 94 shows two forms of homemade clamps which can be substituted for the expensive steel clamps on some classes of work. The clamps are made to fit loosely and when ready to be tightened, small wedges are driven between the block of the clamp and the edge of

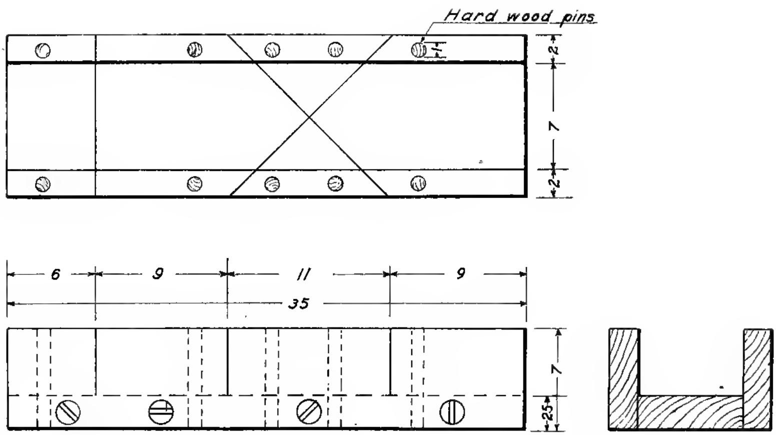


Fig. 89.

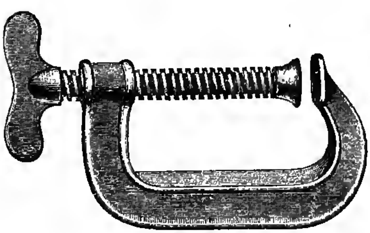


Fig. 90.

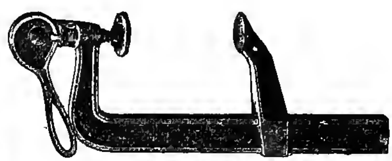


Fig. 91.

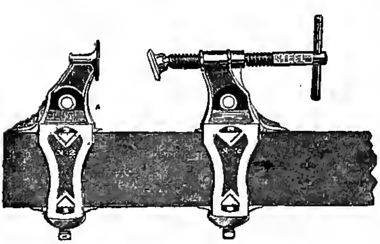


Fig. 92.

Fig. 93.

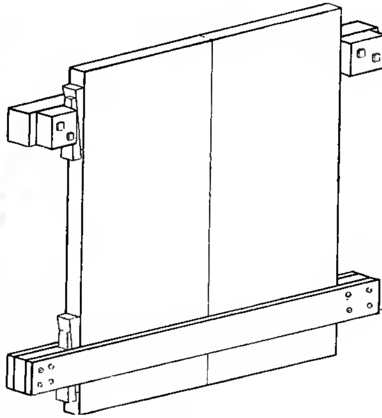


Fig. 94.

the work. These clamps are not as convenient to use as an adjustable steel clamp, nor will they serve for as many different purpose; but they are very cheap and, for this reason, are recommended.

Nail sets are used in connection with driving nails. A nail set is a small bar of steel, either square or round, tapering at one end to a very small surface which is concave. The nail set is used for setting nailheads below the surface. The point is made concave for use in driving out nails whose points are exposed. Nail sets are made in several sizes, with points varying from 1/32 to 1/8 inch in diameter. Two common forms of nail sets are shown in figure 95.

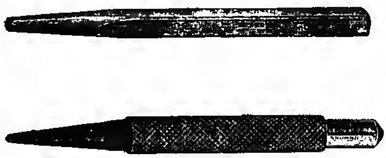


Fig. 95.

The **plumb and level**, represented in figure 96, does not properly belong to the bench worker, but is often found useful in making repairs, setting up machines, etc. It consists of a rectangular bar, either of wood or metal, in which are set two tubes containing alcohol. One of these tubes is parallel and the other is at right angles to the length of the bar. A line is drawn across the middle of the tube and, when the small air bubble is exactly on this line, the object to be tested is level or perpendicular, as the case may be.

Fig. 96.

TOOLS FOR WORKING METAL.

While this chapter deals mostly with tools pertaining to bench work, there are a number of metal worker's tools that

Fig. 97.

Fig. 98.

are often used in the wood shop. A few of the principal ones will be mentioned.

The **hacksaw** (fig. 97) is made on the same plan as the turning saw. It has a metal frame and a highly tempered steel blade which is tightened by means of a screw; it is used for sawing metals.

Cold chisels (fig. 98), are made of steel and highly tempered. They are used for chipping soft metals and cutting iron.

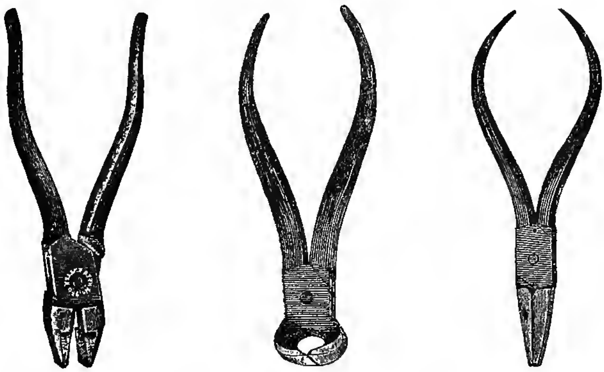


Fig. 99.

Pincers are made in many forms and with many names to describe their special uses. They are often used by the woodworker for pulling nails and for fashioning metal parts for furniture. Figure 99 shows three kinds.

Fig. 100.

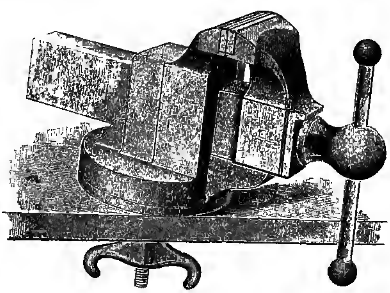


Fig. 101.

Tin shears or "snips" (fig. 100) are sometimes used by the woodworker. They have proved to be a very good tool for trimming window shells. Their proper use is for cutting tin and other soft sheet metals.

The **machinist's vise** (fig. 101) is a very useful appliance to have in the woodworking shop. It can be used for holding either wood or metal, and is useful for small work.

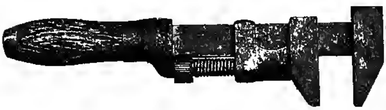


Fig. 102.

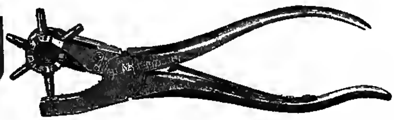


Fig. 103.

The **monkey wrench** (fig. 102) is a necessary part of every shop equipment. It is used for many purposes.

Steel letters and numbers, for marking either on wood or metal, are necessary in a school shop. They are used for marking tools and for numbering exercise work.

Belt punches (fig. 103) are used for making holes in leather belting in the process of lacing the ends of a belt together.

Part II.—BENCH WORK.

System.—It would be difficult do decide on any single point in bench work that is of greater importance than another. The different tools are so closely related that in order to use one, the workman must have a knowledge of many. If he is a careful worker and accustomed to planning his work along other lines, he will decide first of all that he must study out a system by which to work. As each tool is taken up, he will learn the correct use of that tool. There are many times when a tool can be used for different and unusual purposes, but the systematic workman will not consider these until he has learned the standard way of using it.

Mistakes made in the classroom can be corrected with a pencil and paper, but mistakes made in the shop mean an actually money loss. The woodworker can estimate his waste in real money. His material, furthermore, costs much more than the material used in a schoolroom; therefore, the first point in a good system is to start with practice on cheap material and with small pieces, because mistakes are sure to be made.

Considering the subject as a whole, the most necessary thing for a beginner to study is a regular system of doing things. As in the schoolroom we begin by learning the alphabet, so in the shop we start by learning the "A, B, C's" of shop work. The same alphabet that the boy learns in the first grade lasts him all his life; the first lessons in the shop should be something that he will use whenever he uses tools. As a beginner starts to learn the use of a tool, he should study correct methods. Time and practice will give him greater skill and speed.

Accuracy and speed.—Both are necessary to a good workman, but accuracy must be learned first. A project finished quickly but incorrectly is a waste both of time and material. A project finished right is a good lesson, no matter how much time was used. The beginner will often find the practice work very tiresome and uninteresting, but it must be done; if he learns this right at the start, he will soon become a good workman. Mistakes should be corrected; spoiled exercises done over again; and every step should be understood before the next step is started.

Measuring.—As both the English and metric systems of measuring are used in woodworking, it is necessary for the worker to understand both systems. He buys his lumber by the English system and then works it over to the metric system. For this reason, the course of exercises which follow will be alternated in the two systems. Further information on systems of measuring will be found in Part V.

Equipment.—The tool equipment needed to carry out the course of practice is as follows:

1 rule, 24-inch, English and metric.
1 framing square.
1 try-square, 6 or 8 inch.
1 marking gauge.
1 pencil.
1 knife
1 pair dividers, 8-inch.
1 hand ripsaw.
1 hand crosscut saw
1 backsaw.
1 turning saw.
1 fore plane.
1 jack plane.
1 smoothing plane.
1 rabbetting plane.
1 block plane.
1 universal plane.
6 chisels, 1 each 1/8, 1/4, 1/2, 3/4, 1, and 1½ inches.
2 gouges, 1 each 1/2 and 3/4 inch.
1 spokeshave.
1 drawknife.
1 ratchet brace.
1 set bits, auger 1/4 to 1 inch by sixteenths.
4 bits, drill, 1/8, 5/32, 3/16, and 7/32 inch.
1 countersink.
1 bit, screwdriver.
1 hand screwdriver.
1 hammer.
1 nail set.
1 mallet.
1 oilstone.
1 slip stone.
1 grindstone.
1 cabinet scraper.

For further information on ordering tools, see the "Manual in Woodworking for Philippine Public Schools."

FIRST EXERCISE.

Preparing a piece of lumber from rough to finished dimensions. The stock required for this exercise is five pieces, each measuring, roughly, 1 x 3 x 13 inches.

NOTE.—It is supposed that the student has read carefully the preceding pages describing the tools he is about to use.

By adding the length of the five pieces of rough stock, we get a total of 65 inches, or 5 feet 5 inches. With a ruler and pencil, measure and mark out a piece of this size along the edge of a board 1 inch thick. Commence at the end of the board and use the outside edge as one edge of the required piece. Although the dimensions thus measured are called the "rough dimensions," make them with great care, as close measuring and straight sawing save a lot of hard labor with the plane in the work that follows.

With a ripsaw, cut along the line with the grain until the line is reached which marks the end of the piece. With a crosscut saw, cut along the line across the grain until the cut made by the ripsaw is reached. Measure the lengths of the five required pieces, mark their ends with a try-square and pencil, and cut them apart with a crosscut saw.

Sawing.—The saw should be held firmly with the right hand. Better control can be had by extending the forefinger along the side of the handle. In starting the cut, the saw is guided by the thumb of the left hand which is pressed against the blade as shown in figure 104. The saw should be started with a long, back stroke; it cuts less on the back stroke and is more easily guided. The saw must not be crowded against the work, but, on the contrary, should be slightly lifted to prevent its cutting too deeply. It should always be moved with a long stroke, using as many teeth as possible each time. A short, jerky movement is never necessary or desirable.

There are two mistakes which a beginner is likely to make in sawing—first, sawing away from the line; and, second, sawing at a wrong angle.

To guide the saw.—If the saw starts to run away from the line, the blade can be slightly twisted in the direction it ought to take as illustrated in figure 106. The blade will immediately begin to come back into position. The correction should be made as soon as the error is discovered.

To correct the angle of the cut, the saw should be bent as shown in figure 107 and, at the same time, moved up and down vertically instead of at the usual angle. After the saw is started the angle may be tested as represented

Fig. 104. Starting a ripsaw.

Fig. 105. Finishing a ripping cut.

Fig. 106. Twisting the saw to bring it back to the line.

Fig. 107. Correcting the angle of the saw cut.

in figure 108. Attention given to this matter at first will soon enable the workman to judge the angle with his eye correctly enough for most work.

When ripsawing a long cut, the saw should not be allowed to injure the trestle at the finish. This can be avoided as shown in figure 105.

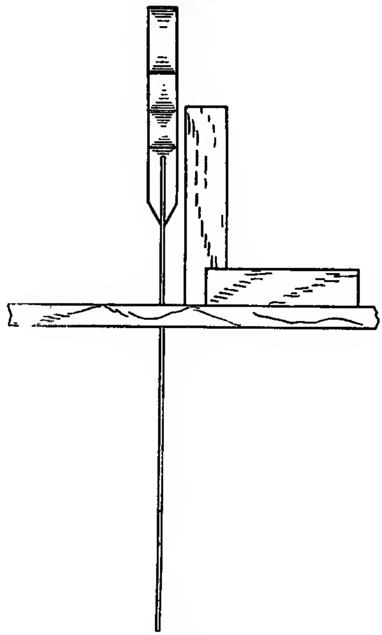


Fig. 108.

In sawing with the cross-cut saw, the same general directions should be followed. When the piece is cut nearly in two, there is always danger of the uncut portion breaking and splintering from its own weight. This can be prevented by supporting the work properly either by hand or by an arrangement of the trestles.

Planing.—Place one of the pieces of rough stock in the vise in such a position that at least one-half of its thickness projects above the bench top. See that the vise is adjusted so as to hold the work evenly. With a jack plane, "face" one side, marking it No. 1 as soon as it is finished.

There are several mistakes that are likely to be made by a beginner. The commonest is that of planing the ends more than the middle. The following rules should be observed:

Assume a natural, easy position, with the bench at the right hand and the plane held firmly by its two handles as shown in figure 109; then apply the plane to the work with a lifting motion, dropping down on the work at the beginning and lifting at the finish. To explain this point a little more clearly: A beginner will often find when he tests his first piece that he has rounded it from one end to the other, planing more at the ends than in the middle. A good way to correct this mistake is to make a pencil line across the piece very close to each end and then plane out all that can be removed between the two pencil marks, keeping the plane parallel with the sides of the piece. The result will be that the surface will become straight. It will be hollowed the

Fig. 109. Correct position for planing.

Fig. 111. Testing for squareness.

thickness of the last shaving, but this amount is so small that it cannot be seen. If no effort is made to hold the plane up, it will drop down from its own weight at each end of the piece and will naturally plane the ends more than the middle. After a few trials, using the pencil marks as suggested, the student will learn the correct motion and will have no more trouble.

If the surface to be planed is wider than the cutter of the plane, the strokes should be equal on all parts of the surface.

The plane should be adjusted to cut a very light shaving, and the work tested just as soon as the old surface has been removed. The student should bear in mind that "a workman is judged by the finished article, not by the waste," so a good workman will stop planing when he thinks he has done enough.

Fig. 110. Testing for straightness.

The mouth of the plane sometimes becomes filled up, or clogged, and ceases to cut. This may be caused by a dull cutting edge, which scrapes instead of cutting; by the cap of the plane being set too close to the edge; or by a bad fit between the cap and the iron, which allows a shaving to get between.

Testing.—Apply the reverse edge of the try-square to the planed surface as shown in figure 110. If the try-square touches in all directions and at all points, the surface is said to be "faced." In case the surface is not exactly right, it should be studied carefully before it is corrected. If the worker does not know what is wrong, he will probably not be able to correct his error. A beginner will often mistake a very small error for a large one and hence will overdo the corrective work, thus continuing back and forth until the whole piece is used up.

Jointing.—Place the piece in the vise so that one of the edges is up. Plane this edge until it is straight and at right angles with the faced surface. The same general rules for planing the first surface can be applied.

Testing for straightness.—Holding the work toward the light, pass the reverse edge of the try-square along its length. It will touch at all points, if the edge is straight. A skillful workman will often test his work by simply holding it in line with his eye and looking along the edge. A beginner needs to use mechanical methods until his eye has been trained by practice.

Testing for squareness.—Holding the try-square with the right hand and the work with the left hand, apply the handle of the square and drop the blade down across the edge as shown by figure 111. Holding the handle tightly against the faced side, move the square slowly along the whole length of the piece. If the edge fits the angle of the square at every point, it is said to be "square." When the edge is both straight and square, it is said to be "jointed." Then mark it No. 2, and the work is ready for the next step.

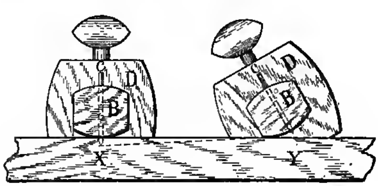


Fig. 112.

Gauging.—The gauge is the best tool for producing lines parallel to the working face. As illustrated in figure 112, the beam of the gauge (*B*) has a steel point (*C*) which makes the mark. The head (*D*) is adjusted by means of a set screw so that the distance between the point and the head is equal to the distance to be gauged. The gauge is held with the fingers against the head and the thumb extended along the beam behind the point (see fig. 113). If the distance to be gauged is too great to permit of keeping the first finger. on the head of the gauge, it should be held with the other three fingers. One thing should be remembered; the force must be applied directly behind the point that makes the line.

The gauge is tipped in the direction it is to work. If a deep mark is desired, the gauging may be repeated. The point of the gauge projects too far to allow of its entering the wood to its full length, and it is regulated by tipping it as shown in figure 112.

It might seem to a beginner that the process of using a gauge was so simple as to need no explanation. A few trials will prove that a little practice is needed before using the tool on work of any value.

While there are many ways of using the gauge with good results, there are several reasons why it is naturally a left-handed tool. It is customary to hold the work for gauging on the top of the bench against one of the stops. This brings one edge of the piece over the edge of the bench and allows plenty of room for the head to slide along without striking anything. This is especially useful when gauging on thin lumber. The natural position of the workman is in front of his bench behind the vise. If he holds the gauge in his right hand he is obliged to step out of position and take the position that a left-handed person would use when planing. It is a little difficult for a person who is naturally right-handed to train his left hand for this work, but the time will be well spent in doing so.

Practice work in gauging should include the making of at least a dozen good lines. These can be made on a piece of scrap lumber and planed off if a second trial is necessary. Special attention should be given to making each line complete from one end to the other. Practice should also be had in starting and stopping the gauge at given points. This can be gained by drawing two lines across the piece and gauging from one to the other. If an impression is made with the gauge at the point where it is to stop, this will be learned very easily. When the gauge reaches the point,

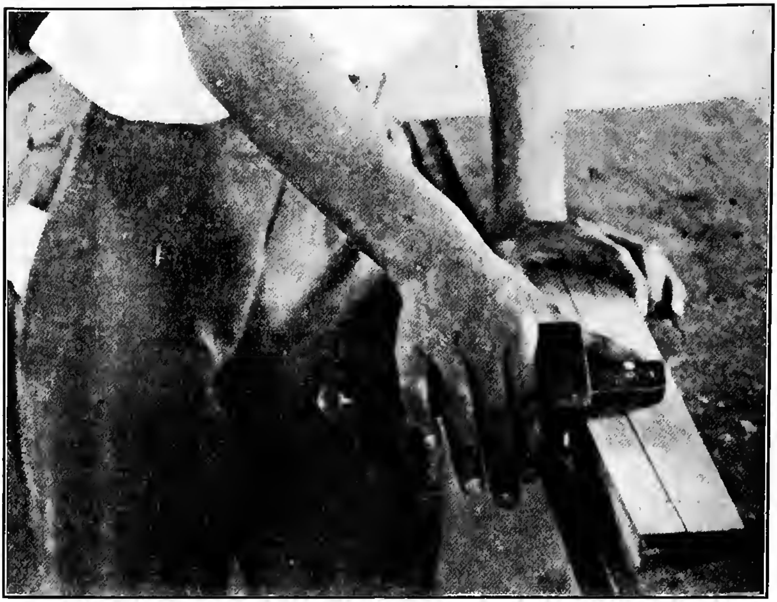


Fig. 113. Position of hand and fingers in gauging.

Fig. 114. Correct position in starting the backsaw.

the workman feels it and knows that he has reached the stopping place.

After practicing until fairly good results can be obtained, set the gauge to the required thickness of the piece and gauge a line all around it from the first faced side. Be careful to make the lines continuous and straight, clear to the corners, and across the grain at the ends. After the line is made, finish it by drawing a pencil through it. As the point of the gauge really cuts, or splits, the surface, the result will be that two pencil lines will show—one on either side of the cut.

Planing to gauge lines.—The piece is next placed in the vise and the waste material is removed with the plane down to the gauge line. When the planing is finished, one of the pencil lines should be visible all around the edge. This is important, because if both lines have been planed off, the piece will be too small.

The work is tested in two ways—first, by examining the line that remains, and secondly, by applying the try-square to see if the planed surface is square with the edge that is already jointed and straight in all directions. As this exercise is intended for practice only, the workman may gauge another thickness and try again if the first attempt is a failure.

Next the gauge is set to the required width and a line is made all around the piece, keeping the head of the gauge against the first jointed edge. The planing process is repeated and the work is tested as in the first step.

It should be remembered that the gauge is a tool that will only copy. If the gauge is used against a straight edge, it will make a straight line; if it is used against a curved edge, it will make a curved line; and if used against an irregular edge, it will make an irregular line. It simply copies the shape of the edge along which it is used.

Squaring with the backsaw.—The thickness and width having been obtained, the next step is to cut the length. This will also require some practice; in fact, it is often more difficult for a beginner to learn to saw than to plane correctly. There are several ways of obtaining a "square end" and several tools that may be used to correct imperfect work done by the saw; but the workman who learns how to saw quickly and accurately to a line close enough so that no other tool needs to be used, has learned something that make him about twice as efficient as the workman who depends on the block plane to finish his saw cuts. A block plane is a very useful tool in the hands of a good workman, but a beginner should not use it until he has learned to saw.

Lining.—The work of sawing includes two lessons—lining and sawing. Making the lines naturally comes first and so will be explained first. With the square held firmly against the first jointed edge, a line is drawn with the point of the knife, close against the blade of the square and across the surface of the piece. The work is turned away from the workman and the line is continued across the jointed edge. The work is again turned away from the workman, but this time the try-square is also turned so that its handle is again in contact with the first jointed edge; the line is then drawn across the third side. The work is again turned, keeping the square in the same position and the line is drawn across the fourth side. If the square is held firmly and the lines are drawn carefully, they will meet on the last corner. A study of the process described will show the reason for turning the square over on the last two sides, namely, that by so doing all four lines are drawn from two sides of the piece. If this is not easily understood, the two marked surfaces (the first faced side and the first jointed edge) can be used. When the first line is drawn, the handle of the square is against No. 2; when the second line is drawn it is against No. 1; when the third line is drawn it is back again on No. 2; and when the fourth line is drawn it is again on No. 1. If these directions are followed, the line is sure to come out right.

When a knife is used to draw lines, the edge should be used and the knife be made to cut. The knife should be placed first where the line is to be made and the square pushed up against it. It is wrong to "scratch" the lines with the back of the knife point or with the corner of a

Fig. 115. Two positions in drawing knife lines.

chisel. The value in using a knife is that it cuts. Figure 115 illustrates the process of drawing a knife line as directed.

Sawing.—Holding the piece on a bench hook, cut off the waste material with a backsaw. The knife, if properly used, makes a cut across the surface. If the sawing is accurate, one-half of the knife line will remain on the end and an examination will show a narrow, smooth surface all around the end as illustrated in figure 116.

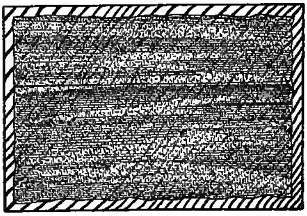


Fig. 116.

The most difficult part for a beginner to learn is how to start the saw correctly. As the work is held on the bench hook, only two of the four lines are visible, the one on top and the one on the edge toward the workman. The saw is guided by the thumb of the left hand which is pressed against the saw and down against the wood (see fig. 114). As soon as the saw is started, the thumb can be removed and all the strength of the left hand used for holding the work. The saw is started on the farthest corner with a long back stroke to prevent splitting. As soon as it is started the saw is gradually brought back across the top surface until the cut has reached the edge toward the workman. He then follows the two lines that he can see. If the saw is in good condition and he cuts accurately to the two visible lines, the workman can be sure that the saw is cutting correctly to the two lines that he cannot see.

The finished work is tested in two ways: First, by examining it to see if part of the knife line is still visible; and, secondly, with the try-square to see if the end is at right angles with the sides of the piece. Even though his first attempt is exactly right, the workman should try this project at least six times before going on with the next step.

Cutting the required length.—The required length is measured from the squared end, a knife line is drawn around the piece, and the second end is squared in the same manner as the first end. The workman should be especially careful in cutting the second end, because if he makes a bad cut he has spoiled his work. When measuring the length, the ruler should be placed on edge so that the scale is brought close to the surface (see fig. 117). The knife point is used to transfer the measurement from the ruler to the work and is held in position while the square is substituted for the ruler.

The *work* and *waste* side of a line should be carefully determined before sawing. To illustrate: If two lines are drawn on a piece of wood exactly 20 centimeters apart and the two ends are cut off exactly *on* the lines, the piece

Fig. 117. Correct position of rule in measuring.

Fig. 118. Position of hands and chisel in starting cut.

remaining will be less than 20 centimeters long by half the width of the saw cut on each end, or, adding the shortage on both ends, by the width of one cut, or about 2 millimeters. This would be enough to spoil the piece if it was to be used where a close fit was required. The saw cut should be wholly on the waste side of the line, leaving just enough of the line to prove it, as shown in figure 116.

Having finished the first piece to required dimensions, the next step for the pupil is to repeat the same process on the four remaining pieces. This may not seem necessary if the first piece has been done successfully; but the workman needs more practice than can be had in doing just one piece. The work of preparing from rough to finished dimensions has such an important place in all bench work that it cannot be practiced too much. A workman should practice it until he is sure. The making of one piece only is not enough proof. The five pieces thus prepared are used in the exercises that follow; therefore all the work counts toward the completion of the course.

Practicing with the block plane.—After the pieces have been made to the required dimensions as directed, the block plane may be used to smooth the sawed ends. This is done by setting the block plane to cut a very light shaving and then planing the rough surface left by the saw until it is even

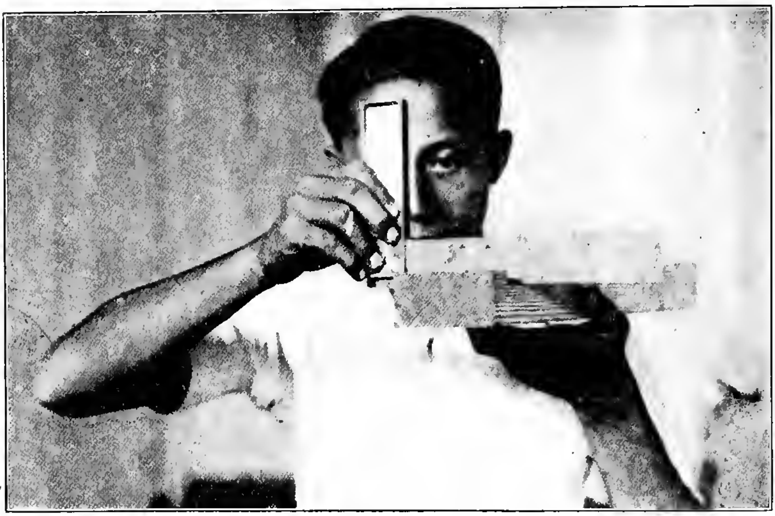


Fig. 119. Testing a finished cut.

with the knife cut around its edges. If the sawing has been well done this can be finished in a few minutes. In action, the block plane is always used from the outside toward the center and never clear across the piece. Used clear across to the other side, it will break and splinter the edge. This can easily be proved by a trial on a piece of scrap lumber.

The process of block planing has nothing to do with squaring except that it makes a more finished job. The block plane should not be depended on to correct mistakes in sawing. The beginner can make no worse mistake than that of using the block plane as a substitute for the saw. If he cannot saw an end perfectly square, he should continue his sawing practice. It is often necessary to smooth a sawed end that is going to be exposed on the finished work; but the sawing should be accurate and close to the line. A good workman will saw so as to cut away half of the knife line. This will leave a very small amount, perhaps 1/100 of an inch, to be taken off by the block plane. The workman who purposely saws away from the knife line and then uses the block plane to remove the rest of the waste is admitting that he does not know how to saw. In the hands of an experienced workman, a block plane is a very useful tool; in the hands of a beginner, it often results in a waste of time. The saving of time by accurate sawing is the most important point to be considered.

SECOND EXERCISE.

PRACTICE WITH BACKSAW AND CHISEL.

Figure 120 shows a plan, elevation, and end view of this exercise. Although the finished project consist of five cuts across the piece, it is better to start the exercise by making the first cut only. If it is not perfect, the workman can study his mistakes and correct them on the other cuts. It the five cuts are made one by one, the last two can usually be made correctly; whereas, if they are all planned and cut out at the same time, the same mistakes may be repeated on all of them.

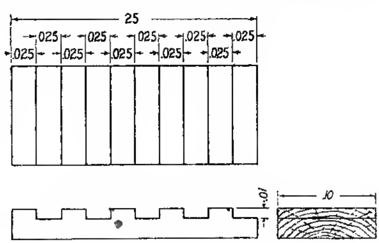


Fig. 120.

Laying out the first cut.—On one of the pieces prepared in doing the first exercise, measure from one end the proper space and the width of the cut as shown in the drawing. With a try-square and knife draw lines through these two points across the surface. Continue these lines down the edge with a sharp pencil. These lines are drawn with a pencil because their length is uncertain. Set the gauge to the required depth of the cut and make a line between the two pencil marks on each edge, using the gauge from the face of the piece. Great care must be taken not to gauge beyond the pencil lines, for knife lines or gauge lines on a finished surface are a sign of bad workmanship. They cannot be removed without cutting, and cutting reduces the size of the piece. Such lines are made only where the workman is sure that he is going to cut.

Cutting out.—The piece is laid on the bench hook and saw cuts are made with the backsaw down to the gauge lines. The workman must watch his saw carefully so as not to cut too deep. The cuts should be made right up to the knife lines on each side so that the sides of the cut will not have to be trimmed afterward.

Selecting a chisel.—When a cut is to be made, as in this exercise, where the sides of the cut are already finished, a chisel should be used which is slightly narrower than the surface to be cut. If a chisel of the exact width of the cut is used, it is liable to "bind" in the sides of the cut and split the wood or leave marks that cannot be removed. Therefore a chisel about 1/8 inch narrower than the cut is about right.

Chiseling.—It may be taken as a definite rule in chiseling that one hand is always used to guide and control the chisel and the other hand used to apply the force which drives it. When both hands are used to push the chisel, the workman loses all control. This rule applies to all chiseling. This exercise is small and the cut is all on the outside, therefore it will not be necessary to use a mallet to drive the chisel, nor will any help be needed except the two hands of the workman. The chiseling should proceed as follows: Holding the chisel with the flat side down, the handle in the palm of the right hand, and using the fingers of the left hand to guide it, commence the cut as shown in figure 118. First cut the two corners of the waste material from one side to a point about half way across the piece. Then remove the middle, a little at a time, down to the gauge line. Turn the work around in the vise and finish the cutting in the same manner from the opposite side. The cutting each time should be small enough so that the chisel can be easily pushed by one hand. If the grain of the wood is found to be very crooked, a small part of the cut may be made from one side and the rest from the other side. Enough must be done from both sides so that the edges will not be split.

The finished work is tested, first, by examination to see if the pencil, knife, and gauge lines are still visible; secondly, the edge of the try-square is applied to the bottom of the cut to see if the cutting has been made straight across from one gauge line to the other as shown in figure 119, thirdly, the sides of the cut are tested with the try-square to see if they have been made at right angles to the edges of the piece. After noting all the mistakes in the first cut, lay out the lines for the remaining cuts as illustrated in figure 120 and the exercise is finished. It is well, however, to make the cuts one by one. The exercise is not necessarily spoiled if the first cut is not perfect. If all mistakes have been corrected and the last three cuts are right, the workman may proceed with the next exercise.

THIRD EXERCISE.

BENCH HOOK.

Figure 121 shows the finished project. The bench hook should be made of some hard wood, such as guijo or palo-maria. Soft wood will wear out very quickly and costs more in the end.

Study the drawing and make out a bill of lumber. The two stops or cross pieces can be best made by preparing them as one piece until they are ready to be cut to the required lengths. Adding these two pieces together the rough stock required will be one piece 2.5 x 21 x 31 centimeters for the board, and one piece 2.5 x 3.5 x 35 centimeters for the stops. As the work of preparing these pieces is exactly the same as that in the previous exercises, the directions will not be repeated.

Assuming that the material has been prepared correctly, the next step is putting together. The detail drawing (fig. 121) shows the outline of the hole to be bored for each screw. Six screws are required, of the kind known as

1¼-inch, No. 14, "flathead, bright." It will be noted that three different borings are required for each screw. The small hole which receives the thread of the screw must be of the same diameter as the core of the screw inside the threads. The large hole which receives the body of the screw is of the same diameter as the body of the screw. The countersink is used to cut the part which receives the head of the screw.

The proper bits are selected by measuring the diameter

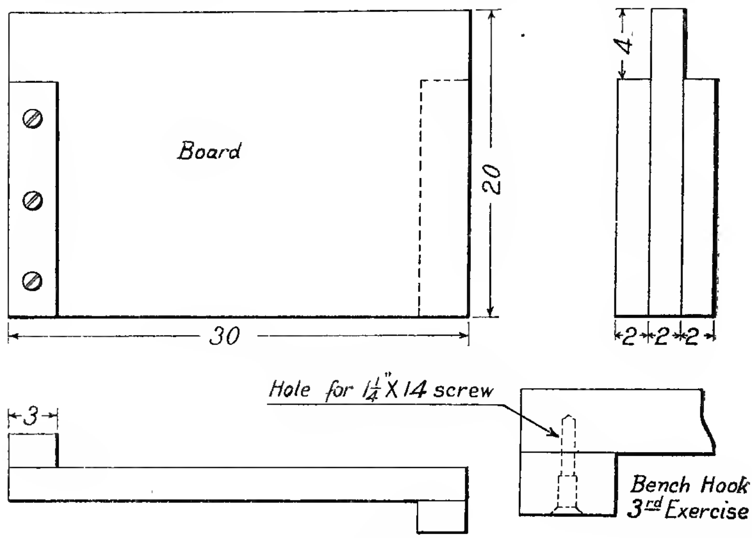


Fig. 121.

of the screw at the different points. For this boring a ¼-inch auger bit and an ⅛-inch drill will be needed.

One of the stops is held in place with a C clamp, and the centers for boring are marked. The first boring is made to the required depth with the ¼-inch auger bit. The small hole is then bored with the drill bit, and, lastly, the edge is cut away with the countersink. As will be seen in the drawing, the countersink is used until the screw head is sunk about ⅛-inch below the surface.

There are several ways of measuring or gauging the depth of a boring. The simplest method, when only a few holes are to be bored, is to mark on the bit with a piece of chalk, the proper distance from its point, and when this mark reaches the surface stop boring.

Bore for the three screws with the same bit before changing to the next size. When the three holes are bored, the screws are put in with a hand screwdriver. The opposite side is finished in the same manner. As the bench hook is used to protect the surface of the bench, it is often marred by the saw and chisel. Therefore no "finishing" work is needed on it and the bench hook is ready for use as soon as the last screw has been placed. The chief requirements are that the bench hook be strong and well made. For convenience in storing it while not in use, a hole is usually bored in the bench hook for hanging it up.

GENERAL RULES FOR BORING.

The bit should be properly placed in the brace. It is very easy to place it wrong, and a beginner often does so. The brace should be opened until the square shank of the bit slips clear into it, then tightened until the bit is held firmly.

The position of the workman in boring is very important. When boring, stand straight up in a natural, easy position. Hold the head of the brace with the left hand and raise or lower it until it is in the right position. Then press the body against it, lightly, to hold it in place. The direction of the boring can be proved by holding a try-square against the bit and the work, but a fast workman learns to judge it by the eye alone. If possible, request another workman to stand a short distance away and direct the movement of the brace up or down until the right position is found. In this way the operator can learn how the brace looks when it is in the right position. Figure 122 shows the correct position for boring.

An auger bit does not need to be forced. If it is sharp and in good condition, a slight pressure at the start makes it enter the wood. After that, the screw on the point pulls it into the wood, and simply turning it does the rest. One of the commonest mistakes made by a beginner is that of leaning against the brace when boring. This makes it very difficult to bore correctly and results in wasted labor. A drill bit needs to be forced, as it has no screw to pull it in; but if it is sharp, very little force is required.

The brace should never be allowed to hang on the bit. Bits of all kinds are very easily broken or bent in this manner. If it is necessary to stop boring before the hole is finished, the bit should be pulled out of the work. When the boring is finished, the bit should immediately be removed from the brace.

Fig. 122. Correct position for boring.

Before using the brace and bit on any of the exercises, take a little practice, as follows: On the two sides of a piece of scrap lumber, locate two points exactly opposite by means of the square and gauge. Bore from the point on one side until the point of the bit comes out on the other side. If the point comes out on the mark, the boring is correct. Try this four or five times before proceeding with the regular work. This is also a test of position and correct use as well as of direction. If the brace is held properly and the directions are followed, the workman can tell without looking when the point has come out on the other side, because the bit will cease to pull and will turn freely in the hole. In actual practice, the work would be turned around and the boring finished from the other side. In this case, the finishing can be omitted.

Putting in screws.—When putting in a screw, the workman must pay strict attention to business and stop turning just as soon as the screw is in as far as it should go; for if the twisting motion is continued, something will break. Sometimes the thread of the screw cuts the hole larger, sometimes the screwdriver breaks, and sometimes the head of the screw breaks. There is an exact limit to the distance that a screw can be put in; when that limit is exceeded damage is sure to result.

FOURTH EXERCISE.

HALF-LAP JOINT.

The stock required can be taken from one of the pieces prepared in the First Exercise. It is shown, with the necessary lines, in figure 123; and the finished joint, in figure 124.

Laying out.—Measure the required length of both pieces, one from each end of the stock, and draw knife lines around the piece at the points thus found. This is necessary in laying out the joint, but the two pieces should not be cut apart until both parts have been planned and cut out. Find the middle of each part, measure one half the width of the cut on each side, and draw pencil lines around the piece at the points thus found.

NOTE.—The width of these spaces is found by measuring the stock itself.

Set the gauge to the required depth and gauge between the lines on both edges of the piece. Be careful, in turning over the stock, to keep the same surface against the gauge. Do not make any unnecessary gauge lines. The process is exactly the same as if the line was gauged all around the piece, except that the space between the cuts is omitted.

The method of gauging the required depth should be closely studied. Both parts of the joint are constructed at the same time. The gauge is used on both parts without changing its set. On one face the cut is made down to the gauge line, while on the other the cut is made up to the gauge line, as shown in figure 123. The joint will fit, even though the gauge line is not in the middle, because the amount that is cut away from one part is exactly equal to the amount left on the other part.

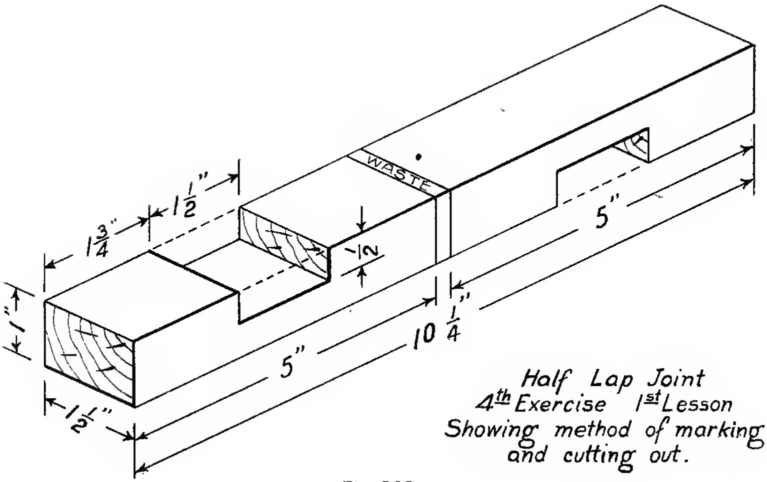


Fig. 123.

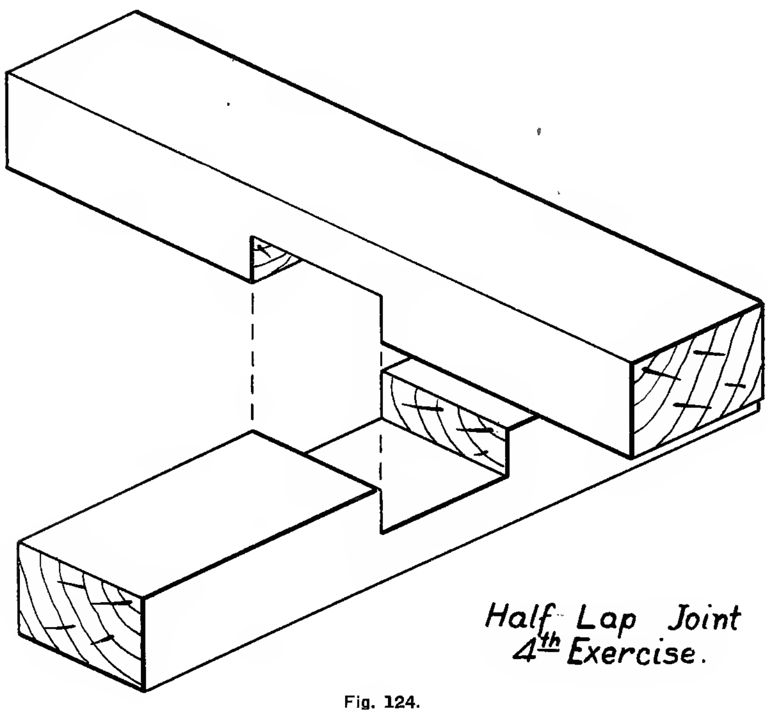


Fig. 124.

After the lines are finished, the waste is marked plainly and the joint is ready for cutting.

The cuts are made in the same manner and with the same tools as the cuts in the Second Exercise. When both parts are cut, the two halves are separated by cutting to the lines already drawn; the joint is then put together.

Care should be used in putting the joint together. It will not need to be driven with a mallet or hammer if it is properly made. The joint should go together easily and yet be tight enough so that it will not need nails or glue to keep it from falling apart. If the work has been done correctly, all the surfaces will be flush and no trimming will be needed.

The system of laying out and cutting out all parts of the joint before separating the stock into short pieces is best on all small work of a similar kind. It is a great help in gauging and allows the workman to compare the construction of the different parts more easily, because he plans all the parts before cutting any of them. There is, furthermore, much less work in preparing the stock; also, the long piece is easier to hold in the vise for chiseling.

FIFTH EXERCISE.

HALF-LAP DOVETAIL JOINT.

Stock required, one of the pieces prepared in doing the First Exercise. Figure 125 shows a front, side, and top view of this joint and figure 126, the stock before the two halves of the joint are cut apart. The stock can be used just as it was prepared for the First Exercise, without any of the dimensions being changed.

Laying out.—Measure the piece and find the exact width. From one of the squared ends, lay off the distance thus found and draw a line with a sharp pencil entirely around the piece, using the try-square. From the other end, lay off the required spaces and draw two pencil lines around the piece in the same manner.

Set the gauge to a distance equal to about one half of the thickness and gauge between the pencil lines on the first edge, from one pencil line to the other around the end, and between the pencil lines on the other side. Use the gauge from the same face of the work all the way around. The motion is the same as if a line were gauged all the way

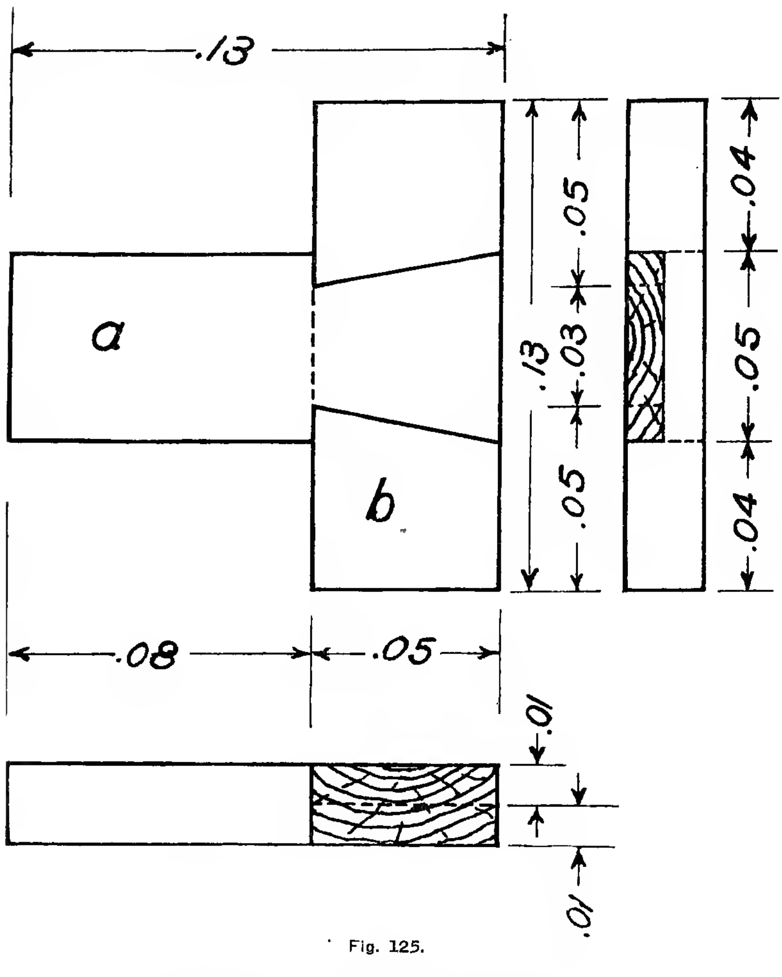


Fig. 125.

around, except that the spaces between the two parts of the joint are skipped. Lay out the joint as if it were an open half-lap. Next, measure the required distance in from each side on both parts of the joint and draw the diagonal lines. Use the straight edge of the try-square and the knife for making these lines. This is the most difficult part of the whole joint and the workman must be very careful and accurate in repeating his measurements.

The joint is now ready to be cut out. The part *a* is cut with the backsaw; first, across the grain down to the gauge line and then along the gauge lines with the grain until the first cut is reached; next, the piece is turned on edge and the cut is made across the grain down to the slanting knife line. The other side is sawed in the same manner. With a wide chisel, the flat side down, the waste material is cut away

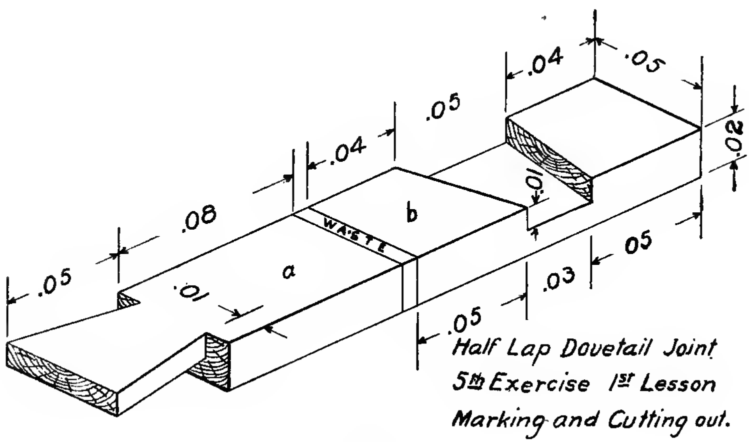


Fig. 126.

down to the knife lines. The chiseling should start with a light cut in the corner where the most material is to be removed. The chisel should be gradually brought back, cutting parallel with the line each time, until the line is reached. The piece should be examined to make sure that the chiseling is being done square across. The last cut with the chisel should leave a little of the knife line showing along the edges.

The other part of the joint *b* is cut in exactly the same manner as the half-lap joint described in the last exercise. It will be found a little more difficult to saw to a slanting line, but the process is the same.

When both parts are finished, the correct lengths are measured and cut; the joint is then put together. It should go together by light driving and be tight enough to hold without glue or nails.

SIXTH EXERCISE.

MORTISING.

The stock required can be made by reducing the width of one of the pieces prepared in the First Exercise. The construction work is shown in figure 127 and the finished project in figure 128.

The ends of the piece have been already squared and so can be used without change. Measure from each end the required length of each piece and draw knife lines around the piece at the points thus found. These will be used later when the joint is ready to go together. Measure from the end of the part *a* the required length of the tenon, plus $\frac{1}{8}$ inch to be trimmed off when the joint is finished; then draw a line around the piece with the pencil and square. On the part *b* lay off the required spaces and draw two lines around the piece with the pencil and square at the points located. Set the gauge to the required dimension and gauge the first line between the two pencil lines on the part *b*, from the line on part *a* around the end to the line on the other side, and between the two lines on the other side of part *b*. Pass the gauge clear around the piece, skipping over the parts where no gauge line is needed. Next, add the thickness of the tenon to the distance already gauged and make the second line, running the head of the gauge against the same face as before. Next, mark the waste which is to be removed, and the joint is ready to be cut out. Figure 127 illustrates the project when the construction work is completed.

Cutting out.—Cut the tenon wholly with the backsaw. If the workman is careful, this can be done accurately enough so that no trimming with the chisel will be required.

It will be remembered that the mortise has been drawn exactly the same on the two opposite sides. To cut the mortise, select a chisel having a width as nearly as possible

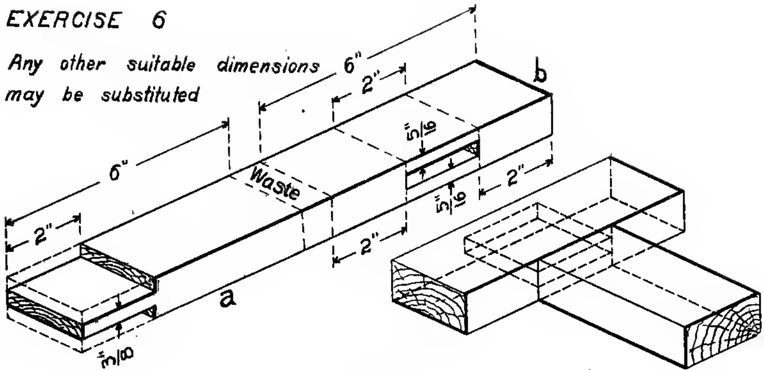


Fig. 127.

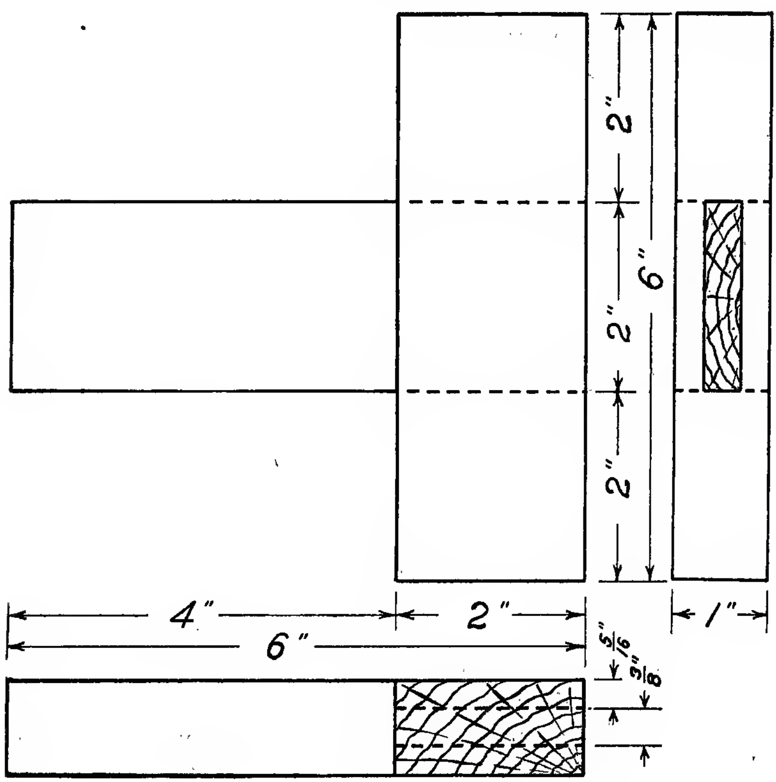


Fig. 128.

equal to the distance between the gauge lines. Beginning on one face near the middle of the mortise, advance toward the end, as shown in figure 129. Make the last cut a short distance from the end line, leaving a small amount to be trimmed back to the line when the mortise is cut through. Commencing at the starting point, cut toward the other end, stopping in the same manner, close to the line. A mallet may be used to aid the hands in cutting the mortise, but it must be used very cautiously. Loosen the portion cut each time by a backward movement of the chisel handle, as shown in figure 129, position *a*. After the first set of cuts have been made and the work passed below the surface, the mallet can be used with more force, as there is then no danger of splitting over the lines. When the

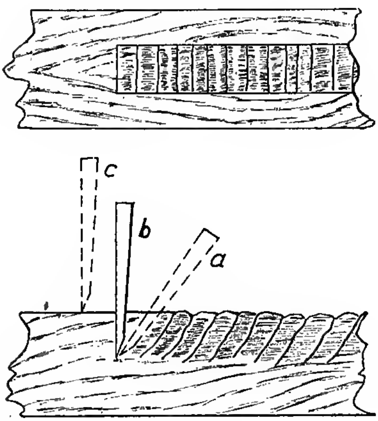


Fig. 129.

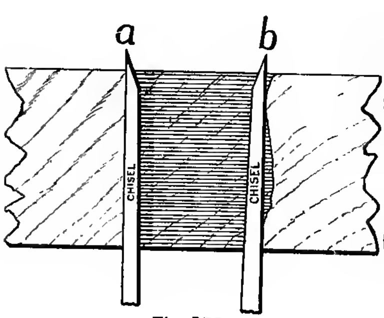


Fig. 130.

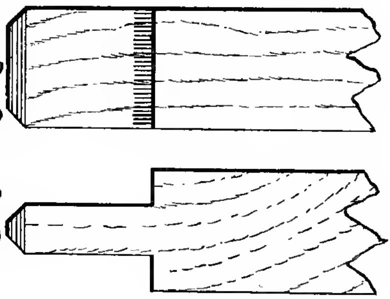


Fig. 131.

cut has been made about half way through, turn the piece over in the vise and repeat the same work from the other side. Drive the chisel to meet the cut made from the first side. After the cutting is finished all the way through clean out the chips and cut away the small part that was left at the ends to protect the lines. When the mortise is cleaned out test it by using the flat side of the chisel as a straightedge, as shown in figure 130. The sides of the finished mortise should agree with the chisel as indicated at the point *a*. Compare *a* with *b*. Remember that one-half the width of the lines should show on the finished work.

The joint is now ready to be put together. Cut the pieces to the lines already drawn for the required length. Chamfer the end of the tenon as shown in figure 131. It

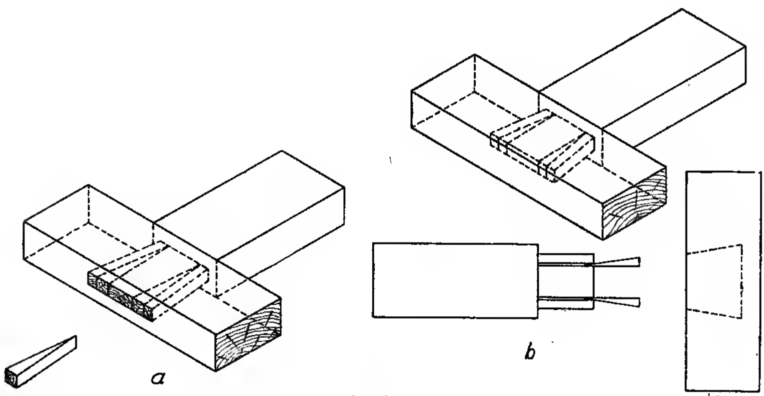


Fig. 132.

will be remembered that the tenon was made $\frac{1}{8}$ inch too long at the start. This portion is chamfered to prevent splitting when the joint is put together. The tenon should fit the mortise tightly, but the workman should first make sure that the joint has been thoroughly cleaned out. Driving a joint that has not been completely cut out will split the mortise every time. A mallet can be used, but the blows should be very light. The joint should fit closely enough so that it will hold itself together. After the fitting has been done, trim off the projecting part of the tenon with the backsaw and block plane.

Fastening.—There are many methods of fastening this joint, several of which will be explained separately. The simplest is gluing. This consists of applying glue to the inside of the mortise and then clamping the joint together until the glue is dry. This system is commonly used in furniture work where visible fastenings are not allowed.

Fastening with wedges is shown in figure 132*a*. The operation consists in making the mortise slightly wider on the end that is going to be exposed. The joint is glued and while the glue is still wet the end of the tenon is split with a chisel; wedges, covered with glue, are then driven in. This makes the outer end of the tenon wider than the other end and it cannot be pulled apart after the glue is dry. Note the direction in which the wedges are applied.

Drawboring is shown in figure 133. It consists in boring a hole through the two sides of the mortise and then boring a hole of the same diameter through the tenon, but slightly closer to the shoulder of the tenon. When the joint is put together, the holes are not in line and a pin driven through the hole will pull the joint together very tightly. The amount of difference in the line of the holes should not be more than $\frac{1}{32}$ inch, and the pin should be pointed to prevent splitting. This kind of fastening is used chiefly on heavy framing where strength is the most important thing to be considered.

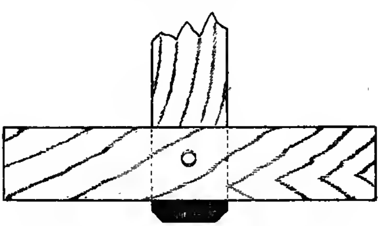


Fig. 133.

Proportion in mortising is very important. A cabinetmaker or carpenter is required to make all sorts of mortises on pieces of different dimensions, and he must know the right proportions to cut his joints so as to give the greatest possible strength. As a general rule, when two pieces of the same thickness and width are mortised together, the tenon is made about one-third of the total thickness. The mortise should never be wider than the amount of wood left on either side of it.

When a "blind" mortise joint is made (fig. 132*b*), the length of the tenon depends on the width of the piece it is to enter. A good rule for general use is to make the tenon square. To illustrate: If the tenon is made on a piece of stock 2 inches wide, it should be 2 inches long to give the greatest strength. There are many exceptions to this rule, and the workman must depend on his own judgement for making strong joints.

SEVENTH EXERCISE.

BOX CONSTRUCTION.

(Fig. 134.)

Stock required: 1 piece 1.5 x 13 x 60 centimeters. The box shown in the drawing has a capacity of 1 cubic decimeter (1 liter).

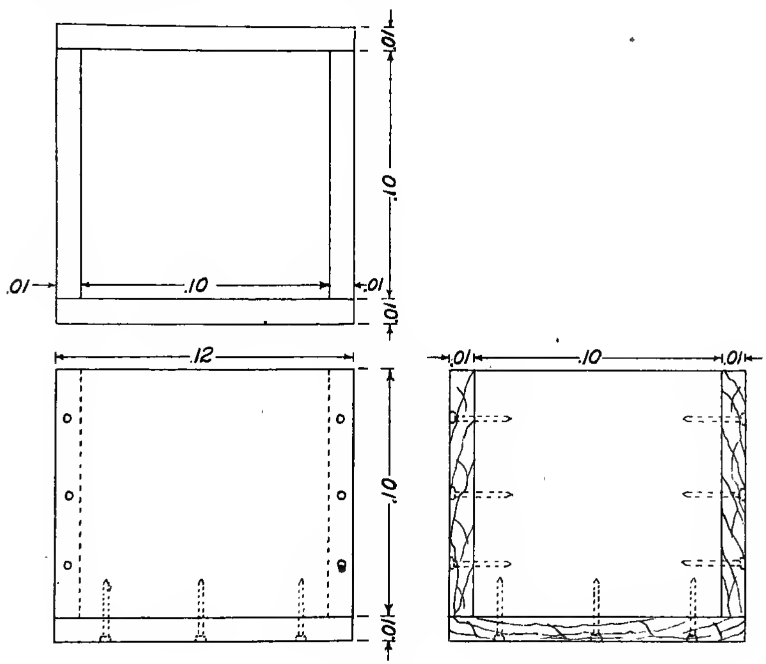


Fig. 134.

The first step in making the box is to study the working drawing and make a list of the different pieces with their exact finished dimensions. This list is called the "bill of lumber." The completed bill of lumber for this box will read as follows:

2 pieces 1 by 10 by 10 centimeters, end boards.
2 pieces 1 by 10 by 12 centimeters, side boards.
1 piece 1 by 12 by 12 centimeters, bottom board.

Note that the height of the box includes the thickness of the bottom board and that the width includes the thickness of the two sides.

By comparing the items of the bill of lumber it will be found that all pieces are of the same thickness and that the ends and sides are of the same width. It is easily understood that one long piece is easier to plane than five short ones; therefore, a great deal of time can be saved by

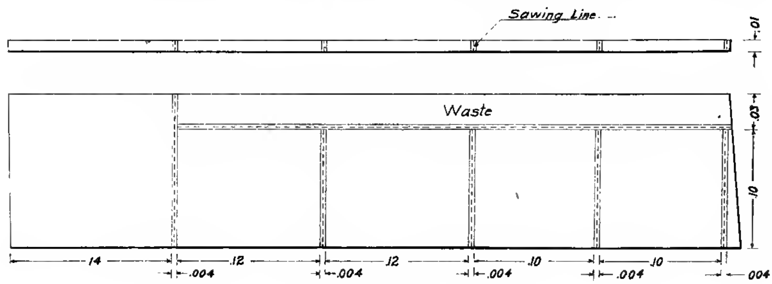
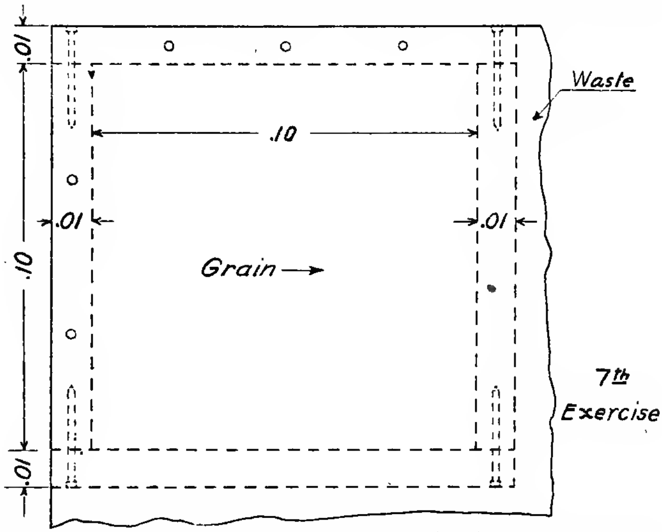


Fig. 135.

preparing all five pieces at the same time in one large piece. They can be combined as shown in figure 135, making one piece 13 centimeters wide and about 60 centimeters long.

A piece of these dimensions is cut from the rough stock and planed to the required thickness. Next, one edge is jointed and the various pieces are laid off on the stock, allowing a sufficient amount for waste as shown by the dotted lines. The bottom board is cut off along the dotted line and laid aside until needed. The long piece, which includes the side and end boards, is ripped to its rough width along the dotted line and is prepared to the required width. The pieces are then separated by sawing across the grain. Each piece is sawed to its exact length and, if no mistakes have been made, should be finished when it is sawed.

The bottom board has already been prepared to the required thickness, and has one jointed edge. Next, one end is squared with the jointed edge. This leaves one edge unfinished and one end not squared. These will be trimmed off to fit the box after being nailed on. This is very important, as it is the only way to make sure that the bottom will fit perfectly. As the system of preparing stock has already been explained, it will be assumed that the workman will prepare his pieces correctly. When the end and sides



Waste to be trimmed off with plane before nailing the last two sides

Fig. 136.

have been prepared, they should be compared by placing them together, first, to see that they are the same width, and, secondly, to see that the end boards are exactly alike and the sides exactly alike.

Nailing.—Figure 136 shows the box in the process of being nailed. The side and end boards are first nailed together, then the straight edge and square end of the bottom board are nailed to fit one side and one end.

There are a few general rules in regard to nailing that should be understood before starting this project. Wire finishing nails are used; in selecting them, the thickness of the lumber can be used as a measure. The nails should be about three times as long as the thickness of the board through which they are to pass. To illustrate: The pieces of this box are 1 centimeter thick; therefore the nails should be 3 centimeters long. The nearest dimension in English measure is $1\frac{1}{4}$ inches. To prevent splitting, the nails should be placed as far in from the edge as the thickness of the lumber. When the bottom board is being nailed to the sides and ends, the nails should be placed far enough from the corners to clear the nails coming in from the sides. The foregoing rules can be applied to nailing a box of any dimensions. For example, when nailing a box whose material is 1 inch thick, 3-inch nails would be used. They would be placed 1 inch from the edges of the side boards and 3 inches from the corners of the bottom board.

Fig. 137.

As this is the first exercise in nailing, the workman should proceed with great care. It is best to measure and mark the location of the nails before putting them in. It is also a good plan to examine the work very carefully before the nails are driven clear in and to make sure that their points have not split through the surface on the inside of the box. A careful workman can often stop in time to prevent a nail from coming through the surface and thereby prevent making a bad mark on the work.

Hammer marks on the work must be avoided. They are a sign of bad workmanship. An experienced workman can drive a nail flush with the surface without leaving a mark on his work, but it is better for a beginner to stop before the hammer has touched the surface and finish with a nail set. Before nailing the box, it is well to practice by driving several nails into a piece of scrap lumber. It is not easy to drive a nail into the edge of a thin board without splitting the board; a little practice will prove this.

Setting nails.—When the nails have been driven as far as possible, they are set below the surface with a nail set. When the nail set is used, the little finger of the left hand should rest on the surface, as shown in figure 137, and the nail set be held firmly against the fingers. There will then be no trouble in keeping the point of the set against the head of the nail.

Withdrawing nails.—It sometimes happens that a nail, when partly driven, is found to be entering the work in

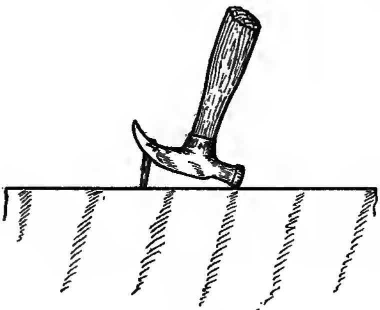


Fig. 138.

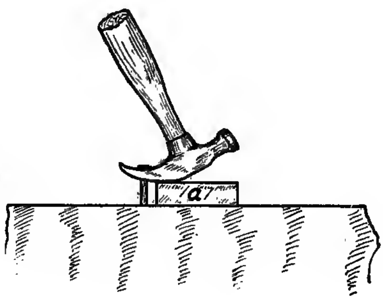


Fig. 139.

the wrong direction. In this case it must be withdrawn. If the hammer, when used for this purpose, is allowed to get into the position indicated in figure 138, it will mar the work; the nail is likely to split the wood when it comes out, and unnecessary force must be used to pull it. A better way is to put a small block of wood under the head of the hammer, as shown in figure 139. A thicker block should be substituted when the nail is pulled farther out. If the work is well done, the nail will not be bent. Never try to drive the nail back in the same hole from which it was drawn out. The second nail will either follow the first or take another direction no nearer right. If the point of the nail comes through the surface after it has been set, the concave point of the nail set can be used to drive the nail back until the head is above the surface where the claw of the hammer will take hold of it.

Fastening the box bottom.—The sides and end pieces of the box, when nailed together, may not form a perfect rectangle, even though each piece is the required length. When the bottom board is put on all parts become fixed. It is therefore important that the frame of the box be in proper form when the bottom is nailed. The bottom piece has been prepared with one straight edge and one square end. It is a little wider and a little longer than necessary, but this will be made right after the nailing is finished.

Place the bottom board with the straight edge flush with one of the sides and the squared corner exactly even with the end, then drive the nails along the side. Now, since one end is perfectly square, if the end of the frame is made to fit it exactly, the corners of the box will be square. If the frame does not fit exactly, a slight pressure will spring it into place, after which it is nailed. Do not drive nails near the corners of the box. One reason is that they are liable to strike the nails already in place, and another reason is that they will not hold firmly. Keep a safe distance from the corner in both directions and the box will be stronger.

When the nails have been driven in one side and one end of the bottom board, the next step is to set them. After setting the nails plane away the waste material along the edge until the edge is flush with the side board. The waste at the end is cut away with the backsaw and block plane. Next, nail the remaining edge and end of the bottom board and set the nails. The box is now ready for finishing.

> NOTE.—In bench work the word "Finishing" is used to mean everything that comes after tool work. This applies to sandpapering, polishing, or painting.

Sandpapering.—Fold a piece of sandpaper over a flat block and sand the box inside and out. Sandpaper should be used with the grain, and care should be taken not to round off the corners.

As this is the first place in the course where sandpaper is used, it will be well to give a few general rules for using it.

Sandpaper is just what its name indicates—*sand* and *paper.* It is made of very hard stone crushed to a fine powder and glued on sheets of paper. When sandpaper is used on wood, the sand becomes loosened from the paper and enters the surface of the wood. Therefore the first and most important rule for using sandpaper is: *It should never be used until all work with edge tools has been finished.* Using a plane on a sandpapered surface has the same effect on the edge of the plane as pushing it over the surface of a hard stone.

As has been explained on page 50, sandpaper is graded as to coarseness, the different grades being numbered. The grade of sandpaper required depends on the quality of the work upon which it is to be used. Sandpapering is a very slow process, therefore a surface should be as smooth as the tools can make it before sandpaper is applied. When a great deal of sandpapering is needed, the coarse sandpaper is sometimes applied with a rotary or circular motion to make it cut faster. This is changed to a finer grade as the surface becomes smooth, the last use of the sandpaper being with the grain as much as possible. The workman must be careful not to leave any sandpaper scratches on his finished work; in fact, it cannot be called finished if any such marks are to be seen.

Sandpaper should always be used over a block that fits the surface; a flat block for a flat surface, a rounded block for a hollow surface, and a hollowed block for a rounded surface. The hand should never be used as a substitute for the sandpaper block. In the finishing room, a block of cork is sometimes used, as it gives a better pressure on the work.

EIGHTH EXERCISE.

MITERING.

The term "mitering" is commonly used to describe the process of joining two pieces of wood cut at 45 degrees, so as to form a right angle. There are several methods of making a miter joint. Figure 140 shows a common one.

The stock may be taken from one of the pieces prepared in doing the First Exercise and the dimensions changed to whatever is required. As in making the other joints, it is best to keep the stock in one long piece until the construction work is finished.

Measure the exact width of the piece and lay off, near one end, a perfect square, having as its sides two pencil lines and the two opposite edges of the piece. (It is not wise to measure from the exact end of the stock, even though it is square, as it makes the work of sawing very difficult.) Continue the two pencil lines around the

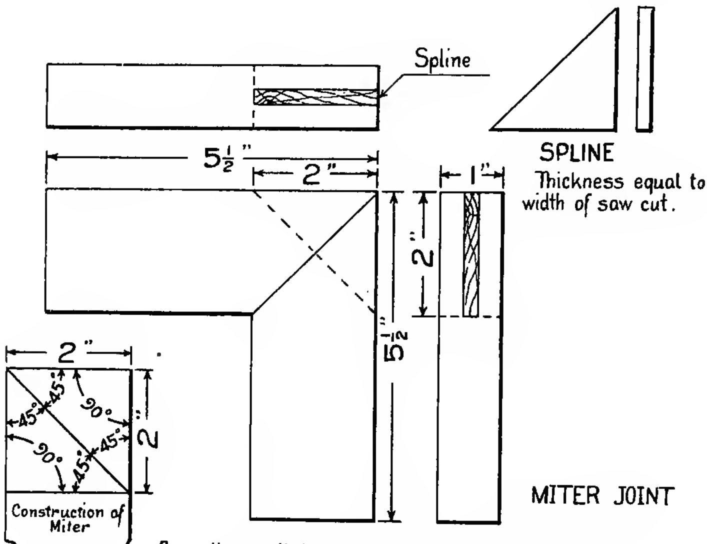


Fig. 140.

piece with the try-square until they meet on the last corner. Repeat this construction on the other end of the piece.

Using the edge of the try-square as a straightedge, with a sharp knife draw one diagonal in each of the squares thus constructed. Be very careful to make the diagonals on the opposite sides agree with each other. The work will then be ready for cutting out. Figure 141 shows the stock with the necessary lines.

The work of sawing at an angle of 45 degrees is exactly the same as in squaring an end, except that it is a little more difficult to hold the work and start the saw correctly. When the sawing is finished, part of the knife lines should remain. The ends should be smoothed to a perfect surface with the block plane.

Next, measure the required length of each piece from the acute angle and separate the pieces. To test the work, place the two halves of the joint together in the inside angle of the try-square. If they do not form a perfect right angle, examine them carefully and find out what is

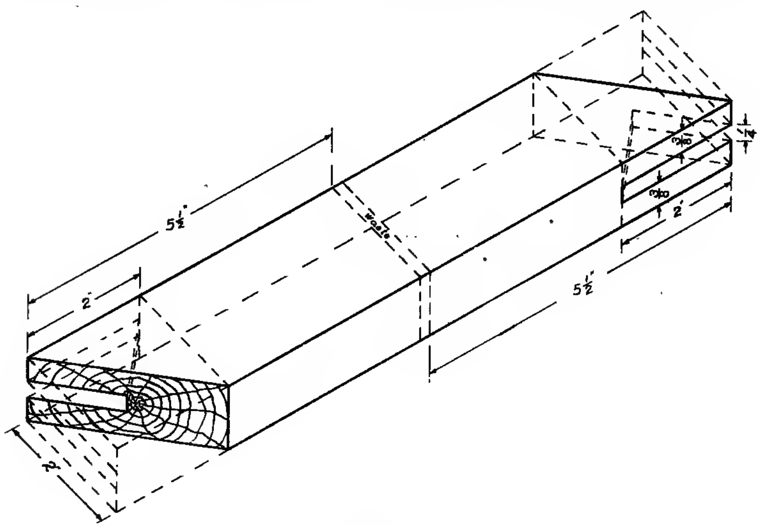


Fig. 141.

wrong. If they require trimming a little more with the block plane, work them separately. Never try to plane them both at the same time. A bevel is a useful tool for testing these angles. It can be set to agree with the lines before the joint is cut out and then used later on to test the finished work. The work of constructing an angle of 45° is explained fully here because a workman must understand it. If he has a bevel, he can set it to the angle thus constructed and use it in the same manner as the try-square for constructing the second half of the joint.

Fastening.—Figure 140 shows the method of fastening. The thin piece which is set into the corner is called a "spline." The joint is held together, either in the vise or with a clamp, and a cut is made across both parts of the joint at the same time at right angles to the miter. It should be as deep as one half of the diagonal surface. The cut can be made with a coarse ripsaw, if one is on hand, or by making two cuts with the backsaw. The spline is made by ripping a thin piece from the edge of a block. For convenience in planing, the piece should be considerably larger than the required finished dimensions. Next, both faces of the joint are covered with a thin coating of glue. The inside of the cut which is to receive the spline is also coated with glue. The joint is then put together and clamped until the glue is dry. Twenty-four hours are usually necessary for this. The clamps are then removed and the surfaces cleaned by taking a light shaving from them with the plane. Clamps should never be applied directly upon a finished surface. When the miter joint is glued, a thin piece should be placed on each side of the work. The clamp is then tightened and the joint driven together with light blows of the mallet.

The grain in the spline should be at right angles to the miter. After the glue is dry, the projecting ends of the spline are cut off flush with the surface.

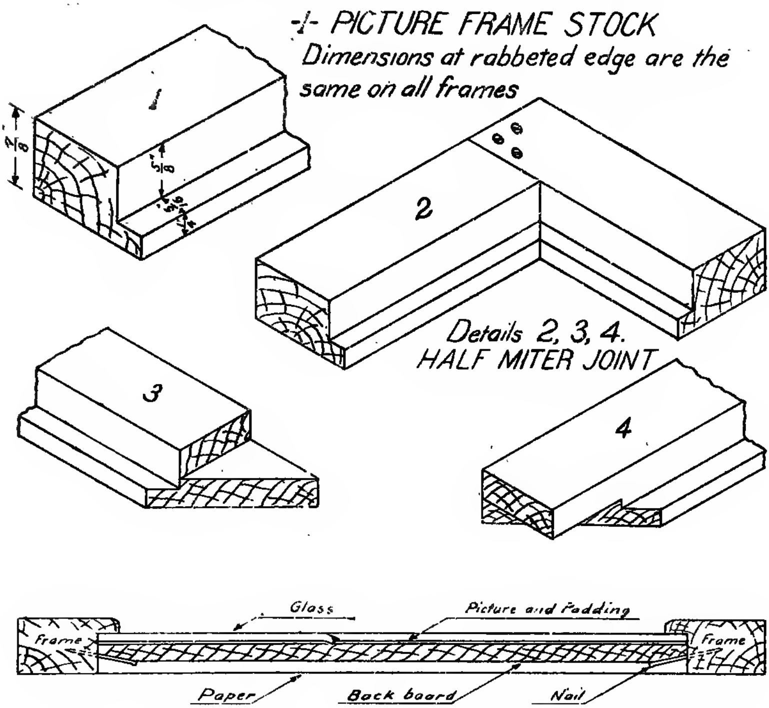
NINTH EXERCISE.

PICTURE FRAME.

Figure 142 shows the kind of joint to be used, a section of the prepared stock, and a sectional view of the finished frame. The amount and dimensions of the stock depend upon the size of the picture to be framed and can be found only by measuring the picture.

The first and most necessary thing in starting this exercise is to select a picture to be framed. Next, the dimensions of the picture are measured and the proportions of the frame are decided. Neither the decoration nor the design of a picture frame should be so prominent that it attracts more notice than the picture itself. A picture frame should be made of good material, well joined and well finished. If a workman wishes to show his skill in design-ing or decorating, he should show it upon something else, never upon a picture frame.

The frame for a small picture should be as narrow as possible and still give the necessary strength. For a picture 20 by 30 centimeters, the frame should not be more than 4 centimeters wide, increasing in width at the rate of about



FI. 142.

1 centimeter to every 10 centimeters in the width and length of the picture.

For convenience in explaining this exercise, it will be assumed that the picture to be framed is 20 centimeters wide and 30 centimeters long. This will require stock 4 centimeters wide. The thickness of the stock varies according to the size of the picture; but it cannot be less than 2 centimeters, as the rabbetted edge for the glass and backboard never changes and is made to the dimensions shown in the drawing on frames of all sizes. As this is a small frame the stock will be made 2 centimeters thick. By adding the lengths of the four-sides and making allowance for waste in planing and sawing and cutting the joints, we find that the work requires one piece whose rough dimensions are 2.5 by 5 by 140 centimeters.

The required thickness and width are obtained in the usual manner, and the length is left to be decided later.

Next, examine the stock and see if there are any holes or bad spots on either side. Select the surface having the best grain for the front of the frame. Gauge the required width and depth of the rabbet from the side that has been selected as the back of the frame.

There are several ways of cutting the rabbet. If a universal plane is at hand, it can be adjusted and used very easily for this work. A common rabbeting plane is next best. By fastening a small, straight strip of wood along the gauge line on the back of the stock to act as a guide, the rabbet can be planed out with ease. If neither of these planes is available, the cut can be made with the mallet and chisel. This is much the slowest way and requires greater care than either of the other methods, but it is the method used in most of our school shops. The edge is first planed from one gauge line to the other, stopping before the lines have been planed away. Then the mallet and chisel are used, chipping along the center of the chamfered edge and working back to the lines little by little. When the rabbetting is finished, it is tested by applying the corner of the square in the angle at different points and also by applying the straightedge along its whole length. The finishing touches are usually made by working straight in from the gauge lines with a wide chisel held with the flat side down.

Next, the four pieces are cut to their required lengths. In doing this, knife lines should be drawn and the ends made exactly square. The two end pieces should agree with each other and the two side pieces the same. The dimensions of a picture frame are usually measured along the inside angle of the rabbetted edge. This makes a little problem which the workman must study out very carefully. To find the lengths of the pieces required, we add the dimensions of the picture to the width of the stock and then subtract the width of the rabbetted edge on both sides. To illustrate: The width of the picture is 20 centimeters, the width of the stock is 4 centimeters, and the width of the rabbet 8 millimeters; 20+8—1.6=26.4 centimeters, or the length of the end pieces. The length of the sides is found in the same way. The picture, glass, and backboard extend to the inside of the rabbetted edge and a narrow strip is hidden by the frame all around. Therefore, the outside opening is smaller than the picture.

Making the joints.—Study the drawing (fig. 142) and lay out the first joint. This joint is a combination of the miter and half-lap joint and is called a half-miter joint. This joint is used to give greater strength, as it can be fastened with screws as well as glue. The lap on the back of the frame does not include the rabbetted edge. The joint is first laid out exactly the same as an end-lap joint. (See fig. 5, Pl. I of the Appendix.) The miter is constructed on the face of the frame and then the lap is narrowed on the back so as not to include the rabbet. Mark the part to be cut away on both parts of the joint and compare the two parts carefully before cutting them out. While the cutting of this joint is very simple, the construction is often very difficult for a beginner; and he is likely to find, if he is in too much of a hurry, that he has cut both pieces alike, spoiling one of them entirely. The joint can be cut out with the backsaw, cleaning the corners with a chisel.

A bevel can be used to repeat the angle of 45 degrees, and the other joints constructed. The bevel can also be used to test the miters after sawing. No matter how much material may be wasted, the frame should not be put together if the miter joints do not fit. It is sometimes possible to cut the picture a little smaller in order to correct bad workmanship; but bad joining should not be allowed in the work.

Fastening.—When all the joints are finished, clamp the joints together one by one and bore the holes for the screws as in the Third Exercise. Put in the screws when the holes are bored. When all the boring is finished and the screws have all been put in place, remove them, glue the joints, put the screws back, and clamp until the glue is dry.

It is often very difficult to clamp a miter joint properly. The method shown in figure 143 can be used in making the frame. Four strips of wood are nailed on the surface of a flat board so as to inclose a rectangular space about 1 centimeter larger than the outside dimensions of the frame. The frame is placed inside this space and small wedges are driven along one edge and one end which force the joints tightly together. It may be held this way while the screw holes are bored, and afterwards while the glue is drying. This makes an even pressure from all sides and tightens all four joints at the same time.

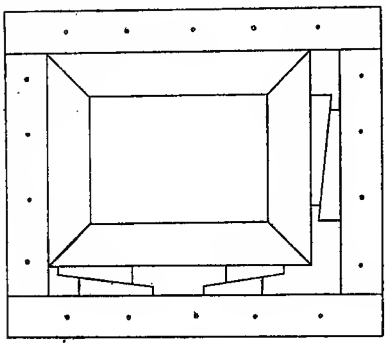


Fig. 143.

The frame should be left in the clamps at least twenty-four hours, so that the glue will become thoroughly dry. It is then taken out, and cleaned by taking a light shaving with the plane from the outer edges and by sandpapering on the front face.

The work of polishing is described in Part IV. Assuming that the polishing has been finished and the frame is ready to receive the picture, we will proceed with the next step.

The backboard is prepared about $\frac{1}{2}$ centimeter thick and the exact size of the space it is to fit. The grain of the backboard should extend with the shortest dimension. This will mean that the backboard will be 20 centimeters with the grain and 30 centimeters across the grain. (This rule applies to all picture framing.) The edges of the backboard are chamfered around one surface from a line about 3 centimeters back from the edge down to the middle of the edge, or about one-half of the thickness. This will give the nails which hold it a downward slant into the frame and prevent splitting.

Next, clean the glass and put in the frame; then, place the picture on the glass. Cut out five or six pieces of soft paper (old newspaper is satisfactory) and place them on the back of the picture so as to make a pad between the picture and the backboard. Place the backboard in the frame with the chamfered side up. The backboard is fastened with small nails placed about 4 centimeters apart all the way round. Hold the sides of the frame against something solid while driving the nails. A long piece of wood held in the vise makes a good backing for this purpose. Press the backboard tightly down into the frame as each nail is driven, continuing all the way round and changing the position of the frame so that the side which is being nailed is always held firmly. The nails should be driven into the frame close against the backboard. The side of a wide chisel can be used as a substitute for a hammer in driving the nails. The square edge fits close to the surface and drives the nails tightly.

Next, a thin coat of glue is applied to the back of the frame and a sheet of paper is put on and trimmed off all round the edges.

NOTE.—It is a fact worth remembering that in gluing wood and paper together, the glue should always be applied to the surface of the wood.

Screw eyes are used in professional work for hanging a picture frame. If they cannot be obtained, a good substitute can be made by driving small nails part way in and bending them over the point of a nail set so as to form hooks. These screw eyes or hooks should be slightly above the center of the frame from top to bottom. Extra wire or string should be allowed for adjusting to the desired length when the picture is hung.

TENTH EXERCISE.

OPEN DOVETAIL JOINT.

The stock required is two pieces, each $\frac{7}{8}$ by $3\frac{3}{4}$ by 4 inches, prepared with correct thickness and width, and with one

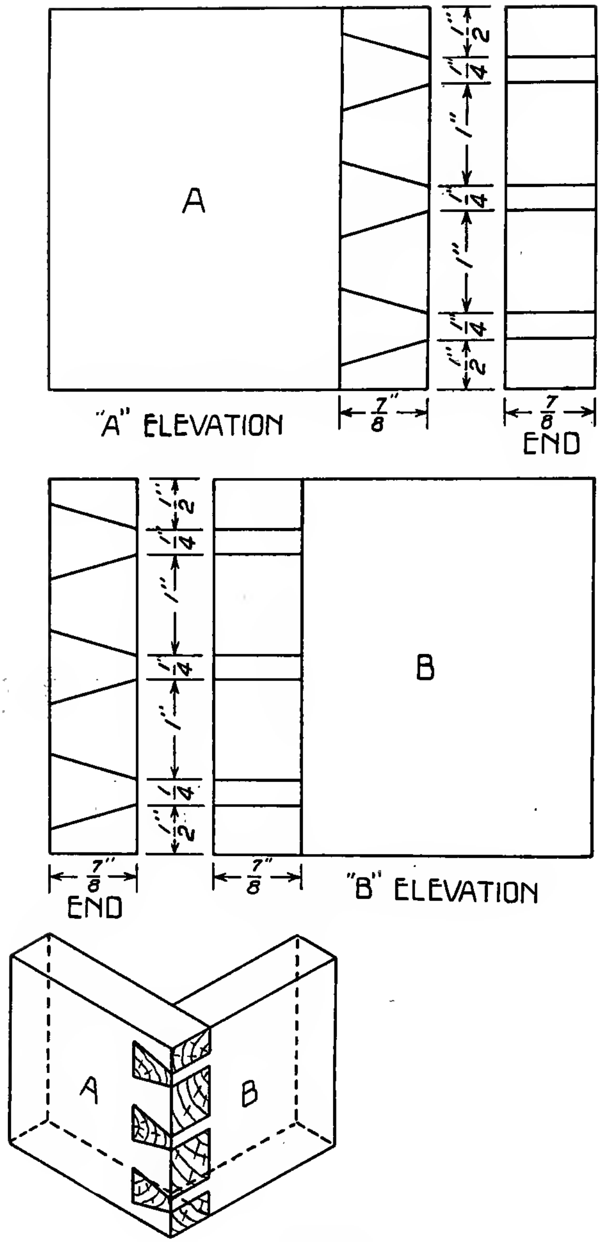

A
1"/2
1"/4
1"
1"/4
1"
1"/4
1"/2
7"/8
"A" ELEVATION
7/8
END
1"/2
1"/4
1"
1/4
1"
1/4
1"/2
7"/8
END
7"/8
B
"B" ELEVATION
A
B

Fig. 144.

end squared. The material can be worked up as one piece and then cut in two with the backsaw, thus giving the two square ends required.

Figure 144 illustrates the completed exercise as well as the plan and elevation of the two parts. Measure from the squared end of each piece $\frac{7}{8}$ of an inch and draw a pencil line with the try-square all around. Fasten the piece *a* in the vise and, on the squared end, lay off the lines shown in the end view. Set the bevel to the required angle and draw the slanting lines shown in the elevation, down to the pencil line. Mark the parts that are to be removed. Put the piece back in the vise with the squared end up and cut down the slanting lines with the backsaw. With a mallet and chisel, used the same as in cutting a mortise, remove the waste material between the lines. A narrow chisel will have to be used, as the sides of the cut are not parallel.

Fig. 145. Transferring measurements from one piece to the other. Dovetail joint.

When the piece *a* is finished, place the piece *b* in the vise with the squared end up. Holding the working face of the piece *a* against the squared end as shown in figure 145, transfer the slanting lines on *a* to the end of *b*, using a knife point to draw the lines. Remove the piece from the vise and, holding the handle of the try-square against the squared end, draw the vertical lines down to the pencil line which passes around the piece. Mark the waste material to be removed. Place the piece in the vise with the squared end up and saw the vertical lines with a backsaw down to the cross line. Removed the waste material with a chisel.

The joint should go together by light driving and be perfectly square, both on the inside and the outside. If the joint is found to be all right, take it apart, apply a light coating of glue and drive it together again. When the glue is dry, the joint may be cleaned and the ends squared to the required dimensions as shown in figure 144.

It will be noted that the system used on the previous

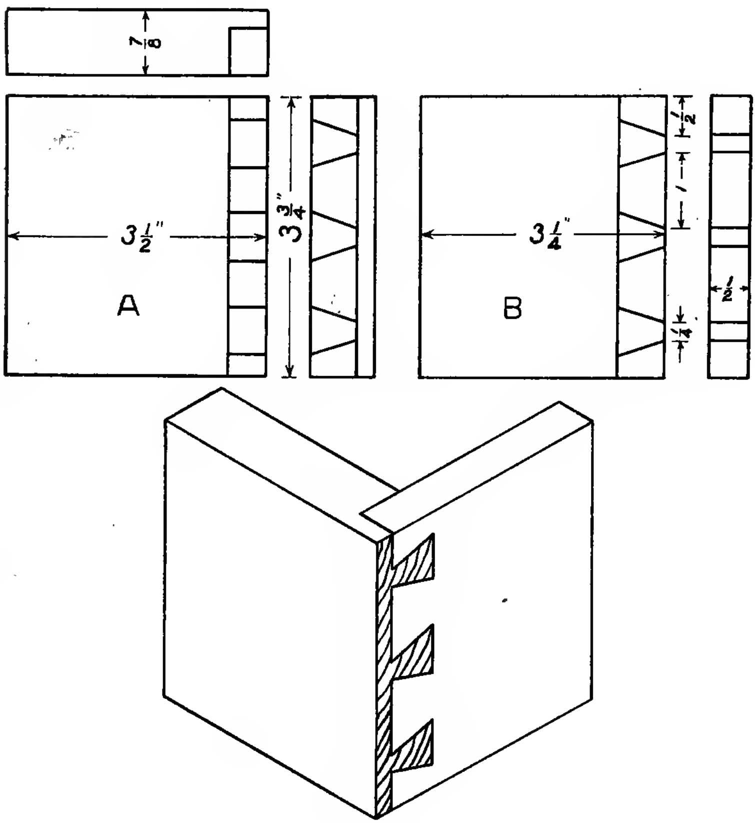


Fig. 146.

joints is changed in making this joint. One part is finished and used as a guide in making the other part. This is done because the slanting cuts are very hard to copy by exact measuring and because the gauge is not used at all.

ELEVENTH EXERCISE.

HALF-BLIND DOVETAIL JOINT.

Figure 146 represents a front, top, and side view of this joint. The two pieces are of different thickness as indicated in the drawing. As in the Tenth Exercise, it is well to prepare each piece a little longer than the finished dimensions. This allows of a second trial on the same piece in case the first is a failure. The thickness and width are obtained in the usual manner and one end of each piece is squared.

The joint is first laid out on the piece *B* in the same manner as the open dovetail; it is then cut out. Next, the depth of the required cut is measured and lined on the piece *A* and the shape of the piece *B* is transferred with the knife. These lines are continued down the side to the crossline as in the previous exercise.

The cuts can be made partly with the backsaw, sawing diagonally from one line to the other. The remaining waste material is removed with a mallet and chisel.

The joint should be examined and tested before it is put together. It should fit tightly by light driving.

This is a very comon joint in furniture making, being the best for use on drawers and articles of similar construction. It has the strength of the open dovetail with the valuable feature of being invisible from the front.

Note.—Plate II of the Appendix shows two other joints used in drawer construction.

TWELFTH EXERCISE.

FOOTSTOOL.

This project is shown in figure 147. It does not involve any new tools or methods of work and therefore requires no explanation other than what is given with the drawing. The seat is made either of rattan or hemp, and is made in connection with a class of industrial work not included in this book. Made in a school shop, the wooden frame would be prepared by the woodworkers and the seat would be put in under the instructions of the teacher of basketry or weaving.

THIRTEENTH EXERCISE.

HAUNCHED MORTISE AND TENON JOINT.

This joint is used chiefly for door and window frames and is a variation of the mortise and tenon joint already described. Figure 148 illustrates a top, front, and side view

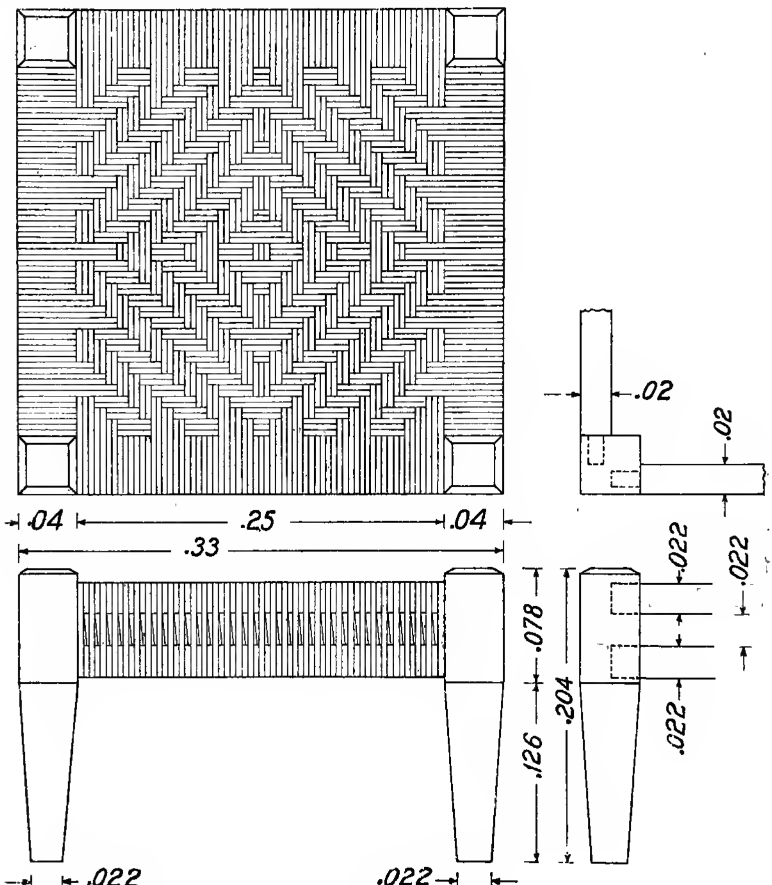


Fig. 147.

of this joint. In cheap work it is sometimes fastened by drawboring. In furniture work it is often made "blind" and fastened with glue alone. In common, commercial work it is made "open"—that is, passing clear through—and is

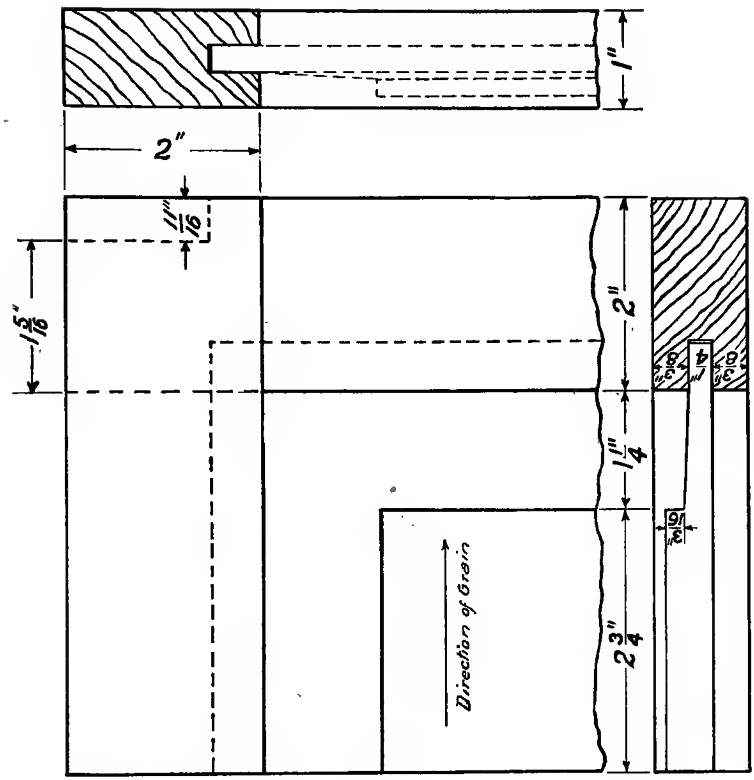
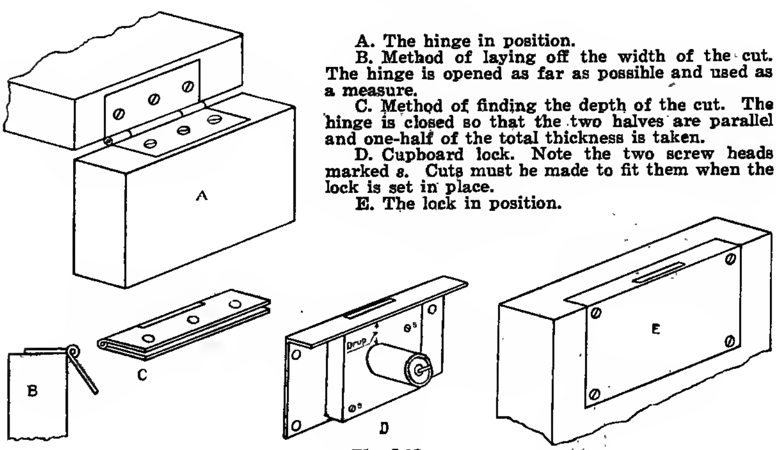


Fig. 148.



A. The hinge in position.
B. Method of laying off the width of the cut. The hinge is opened as far as possible and used as a measure.
C. Method of finding the depth of the cut. The hinge is closed so that the two halves are parallel and one-half of the total thickness is taken.
D. Cupboard lock. Note the two screw heads marked *s*. Cuts must be made to fit them when the lock is set in place.
E. The lock in position.

Fig. 149.

fastened with wedges as already described. (See fig. 132.) As no new tools or methods of work are used in making this joint, it will not be necessary to give further detailed explanations. The general instructions given for the Fifth Exercise can be followed, changes being made to agree with the drawing.

FOURTEENTH EXERCISE.

SETTING HINGES AND LOCKS.

The work of fitting hinges and locks is often difficult for a beginner. It is, therefore, necessary to practice before attempting this operation on valuable work. Figure 149 *A* shows two pieces of wood hinged together correctly and figure 149 *E* illustrates the correct method of setting a lock.

The type of hinge called a "fast pin butt" has been used as a model.

The first step in setting hinges is to see that the wood is in proper shape to receive them. The edges are jointed and fitted closely together, because the hinge does not in any way change the shape of the work, and very little change can be made after the hinges are placed. Next, the location of the hinge is found and a point made with the knife where the end of it will come. The hinge is then opened as far as it will go and is placed over the edge of the work as shown in figure 149 *B*. The exact size of the hinge is transferred to the edge with the knife point. Next, the hinge is closed to the position shown in figure 149 *C* and the thickness of the two laps is measured plus the space between them when they are parallel with each other. The gauge is set to one half of this thickness. The knife lines which mark the ends of the hinge are carried down the side with the try-square and pencil and the distance found is gauged between them. Next, the piece which is to receive the other half of the hinge is placed in the vise with the first piece so that their edges exactly coincide and the measurements are transferred from the first piece to the second. The depth is gauged and the work is now ready to be cut out.

The cutting out is done with the chisel. The workman must proceed very carefully, as there is no way to correct a slip of the chisel or a mistake of any kind. The work must simply be done over again on another piece if it is wrong.

When the cuts are finished, the hinge is placed in position and the screws are put in. If the wood is soft, no boring will be needed. The holes can be made with some sharp-pointed instrument, such as a brad awl or the point of a divider, deep enough to allow the screws to take hold. If the wood is very hard, holes must be bored with a drill bit; but even if the bit is used, the centers should be marked first with a sharp point. The most difficult part of setting a hinge is getting the screws exactly in the center of the holes. If they are put 1/32 of an inch to one side of the center, they will pull the hinge out of place and make a bad joint. The test of the work is in its utility. If the edges of the two pieces join perfectly without trimming and open evenly, and if the job is neat and looks good, it is successful.

Setting a lock.—There is very little to explain about setting a lock. The tool work is with the same tools and with the same methods as in many of the previous exercises. The kind of lock shown in figure 149*D* is what is called a "cupboard lock." The round part which receives the key is called the barrel. The first step in setting a lock is to find the diameter of the barrel and the distance from the outer edge of the lock to the center of the barrel. It is customary to set the lock about 1/16 inch in from the edge to permit of trimming the edge later on if there is trouble from the wood swelling. The center for the boring is located, plus 1/16 inch as suggested, a bit of the right size is selected, and the hole is bored. The barrel of the lock is then placed in the hole and measurements taken with the knife point around the other parts of the lock. The cut is made with the mallet and chisel. Before putting in the screws, the workman should examine the lock very carefully and see if there are any projecting screw heads or rivet heads that will prevent it laying flat in the work. Cuts should be made to receive all such projections. If the lock is bent the least bit when the screws are tightened, it will cause the key to work very hard and will finally break something.

FIFTEENTH EXERCISE.

This exercise is optional—that is, the workman can choose any one of the three designs shown in Plates IV, V, and VI. The general tool work does not include any new tools or processes and, therefore, no explanation is needed other than that given with the drawings.

MISCELLANEOUS EXERCISES.

DOWELLING.

Figure 150 shows a dowel joint. While this joint is very simple in construction, it is not easy to make; and before a beginner uses it on any practical work, he should try it on two pieces of scrap lumber. It is used in making drawing boards, table tops, and split patterns, and on any large surfaces where a wide board is "built up" from several narrow pieces.

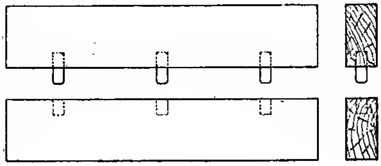


Fig. 150.

The two edges are first jointed so that they fit together perfectly A beginner often makes the mistake of leaving a slight error in fitting and expects the clamps to squeeze the edges together. This can actually be done with soft wood; but such a correction is only temporary and the bad joint is sure to open up later on, after the clamps have been removed. When the edges have been prepared, the pieces are placed together in the vise with their jointed edges exactly flush and the two corresponding surfaces opposite each other. To illustrate: If two surfaces have been selected as the top, they should be either both inside or both outside. Next, a gauge line is made down the middle of each edge, running the head of the gauge along the two outside surfaces. With the work still in the vise, lines are drawn with the try-square across the two edges at the points where the dowel pins are to be inserted. The points where the pencil lines cross the gauge lines are the centers for boring.

The dowel pins are prepared next. This can be done best on a turning lathe; but if the shop has no lathe, they can be made by hand. A square stick is first prepared. This is rounded with the block plane, turning the stick with the left hand and planing with the right hand until one half of its length is rounded. The piece is then reversed and the other half is rounded. In connection with this work it is best to try the dowel pin first by boring a hole of the required size in a piece of scrap lumber. The rounded stick should fit tightly by light driving.

NOTE.—An appliance called a dowel plate is often used for making dowel pins, and is very useful. It consists of a steel plate with holes of various sizes bored through it. The edges of the holes are countersunk so that they have a sharp edge on one side of the plate. The stick is partly rounded and then driven through the hole in the plate. The edges of the steel plate scrape off the remainder of the waste material and make the stick round.

When finished, the stick is cut into the proper lengths and the ends are slightly chamfered so that they will enter the holes without wedging. When all is ready, a thin coat of glue is applied to both of the jointed edges and to the holes that are to contain the dowel pins. The pins are driven into one edge and the work is then put together and clamped. It should be clamped at points about 6 inches apart. The clamps should pull evenly and not bend the boards side ways. This can be prevented by putting the clamps on alternately—first from one side and then from the other. If it is done in rainy weather, the clamps should not be removed for forty-eight hours.

CHAMFERING.

Figure 151*a* shows the operation commonly called chamfering. It is different from beveling in the fact that beveling extends from one side to the other across the whole thickness or width of the piece as illustrated in figure 151*b*. This work can be done on the unused side of the piece finished in the Second Exercise. The laying out is started by drawing pencil lines of indefinite length at the points *c* and *d*, extending from the corner both ways. Next, the gauge is set to the required dimension and very light gauge lines are made on the two adjacent sides in order to mark the width and depth of the chamfer. The gauge line starts at the pencil line on one side, passes around the end, and stops at the pencil line on the other side. The gauge lines must be made very light, showing just enough so they can be used as a guide in drawing pencil lines over them. A deep gauge line will spoil the work right at the start because the chamfering will not remove it.

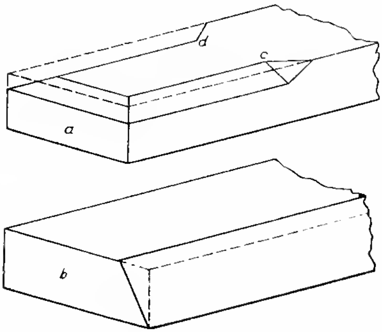


Fig. 151.

A chisel of any width greater than the cut can be used. The chisel is held and controlled as described in the Second Exercise. The cut is commenced by chipping the edge, as shown in figure 152. It is always best when removing waste wood with the chisel to cut across the grain. If the workman tries to chisel exactly with the grain, the chisel is liable to follow it and split over the lines. The work should be held in the vise with the working face toward the workman. Beginning at the end farthest away, successive cuts are made with the chisel. Each stroke of the chisel should cut almost to the full depth required. The amount of cut depends on the strength of the workman, but it should never be so much that both hands are needed to force the chisel. The surface thus made will not be smooth, but it will be true to the line. To smooth it, the same chisel

Fig. 152. Method of starting out in chamfering.

may be used, holding the flat face down on the work so that it will act as a guide and prevent the edge from following the grain. The short, triangular surface at the ends of the chamfered edge should be cut clean, so that a distinct line marks the change in angle.

As chamfering is usually done as a decoration to work, the operation is a failure unless it is done very well. All angles must be sharp, all surfaces flat and smooth; and there must be no left-over gauge lines.

Short chamfers are cut in the manner described. Long chamfers can be started with the drawknife and finished with the smoothing plane.

KEYING.

Figures 153 and 154 show different methods of fastening a joint with a key. In woodworking or ironworking, a key is a piece driven in to hold work together and so made that the different parts can be easily separated when the key is removed. It differs from a wedge in that it does not taper away to an edge and is not fastened. Key joints are used chiefly in making "knock-down" furniture.

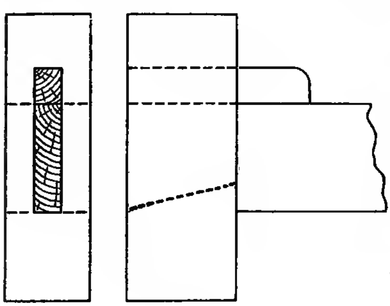


Fig. 153.

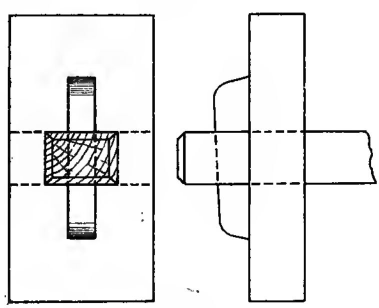


Fig. 154.

CONSTRUCTING ANGLES.

Plate VII.

This work can be done on the surface of the bench hook. If a sharp knife is used to draw the lines, a very useful addition to the bench equipment will be made. Figure 18 shows a bench hook with the angles constructed upon it.

To construct an angle of 45 degrees (see fig. 18).—A right angle is first drawn, holding the handle of the try-square against the straightedge and marking with a knife along the blade. The straight edge of the board and the knife line make the correct angle. Next, the divider is set to any radius convenient, and the arc *b-c* is drawn. From the points where this arc crosses the sides of the right angle as centers, the two small arcs are drawn which cross each other at the point *g*. A line drawn from *g* to the corner of the right angle divides it into two equal parts, each one of which is 45 degrees.

To construct angles of 30 and 60 degrees (fig. 18).—From the corner of the right angle as a center, draw the arc *b-c*. Keeping the same radius, place the point of the divider at each end of the arc in turn and draw the small arcs crossing the arc *b-c* at the points *f* and *d*. Lines drawn from these two points to the corner of the right angle divide it into three equal parts, each one of which is thirty degrees. By setting the bevel to the first line, an angle of thirty degrees is obtained; by setting it to the second line, an angle of sixty degrees is obtained. Angles of thirty and sixty degrees are often used in woodworking.

To construct an octagon in a square (fig. 14).—This method is often used in woodworking where it is necessary to make a square stick round. By drawing an octagon on each end of the piece and connecting the corners by straight lines along the sides, the workman obtains an accurate guide to follow in cutting.

BEADS AND MOLDINGS.

Figure 155 illustrates several common forms of beading. Beads are sometimes used wholly for decoration, but their chief use is to conceal cracks where two boards are joined together. One of the rules of joinery is that when two boards are joined together, they must be made to look like one complete board, with the joint so well concealed that no crack is left; or there must be a very plain crack which will appear to have been made purposely. The first kind of joint is made with glue; but when a very large surface

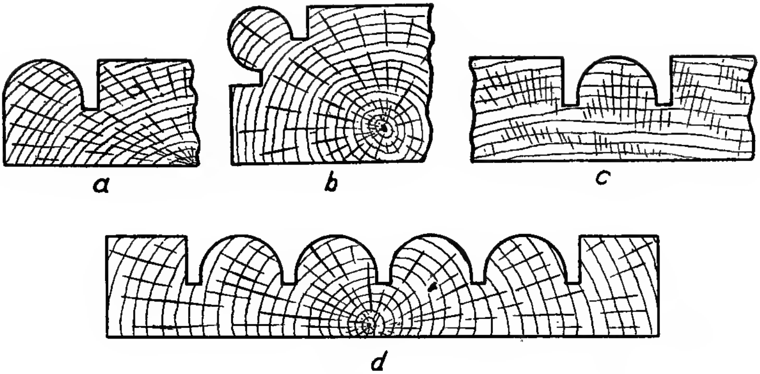


Fig. 155.

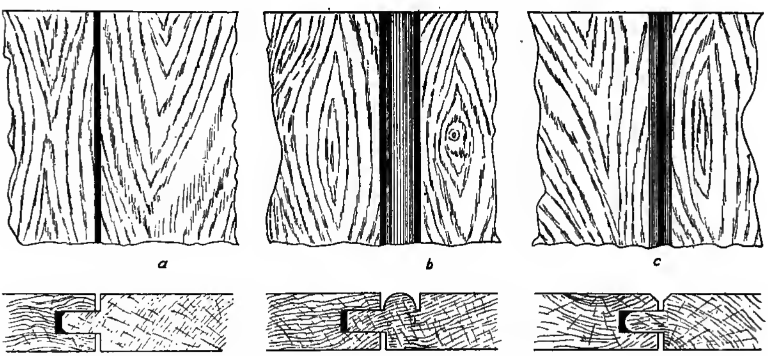


Fig. 156.

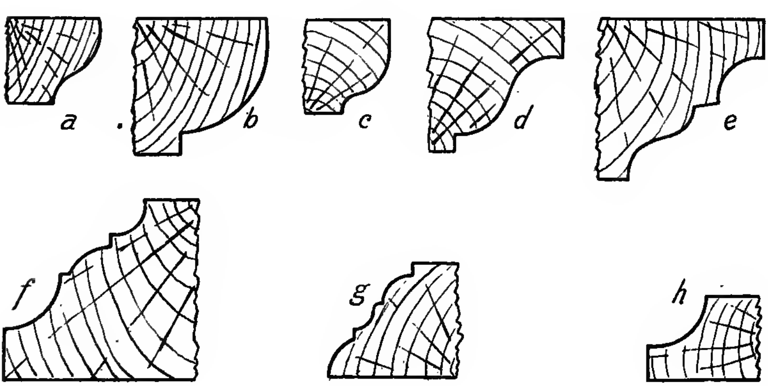


Fig. 157.

is made it cannot be glued and so another system must be used to conceal the cracks. In such a case beading is used. With a bead such as is shown in figure 156*b*, the boards can shrink or swell considerably and the beaded edge will still hide the cracks.

Moldings are used for decoration and are made in many forms. Figure 157 shows several of the commonest. Any of the forms shown can be reversed.

Matching, by means of a tongue and groove joint, is often used in woodworking. It is found chiefly in floors and interior finishing, but is sometimes used by the bench worker, for covering the backs of bookcases, etc. Figure 156 shows three common forms of matching.

CLEATING.

A cleat is a piece of material fastened across the width of a board to prevent its warping. If the surface is made of several pieces, the cleat is also used to hold them together. Figure 158 shows four common methods of applying cleats.

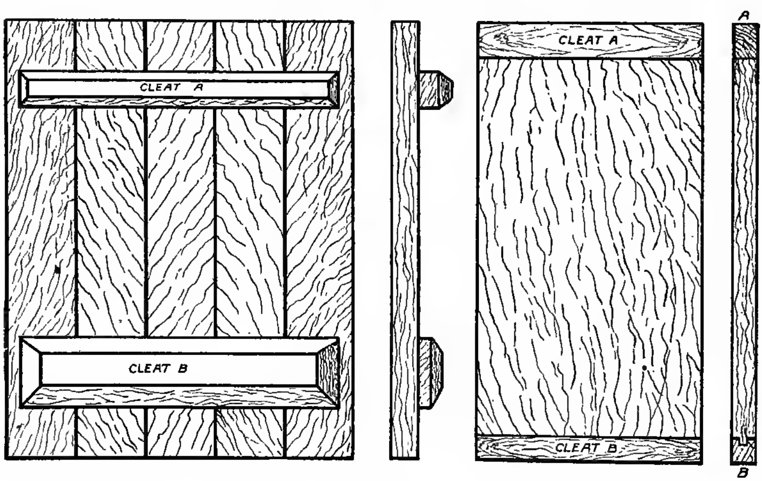


Fig. 158.

PANELING.

A panel is a board or a combination of boards used to fill an opening inside of a frame. Figure 148 shows one corner of a paneled door. The frame, taken by itself, is made up of vertical and horizontal pieces framed together by mortise and tenon joints. The vertical pieces, which extend from top to bottom, are called "stiles," and the horizontal pieces are called "rails." To give correct proportion the rails should never be more than twice the width of the stiles.

Paneling is used for two purposes—utility and decoration.

A surface does not shrink or swell if paneled, as it would if made solid. Paneling also allows of ornamentation and looks much better than a plain surface.

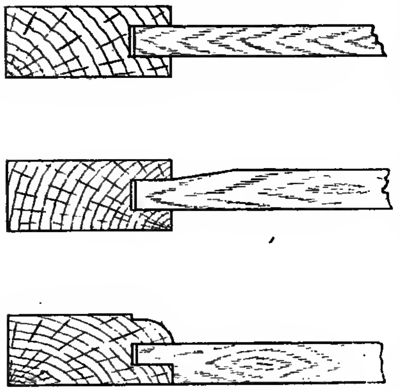


Fig. 159.

The panel is set in a groove in the stiles and rails. The panel is usually made slightly smaller than the space it fills, so that it can shrink or swell without damaging the construction. The shrinking or swelling is hidden by the groove.

Panels are made in several forms, three of which are illustrated in figure 159.

Part III.—TIMBER AND ITS PREPARATION FOR USE.[1]

Timber is that portion of the woody material of trees which is serviceable for carpentry and joinery. All woody plants of the Philippines may be grouped according to their stem structure and botanical relationship in three groups:

1. Ferns.
2. Bamboos, palms, etc.
3. Trees.

These groups are given in the order of their value as wood producers, the fern having the least amount of wood in its stem, the bamboos and palms having either a hollow or a very soft center, and the trees being solid throughout.

Ferns.—The hard tissue is scattered in large, irregular bundles through the stem; the latter is uneven, being made up of soft and very hard material. Tree ferns (fig. 160) belong to this class. They do not come into market, but the trunks of certain species are used locally in Benguet and northern Luzon as posts for houses.

Bamboos and palms.—The wood is composed of scattered small bundles of hard, woody tissue, the interspaces being filled with soft tissue. Bamboos, palms, pandans, etc., belong to this group.

Trees.—The remainder of our woody plants belong to this group. The stem grows in a cylindrical form which increases in diameter by the addition of concentric layers around the wood already formed.

In the *Exogen* group there are two distinct classes—the *conifers* (fig. 162) and the broad leaved plants, or *Angiosperms* (fig. 163). Of the conifer group, only one is found in the Philippines worthy of mention here—the Benguet pine; and very little, if any, finds its way to the Manila

[1] Adapted from Goss's "Bench Work in Wood," with aid from various publications of the Bureau of Science and the Bureau of Forestry. Reviewed by E. E. Schneider, Bureau of Forestry.

Fig. 160. A growing fern tree.

Fig. 161. Palm trees.

Fig. 162. A tree of the conifer group (Benguet pine.)

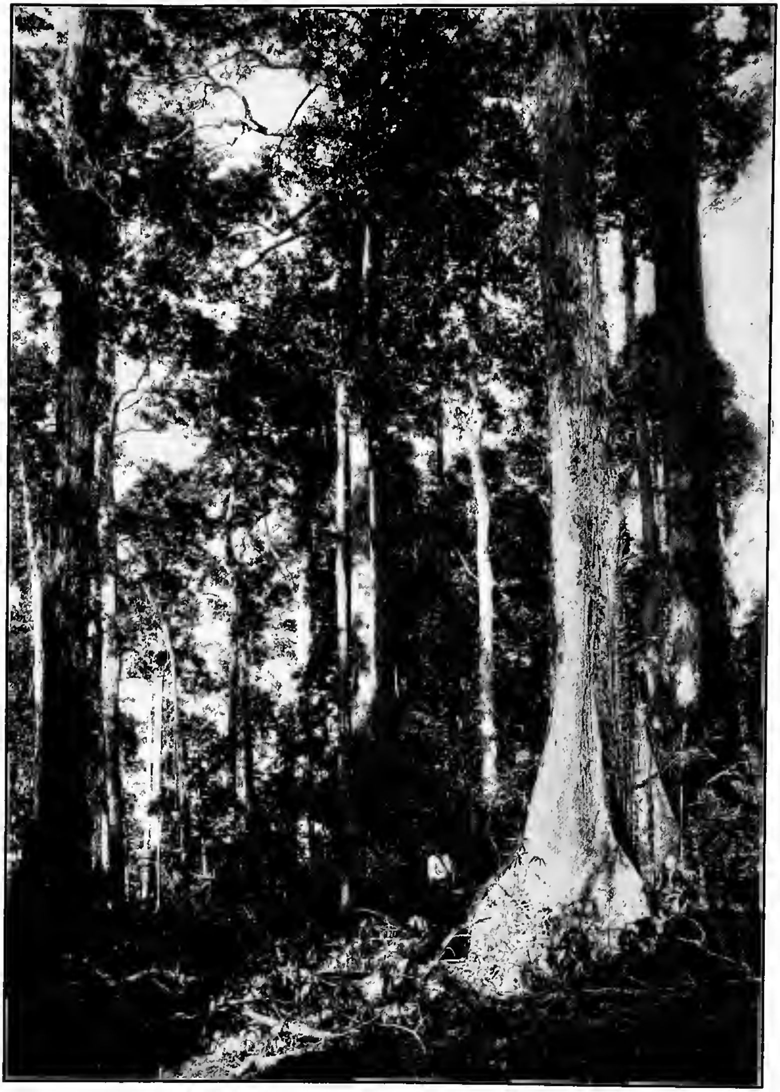


Fig. 163. A tree of the broad-leaved type.

market. A large amount of this class of wood (Oregon pine and California redwood) is imported into these Islands from the United States and, occasionally, from Australia and the China coast.

The remaining group (*Angiosperms*), furnishes practically all the Philippine timber that is found in the local market; it is with this group that this part of the text will deal.

PITH, WOOD, AND BARK.

In examining the end of a log, three distinct areas are seen—namely, the pith, a small central portion made up of soft tissue; an outside, more or less corky covering, called the bark; and the wood, which is the hard tissue making up the greater portion of the log and extending from pith to bark. The pith is usually very small, seldom greater than 1 centimeter in diameter, and in the majority of woods less than 5 millimeters. This fact is important, as the pith is an element of weakness in the wood.

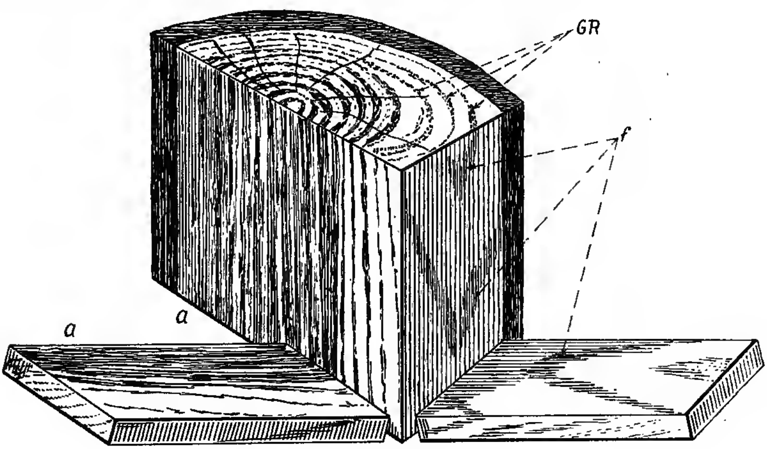


Fig. 164.

SAPWOOD AND HEARTWOOD.

The outer portion of a log is often of lighter color and weight and much softer than the center. The distinct, central portion of the log is called the *heartwood.* In many trees there is no difference in color between sapwood and heartwood. The proportion of sapwood and heartwood varies with each tree and depends upon the age of the tree and the part of the log from which it was taken.

Pith rays (medullary rays).—Pith rays are horizontal bundles of fibers which radiate from the pith to the bark of the tree. They are an important factor in the structure of wood, as they figure both in strength and beauty.

In some woods these rays are very large and distinct, as for example catmon (Philippines) and oak (North America); in others they are so small that they can be seen only with a magnifying glass, as in acle and betis. In the cross section of a log these rays appear as simple lines running from the center to the circumference. In a lengthwise section they often appear as glistening plates which add greatly to the beauty of the grain. The woods in which they are prominent are often cut "quartering" so as to show them to the best advantage. This method of cutting greatly increases the amount of waste and therefore "quarter-sawed lumber" is much more valuable than plain lumber.

Growth rings (fig. 164 *GR*).—The growth rings are layers of wood which form in concentric circles around the pith. Where only one of them is formed in a year they are called "annual rings;" but this name is not suitable for use with our woods, as it is not known whether one or several rings form every year.

These rings are formed during certain seasons of the year, the tree "resting" the remainder of the time. Many things may affect these periods of growth; an unusually dry season, a storm which injures the tree, insects which destroy the leaves, or any unnatural conditions. Therefore, it is quite possible for a tree to produce several growth rings in one year.

The term growth ring will be used in this connection instead of annual ring which is commonly used in American textbooks. Distinct growth rings are found in narra, banaba, calantas, ipil, molave, supa, and several other woods, but there are many Philippine woods in which they are not found.

False growth rings are found in woods of the lauan family. They are caused by concentric lines of resin canals, and can be distinguished from true growth rings because the false rings are irregular and do not extend clear around the trunk.

Pores.—Fine, tubular passages are found in all woods except the pines. They appear as sievelike openings on the cross section.

Concentric lines of soft tissue are found in some woods. They are fine or coarse, wavy, broken, or straight. They are chiefly valuable in studying the different species of woods.

GROWTH OF TIMBER.

The structure of wood is entirely cellular (fig. 165 shows a group of cells greatly magnified), the cells varying in form and size, and each having its value to the tree—some carry water from the roots to the leaves and some carry food downward from the leaves to the roots. Again, some store digested food and some give strength to the tree's structure and hold it together. Over 90 per cent of the volume of wood is made up of these cells. Most of them are long and slender, extending in lines parallel with the trunk and branches, of which they form a part. Their tapering ends overlap and increase the strength and toughness of the stem. These cells are separated most easily in the direction of their length, as is illustrated by the way that most wood splits "with the grain." On the surface of a board they are seen in the fine parallel lines which are commonly called the *grain.*

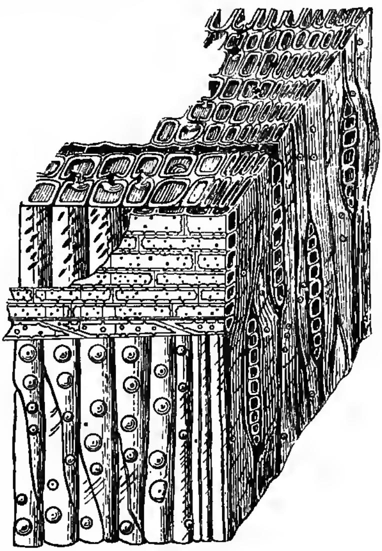


Fig. 165.

As indicated by its name, the movement of sap takes place in the sapwood. Water containing small quantities of minerals is taken up by the roots, and, passing upward through the cells or sap pores, ascends through the outer layers of the roots, trunk, and branches to the leaves. Here a large part of the water is evaporated by the sun and the remainder passes downward through the inner layer of the bark (called bast) to the roots, distributing food along the way wherever it is needed to form new cells, buds, and roots. Movement of sap takes place in both directions at once. As the tree grows older, the cells next to the heartwood gradually dry out and are partially filled with other substances, changing the color of the wood and increasing its density. This explains why the heartwood is usually harder and of a darker color than the sapwood. In such woods as ebony and camagon the cells of the heartwood are almost entirely filled.

The growth of a tree is entirely from the outside. The regular addition of growth rings to the outside of the tree increases the diameter and compresses the heartwood. This can be seen by examining the grain of a knot. Where the base of a branch is buried in the tree, the grain is very close and hard. This prevents the passage of the sap and so keeps the branches always smaller than the trunk.

Grain is the figure displayed by the structure of wood. It is fine or coarse, straight or crooked, according to whether the elements of the wood are coarse or fine, crowded or loosely put together, straight, or twisted.

The best grain of wood is brought out by careful attention to cutting. The occurrence of a knot or branch, an irregularity of the trunk or root, or some local imperfection in the wood may produce modifications of the grain in the parts affected, causing what is called curly or bird's-eye grain or burl. Specimens of these peculiar grain formations are often very pretty and are greatly prized for certain kinds of furniture. One of the commonest is found in the buttress roots of the narra. Some of these roots are large enough to permit of cutting one-piece table tops 5 or 6 feet in diameter. Narra is the commonest of these, but a number of Philippine trees have this peculiarity. Among the trees having a curly grain may be mentioned tindalo, palomaria, tanguile, and calantas.

Markings of wood depend more upon the arrangement of the fibers than upon difference in color. Timber may have a very fine color with no figure to the grain at all. Camagon is a good example of this condition. The heartwood and sapwood are often of a different color. Usually the heartwood is much darker than the sapwood, and the line of demarcation between the two is very distinct. In some woods there is very little difference between the heartwood and sapwood and the change is gradual, as in the case of malugi. In others there is no heartwood, the color being the same throughout, as in dita and lanete. There are usually characteristic colors by which each kind of wood can be told. In some cases there are a variety of colors as in narra, where white, red, yellow, and brown are sometimes found in the same tree.

Some trees grow in a spiral direction. This gives the grain a twist which is very evident when the surface of a board is planed, the grain appearing in stripes which are alternately rough and smooth. This occurs in lauan, amuguis, guijo, and some others.

Color in the heartwood is caused by deposits in the cells after they have ceased to be of use in the sap circulation of the tree. In camagon a compound of tannic acid fills the cells of the heartwood.

Odor.—Some woods, when they are freshly cut, have an odor by which they can be told, as for example, narra, cupang, teak, and calantas, which retain their odor after they are dry. Others may be recognized by their taste, as for example, anubing, batino, betis, dita, and yacal, which have a bitter taste.

PREPARING TIMBER FOR THE MARKET.

Cutting regulations.—In order to preserve our forests, laws have been made to regulate the cutting of timber. These laws are enforced by men employed by the Bureau of Forestry. On land that is more valuable for farming than for forest growth, clear cutting is allowed—that is, the lumbermen are allowed to cut down all the timber. When the land is suitable only for forests, regulations have been made limiting the size of trees that can be cut. For the lower-group timbers a diameter of 40 centimeters (16 inches) is the minimum; for the higher-group timbers 60 centimeters (24 inches). This measurement is taken about 4 feet above the ground. The lumber companies are required to use all the timber that they cut and must not leave any of it lying in the forest. These rules insure a steady supply of timber and prevent the destruction of our forests. The lumber company does not own the land, but simply pays the Government for the timber that is cut and taken away. These payments are called "forest charges" and are based on the value of the timber cut.

Philippine woods are classified in four groups. This classification is based on several properties that the woods may have. Supply and demand are two of the most important considerations. After these come strength, durability, hardness, and beauty. Very few of the first-group woods have all of these properties. Baticulin, for example, is scarce and much in demand for wood carving. It is sold

First group.	Second group.	Third group.	Fourth group.
Acle. Baticulin. Betis. Camagon. Ebony. Ipil. Lanete. Mancono. Molave. Narra. Tindalo. Yacal.	Alupang. Aranga. Banaba. Bansalaguin. Banuyo. Batitinan. Bolongeta. Calamansanay. Calantas. Dungon. Guijo. Macaasin. Malacadios. Mangachapuy. Palomaria. Supa. Teak. Tucang-calao.	Agoho. Amuguis. Anubing. Apitong. Batino. Bitanhol. Catmon. Calumpit. Cupang. Dalinsi. Dita. Dungon-late. Malacmalac. Malapapaya. Malasantol. Mayapis. Panao. Sacat. Santol. Tamayuan. Tanguile.	All other timbers are placed in this group. Some of the commonest are: Red lauan. White lauan. Almon. Palosapis, Lumbayao.

for a high price; therefore the tax or forest charge is high and the wood is placed in the first group. Camagon is valuable because of its color; mancono for its durability; and lanete for its softness. In fact nearly all of the first-group woods are placed in this group because of some special property which makes them valuable. The present grouping is as shown in the table on the preceding page.

The forest charges on the different groups are as follows:

First Group ₱2.50 per cubic meter.
Second Group ₱1.50 per cubic meter.
Third Group ₱1 per cubic meter.
Fourth Group ₱0.50 per cubic meter.

For the purpose of enforcing the cutting regulations, men called "forest rangers" are employed by the Government and are stationed at the places where timber is being cut.

METHODS OF CUTTING TIMBER.

Logging.—In the actual felling of trees the common method is to use the axe and saw (see fig. 166). Small trees of comparatively soft wood are cut entirely with the axe. Large trees are partly cut with the axe and finished with the saw. It is first decided which way the tree is to fall in order to save the other trees around it; then an undercut is made with the axe on the side next to the fall. The saw is then applied to the opposite side; and when the tree is nearly sawed through, wedges are driven into the saw cut to make the tree fall in its proper place. After the tree is felled, its branches are trimmed off and the trunk is cut into logs for transportation to the sawmill.

In former times, before modern machinery had been imported into the Philippines, it was customary to square the timber in the forest, so as to save transportation on the waste part of the log.[1] The squared timbers were drawn to the town by carabao and sawed into boards by means of a whipsaw.

The problem of transportation is today the most important factor in the lumber business of the Philippines

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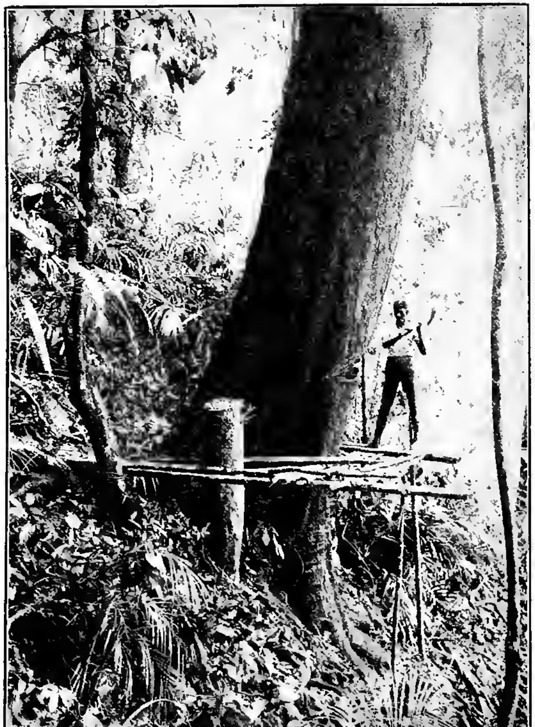
[1] This custom is still practised in many localities in the Philippines.



Making the undercut.

Sawing.

Fig. 166. The process of felling a tree.

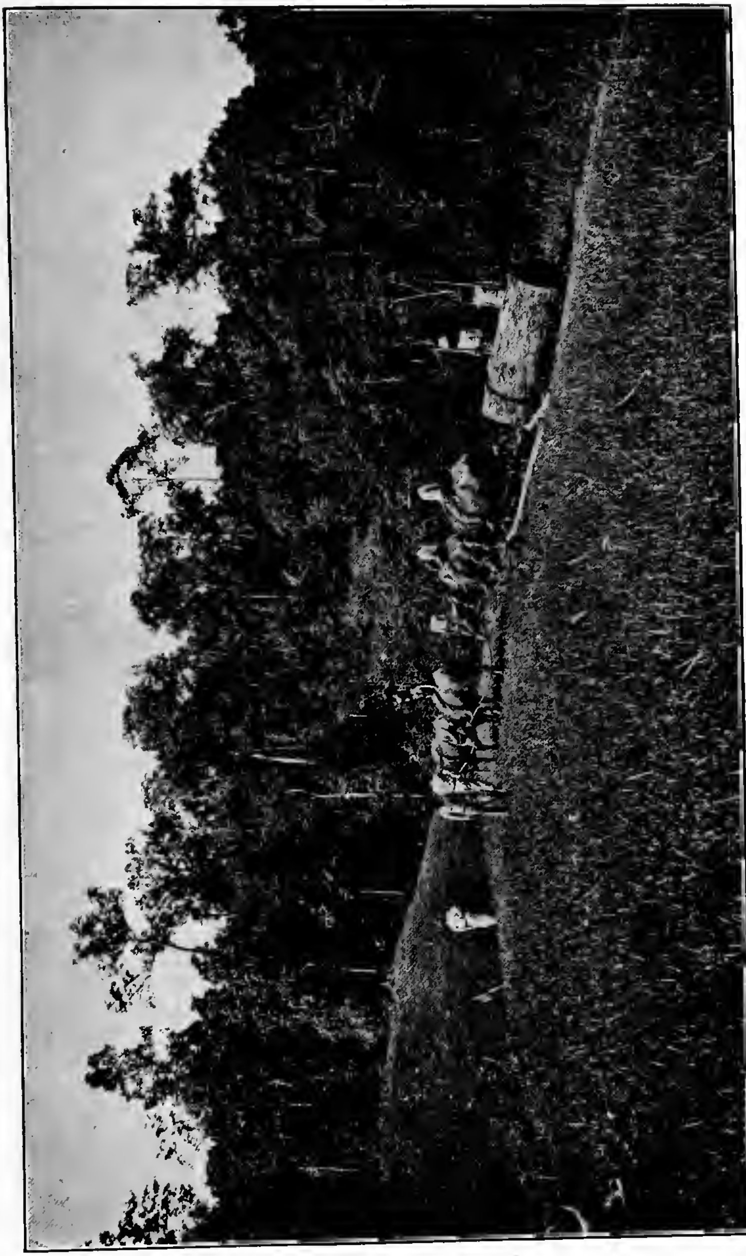


Fig. 167.

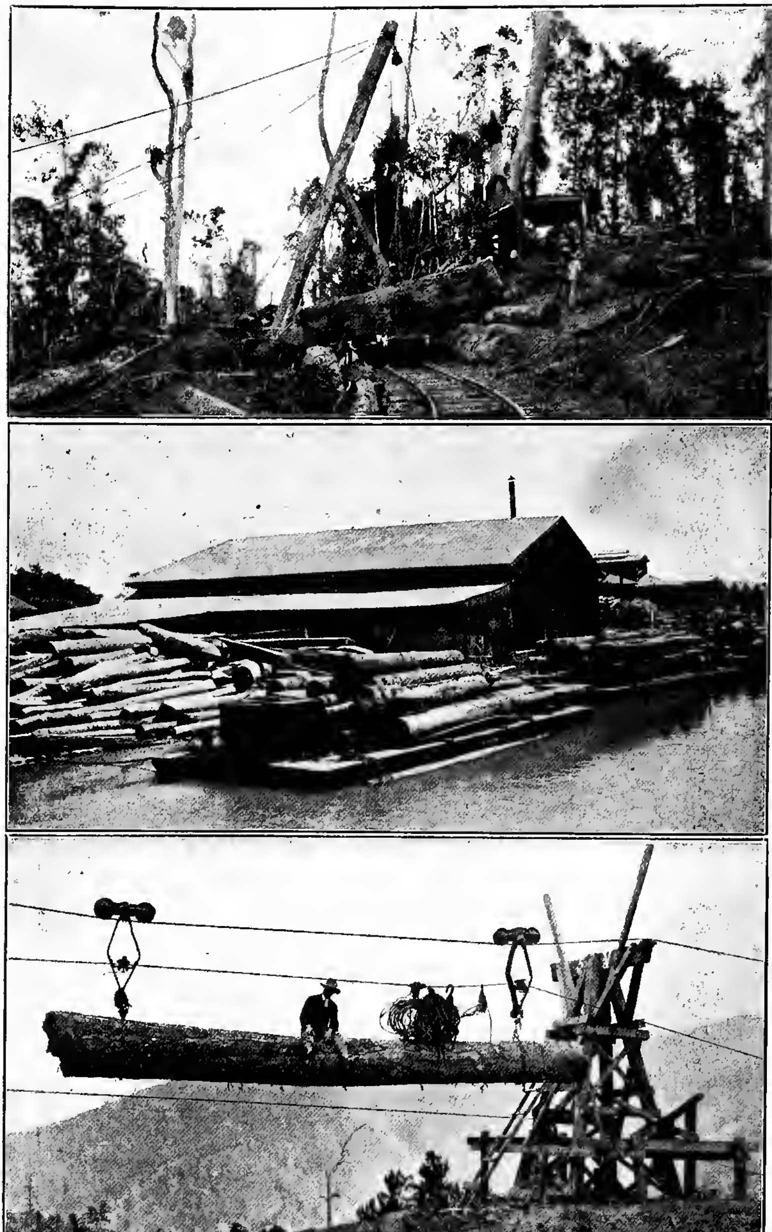


Fig. 168. Modern methods of transporting logs.

Fig. 169.

and has a strong bearing on the market prices of lumber. Until very recently (1912) the cheapest lumber that could be purchased in Manila was Oregon pine brought from the United States, a distance of 6,000 miles. The price of our native timber varies in different localities. For example, red narra, which sold in Dagupan for ₱150 per 1,000 board feet, sold in Manila for ₱300 per 1,000 board feet. One of the chief difficulties in the transportation of our hardwoods is that a majority of the best kinds will not float

Fig. 170. Scene in a sawmill.

when freshly cut. Therefore the lumberman cannot use what is commonly the cheapest means of transporting logs.

The log must be dragged, rafted, or carried on boats, wagons, or cars from the forest to the sawmill. One of the large lumber companies operating near Manila has built more than 40 kilometers of railroad. Their system is to cut all the timber on a certain section of land, haul all the logs together by means of a donkey engine and a wire cable, and then build the railroad up to the pile of logs. The general custom is to build the sawmill right in the forest;

Fig. 171.

this has lowered the price of lumber somewhat as only the sawed lumber, ready for market, has to be transported. However, there will always be an extra charge for transporting to market and it is not likely that the present values will ever be much lower.

Sawmill machinery.—In the largest mills the timber is sawed by band saws. The circular saw is used to some extent, but the band saw has proved to be the best for sawing our hardwoods on account of their interwoven grain and great

Fig. 172. Scene in a lumber yard.

density. A band saw cuts with less waste, and, being narrower, does not "bind" in the cut and so requires less power. The saw is fixed in its position and the log is "fed" against it by means of a carrier which is so arranged as to advance toward the saw while the cut is being made and to return after the cut is finished.

The process of sawing.—The first step is squaring the log. A slab is cut from each side, which leaves the log squared. Next it is cut into planks or boards. From the saw, the slab passes on rollers to the "edger," where it is trimmed so as to give the greatest possible width with parallel edges. From the edger the lumber passes to the "trimmer," where the ends are trimmed off and the pieces cut to standard lengths. The pieces are then taken to the yards for storage, or to the cars and ships for transportation to the market.

Milling.—The next step in the preparation of timber is done in the finishing mill. On account of the important part that the planer has in this mill, the place is usually called a planing mill. Lumber is prepared for sale in many forms. For house framing it is delivered from the sawmill in its rough state; for interior work, cabinetwork, furniture making, etc., it is passed through various machines which give it the required finish. The planing mill is often run in connection with the sawmill, yet sometimes it is a separate plant. The planing mill is usually located near the market, where each separate order can be filled to the best advantage. It usually handles seasoned or partly seasoned lumber, as freshly cut, green lumber cannot be satisfactorily milled.

The machines of a finishing mill are numerous. There are planers, which dress the lumber to a smooth surface and a uniform thickness; matching machines, which cut the tongue and groove on the edges of boards which are to be used for flooring, siding, and ceiling; moulding machines, which finish edges to any desired shape; saws for ripping and crosscutting; and a number of special machines such as boring, mortising, tenoning, joining, sandpapering, etc.

USES OF PHILIPPINE TIMBERS.

Next to fine furniture and cabinetmaking woods, the Tropics are noted for their hard, durable timbers. Teak is the best known of this class of woods; it is not native to the Philippines, but has been grown successfully on plantations in Mindanao and the Sulu Islands. Because of their qualities and comparative abundance, three Philippine timbers can be classed with teak. These are molave, ipil, and yacal.

Molave is the most common of these three. It is a member of the teak family. The wood is a pale yellow in color and has a fine but usually twisted grain. It is found along the coastal hills throughout the Islands and generally has a short trunk, which makes it less valuable. The demand for molave is so great in the Islands that very little is exported. It is chiefly used for house posts, hardwood floors, window sills, railroad ties, bridge timbers, paving blocks, salt-water piling, carving, and many parts of ship building.

Ipil, while being a good furniture wood, is chiefly used for building, on account of its superior hardness and durability. It is bright yellow when freshly cut, rapidly turning dark after being cut, and has a fine grain, usually straight. Ipil is used for the same purposes as molave.

Yacal is the only one of the three timbers mentioned that exists in large enough quantities to have much importance as an export. It is of a yellowish brown color and has a coarse, straight grain. It is estimated that there is more yacal standing in the Islands than all the other hardwoods combined.

SOFT WOODS.

Our commonest and cheapest soft woods are the lauans. There are many species, the commonest of which are almon, bagtican, white lauan, red lauan, lumbayao, and tanguile. Their color varies from white to reddish brown, and in hardness they grade from soft to moderately hard. Their weight is heavy as compared with American softwoods, but light as compared with other Philippine woods. They are all coarse but fairly straight grained, and free from knots. They are easily worked and similar in many ways to pine, although they have a much superior grain. In growth they often reach a height of 150 feet and a diameter of from 5 to 6 feet, with a straight, regular trunk 100 feet up to the first limb.

Commercially they are sold under three names—white lauan, red lauan, and tanguile. The better grades of red lauan and tanguile have a grain quite like mahogany. Large quantities of this lumber are shipped to the United States every year and sold as "Philippine Mahogany."

MEDIUM HARDWOODS.

The apitong family furnishes the timbers of this group, of which the commonest are apitong and guijo. In color they are red, or a dirty brownish red, and are never used where beauty of grain is desired. They are suitable for construction where contact with the ground is not necessary. While used for carriage building and in all branches of wheelwrighting, they are not good furniture woods as they are subject to warping, and also because of their dull coloring.

Salt-water piling.—There is a large demand for woods that will resist the attacks of the shipworm (teredo) ; very few of our woods will do so. The best woods for this purpose are molave, dungon, aranga, betis, and liusin. Molave is the best; but it cannot be used very much as it grows in such short lengths. None of these woods are plentiful, especially in sizes suitable for piling.

Ship building.—Teak is the standard ship-building wood. In the Philippines the following are considered as well suited for this purpose: molave, dungon, yacal, mangachapuy, betis, ipil, narra, batitinan, palomaria, banaba, aranga, and liusin.

Bridge building.—The woods most commonly used for bridge building are ipil, yacal, guijo, macaasin, apitong, and dungon.

Railroad ties and mining timbers.—In this sort of construction the timbers are buried in the ground; therefore only the hardest and most durable can be used. Those in most common use are ipil, molave, yacal, tindalo, betis, acle, anubing, and dungon.

House construction.—Houses in the Philippines are usually built on posts which raise the living rooms well above ground. This custom has developed on account of the low swampy conditions in many localities. This type of construction is also adapted to resist earthquakes, which are common in the Islands. These posts, or "harigues" as they are called, to which the lighter timbers of the floor, roof, and sides are bolted, are usually made of hardwood. The commonest woods used for this purpose are ipil, molave, yacal, tindalo, betis, dungon, aranga, and anubing.

The medium hardwoods are used for the framing, while the floors, ceilings, walls, and other visible parts are made of lighter material. The stability of the house depends upon the harigues, while the covering can be as light and cheap as the builder desires. (It is not an uncommon sight to see the posts of a house standing firm and solid after a fire has destroyed everything else.)

Paving blocks.—Molave and ipil are in the greatest demand for this purpose, but their high cost and the scarcity of supply has forced the Government to substitute cheaper and softer woods, first treating them with creosote. These have been found to give fairly good results.

Furniture and cabinet making.—Under this heading there is included almost every kind of wood found in the Philippines. Of the hardwoods, narra is the favorite; of the softer woods, red lauan, tanguile, and lumbayao.

Carving and engraving.—Lanete is the favorite wood for carving. Others comonly used are molave, ebony, camagon, banuyo, acle, narra, acleng-parang, tindalo, and baticulin.

Canes.—Ebony, camagon, and bolongeta are most commonly used for this purpose, as the desired color is usually black. Many other woods are used for canes, depending upon individual choice.

Boxes and dry measures.—For this purpose softwoods are commonly used. Calantas is in great demand for cigar boxes. Narra is often used for the largest sizes of dry measures.

Tool handles.—The following are the woods most suitable for tool handles: Dungon, dungon-late, kulis, bansalaguin, banaba, alupag, liusin, camagon, tindalo, and narra.

Carriage building.—The commonest woods are: For shafts—guijo, lanutan; for hubs—palomaria, guijo, dungon, and ipil; for spokes and frames—guijo and palomaria.

Wooden shoes.—The following are used for wooden shoes and slippers: Tui, dita, anubing, bayabas, cupang, balacat, ligas, lumbang, pinkapinkahan, white nato, daluro (air roots of pagatpat and api-api).

Telegraph and telephone poles.—Ipil is considered the best, but the nearest available hardwood is often used. In

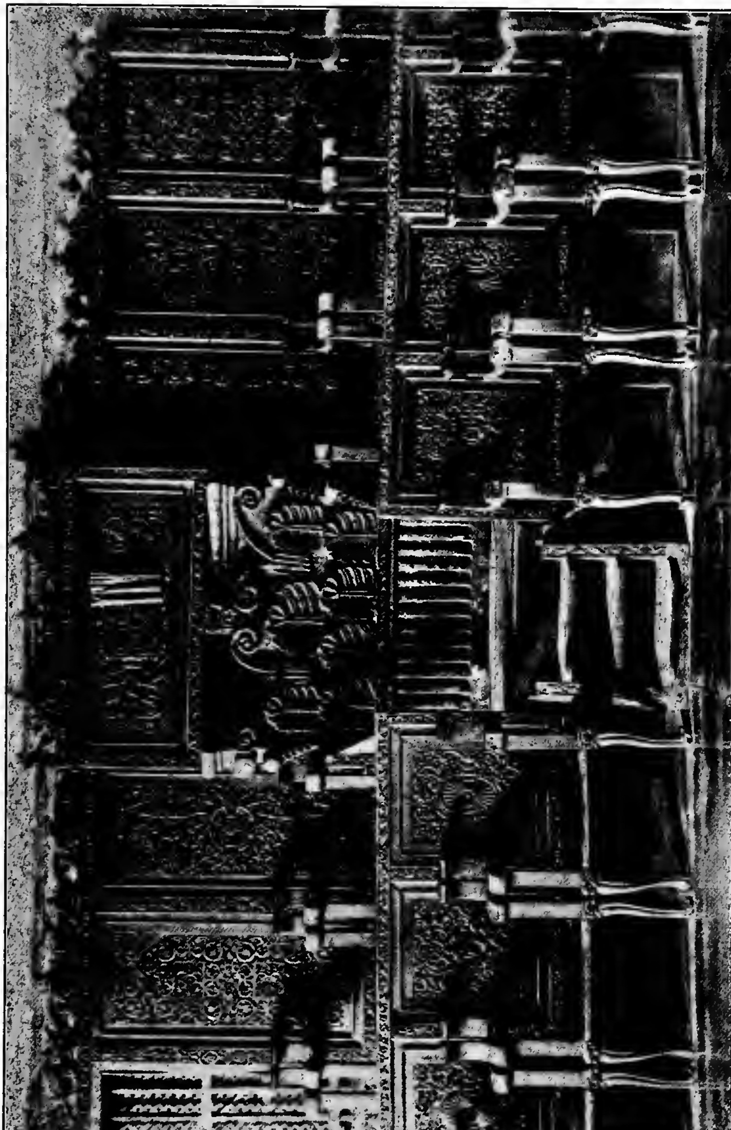


Fig. 173. Wood carving.

some parts of the Philippines green poles of kapok (the cotton tree) are planted in the ground. They take root and become trees and as such are extensively used for the purpose indicated.

Match making.—The woods most commonly used in match-making are malapapaya, taluto, gubas, and lumbang.

Musical instruments.—Woods commonly used in the manufacture of musical instruments are: Sides and backs of guitars and mandolins—narra, lanutan, nangka, banuyo, acle, and camagon; for sounding boards—imported and native pines; for pins—dungon and camagon. Calantas is employed for piano cases and ebony for keys.

GENERAL INFORMATION.[1]

FIRST GROUP TIMBERS.

Acle is widely distributed throughout the Islands and is found in almost every province of Luzon, and on Masbate, Mindoro, Negros, and Palawan. It is moderately heavy and hard, fine-grained, durable, and it seasons well. Sapwood, whitish; heartwood, dark brown, like English walnut. It has a decidedly peppery odor when planed or sawed.

Acle is one of the most satisfactory woods for furniture and cabinet making. It is also used for railroad ties, posts, bridges, interior finish, naval construction, and musical instruments.

Baticulin.—This family contains a large number of species. The best known is called yellow baticulin. It is widely distributed but not common. Color, greenish yellow to deep yellow; grain, straight and fine. It is chiefly used for sculpture and wood carving.

Betis is found principally on the island of Luzon in scattered trees. The wood is dark red in color, very hard, very heavy, and has a bitter taste. Grain, straight and clear.

Betis is used chiefly for piling, shipbuilding, and house posts where it is in constant contact with water or earth.

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[1] Only the commonest Philippine timbers are mentioned here. For full information concerning all species, see Bulletin No. 10, part 2, and Bulletin No. 11, Bureau of Forestry.

It is very durable and is used for all purposes where such wood is needed.

Camagon is cultivated in almost every province in the Islands. The fruit of the camagon tree is called "mabolo." Heartwood, black with brownish red streaks; sapwood, pink to pale red; very hard, very heavy, and very fine-grained. It is used chiefly for musical instruments, fine furniture, canes, and wood carving.

Although the camagon tree grows to a diameter of from 60 to 80 centimeters, it seldom comes to market in large pieces. It is difficult to cut, takes a long time to season thoroughly, and checks a great deal while seasoning. The heartwood is often less than one-third of the diameter of the tree and the sapwood is light colored, so that the wood is usually used in small pieces.

Ebony is found on the dry hills along the sea coast in almost every province. It is not very plentiful and seldom grows to more than 40 centimeters in diameter. Sapwood, gray to white; heartwood, very small and jet black; very hard and very heavy; grain, fine and straight.

Uses.—For canes, handles, hilts, frames, fine furniture, inlaying, and carving. It is also used throughout the world for piano keys, but is not found in the Philippines in large enough quantity for export.

Ipil is found along all the sea coasts and in the Cagayan Valley. It grows to a maximum diameter of 180 centimeters and a maximum height of 45 meters. Sapwood, light colored; heartwood, yellow when first cut but darkening to a chocolate color when dry. The wood is hard, heavy, stiff, and not difficult to work. It is one of the best of our hardwoods on account of its durability. It is a good furniture wood, but is more commonly used for posts, flooring, paving blocks, telegraph poles, and construction that comes in contact with the ground.

Lanete is widely distributed over Luzon and in many other parts of the Islands. The wood is a pale, cream color, turning slightly yellow with age. It is moderately heavy and hard and there is no difference between the heartwood and sapwood.

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Uses.—It is one of the favorite carving woods of the Philippines; it is also used for musical instruments, wooden shoes, dishes, scabbards, and wood turning.

Mancono is very rare and is found only on a few of the southern islands; it is most abundant in Surigao. The heartwood is yellowish brown, turning darker when seasoned; grain, fine and twisted; very hard, very heavy, and very durable. Mancono is the hardest and heaviest wood in the Philippines and is a good substitute for lignum-vitæ, a South American wood used for bowling balls.

Uses.—Piling, posts, wooden tools, tool handles, pulleys, and bearings.

Molave is found throughout the Islands on the low coastal hills. It grows in the open, away from the shade of other trees, and sheds its leaves during the dry season. Its trunk is irregular and short. The sapwood is creamy white; heartwood, pale yellow, turning slightly darker when exposed to the light. Molave has a fine grain, usually crossed; short, brittle fibers, which make it easy to work; is hard, heavy, and very durable, resisting the attacks of the teredo and anay.

Uses.—It is a good substitute for teak in shipbuilding; it is also used for house construction, wagon making, bridge building, cabinetmaking, gear wheels, carabao yokes, docks, salt-water piling, paving blocks, turned work, and carving; and practically everywhere that a hard, fine wood is required. Molave grows in almost every province in the Islands, though not in large quantities.

Narra is found in nearly every province of the Philippines. It usually grows on the plains along the sea coast and on the banks of streams. Its trunk is irregular, reaching the maximum diameter of 200 centimeters and a maximum length of 15 meters. It has wide buttresses at its base. The 1-piece table tops are cut from these buttress roots. The tree sheds its leaves during the dry season. The sapwood is nearly white; heartwood, red, yellow, brown, or pale straw color; medium heavy and hard with coarse and sometimes twisted grain. The heartwood is very durable and is seldom attacked by insects.

Narra is undoubtedly the finest wood on the local market that can be obtained in large quantities for making high-grade furniture or cabinetwork. It has a beautiful grain, seasons without checking, can be obtained in good width, and takes a fine polish. It is used for every purpose where beauty and fine finish are desired. Its fine qualities also make it a good wood for construction work.

The price of narra varies according to the color, the deep red bringing the highest price. The price per 1,000 board feet in Manila ranges from ₱200 to ₱350. Since the American occupation it has been in such demand for furniture and export to the United States that it has been used for little else. It is one of the best furniture woods known.

Tindalo is widely distributed through the Islands, but is not plentiful. It is found on the low hills along the sea coast. It grows to a fair size but is not buttressed like the narra. The sapwood is white to creamy brown; heartwood, yellowish red, turning very dark red with age; heavy, hard, and durable and seasons without warping. The grain is usually straight, fine, and easy to work.

Uses.—Furniture, cabinetmaking, interior finish, shipbuilding and for general construction purposes. Like the narra it has a very attractive grain, takes a fine polish, and is in great demand for furniture work.

Yacal.—There are many species of trees belonging to the yacal family, several of which are sold in the market under the same name. Yacal is the most plentiful of the heavy, hard, and durable timbers. It is found in many of the provinces of Luzon and on the islands of Mindoro and Mindanao. It grows on the low hills along the sea coast and especially on headlands extending into the sea.

The yacal tree attains a large size and its trunk is regular and free from knots. It is usually found in dry, sandy soil with large buttress roots. Color, yellowish brown, turning darker with age; grain, crossed and coarse. It is hard, heavy, and very durable.

Uses.—Yacal is valuable in all classes of construction work where contact with the ground is necessary, such as paving blocks, railroad ties, and house posts, but is easily destroyed by the teredo. It is also used in shipbuilding carriage making, and bridge construction.

SECOND GROUP TIMBERS.

Banuyo is found in the Provinces of Cagayan, Isabela, Benguet, Tayabas, Camarines, Camiguin Island, Masbate, Burias Island, Ticao Island, Samar, and Negros. It grows in dry places on the low hills along the coast. The trunk is short, irregular, and of medium size. The color is golden brown, somewhat like acle, but coarser grained, lighter in color, and softer; moderately heavy and hard; durable and easily worked.

Uses.—Furniture, cabinetwork, carving, carriage bodies, picture frames, and interior finish.

Bolongeta grows on the lowlands of Luzon and in practically the same localities as banuyo. It is very much like camagon in many respects. It does not often grow as large as camagon, but when it does, is exactly like camagon, though having a smaller heartwood. Its sapwood is light red in color, and the heartwood is the same color in small trees. In large trees the heartwood is black, with reddish streaks. Bolongeta is very hard, very heavy, and very fine-grained. It is used for the same purposes as camagon.

Calantas is widely distributed throughout the Islands, but is not plentiful. It grows under the same conditions as molave—on river banks and wet lowlands. The trunk is medium size, sometimes reaching a diameter of 150 centimeters. The sapwood is very light red; heartwood, dark red; grain, very coarse and straight; soft in texture and light in weight; durable and resists the attacks of anay.

Uses.—Calantas is very much like Spanish cedar and is used for the same purposes, such as fine furniture, cabinetmaking, and cigar boxes. In furniture it is commonly found in panels, shelves, and other protected places, as it is very easily marred. Calantas is sometimes used for pattern making, interior finishing, musical instruments, and bancas. At present it is in great demand for cigar boxes, and most of the wood on the market is used for that purpose.

Guijo is found throughout the Islands and grows on fairly dry ground about 500 meters above sea level. The tree reaches a maximum diameter of 180 centimeters; the trunk is straight and attains about two-thirds of the height of the whole tree. The sapwood is very light in color; heartwood, ashy red to brownish red; moderately heavy and hard; grain fine and straight. This wood is one of the most useful timbers in the Islands and is quite plentiful; it is fairly durable when painted or kept dry.

Uses.—House construction, shipbuilding, wheelwrighting, furniture, telegraph poles, vats, and barrels. Guijo is not a very desirable furniture wood as its grain is very plain, lacking both color and patern.

Palomaria is found on all coasts of the Philippines, except where the ground is swampy. In appearance it is a medium-sized, scraggly tree, with a very short trunk and wide-spreading branches. The color is reddish brown; grain, fine and very crooked; easy to saw but very difficult to plane; hard and moderately heavy.

Uses.—Furniture, turning, house construction, bridge building, shipbuilding, and carriage making. Palomaria checks badly while seasoning, and wide pieces free from checks can seldom be found in widths suitable for use. A valuable oil is extracted from the seeds of this tree.

Teak is not a native tree of the Philippines, but is now grown on plantations in the Zamboanga districts, Basilan, and Sulu, where it thrives well. The sapwood is light colored; heartwood, a golden yellow, turning very dark with age; grain, coarse and straight; moderately heavy and hard and very durable, resisting the attacks of anay and teredo.

Uses.—Shipbuilding, high-class construction of all kinds, furniture, and carving.

THIRD GROUP TIMBERS.

Amuguis is widely distributed, grows to a medium-sized tree, and is usually found on wet ground. The sapwood is pale red; heartwood, red; moderately heavy and hard; durable when kept dry; grain fine but crooked.

Uses.—Amuguis is one of the best woods for house construction, especially for flooring; also used for furniture, shipbuilding, interior finishing, and carriage building.

Apitong is found in most of the provinces of the Philippines. It is most plentiful in those regions where there is very little rain during the dry season and grows on the hills in open places. The sapwood is grayish brown; heartwood, pale red to dark reddish brown; grain straight and coarse; moderately heavy and hard.

Apitong is used for the upper parts of house frames and is the most abundant construction timber in the Islands. It cannot, however, be called a durable timber. It is also used for cheap furniture, bridge timbers, wagon beds, and for making charcoal.

Tanguile is found in several provinces on Luzón, Polillo Marinduque, Mindoro, Cebu, and Negros. It grows to its greatest sizes on the lower slopes of the hills where the soil is deep and well drained. The sapwood is creamy in color; heartwood, light red to reddish brown; grain, medium fine and straight; moderately hard and heavy.

Tanguile is very similar to high-grade red lauan and the two are often mixed in the market. It is the best wood in the Philippines for cheap furniture, as it can be obtained in wide pieces, seasons well, and has a fairly good grain. When properly stained, it closely resembles mahogany. With red lauan, it is the principal wood exported from the Philippines and is sold in other countries as a substitute for mahogany.

FOURTH GROUP TIMBERS.

The best known woods of this group are the *lauans*. Red lauan has been described under the heading of tanguile. While it differs from tanguile in color and weight, in other respects it is about the same.

White lauan is grayish white in color.

Almon is pale red, fading to a dull yellow.

Bagtican is a dull, reddish brown.

Dao, palosapis, lumbayao, malugi, pagatpat also belong to the fourth group and are fairly well known. Lumbayao is sold in Manila in large quantities and is used for the same purposes as red lauan.

BAMBOOS.

No work on the woods of the Philippines would be complete without some mention of the bamboos, which have such an important place in all of our cheap furniture and house construction. They belong to the group called *Endogens*, and while they do not classify strictly as woods, often take the place of wood. They are especially valuable for light framing and for temporary construction, such as scaffolding and temporary building.

The palms, which also belong to this group, are widely used for posts, canes, spear handles, bows, pinkas, and other articles. The hardest and heaviest of these is *palma brava*. Pandans have an outer shell similar to the *palma brava* and are used for the same purposes.

The rattans (bejuco) also belong to this group.

It is not possible to give a complete description of all the woods in the different groups. In the foregoing pages an attempt has been made to select a list of the common woods known to commerce, then in turn to extract from the mass of information furnished by the Bureau of Forestry and the Bureau of Science such facts as will be most useful to a trade school student.

SEASONING.

Water in timber.—As has already been explained, wood is composed of cells of varying shapes and with different uses. These cells contain a large amount of water. The sap of a tree consists mostly of water, which is taken up from the ground by the roots, and from the air by the leaves. Water is found in every part of the tree. The roots contain the most; the upper branches and the sapwood, less; and the heartwood, the least. In some cases the water in growing timber comprises more than one half the weight of the wood. The amount of water in a tree depends upon the conditions of growth. A tree that grows in rocky or shallow soil does not grow as large or contain as much water as the same kind of a tree under more favorable conditions. A young tree contains more water than an old one, and the amount of water in all woods changes with the different seasons of

Fig. 174. A olump of bamboo.

the year. All of our woods contain more water during the rainy season than during the dry season.

The process of seasoning consists in drying, or evaporating, this water out of the wood. Seasoning is done either by natural or by artificial means.

The length of time required to season timber depends upon the kind of timber, the size of the piece, and the part of the trunk from which it is taken. The process also depends upon the means used for drying. For example, lauan dries faster than narra; thin boards faster than thick ones; and sapwood dries faster than heartwood. It is not possible to give an accurate estimate of the time required for seasoning. The user should test each new lot of lumber that he buys and determine in what condition of the seasoning process it is when delivered. He should then keep a record of the time the lumber is piled for drying, and estimate the probable time when it will be fit for use, testing it frequently to see how long it takes to season.

After careful observations, taken during a period of six years, the following estimate for seasoning has been made:

Dimensions of piece, 2 by 12 inches.
Lauan and similar woods, about one year.
Narra and similar woods, about two years.
Molave and similar woods, about three years.
Camagon and similar woods, about five years.

Conditions under which the preceding test was made.—The lumber was freshly cut when delivered. It was piled on sills which raised it well off the ground, in a shed open on all sides but well roofed so that no rain could fall on the lumber. Sticks were placed between each two layers of boards to allow a good circulation of air.

Air seasoning is the name given to the method just described. It is the only means available in most of our trade schools and so should be carefully studied with a view to obtaining the quickest results.

The following rules should be observed for piling lumber to be seasoned:

1. Start the lumber pile with level sills which raise it at least 6 inches off the ground, or above high water. These

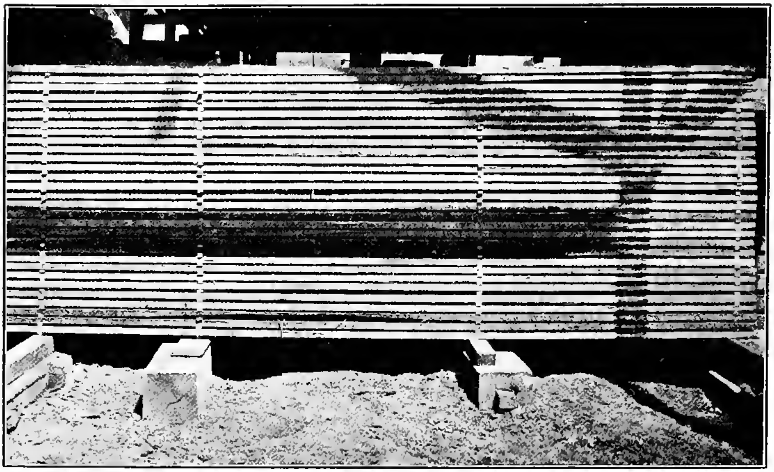

Fig. 175. Lumber properly piled for seasoning.

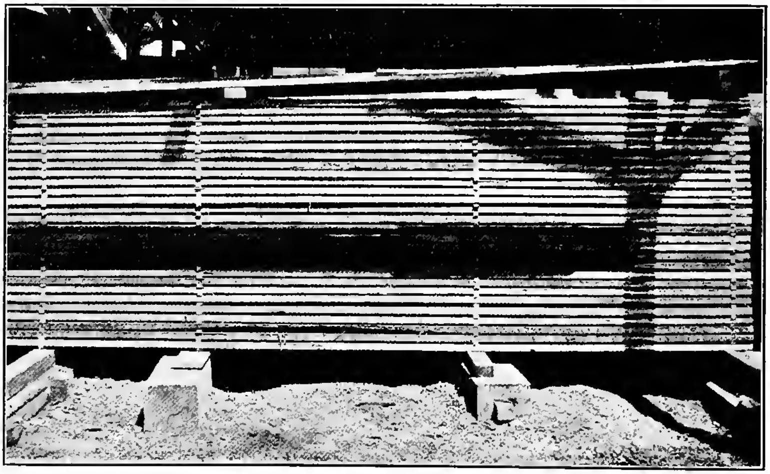

Fig. 176. Note temporary roof (See fig. 175).

sills should be about 1 meter apart and should be well set so that they will not sink out of line when the weight of the heavy lumber rests on them. They should be close enough together so that the timber does not sag between them from its own weight.

2. Sticks should be placed between each layer of boards in exact line, vertically, above the sills. These sticks should be thick enough so that the boards cannot touch each other, and long enough to reach the full width of the pile and project a little on each side. Figure 175 shows a pile of lumber properly stacked for seasoning.

An even better arrangement can be made by laying the whole pile so that the boards slope in the direction of their length. This gives a better circulation of air than if the layers of boards are exactly level. For lumber piled in this manner, the sills should be of different heights.

3. If it is not possible to pile the lumber inside of a building, a roof must be built over it to keep out the sun and rain. A roof of corrugated iron is the best; but if the iron cannot be obtained, a roof can be made of the last layer of boards, as shown in figure 176. The pieces used as a roof will be injured, but this is better than spoiling the whole pile.

Kiln-drying, or drying by artificial heat, is much the quickest way of seasoning lumber. Kilns are built in connection with most sawmills, planing mills, and furniture factories. In such establishments air-seasoned lumber is usually piled in the kiln for a few days before using.

Dry kilns are built in many forms, but they all possess the same general principles. They are built of cement, brick, iron, or wood, and are heated by coils of steam pipes or by hot air blown through the kilns by fans.

Another process consists of sealing the lumber tightly inside of an iron box or tube. Live steam is turned in, under high pressure, penetrating the pores of the wood and dissolving the sap. The steam is then shut off and the seasoning process is finished in the usual manner. This is much more rapid than a regular dry kiln.

The most important principle of all dry kilns is ventila-

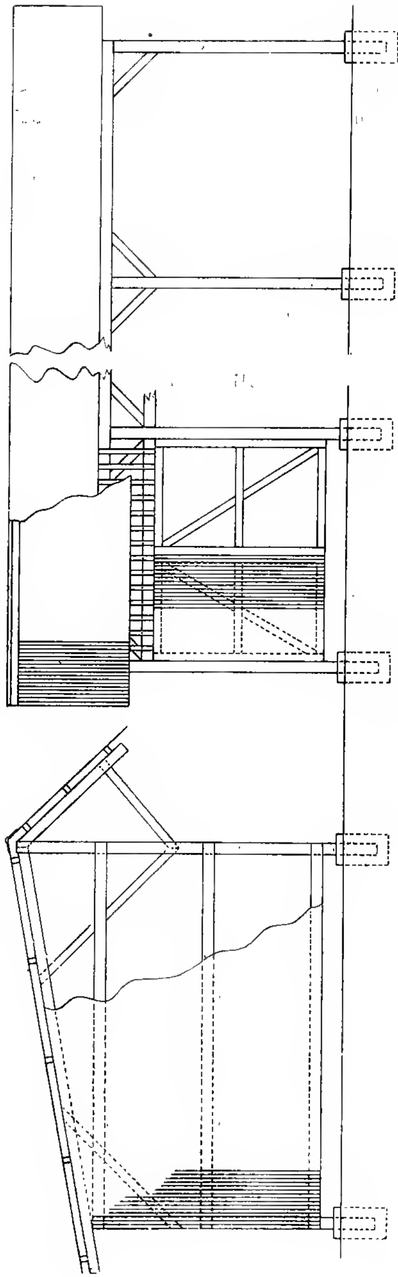

Fig. 177. A simple type of lumber shed.

tion. The difference between kiln-drying and air seasoning is that in the former process the air surrounding the lumber is artificially heated. The air must be kept moving. In a simple, steam-heated dry kiln this is accomplished by making two openings in the walls of the kiln—one level with the floor and the other in the roof or just under it. The fresh air enters through the lower opening and the hot, moisture-laden air passes out through the upper opening. The lumber is piled in the kiln in the same manner as for air seasoning, the doors are closed tightly, and the heat is turned on.

It is not possible to give an accurate estimate of the time required for kiln-drying lumber. Each man must keep a record of his own kiln to decide this point.

The matter of expense often makes it

impossible to build a dry kiln. In such cases, the next best thing can be one, which is to make as good a lumber shed as possible for air seasoning.

Lumber sheds are built in many forms. The one represented in figure 177 has proven very satisfactory. The essential points to be observed in building a lumber shed are as follows:

1. The shed should stand on dry ground if possible—that is, on ground that is not flooded during the rainy season.

2. The roof should be built with wide, overhanging eaves, so that no ordinary rain will drive in under it.

3. If walls are used, they should end at least 12 inches above ground, so that there will be an opening at the bottom all around. They should, also, stop a few inches short of the roof at the top, so that the hot air may escape.

4. If a floor is built in the lumber shed, it should consist of slats with wide cracks between them.

Corrugated iron makes the best covering for walls and roof. If this cannot be obtained, it is better to leave the walls off, or to build them of narrow strips of wood with wide cracks between them.

Water seasoning is accomplished by sinking the timber for a long time under water. By this means the sap is dissolved and replaced by water, which dries out very quickly when the lumber is piled for seasoning. Camagon and ebony are often treated in this way, the practice being to put them under water for six months or a year. If they are piled in a hot room or in a dry kiln, they will "case harden"—that is, they will dry for a short distance in from the surface, and when the center does become dry, it will check. This explains the presence of large cracks in camagon and ebony, which are invisible until the log is sawed up. Timbers for the spars of ships are also water seasoned.

GENERAL INFORMATION FOR SEASONING LUMBER.

Notes on the length of time required for seasoning timber given in American textbooks, concerning American woods, will not apply to Philippine timbers.

Lumber will not season unless it is piled properly. Green boards piled close together without proper ventilation will stay wet until they rot.

Ventilation is the first and most important requirement. In order to dry lumber naturally or artificially, there must be a free circulation of air. A dry kiln without ventilation would simply "bake" the lumber and it would remain wet permanently.

Lumber will not season properly if piled under a tree. The shade of the tree keeps the moisture in and the sunlight out.

Lumber that has been dried in a kiln should be piled outside of the kiln for a few days before used, for the wood will take back a very small amount of moisture from the air and allowance should be made for this.

Lumber must be well seasoned before it is used in furniture or cabinetwork. The seasoning process will continue until the lumber is dry, whether it is in the lumber shed or made up into a piece of furniture. If unseasoned lumber is used, joints will open up, cracks will appear, and the finish will be absorbed into the pores of the wood. A shopman who puts green lumber into his work is sure to regret it. It is therefore better to wait for dry lumber, even though an order is lost by doing so.

When lumber is delivered from the mill, it should be piled for seasoning at once. Serious damage will be caused if it is allowed to lie around in the sun and rain. A little water on the lumber does no great amount of harm; but if it is rained on and then dried by the hot sun three or four times, the lumber may be entirely spoiled.

In order to get some definite information on the length of time required to season timber, and the change in weight and dimensions of a piece of timber while seasoning, the following notes were taken at the Philippine School of Arts and Trades, Manila:

During the month of August, 1913, a shipment of narra was delivered at the school. This lumber was cut from logs selected at a sawmill in Manila. At the time of selection they were lying partly submerged in an estero, so it is reasonable to suppose that the logs were as wet as possible.

A piece $1\frac{1}{8}$ inches thick, $17\frac{15}{16}$ wide, and 36 inches long was planed on two sides and placed in the dry kiln on August 29, 1913. At the time it was placed in the kiln the piece weighed exactly 13.6 kilos.

It was weighed and measured on the dates given below:

	Weight.	Width.
	Kilos.	*Inches.*
Aug. 29, 1913	13.6	$17\frac{15}{16}$
Sept. 5, 1913	10.2	$17\frac{11}{16}$
Sept. 13, 1913	9.6	$17\frac{9}{16}$
Sept. 19, 1913	9.2	$17\frac{1}{4}$
July 30, 1914[a]	9.2	$17\frac{1}{4}$
Aug. 24, 1914	9.5	$17\frac{3}{8}$

[a] Taken from kiln.

The piece was found to have held the same weight and dimensions from September, 1913, to August, 1914. On July 30, 1914, it was taken from the kiln and stored in a shed where it was protected from the rain.

It will be seen by studying the notes that the piece first lost 4.4 kilos in weight and $\frac{11}{16}$ inch in width. After being taken from the kiln, in twenty-four days it took back 0.3 kilos in weight and $\frac{1}{8}$ inch in width. From the time that the piece was placed in the kiln until it was thoroughly dry was exactly twenty days.

Another piece, 4 by 6 by 36 inches, from the same lot of lumber, was not thoroughly dry after being in the kiln for eleven months. It will, therefore, be seen that the thickness of a piece of timber has considerable affect on the length of time required to season it.

DEFINITIONS.

Shrinking, or shrinkage, is the natural decrease in size of a piece of timber caused by drying out the moisture. Shrinkage reduces the thickness and width, but not the length. Wood cannot be seasoned so well that it will not shrink when the surrounding dryness is increased. Wood will often shrink after planing, as new pores are opened which allow the interior moisture to escape.

Swelling is the natural increase in size of timber caused by taking in moisture. Timber is less likely to swell than to shrink, but there is always a slight change when the surrounding moisture is increased. Painting or finishing a surface with varnish or shellac will prevent swelling to some extent, but not entirely. Softwood usually shrinks and swells more readily than hardwood.

Warping in wood is a change of shape caused by shrinking or swelling. In figure 164, which shows the end of a log, it will be seen that besides the lines *G–R* which represent the growth rings, there are other lines extending from the center in all directions. These lines have already been defined as the pith rays. They are not shortened very

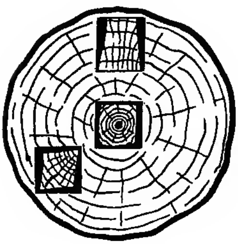

Fig. 178.

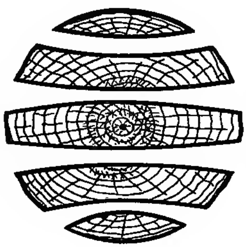

Fig. 179.

Fig. 180.

much by shrinkage. In seasoning they are liable to separate, as the shrinkage occurs in the lines of the growth rings see fig. 180. If the seasoning is carefully done no cracks will appear, but the wood will be a little weaker along these lines. For example, if a log is cut into boards, the one taken from the center will become slightly thinner at its edges as it dries out (fig. 179). The other four pieces will warp as shown, the surface which was nearest the center being the convex side.

The shrinkage of a square piece will vary according to the part of the log from which it is taken (fig. 178). Thus it will be seen that by examining the grain on the end of a board, the direction of shrinking and warping can be told in advance.

Timbers also warp in the direction of their length. This is caused by unequal drying, or by a crooked grain which exposes more sap pores in one part than another. Where the ends of the wood cells come to the surface, the sap dries out quicker. For example, suppose figure 181 to show the edge of a board having the grain as indicated. Moisture will escape more quickly from the surface marked *A* than from the surface marked *B*, causing the board to warp as shown by the dotted lines.

The commonest cause of warping is uneven exposure. If one side of a board is exposed to heat and light and the other is not, the exposed side will dry the quicker and will become concave, both in width and length. If a board is laid on the ground in the sun, the edges will turn up, as the top side will dry much faster than the side next to the

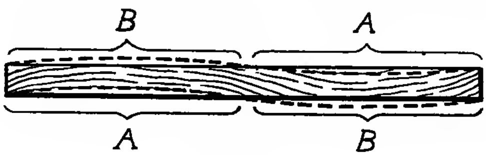

Fig. 181.

ground. If a seasoned board is laid on the ground, the same thing will happen, from another cause—the side next to the ground will absorb moisture and will swell. If a piece of lumber is planed on both sides and laid flat on a floor or bench, it will warp. The best way of storing planed, seasoned lumber in small amounts is to stand it on end against the wall until it is used.

Warping sometimes occurs in finished furniture. This results from one of the two causes described—shrinking or swelling. To illustrate: A table top made of seasoned lumber and polished on the outside warps so that the edges turn up. This is caused by the under side, which is unfinished, taking moisture out of the air and swelling. If the top warps downward, this proves that the lumber was not seasoned before it was used and that the unfinished surface is shrinking. If a board is finished on one side and left in the raw state on the other side, all the shrinking and swelling will occur on the unfinished side. When a large surface, such as a table top, is polished, the under side should be given a coat of varnish, shellac, paint, or some other cheap finish at the same time. This will prevent warping and will make the shrinking or swelling even, if any occurs.

Checking (fig. 180) is the opening up of cracks in timber caused by unequal or too rapid seasoning. As has been explained in the previous section, the lines of the pith rays are the weakest point in timber. If one part of a board dries faster than another part, the layers of cells are liable to separate on the pith rays, leaving cracks in the surface which are called checks. When a log checks on the inside but not on the outside, it is said to be "honey-combed." This often occurs in camagon and ebony and is caused by the too rapid drying of the outer rings. To be dried correctly, lumber should be heated all through, slowly enough so that the inside will season at the same time as the outside. If the heat is too strong, the outer shell of the timber dries out before the inside has become heated and this causes the outside to become dry while the inside is wet. This results in the two parts pulling away from each other and leaving cracks in the interior of the timber.

Rot or decay in wood is caused by a form of plant growth called fungus. It appears on wood that is not properly cared for and is commonly found in the forest upon fallen trees; it also occurs on timber used in construction work when it is exposed to the weather for a long time. For this reason many of our woods are not good for outside work. In time this fungus will absorb the wood cells and their contents, weakening and destroying the timber. Well-seasoned wood is not liable to rot if it is kept dry. Many of our timbers, such as molave, mancono, and camagon, are said to be durable. This means that they are very slow to decay.

Knots in timber are the bases of branches. Knots are sometimes entirely buried under the surface of the tree; in such cases they are called undeveloped buds. In other instances they are the bases of branches which grow out from the trunk. Figure 182 shows a dead knot caused by the breaking away of a branch. The branch was a living one for several years, as is shown by the growth rings, some of which are united with it. After the branch died the growth of the tree was around it and in the course of time it would have been entirely covered up. It will be noted, by examining the grain of a knot and the grain of the timber around it, that a knot is a growth separate and distinct from the rest of the timber. In the beginning the base of the knot is joined to the growth rings. After several years, they begin to spread out and pass around it. The tree must make room for the knot; and it does so by compressing the knot and the wood around it until they occupy the same space as if the knot was not there. This is easily seen in the grain of the knot and the wood that surrounds it. Both are much finer and harder than the wood of the straight trunk where there are no branches.

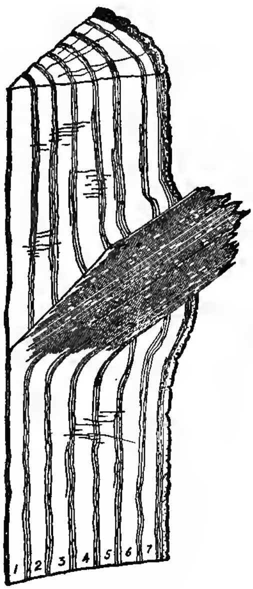

Fig. 182.

Some of the commonest markings in timber are caused by knots. The crooked grain around a knot is often very beautiful and adds to the value of a furniture wood. A large knot will often affect the grain for a wide space around it.

The best grain for cabinet and furniture making is found in trees that grow out in the open, away from the shade of other trees, because such trees have a better chance to develop all of their branches, are more exposed to the wind, which often changes their shapes, and therefore have the handsomest grain. Trees which grow in the forest must grow straight and tall to get their tops up to the sunlight; and, therefore, they have very few branches on their trunks. They are the best for framing timber, where a straight, clear grain is necessary.

Shaky timber is that which has been split or loosened in the direction of its grain while it is green. Shakes in timber are sometimes caused by a storm which bends the tree so badly that the wood fibers separate in the direction of their length. Shakes are sometimes caused by careless felling. In either case, they injure the timber very badly.

Pinholes in timber are caused by small insects which bore through the wood, usually across the grain. They are commonest in woods of the lauan family. The commonest form is called "buc-buc."

Timber preservation is the process of filling the exposed pores of wood with some fluid that destroys the fungus growth and prevents rotting. It is also used as a protection against the attacks of white ants and other insects. The commonest methods are painting and varnishing. Such woods as molave, ipil, and yacal are very durable and do not need this protection. The demand for these timbers is greater than the supply, however, and substitutes are often used. The city of Manila has a system of creosoting soft wood for use as paving blocks which has proven quite satisfactory. The wooden blocks are steamed under high pressure and creosote, a compound of tar, is forced into the block immediately after, completely filling the pores. Creosote, besides keeping out water, gives the wood a very disagreeable odor and taste which protects it from insects. A simpler means of timber preservation is sometimes used in building. Small holes are bored to the center of a post just above the ground. These are filled with petroleum, creosote, carbolaneum, or some similar liquid. This gradually soaks through the wood and serves to protect it from insects.

Part IV.—WOOD FINISHING.[1]

The following notes on wood finishing are based on "The Modern Wood Finisher," by F. Lemaire, on information furnished by Mr. Bartolome Pascual, of the Philippine School of Arts and Trades, and on the personal experience of the writer. From the many ways used by different wood finishers to apply varnish, shellac, or wax finish, one of each has been selected and explained. As far as possible, the exact words of the authority from which they were taken have been used.

There are a few rules for finishing hardwoods that should be well understood before the details of any particular method are taken up. They are as follows: All kinds of wood are made of fine, threadlike fibers bound together in large numbers. In some woods they are very fine and the wood is said to be "fine-grained." In others they are very coarse and the wood is said to be "coarse-grained." There are also a number of medium grades between the two. In some woods the fibers are straight and parallel, in others they are twisted and interwoven. The first is called "straight-grained" and the second "cross-grained." Cross-grained wood has the better appearance when finished, and is therefore the more often used in furniture making.

The spaces between the fibers are called cells or pores. These pores are different in size according to the structure of the wood; they are really the hollow passages through which the sap flows in the living tree. When the wood has been dried so that there is no sap in these pores, they will absorb any liquid that is applied to the surface. It is very plain that the sap must be dried out before any finishing can be done successfully. It is also evident that these pores must be filled up before the surface can be polished. If any stain is to be used, it must be applied before the filling

[1] First published in No. 8, Vol. I, The Philippine Craftsman.

is put on. This is explained further under the subject of staining. If varnish or shellac is applied before the pores have been filled, part of it will sink into the pores and the whole surface will appear rough. More varnish or shellac will not improve the surface or make it even. One of the first principles of wood finishing is: "The less varnish or finishing material used, the better." Numerous coats cover up the grain and give it a muddy appearance; it should therefore be the aim of every wood finisher to get the best polish with the least amount of material. When the varnish, shellac, or wax is applied, it should be upon a perfectly smooth, glasslike surface that will not absorb any of it. Filling is a very important part of the finishing process. If the workman understands the nature of wood, he can easily see the reasons for the foregoing rules.

Sandpapering and preparation for filling.—This work properly belongs to the shop, not to the finishing room. Woodwork is supposed to come to the finisher sandpapered and ready; but in most of our trade schools and school shops the teacher in charge is also responsible for the finishing, so a few of the necessary things to be kept in mind will be here given.

Too much importance cannot be placed on the proper preparation of work for finishing. There have been many pieces of furniture exhibited at our annual exposition that have been spoiled at the finish by too hurried work. It may be taken as a positive rule that a perfect polish can be obtained only on a perfect surface. Another half day, or even another hour, of scraping and sandpapering will make the difference between a good and bad finish. It is just a matter of patience; and poor finishing can usually be called laziness on the part of the man in charge of the job. The general public judges furniture by its outward appearance and seldom notices good joints if the finish is bad.

A beginner in wood finishing will learn one thing very quickly—that is, never to leave marks, sandpaper scratches, or other imperfections to be covered up by the finish. The finish will do just the opposite—it will make them plainer than they were before. When a woodworker prepares a piece of furniture for finishing, he should not stop until this work is just as good as he knows how to make it.

VARNISHING.

There has been a great deal of objection to this kind of finishing in the Philippines. The reason given is that varnish will not dry in this climate. Most of these cases can be blamed on the contractor who uses cheap materials. The best kinds of American varnish are just as satisfactory here as in other places if they are properly applied. A little more time is needed for drying during the rainy season; but if the workman buys good, high-grade varnish, he will secure good results.

The process known as French polishing is now being taught in the school shops of the Islands. When used, there results a fine polish but one which is very slow to obtain. The process is not economical except where labor is cheap. No furniture factory could use it with profit. Varnishing is the only method that a manufacturer can afford.

Filling.—As this chapter deals with the use of real varnish, the user is advised to buy his filler at the same time that he purchases his varnish. Every manufacturer of varnish also makes filler which is much better than the homemade kinds. If liquid filler is used, no directions need to be given; it should be applied according to the directions that come with it. If a paste filler is used, a little more knowledge is necessary. One of the best fillers on the local market is put up in the form of a paste which is thinned with turpentine until it is about as thick as varnish. The following directions for applying paste filler should be followed:

Thin with turpentine, as directed, and apply with a flat brush. Before starting work, collect a quantity of soft, fine shavings and keep them close at hand, ready for use. Apply the filler to small surfaces, 2 or 3 square feet at a time. When the filler is first put on it has a wet, shiny appearance. As it sinks into the surface it turns dull and flat. As soon as this change occurs, rub the filler into the surface with a handful of dry, fine shavings. Then rub across the grain with a cirular motion until no filler is left on the surface, all of it having been either rubbed in or taken up by the shavings. When one section is finished, apply filler to the next; and so on until the entire surface has been filled. The grain of the wood should show up just as plainly after filling as before. If the grain is covered up and has a muddy appearance, either the filler is too thick or it is not properly rubbed in.

Allow twenty-four hours for drying, then go over the surface lightly with sandpaper No. 00. The same process of applying and rubbing in is used both with paste and liquid filler.

NOTE.—A well-known manufacturer of finishing materials makes the statement: "In our opinion, the poorest grade of paste filler on the market is superior to the best grade of liquid filler." This statement can be taken for what it is worth. In the writer's experience it has proved true.

It is very easily understood that filling cannot be done successfully on a dirty surface. All sandpaper dust must be first removed or it will mix with the filler and spoil it.

Shellacking.—This operation is omitted in finishing cheap work on softwoods. It is used on high-class work with hardwoods, because it gives a better surface for the varnish. Shellac dries very quickly and does not sink into the surface and dissolve the oil in the filler.

The first step in shellacking is to see that the filler is perfectly dry. The safest plan in the Philippines is to allow about twelve hours more for drying than is directed by the manufacturers. This allows for the difference in climate between this country and the United States.

Shellac is usually mixed by the user. A good formula is as follows:

Alcohol	liter	1
White shellac	grams	100

Increase in proportion for larger quantities.

Dissolve the shellac in the alcohol; and stir or shake it often while using it, as the shellac separates from the alcohol and settles very quickly. If the alcohol is slightly warmed, the shellac will dissolve faster. This can be done safely by placing the can or bottle in a dish of warm water.

See that the surface to be shellacked is clean and free from dust. Apply the shellac evenly, with a soft, flat brush. First cover all projecting parts, such as panels. Spread the shellac across the grain, taking a very small amount on the brush at one time. It is very easy to put on too much shellac, but very difficult to get it off again as it dries very quickly.

Allow twenty-four hours for drying, then go over the surfaces lightly with sandpaper No. 00. It is now ready for varnishing.

Applying varnish.—The real difficutly in using varnish in our school shops is that no room which is "dust proof" can be found. The following plan is suggested: Select the best room available—a classroom with tight windows and doors will do. It must be well cleaned, perhaps on a Friday afternoon. On Saturday morning have it swept with wet sawdust which will pick up most of the dust on the floor. With a damp cloth wipe off all articles of furniture or parts of the woodwork that are likely to be touched by the workmen. Dusting with a brush will *not* do; this only stirs up the dust, which settles elsewhere. All windows should be closed before the last dusting and should not be opened again until the varnish is dry.

Wipe off the surfaces of the work to be varnished with a soft cloth slightly damp, but not wet. Allow time for drying and then apply the varnish. Do this carefully, taking pains not to spread the varnish on too thick. The varnish will be dry enough by Monday morning so that the article can be moved; but two or three days must be allowed for drying before applying the second coat of varnish.

The same directions are followed and the second coat of varnish is applied on the following Saturday.

Many books have been written on the subject of varnishing. There are all kinds of right and wrong ways of doing it and the workman can learn only by experience. A good painter can learn varnishing very quickly, but it requires much time and training to teach this process to a beginner.

No amount of reading "book rules" will give him what he must obtain by practice. It is a good plan to practice varnishing on waste pieces before trying it on valuable furniture.

Rubbing and polishing.—After the varnishing, if the work is of a high class, it is finished by rubbing and polishing. The rubbing reduces all the unequal surfaces and the polish brings back the gloss to the varnish. The first of these processes is about as follows:

Test the varnish and make sure that it is perfectly dry. This can be done by pressing it with the thumb nail. If no impression can be made, it is dry enough. A pad for rubbing is then used. This pad can be made by wrapping a ball of cotton waste in a piece of soft, cotton cloth. The professional finisher uses a felt pad, but this cannot always be obtained and a substitute has to be made. The common practice is to dip the pad into oil or water and then into powdered pumice stone. This can be repeated whenever the cloth gets too dry to pick up the powder. The pumice is rubbed with the grain of the wood. Care must be taken not to wear the varnish off the corners. The rubbing is continued until the surface looks the same all over. Only the finest grade of pumice should be used.

Polishing is the next step, and it can be omitted if a dull finish is wanted. After the rubbing, the surface should at once be cleaned thoroughly. This is usually done by sprinkling the work with damp, softwood sawdust. The sawdust is dampened to keep it from scratching the surface and is wiped off with a soft cloth.

A mixture of oil and alcohol in equal quantities is used for polishing (coconut oil will do). A new rubbing pad is made. It is dampened with the mixture by dropping it on the waste inside of the cloth and allowing it to soak through from the inside. The surface is rubbed with a rotary motion until it is polished.

FRENCH POLISHING.

This method of finishing consists of gradually filling the pores of the wood with pumice, shellac, and alcohol, and bringing the surface to a high polish by means of rubbing.

Fig. 183.

As in varnishing, the surfaces to be polished must be prepared with great care. Every little defect must be removed and every scratch taken off, as polishing will make them plainer than ever. About one half of the whole process consists of the sandpapering. Several grades of sandpaper are used; and when the surface is ready for polishing, it is as smooth as glass. A filler is sometimes used, as in varnishing; but the usual way is to start from the raw surface, working in the filler and polishing at the same time.

The process approved and used in the school shops of the Philippines is as follows: When the surface is prepared, give it a coat of coconut oil. Take a piece of No. 00 sandpaper which has already been used until it is worn smooth and rub the surface until it is dry.

Make a ball of cotton waste and wrap it in a piece of soft cotton cloth. Make sure that there are no wrinkles in the cloth. Wet the ball of waste with alcohol from the inside, so that the alcohol will soak through. Sprinkle the surface of the wood with powdered pumice stone and rub with a rotary motion until the ball becomes dry. Repeat until the pores are filled.

The shellac is prepared as described in the directions for varnishing and is put in a bottle with a tight cork. A small hole is cut in the cork so that a few drops of shellac can be shaken out at a time. Moisten the inside of the ball with shellac and continue the rubbing until the surface is polished. This will give what is called a natural polish to the wood, as none of the materials used has any color that will affect it.

The foregoing description gives about all that can be said in the way of directions. In simply reading the rules, this method of polishing appears to be very easy. A practical test will prove it to be just the opposite. Much time and patience are required. Like varnishing, it can be learned only by doing. The materials required have been well described as 5 per cent oil, alcohol, pumice, and shellac, and 95 per cent "hard labor."

French polishing is not the best system for factories, because it is so slow. On the other hand, the materials are very cheap and the results are excellent. It can be used where good varnishing would be impossible, and will be for many years the only method practicable in the school shops of the Philippines.

WAX FINISHING.

Wax finish is the easiest and, at the same time, the best for some classes of work. It is also easy to repair when damaged. Wax finish has many points to recommend it for use on softwood furniture. It is cheap, easy to apply, and easy to keep in good condition. Even a wax finish, however, can be put on badly, and a few ordinary rules must be followed.

Prepare the surface to be waxed just as carefully as if it were to be polished. Fill the wood with some good filler, using the method already described under varnishing. When the filler is dry, sandpaper the surface lightly and apply the wax, rubbing until a good polish is obtained. The mistake is often made of using too much wax. The best results can be obtained by giving the surfaces a thin coat of wax, using a soft cloth to apply it. Allow about half an hour for drying and then, with a clean cloth, rub until the surface is perfectly dry and smooth. As long as the wax is sticky, it needs more rubbing. A surface can never be polished with the same cloth used to apply the wax.

One of the objections to a wax finish is that it needs constant care to keep it in good condition. This is partly true, but the repolishing does not take very much time and can be done by a servant with the same kind of wax that he uses on the floors. It will also be found that less wax and less work are needed each successive time. Another objection is that wax is always sticky. This is not true if the right kind of wax is used, and in the right way. The prepared wax sold by dealers, if used in small quantities and rubbed enough, will give a high polish and will not feel very different from varnish. The sticky kind of wax is the kind that the workman tries to make himself.

Wax is sometimes applied without using a filler. This is only on very cheap work and is not to be recommended even for cheapness, as filler is also very cheap and improves the work at least 50 per cent.

STAINING.

Cheap woods are often stained to look like some better class of wood. Different colors of the same wood are sometimes stained so that they match. There are many kinds of stain sold in the Philippines, several of which are very good. Paste filler is made in different colors and is used as a stain, changing the color at the same time that the surface is filled. The directions for using stain are usually printed on the bottle or can, so it is not necessary to give them here in detail. A few general rules that apply to all kinds may well be given.

Stain is always applied either before or at the same time as the filler, and comes next in order after sandpapering. Apply the stain carefully, going over all parts of the surface, but taking care not to double anywhere because doubling will produce streaks in the stain which cannot be removed easily. Most of our stains are mixed with water, benzine, or alcohol, which "raise" the grain—that is, cause it to swell slightly, so that it feels rough. Plenty of time should be allowed for drying. The surface is then sandpapered lightly and the work is ready for the next step.

Most of our stained furniture is made of lauan or tanguile. These woods, if properly stained, can be made to look like oak or mahogany. The usual object in staining is to make the article match something else, or to make an imitation of something better. Therefore stain should always be selected with great care and tested on a sample piece before using. If it is not the right shade, it can be thinned to make it lighter or mixed with a darker stain to increase its color.

No stain will give quite as deep and rich a color as is shown in the catalogue sent out by the manufacturers.

GENERAL SUGGESTIONS.

In conclusion, it is suggested that filler, varnish, stain, or wax be purchased already prepared whenever possible. The manufacturers have spent a good many years in perfecting their products, and it is foolish for an amateur workman to try to make his own finishing materials. Even though he secures the best that can be bought and tries as hard as he can, he will not do perfect work; he has no chance at all when he is using poor materials.

If possible, always get the *best*. The saving of a peso on finishing materials may mean a loss of ten pesos in the sale.

Part V.—SYSTEMS OF MEASURING.

The metric system of measuring has been adopted as the only legal one for use in the Philippines. It is, without doubt, the best system, though conditions of trade and manufacture have made it necessary to use the English system in a good many instances. The skilled worker must, therefore, understand both systems and be able to transpose quickly from one to the other.

This ability is especially necessary to the woodworker. Almost all of our woodworking machines and tools come from a country that uses the English system of measuring. The Government permits the use of the English system in cutting timber; therefore a woodworker must learn to work by this system. In furniture making, the centimeter is used very often as the unit of measure, which of itself creates something of a problem, as the workman gets all of his lumber in English sizes. The builder, especially, has a difficult task, as all plans and specifications are given in the metric system and all of his lumber is cut to English dimensions; if he does not understand both systems, he is likely to make very costly mistakes.

The tables which follow give the common units of measure in both systems, also their approximate equivalents. These tables are not exact, because the exact equivalent often means a fraction, the use of which is impracticable. The tables are intended for use in estimating, and an estimate should always be slightly greater that the quantity shown by the figures; therefore it is possible to drop the small fractions when transposing from metric to English.

The word "about" has been used to indicate that the equivalent given is not exact. It is very close in every case and can be used for making quick and fairly correct estimates. To illustrate: 30 centimeters is given as the equivalent of 1 foot and 91 centimeters as the equivalent of 1 yard (3 feet). The unit for transposing should be chosen to suit the measurement to be changed. If it is in inches, use the equivalent of 1 inch; if in feet, the equivalent of 1 foot; if more than 3 feet, the equivalent of 1 yard; and if in long distances, use the equivalent of 1 mile. This system applies to all of the tables.

ABBREVIATIONS.

Abbreviations for metric and English terms, used in this text:

LINEAL MEASURE.

METRIC.		ENGLISH.	
Millimeter	mm	Inch or inches	in. or ″.
Centimeter	cm	Foot or feet	ft. or ′.
Decimeter	dm	Yard	yd.
Meter	m	Mile	mi.
Decameter	Dm		
Hectometer	Hm		
Kilometer	Km		

Square measure is expressed by placing the abbreviation "sq." before the term indicating length, as: Square decimeter, sq. dm.; square yard, sq. yd.

Cubic measure is expressed by placing the abbreviation "cu," before the term indicating length, as: cubic meter, cu. M; cubic inch, cu in.

LIQUID MEASURE.

METRIC.		ENGLISH.	
Liter	l.	Pint	pt.
		Quart	qt.
		Gallon	gal.
		Barrel	bbl.

WEIGHT.

Kilo or kilogram	kg.	Ounce	oz.
		Pound	lb.
		Hundredweight	cwt.
		Ton.	

MISCELLANEOUS.

One thousand (when used in measuring lumber), M. As, "Yacal is sold at the rate of ₱75 per M."		Dozen	doz.
		Package	pkg.
		Board foot	bd. ft.

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COMMON METRIC MEASURES OF LENGTH.

The millimeter is the unit of measure in the machine shop.

The centimeter, in furniture and cabinetwork.

The meter, in building and in measuring short distances.

The kilometer, in measuring long distances.

COMMON ENGLISH MEASURES OF LENGTH.

The inch is the unit of measure in furniture, cabinetwork, and building. (In the machine shop the inch is divided into hundredths.)

The yard (3 ft.), in measuring short distances.

The mile (5,280 ft.), in measuring long distances.

TABLE OF EQUIVALENTS.

1 centimeter equals about	⅜ of an inch.
1 meter equals about	39½ inches.
1 kilometer equals about	⅝ of a mile.
1 inch equals about	2½ centimeters.
1 foot equals about	30 centimeters.
1 yard equals about	91 centimeters.
1 mile equals about	1⅗ kilometers.

COMMON METRIC MEASURES OF SURFACE (SQUARE MEASURE).

Square centimeter. Square meter. Hectometer or hectare.

COMMON ENGLISH MEASURE OF SURFACE.

Square foot	144 sq. in.
Square yard	9 sq. ft.
Acre	4,840 sq. ft.
Square mile	640 acres.

The metric measure of land, in small lots, is the square meter; in large areas, the hectare.

The English measure of land in small lots is the square foot or square yard; in large lots, the acre or square mile.

TABLE OF EQUIVALENTS.

1 square foot equals about	0.093 square meter.
1 square yard equals about	0.836 square meter.
1 acre equals about	0.4047 hectare.
1 square meter equals about	11 square feet.
1 hectare equals about	2.47 acres.

COMMON METRIC MEASURES OF VOLUME.

The metric unit in measuring volume is the cubic centimeter, the cubic decimeter, or the cubic meter.

The English unit for measuring volume is the cubic inch, the cubic foot, or the cubic yard.

Table of equivalents.

1 cubic inch equals about	16.5 cubic centimeters.
1 cubic foot equals about	0.028 cubic meter.
1 cubic yard equals about	0.765 cubic meter.
1 cubic centimeter equals about	0.06 cubic inch.
1 cubic decimeter equals about	61 cubic inches.
1 cubic meter equals about	1.3 cubic yards.

BOARD MEASURE.

The metric unit for measuring lumber is the cubic meter.

The English unit for measuring lumber is the board foot. It is equal to the contents of a piece of wood 12 inches square and 1 inch thick, or 144 cubic inches. The value of lumber is usually calculated by the value of 1,000 board feet; in very small quantities, by the board foot.

One cubic meter of wood is equal to about 423 board feet, actual volume; but making allowance for the waste in cutting from a round log to sawed lumber, the lumbermen use the equivalent of 4 cubic meters to 1,000 board feet of lumber ready for the market.

Table of equivalents.

One cubic meter in the log equals about 250 board feet of sawed lumber.
One board foot equals about 0.00236 cubic meter.

The woodworker in the Philippines seldom has to change board measure from English to metric in keeping his accounts. His problems are the reverse. He buys his lumber by the English system and accounts for it by the same system. He is often required to take plans drawn to the metric system and estimate in English measure the amount of lumber that will be needed. When changing from metric to English in measuring lumber, the exact equivalents cannot be used, because the lumber is cut to standard sizes; if the dimensions of a piece come between two standard sizes, the next larger size is used. To illustrate: Suppose a drawing calls for a piece of wood 2 centimeters thick and 1 meter square. The exact equivalent would be 8.7 board feet; but 11 board feet would actually be used in making it, as lumber 1 inch thick would have to be cut down to the required dimensions.

The following rules can be used in transposing board measure:

(*a*) If changing from metric to English, transpose all the dimensions by lineal measure and then compute the board feet.

(*b*) If changing from English to metric, for small quantities compute the number of board feet and multiply by 0.00236; for large quantities allow 1,000 board feet to equal 4 cubic meters in the log.

Standard sizes.—Lumber is cut at the mills to standard sizes. These sizes are used chiefly on building materials of softwood. Many sizes are found in the local markets which are not standard. This is on account of the crude methods of cutting used in the provinces. Our valuable first-group woods are cut in any size convenient for the lumberman. They come to market in the form of squared logs which are cut, either by hand or at the mills, to standard thickness, but not to standard width or length.

TABLE OF STANDARD SIZES, ENGLISH DIMENSIONS.

[Thickness and width in inches.]

1 × 2	2 × 2	3 × 3	4 × 4	6 × 6	8 × 8	10 × 10	12 × 12
1 × 3	2 × 3	3 × 4	4 × 6	6 × 8	8 × 10	10 × 12	
1 × 4	2 × 4	3 × 5	4 × 8	6 × 10	8 × 12		
1 × 6	2 × 6	3 × 6	4 × 10	6 × 12			
1 × 8	2 × 8	3 × 8	4 × 12				
1 × 10	2 × 10	3 × 10					
1 × 12	2 × 12	3 × 12					
1 × 14	2 × 14						
1 × 16	2 × 16						
1 × 18							
1 × 20							
1 × 22							
1 × 24							

[Standard lengths in feet.]

10	12	14	16	18	20	22	24	26	28	30	32	36	40

The foregoing table can be used for transposing from metric to English in estimating building timbers. Following is a sample problem:

The posts of a house are to be .12 by .12 by 7.0 meters. These dimensions, transposed to the English system, give 4¾ by 4¾ inches by 23 feet ½ inch. The nearest standard size is 6 by 6 inches by 24 feet, so a piece of that size would have to be obtained and charge would be made for the full amount.

Liquid Measure.—The metric unit for both liquid and dry measure is the *liter,* which represents the contents of 1 cubic decimeter.

COMMON ENGLISH MEASURES OF LIQUID.

4 gills equals	1 pint.
2 pints equals	1 quart.
4 quarts equals	1 gallon.
31½ gallons equals	1 barrel.

Equivalents.

1 liter equals about	1.1 quarts.
1 liter equals about	.264 gallon.
1 quart equals about	.95 liter.
1 gallon equals about	3.79 liters.

METRIC MEASURES OF WEIGHT.

The metric unit of weight is the *kilogram,* or *kilo.* It is the weight of one liter of water.

ENGLISH MEASURES OF WEIGHT.[1]

16 ounces equals	1 pound.
100 pounds equals	1 hundredweight.
2,000 pounds equals	1 ton.

Equivalents.

1 kilo equals about	2.2 pounds.
1 pound equals about	0.45 kilo.
1 ton equals about	907 kilos.

ENGLISH NAMES USED IN COUNTING.

12 of anything equals	1 dozen.
12 dozen equals	1 gross.

[1] Several other systems of weight are used for special purposes. The one given, avoirdupois weight, is used most commonly.

FOR COUNTING PAPER.

24 sheets equals	1 quire.
20 quires equals	1 ream.

OLD WEIGHTS AND MEASURES OF THE PHILIPPINES.

1 vara equals about	$33\frac{3}{8}$ inches or .836 m.
1 cavan equals about	$20\frac{3}{8}$ gallons or 75 l.
1 picul equals about	$137\frac{1}{2}$ pounds or 63.262 kg.
1 ganta equals about	$3\frac{3}{10}$ quarts or 3 l.

The English system of measuring is in common use in the United States, Great Britain, and the English colonies. Most of our manufactured supplies come from the United States, made to English dimensions and packed by the English system of weights and measures. Following is a list of some of the commonest ones:

1. Bolts of all kinds: Made to English dimensions and packed by the hundred.
2. Hinges: Made to English dimensions; packed by dozens.
3. Screws: Made to English dimensions; packed by the gross.
4. Nails: Made to English dimensions; packed by the pound.
5. Tools: Made to English dimensions; packed by the dozen.
6. Oil and gasoline: In cans or barrels; measured by the gallon, or fraction of the gallon.
7. Paint and varnish: Same as for 6.
8. Sandpaper: By the quire or ream.
9. Floor wax: Packed by the pound.
10. Woodworking machinery: All dimensions and adjusting scales in English.
11. Builder's hardware of all kinds: Made to English dimensions.

CLASSIFICATION OF HARDWARE.

A woodworker often has to order manufactured supplies to be used in the construction of a piece of work. He should understand how such articles are measured and should know the commercial names for them. If a catalogue is available, it is best to pick out the articles wanted and give the manufacturer's name and number for them. When no catalogue can be obtained, the description must be made very complete or articles may be substituted that cannot be used. In the chapter which follows a few of the common articles of hardware used by the woodworker will be taken up and their most important details described.

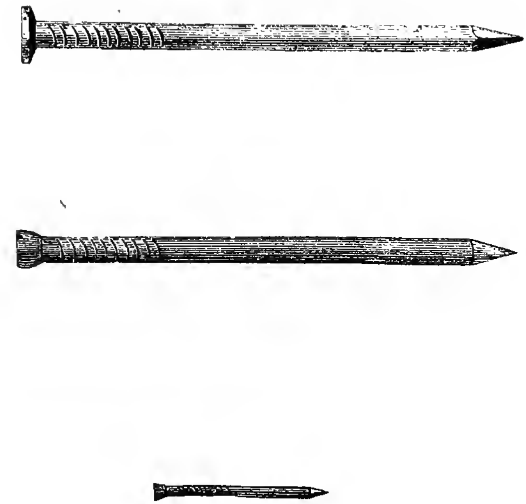


Fig. 184.

The fact should be remembered that the Philippines are a long distance from the places where hardware is manufactured. No merchant in the Islands carries a complete stock of hardware. He usually has to pay cash for everything he orders from the United States or other countries; therefore he is very careful to buy only such articles as are sure to sell. The tables of sizes given are complete—that is, they include every size that is made. A great many of these sizes cannot be obtained in the Philippines, hence in ordering it is advisable to state, in addition to the sizes actually desired and expressed in the order, the nearest substitute that will be accepted if the size wanted cannot be furnished.

NAILS.

Nails are classified according to the way they are made, the material used, their shape and proportions, and the use for which they are intended. Iron or steel wire is the common material, but other materials such as copper and "galvanized" iron are used where iron nails would be destroyed by rust.

The kinds most commonly used by the woodworker are classed as "common nails" and "finishing nails." Figure 184 illustrates these two kinds of nails. The wide head of the common nail makes it stronger; it is therefore used where the appearance of the head does not injure the work. Finishing nails are used where it is necessary to conceal the head as much as possible.

Under the heading "Wire Nails" there are several trade names which indicate the different forms.

Common wire nails are made of drawn wire and have a wide flat head.

Wire finishing nails are made of drawn wire and have a head but slightly wider than the diameter of the body of the nail.

Brads are the smaller sizes of wire finishing nails. As a rule, a nail less than 1½ inches long is called a brad.

Spikes are the large sizes of common wire nails. Any nail of this kind from 4 inches up is called a spike.

Table of sizes in which common wire nails are made:

Length in inches.			
1	2	3¼	5½
1⅛	2¼	3½	6
1¼	2½	4	
1½	2¾	4½	
1¾	3	5	

Table of sizes in which wire finishing nails are made:

Length in inches.			
⅜	¾	1¼	2
½	⅞	1½	2½
⅝	1	1¾	3

From ¾ inch to 3 inches, inclusive, wire finishing nails are made in two diameters of each length. When ordering, specify whether "fine" or "common" is wanted. The fine nail is about two-thirds the diameter of the common nail. Sample order:

10 kilos, nails, common wire, 2½-inch.
15 kilos, nails, wire finishing (common), 2-inch.
5 kilos, nails, wire finishing (fine), 1½-inch.

Nails are measured by their length in inches. The diameter increases in proportion to the length. The term "penny" is often used in describing nails, as a 6-penny nail, an 8-penny nail. The origin of this word is uncertain and it is now used only as a name. Following is a table of lengths in inches:

Kind of nail.	Inches.	Kind of nail.	Inches.
2-penny	1	10-penny	3
3-penny	1¼	12-penny	3¼
4-penny	1½	16-penny	3½
5-penny	1¾	20-penny	4
6-penny	2	30-penny	4½
7-penny	2¼	40-penny	5
8-penny	2½	50-penny	5½
9-penny	2¾	60-penny	6

The abbreviation for penny is "d.," as a 5d. nail, a 10d. nail. These terms are not used as much now as formerly, and many manufacturers have ceased using the word "penny" and label their nails as 2-inch common wire, or 1½-inch wire finishing nails.

Tacks are of little value for fastening pieces of wood together, but are very useful where lighter material, such as cloth or leather, is to be fastened to wood. They are made in different forms for different uses. Their size is measured in ounces. Figure 185 shows a 12-ounce tack, exact size. Following is a table of lengths in inches of the common sizes:

Kind of tack.	Inch.	Kind of tack.	Inch.
1-ounce	$\frac{3}{16}$	10-ounce	$\frac{5}{8}$
2-ounce	$\frac{1}{4}$	12-onnce	$\frac{11}{16}$
3-ounce	$\frac{3}{8}$	14-ounce	$\frac{3}{4}$
4-ounce	$\frac{7}{16}$	16-ounce	$\frac{13}{16}$
6-ounce	$\frac{1}{2}$	18-ounce	$\frac{7}{8}$
8-ounce	$\frac{9}{16}$	20-ounce	$\frac{15}{16}$

Fig. 185.

Fig. 186.

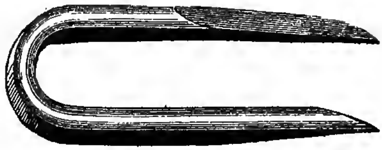


Fig. 187.

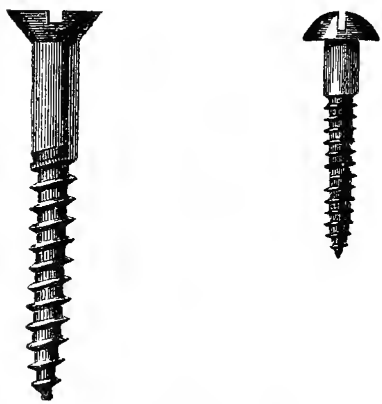


Fig. 188.

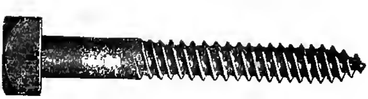


Fig. 189. Lag screw.

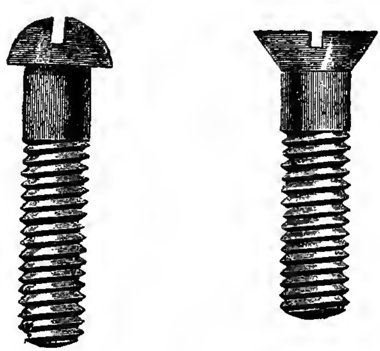


Fig. 190. Machine screws.

Tacks are made for many purposes. The kind described is called a "carpet tack." Besides these there may be mentioned basket tacks, lining tacks, upholsterers' tacks, shoe tacks, and double-pointed tacks. *Double tacks* are used for fastening two edges at the same time (fig. 186). They are made in several sizes, the smallest ½ inch long and the largest ¾ inch long.

Staples (fig. 187) are somewhat like nails in construction. They are generally used to form the loop for a hasp or hook in fastening. They are made of wrought iron and can be clinched without breaking—that is, they may be driven through a board until the points project on the other side and the points bent and driven back into the wood so that the staple cannot be pulled out. Staples are measured by their length and are made in the following sizes:

Length in inches.			
½	1½	2½	4
¾	1¾	3	4½
1	2	3½	5
1¼	2¼		

SCREWS.

Wood screws are made in two common forms—round head and flat head. Figure 188 illustrates the two forms. Under these two headings there are:

Round head	Bright (polished iron). Brass (polished brass). Blue (blued finish). Nickel-plated iron.
Flat head	Bright. Brass. Blue. Japanned (coated with brown shellac).

Wood screws are measured in two ways—by their length in inches, and by their gauge. The sizes of the screw gauge range from No. 0, which is a little less than $\frac{1}{16}$ inch in diameter, to No. 30, which is a little more than 7/16 inch in diameter. After working with screws for a short time, the workman learns to tell their diameters from their numbers. Following is a table of diameters in inches:

	Inch.
No. 4 gauge screw is about	3/32
No. 8 gauge screw is about	5/32
No. 12 gauge screw is about	7/32
No. 14 gauge screw is about	1/4
No. 20 gauge screw is about	5/16

If a few of the common gauges are memorized, it is easy to estimate the diameters of the other numbers.

The length of screws changes as follows:

From 1/4 to 1 inch by eighths.
From 1 to 3 inches by fourths.
From 3 to 5 inches by half inches.
From 5 to 6 inches by inches.

Very short screws are not made in the large gauges, and very long screws are not made in the small gauges.

Table of sizes in which screws are made.

IRON SCREWS, FLAT HEAD, BRIGHT.

Length.	Gauge.
1/4-inch	From No. 0 to 4, inclusive.
3/8-inch	From No. 0 to 9, inclusive.
1/2-inch	From No. 1 to 12, inclusive.
5/8-inch	From No. 1 to 14, inclusive.
3/4-inch	From No. 2 to 16, inclusive.
7/8-inch	From No. 2 to 16, inclusive.
1-inch	From No. 3 to 20, inclusive.
1 1/4-inch	From No. 4 to 24, inclusive.
1 1/2-inch	From No. 4 to 24, inclusive.
1 3/4-inch	From No. 6 to 24, inclusive.
2-inch	From No. 6 to 24, inclusive.
2 1/4-inch	From No. 8 to 24, inclusive.
2 1/2-inch	From No. 8 to 24, inclusive.
2 3/4-inch	From No. 10 to 24, inclusive.
3-inch	From No. 10 to 26, inclusive.
3 1/2-inch	From No. 10 to 26, inclusive.
4-inch	From No. 12 to 26, inclusive.
4 1/2-inch	From No. 16 to 26, inclusive.
5-inch	From No. 18 to 28, inclusive.
6-inch	From No. 20 to 30, inclusive.

Table of sizes in which screws are made—Continued.

BRASS SCREWS, FLAT AND ROUND HEAD.

Length.	Gauge.
¼-inch	From No. 0 to 4, inclusive.
⅜-inch	From No. 0 to 7, inclusive.
½-inch	From No. 1 to 10, inclusive.
⅝-inch	From No. 2 to 12, inclusive.
¾-inch	From No. 2 to 16, inclusive.
⅞-inch	From No. 2 to 16, inclusive.
1-inch	From No. 3 to 18, inclusive.
1¼-inch	From No. 3 to 20, inclusive.
1½-inch	From No. 4 to 20, inclusive.
1¾-inch	From No. 6 to 24, inclusive.
2-inch	From No. 6 to 24, inclusive.
2¼-inch	From No. 8 to 22, inclusive.
2½-inch	From No. 10 to 24, inclusive.
3-inch	From No. 10 to 26, inclusive.

ROUND HEAD, BLUE.

⅜-inch	No. 3 only.
½-inch	Nos. 3 and 6 only.
⅝-inch	From No. 4 to 6, inclusive.
¾-inch	From No. 5 to 10, inclusive.
⅞-inch	From No. 6 to 10, inclusive.
1-inch	From No. 5 to 12, inclusive.
1¼-inch	From No. 6 to 12, inclusive, and No. 14.
1½-inch	From No. 7 to 12, inclusive, and No. 14.
1¾-inch	Nos. 9, 10, 12, 14 only.
2-inch	Nos. 8, 10, 12, 14 only.
2½-inch	Nos. 8, 10, 12, 14, 16 only.

FLAT HEAD, JAPANNED.

¾-inch	Nos. 7 and 8 only.
1-inch	From No. 7 to 11, inclusive.
1¼-inch	From No. 9 to 12, inclusive.
1½-inch	From No. 10 to 13, inclusive.

ROUND HEAD, NICKEL PLATED.

Practically the same sizes as round-head, blue screws.

Lag screws or bolts (fig. 189) are a combination of screw and bolt, having the body of a screw and the head of a bolt. They are measured like a machine bolt.

BOLTS.

Bolts of all kinds are measured by their diameter and the thickness of the piece through which they will reach. If the head of the bolt is so made that it rests on the surface, then the length of the bolt is measured from the head to the end; if the bolt is so made that the head is buried, or countersunk, in the surface, then the length of the whole bolt is measured, including the head. Bolts are made for special purposes and are named from their commonest use, as a carriage bolt, a tire bolt; but, like many other articles of hardware, they may be used for any purpose desired.

Fig. 191.

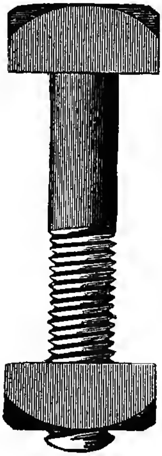


Fig. 192.

Fig. 193.

Carriage bolts (fig. 191) take their name from their common use in carriage building. The smooth, round head of the bolt fits close to the surface. The body of the bolt next to the head is square. In use, the hole is bored to fit the round body of the bolt and the square part is driven into the wood. This prevents it from turning when the nut is tightened. Carriage bolts are made in many sizes, the diameter changing by sixteenths and the lengths ranging from 1 to 24 inches.

Table of sizes in which carriage bolts are made.

Length.	Diameter in inches.						
1-inch	3/16	1/4	5/16	3/8	----	----	----
1¼-inch	3/16	1/4	5/16	3/8	----	----	----
1½-inch	3/16	1/4	5/16	3/8	----	1/2	----
1¾-inch	3/16	1/4	5/16	3/8	----	----	----
2-inch	3/16	1/4	5/16	3/8	7/16	1/2	----
2¼-inch	3/16	1/4	5/16	3/8	7/16	1/2	----
2½-inch	3/16	1/4	5/16	3/8	7/16	1/2	----
2¾-inch	3/16	1/4	5/16	3/8	7/16	1/2	5/8
3-inch	3/16	1/4	5/16	3/8	7/16	1/2	----
3¼-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
3½-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
3¾-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
4-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
4¼-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
4½-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
4¾-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
5-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
5¼-inch	----	----	----	3/8	----	1/2	----
5½-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
5¾-inch	----	----	----	3/8	----	----	----
6-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
6¼-inch	----	----	----	3/8	----	----	----
6½-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
6¾-inch	----	----	----	3/8	----	----	----
7-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
7½-inch	----	1/4	5/16	3/8	7/16	1/2	5/8
8-inch	----	----	5/16	3/8	7/16	1/2	5/8
8½-inch	----	----	5/16	3/8	7/16	1/2	5/8
9-inch	----	----	5/16	3/8	7/16	1/2	5/8
9½-inch	----	----	5/16	3/8	7/16	1/2	5/8
10-inch	----	----	5/16	3/8	7/16	1/2	5/8
10½-inch	----	----	----	3/8	----	1/2	----
11-inch	----	----	----	3/8	7/16	1/2	5/8
12-inch	----	----	----	3/8	7/16	1/2	5/8
13-inch	----	----	----	3/8	7/16	1/2	5/8
14-inch	----	----	----	3/8	7/16	1/2	5/8
15-inch	----	----	----	----	----	1/2	5/8
16-inch	----	----	----	----	----	1/2	5/8
17-inch	----	----	----	----	----	1/2	----
18-inch	----	----	----	----	----	1/2	----
19-inch	----	----	----	----	----	1/2	----
20-inch	----	----	----	----	----	1/2	----
22-inch	----	----	----	----	----	1/2	----
24-inch	----	----	----	----	----	1/2	----

Carriage bolts are packed for shipment in packages of 100, 50, and 25.

Machine bolts differ from carriage bolts in several ways. They are made with square or hexagonal heads, so that a wrench can be used on both ends. The thread, also, is different; and a nut from a machine bolt will not fit a carriage bolt of the same diameter. Machine bolts in large sizes are used in building construction. They are often made to order for builders, as they require special lengths. Machine bolts are made in stock sizes, ranging from 1 inch long by $\frac{1}{4}$ inch in diameter to 30 inches long by $1\frac{1}{4}$ inches in diameter. Figure 192 represented a common form. An order should specify whether square or hexagonal heads or nuts are wanted.

Tire bolts (fig. 193) are used chiefly in carriage building, for fastening iron tires to wooden rims. The head is countersunk in the metal and so is included in the length of the bolt.

Tire bolts are made in four diameters—$\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, and $\frac{3}{8}$ inch, and in thirteen lengths, from 1 to 4 inches, by fourths, inclusive.

Stove bolts take their name from their common use in fastening the different parts of stoves together. They are made with both flat and round heads. Figure 194 shows both forms. Stove bolts are a combination of bolt and screw having the thread and nut of a bolt and the head of a screw. This allows for tightening them with either a

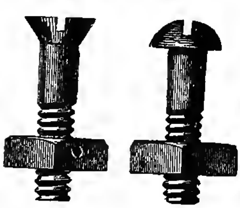


Fig. 194.

Fig. 195.

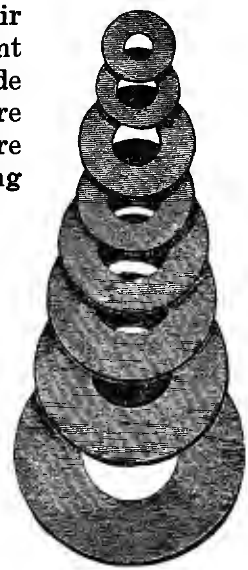


Fig. 196.

wrench or a screwdriver. They are also made with an extra long thread, which permits using the same bolt for several lengths. Stove bolts are manufactured in sizes ranging from 3/16 inch in diameter by 1/2 inch long, to 5/16 inch in diameter by 3 inches long.

Cap screws (fig. 195) are mentioned here because they are used very commonly in the construction of woodworking machinery. They are made with square and hexagonal heads.

Washers are used in connection with bolts. They are made of wrought iron, and measured by the diameter of the hole in the center. Their chief use is to give a wider bearing surface for the head or nut of a bolt. The diameter of the hole is always 1/16 inch larger than that of the bolt—that is, a 5/16 inch bolt takes a 3/8 inch washer. Washers are made to fit all sizes of bolts and are sold in two ways—in small quantities by count, and in large quantities by the kilo or pound. Figure 196 illustrates a common form.

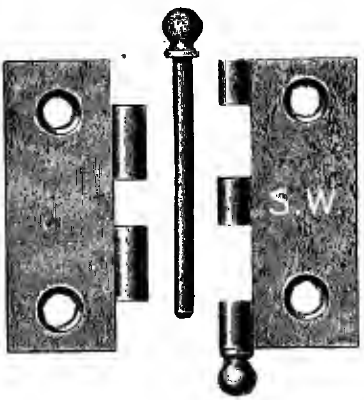


Fig. 197.

HINGES.

Hinges are made in many different forms, each form having a different "trade name" which must be given when ordering. It will be impossible to describe all the different forms, therefore a selection of the commonest will be given. It is advisable to write for a catalogue before making out an order for hinges.

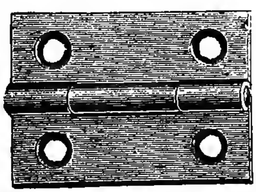


Fig. 198.

Butts are made in two general forms—"loose pin" (fig. 197) and "fast joint" (fig. 198). These terms refer to the pin which holds the two parts of the hinge together. The former is used chiefly for doors. The loose pin is removed and the two halves of the hinge are fitted separately. In the latter the pin is riveted in and cannot be removed.

Butts are measured by their width and length when open, as, a loose-pin butt 1½ by 2 inches. They are packed by the dozen. When ordering butts, it should be specified as to whether brass or steel, loose pin or fast joint is desired. It is also advisable to give dimensions of the nearest substitute that will be accepted.

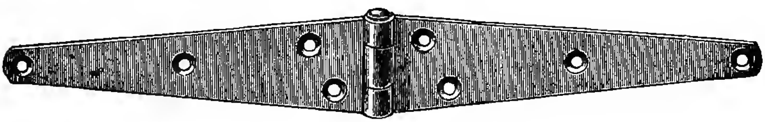


Fig. 199.

Strap hinges (fig. 199) are used chiefly for heavy construction on rough outside work. For outdoor use they are usually galvanized. Strap hinges are measured by the

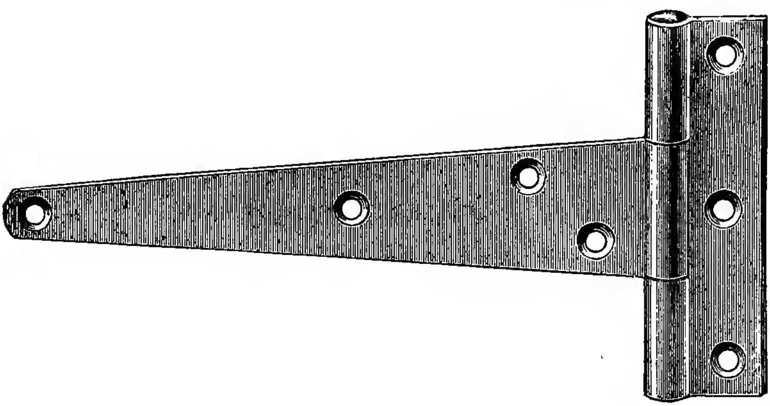


Fig. 200.

length of one-half of the hinge and are made in the following lengths: 3, 4, 5, 6, 8, 10, 12, and 14 inches. When ordering, it should be specified whether heavy or light weight is wanted.

Fig. 201.

T-Hinges (fig. 200) are measured by the length of the strap and are made in about the same sizes as the strap hinge. When ordering, specify heavy or light weight.

Hook and strap hinges are illustrated by figure 201. They are used for hanging heavy doors or gates. While manufactured in several sizes, they are usually made to order in a blacksmith shop.

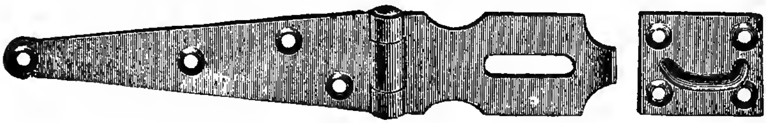


Fig. 202.

Hinge hasps (fig. 202) are used in connection with padlocks for fastening doors and chest covers. They are measured by their whole length and are made in the following sizes: 3, 4, 6, 8, and 10 inches. Hinge hasps in small sizes are also made, of brass.

Special hinges are made for special uses; such as refrigerator hinges, spring hinges, shutter hinges, box hinges, trunk hinges, gate hinges, and blind hinges.

LOCKS AND FASTENINGS.

Locks are made in so many different forms that it will be possible to describe only the commonest kinds. When ordering locks, it is advisable to use a catalogue, giving the manufacturer's name and number.

Drawer locks (fig. 203) are measured by their width and length in inches, and the thickness of the wood they are to fit.

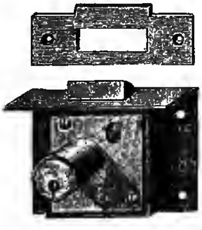


Fig. 203.

Fig. 204.

Cupboard locks (fig. 204) or **wardrobe locks**, are very similar to drawer locks, the only difference being that the cupboard lock is applied vertically. Drawer locks are often substituted for cupboard locks.

Chest locks (fig. 205) are made in two pieces, one of which is fastened to the cover of the chest. The two hooks on the cover enter the lock, and a bolt passes through them when the key is turned.

Padlocks (fig. 206) are made in many forms and are measured by their width, or diameter, across their widest place.

Each of the locks described is made in many varieties. In price, they run from 20 centavos to ₱5 or ₱6 each. When ordering locks of any kind, a complete description must be given. If the purchaser lives in a town where

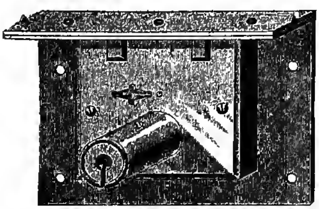


Fig. 205.

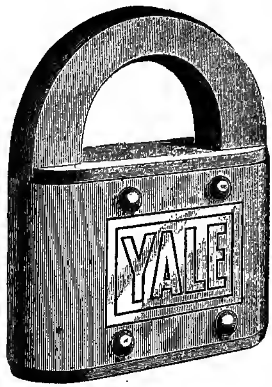


Fig. 206.

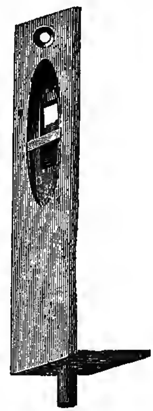


Fig. 207.

there is a hardware store, he can go to the store and pick out the kind of lock he wants; if he has to order by mail, the only safe way is to write for and secure a catalogue. Following is a sample order for locks;

1 doz. locks, cupboard, 2¼" for ¾" wood.
(Y. & T. No. PA203 preferred.)
½ doz. locks, chest, 2½" for 1½" wood.
(Corbin, No. 080, preferred.)
2 doz. padlocks, 1½" Yale, No. 833.

When the manufacturer's name and number for the lock can be given, a good deal of the description can be omitted, as in the above order. If they cannot be given, a full description must be furnished, as:

1 doz. locks, cupboard, 2¼", three lever, 1" drop, for ⅞" wood; flat key, all brass.

Flush bolts (fig. 207) are used in cabinetmaking for fastening at the bottom and top of a door. Flush bolts are measured by their width and length in inches and are made in the following sizes:

½-inch by 3 and 4 inches.
⅝-inch by 4, 6, 8, and 10.
¾-inch by 4, 6, 8, and 10.
1-inch by 6, 8, and 10.

Door bolts are made in many forms. The one shown in figure 208 is what is called a "barrel" bolt. Door bolts are measured by their length in inches and are made in lengths ranging from 2½ to 8 inches.

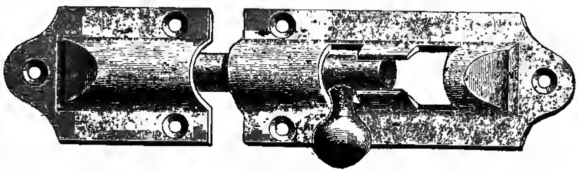


Fig. 208.

Elbow catches serve the same purpose as flush bolts but are superior to them, in that they are easier to release and that one is usually sufficient on a single door. An elbow catch is fastened in such a manner that it hooks on the under side of a shelf. It is held in place by a spring which is released by pressing the opposite end of the "elbow." Elbow catches are made in several sizes. When ordering, specify whether large or small size is desired.

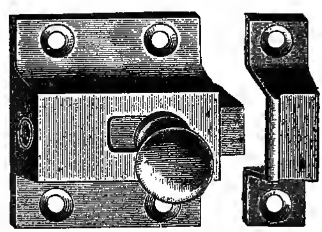


Fig. 209.

Cupboard catches (fig. 209) serve for fastening small doors where a lock is not needed. They are measured by their width and length. A common size is 1¼ by 2¼ inches.

Screw hooks and eyes (fig. 210) are also used for fastening where locks are not needed. They are made of brass or of iron, and are measured by their length in inches.

Screw hooks are made in several forms. Figure 211 shows two of them. They are made both of steel and of brass, and are measured by the gauge of wire from which they are made—No. 0 being the largest and No. 14 the smallest.

Fig. 210.

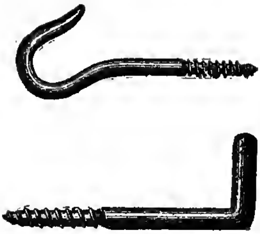


Fig. 211.

Fig. 212.

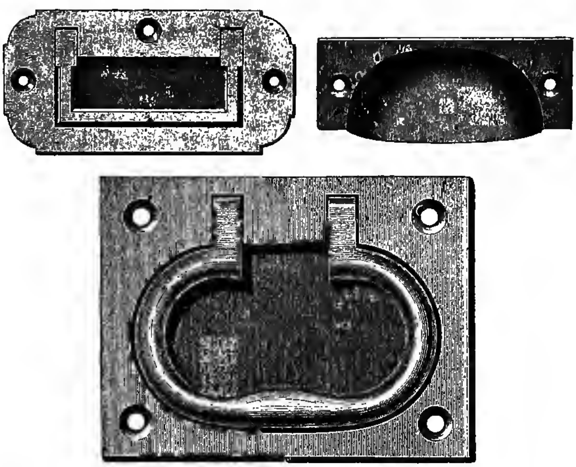


Fig. 213.

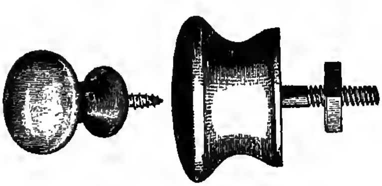


Fig. 214.

Screw eyes (fig. 212) are manufactured of steel or brass wire; their gauge is the same as that of screw hooks. When ordering, it is advisable to give the desired length in inches.

MISCELLANEOUS ARTICLES.

Other articles of hardware are made in so many varieties and for so many special purposes that space is wanting to describe any of them in full. A few descriptions will be given, with illustrations of the articles described. They will serve as a help in learning names, but cannot be used for ordering purposes. A catalogue should be obtained first, and the manufacturer's name and number for the article should be given when the order is written.

Drawer pulls and handles are usually chosen to suit the article of furniture on which they are used. Figure 213 gives several varieties.

Drawer knobs are shown in figure 214.

Casters are made in several common forms and are used on the bottoms of heavy articles of furniture to assist in moving them. They are often made in the form of small wheels, sometimes in the form of a steel ball set loosely in a socket. The large, ball-bearing caster is much the best for heavy furniture.

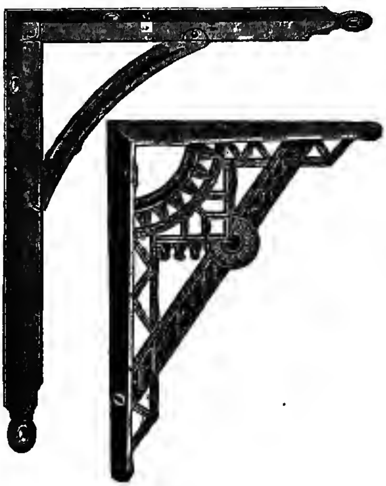


Fig. 215.

Label plates are attached to the ends of drawers to hold labels or cards which indicate the contents of the drawer. They are made of brass, nickel-plated iron, and of iron with several other finishes; they are also made to combine with a drawer pull.

Brackets (fig. 215) are used for supporting shelves. They are made in many forms, varying from very cheap, iron brackets to elaborate designs of decorated brass and bronze. They are measured by their length from the angle to the outer end.

GLASS.

Glass is made in several qualities, which differ in strength and clearness. It is also cut in standard sizes. Following is classification of glass carried in local stores, Manila.

French plate glass is used for mirrors, large windows, and show-cases. It is sold in sizes ranging from 12 by 30 inches to 84 by 108 inches.

Double-strength glass is employed in cheap woodworking where large pieces of glass are needed. It is cheap, but not very clear, and it can be obtained in sizes ranging from 18 by 20 inches to 36 by 60 inches.

Clear glass is used for picture framing and on all high-class work. It can be secured in sizes ranging from 10 by 12 inches to 40 by 60 inches.

Window glass is employed for windows and for very cheap furniture work. It is nearly always imperfect, either in thickness or in clearness, and is sold in sizes ranging from 8 by 10 inches to 24 by 30 inches.

When ordering glass, it is advisable to get a list of standard sizes and prices from the dealer.

Mirrors are made to order from plate glass, and special charge is made for beveling and silvering.

GLUE.

Glue is chiefly of two kinds—animal and fish. Animal glue is made from the bones, horns, hoofs, and skins of animals. Fish glue is made from the eggs and intestines of fish. Both forms of glue are prepared for the market in the form of cakes varying in thickness from an eighth of an inch to very thin chips. For bench work these chips are dissolved in hot water and applied to the work while hot.

For melting the glue, special gluepots are made, similar in plan to that of a double boiler—one pot being within the other. The glue is put in the inner pot, with enough water to melt it, and the outer pot is filled with water. This prevents the glue from burning when it is heated.

Gluing.—When ready for use, the glue should be hot, and thin enough to spread very easily with a brush. It should be applied in an even coat to both surfaces that are to be joined. Too much glue will make a bad joint. The glue must be put on very rapidly; and no time should be lost in joining the two pieces, as the glue begins to cool and harden the minute it is taken from the pot. After the pieces have been put together, they should be rubbed to squeeze out the extra glue, then finally clamped in place and allowed to dry for at least twenty-four hours.

When end grain is to be glued, it should first be given a thin coat of glue in order to fill the pores of the wood, then allowed to dry a little before the final coat of glue is put on and the joint fastened together.

It is important to remember that while the surfaces which are to be joined should be entirely covered with glue, the pieces themselves should be brought as close together as possible. A well glued joint should not show the glue at all.

Liquid glues which are always ready for use are sold. They cost more, however, and are no better than the kinds already described.

GALVANIZED-IRON ROOFING.

Galvanized-iron roofing is made both flat and corrugated. Corrugated iron is most commonly used. The sheets are pressed in a machine so that the surface is channeled, or corrugated, in the direction of its length. When the roofing is laid, these corrugations overlap and make a very tight roof.

Iron roofing is measured by its gauge and by its dimensions. The following sizes are sold in the Philippines:

Width, 32 inches.
Length, 6, 7, 8, 9, 10 feet.
Gauge, 22, 24, 26, 28, 29.

The gauge number indicates the thickness, 22 gauge being the heaviest and 29 gauge the lightest; 24-gauge roofing is required on all Government work.

In laying corrugated-iron roofing, it is usually overlapped at its sides two corrugations, or 4 inches, and 6 inches at its ends. Therefore, in estimating the amount of roofing necessary to cover a given space, 6 inches should be subtracted from the length and 4 inches from the width of each sheet.

Ridging is usually made to order in any width desired The common width is made from sheets of iron 18 inches wide and 8 feet long. When placed on the ridge it extends each way about 8 inches down the slope of the roof.

Sheet iron is sold locally in sheets 3 by 8 feet and 4 by 8 feet, in the same gauges as roofing.

Roofing nails of galvanized iron are made for special use in putting on roofing. The head of the nail is widened by a washer which is soldered to the nail, thereby covering a much wider space than an ordinary nail head. These nails are always used in putting on a permanent roof.

Eave troughs, drain pipes, and ventilators of galvanized iron are made to order in any required sizes.

Part VI.—PRACTICAL QUESTIONS.

[Based on the use of Bench Tools, Part I.]

1. What are the necessary features of a workbench?
2. Described a bench stop and its use.
3. Make a sketch of a bench hook and describe its use.
4. What is a "sawhorse"? For what is it used in the shop?
5. Describe a 2-foot, twofold, ruler, English—metric, explaining the meaning of each term.
6. Describe a carpenter's square. Name three of its uses.
7. What is a vise? Illustrate by sketch.
8. What is a try-square? Describe its uses.
9. What is a miter square? Describe its uses.
10. What is a bevel? Describe its uses.
11. What are dividers? Describe a pair of dividers, giving two of their common uses.
12. Describe the method of finding the hypotenuse of a right-angled triangle, the length of other two sides being known, by means of a carpenter's square and ruler.
13. Where is the problem in No. 12 actually used in woodworking?
14. Explain by drawing the method of constructing with the dividers and ruler: A right angle; a square; a hexagon in a circle; an octagon in a square; bisecting a line; bisecting an angle; an equilateral triangle.
15. How is a bevel set to an angle of 45 degrees on a carpenter's square?
16. Sketch a marking gauge, naming its parts.
17. What is a mortise gauge? For what it is used?
18. Describe the construction and use of a panel gauge.
19. What is a cutting gauge and for what is it used?

20. For what are chalk lines used?
21. What is a brad awl?
22. Describe a jack plane, naming its important parts.
23. In what lengths are smoothing planes made? For what are they used?
24. What is the length of a foreplane? For what is it used?
25. What is the length of a jointer plane? For what is it used?
26. What is the difference between a smoothing plane and a jointer plane?
27. What is the rule by which a good workman selects the plane he is to use?
28. What is a block plane? For what are block planes used?
29. Describe a circular plane.
30. Describe a rabbetting plane.
31. Describe a router plane and its uses.
32. Describe a scraper plane and its uses.
33. Describe a scraper and its uses.
34. Describe a spokeshave and its uses.
35. What points of similarity are there between planes and sandpaper?
36. How are planes measured?
37. How are chisels measured?
38. How are all cutting tools measured?
39. Described a socket-firmer chisel.
40. Describe a tanged-firmer chisel.
41. Describe a framing chisel.
42. Describe a gouge.
43. How are gouges measured?
44. Write an order for three kinds of chisels and two kinds of gouges.
45. What is a ferrule?
46. What is a drawknife?
47. How is a drawknife used as a substitute for the chisel?
48. In what way does a drawknife resemble a chisel?
49. What is the difference between grinding and sharpening?

50. Describe the process of grinding a plane.
51. Describe the process of sharpening a plane without grinding it.
52. Describe the process of grinding and sharpening a chisel.
53. What is an "edge tool?"
54. What is meant by "wire edge?"
55. What is meant by "honing?"
56. How are, grindstones measured? Of what are they made?
57. How are oilstones measured? Of what are they made?
58. Why is water used on a grindstone?
59. What will happen to a grindstone if it is allowed to stand still in water?
60. Why is petroleum the best oil for use on an oilstone?
61. How can an oilstone be trued up when it becomes worn?
62. Describe the process of truing a grindstone.
63. What is a slip stone?
64. What is a handsaw?
65. What is a crosscut saw?
66. How are saws described or measured?
67. What is meant by a 24", 10-point, hand crosscut saw?
68. Describe a hand crosscut saw. What is the shape of the teeth?
69. Write a sample order for two kinds of hand crosscut saws.
70. How are handsaws measured?
71. Write an order for two kinds of hand ripsaws.
72. How are hand ripsaws measured?
73. Describe the teeth of a crosscut saw.
74. Describe the teeth of a ripsaw.
75. Explain the action of a crosscut saw when cutting across the grain; when cutting with the grain.
76. Describe the action of a ripsaw when cutting with the grain; when cutting across the grain.
77. What is meant by the "set" of a saw?
78. What is the first step in sharpening a saw?

79. Describe a saw vise that can be made in the shop, using a sketch.
80. What kind of a file is used for sharpening a handsaw?
81. How are slim-taper files measured?
82. Describe a backsaw.
83. From what does a backsaw derive its name?
84. For what kind of work is a backsaw used? Why?
85. How are backsaws measured?
86. What is the difference in use between a Japanese saw and an American saw?
87. In what way is a Japanese saw superior to an American saw?
88. Describe a turning saw, using sketch.
89. For what is a turning saw used?
90. Describe a keyhole saw.
91. What are keyhole saws used for?
92. Describe a saw set.
93. How is a saw set adjusted?
94. Describe the action of a saw set.
95. Name the three processes of putting a saw in good order.
96. Describe fully the process of jointing a saw.
97. Describe fully the process of filing a ripsaw.
98. Describe fully the process of setting a saw.
99. Describe fully the process of filing a crosscut saw.
100. What is the difference in the shape of the teeth between a crosscut saw and a ripsaw?
101. What is an auger?
102. What is an auger bit?
103. How are auger bits measured?
104. How is the size of an auger bit shown, and on what part of the bit?
105. What does the number on an auger bit indicate?
106. Describe a bit brace.
107. How are braces measured?
108. What is a ratchet brace? Describe the mechanical principle of a ratchet brace.
109. Describe the process of sharpening an auger bit.

110. Name and describe the parts of an auger bit, telling the use of each part. Use sketch.
111. Explain the construction of an expansive bit.
112. What is a gimlet bit? In what way does it differ from an auger bit? For what is it used?
113. Describe a drill bit.
114. For what are drill bits used by a woodworker?
115. How are drill bits measured?
116. How are drill bits sharpened?
117. What is the commercial name for the kind of drill bit made for use in a bitbrace?
118. Explain the method of putting a bit in a brace.
119. How are screwdrivers measured?
120. How are screwdriver bits measured?
121. Make a sketch showing the proper shape of the bit of a screwdriver. (Bit in this case means the edge which comes against the screw.)
122. How are hammers measured?
123. Describe a "bell-faced claw hammer, 12-ounce," explaining the meaning of each term in full.
124. For what is a mallet used?
125. Why should a mallet instead of a hammer be used in chiseling?
126. Why should a hammer never be used in place of a mallet?
127. Give a rule for the use of the mallet and hammer that applies to all kinds of work.
128. Describe a hatchet.
129. For what is a hatchet used?
130. Describe an adze.
131. For what is an adze used?
132. Describe an axe.
133. For what is an axe used?
134. What is sandpaper? (Describe in full, telling how it is made, how it is classified, for what it is used, and give a general rule for its use.)
135. Describe a wooden miter box, using sketch.
136. What does "miter" mean?
137. Describe the construction of a C clamp, using sketch.

138. How are C clamps measured?
139. Describe a cabinetmaker's clamp. How does it differ from a C clamp?
140. For what are clamps used?
141. Sketch a simple form of clamp that can be made in the shop.
142. Describe a nail set. Explain its use and tell how nail sets are classified.
143. What is a countersink? Describe two kinds.
144. Describe a plumb and level.
145. For what is a plumb and level used?
146. Describe a hacksaw. For what is it used by woodworkers?
147. What are pliers? For what are they used by woodworkers?
148. Describe a woodworker's vise made with an ordinary bench screw.
149. How are bench screws measured?
150. Describe a rapid-acting vise.
151. Describe a machinist's vise.
152. Describe a wood rasp. How are wood rasps measured?
153. Describe calipers and give their principal uses.
154. What is a monkey wrench? Make a complete sketch.

[Based on Bench Work, Part II.]

1. What is mean by system in working?
2. What is mean by the term "rough dimensions?"
3. What is meant by the term "finished dimensions?"
4. What is meant by surfacing?
5. What is meant by facing?
6. Define jointing.
7. Describe the process of making a gauge line.
8. Describe the process of drawing a knife line around a piece of wood.
9. Describe the process of squaring an end with a backsaw.
10. Define (1) adjacent, (2) working face, (3) jointed edge.

11. Describe two ways of testing a surface that has been planed to a gauge line.
12. Describe two ways of testing an end that has been sawed to a knife line.
13. Name, in their order, the six steps in the process of preparing a piece of wood from rough to finished dimensions.
14. What is meant by the "work side" of a line? The "waste side?"
15. Describe the action of a block plane, explaining its use.
16. For what are block planes used? (Give proper use of the tool.)
17. Describe the process of measuring several spaces on the surface of a board, using the knife and ruler.
18. Why should a gauge line be made only where it is intended making a cut?
19. Explain the method of stopping the gauge at a given point.
20. Describe the process of chiseling across the grain between two saw cuts.
21. What size chisel should be used for making a cut $\frac{7}{8}$ inch wide between two saw cuts?
22. What is meant by splitting?
23. Explain the method of locating two points exactly opposite each other on the opposite sides of a piece of wood.
24. Make a sketch of a half-lap joint.
25. Illustrate by a sketch a half-lap dovetail joint.
26. What is a mortise?
27. Illustrate by a sketch a through mortise and tenon joint.
28. What is drawboring?
29. What is the correct proportion of wood to be cut away in making a mortise and tenon joint?
30. Illustrate by a sketch the proper method of constructing a nailed box.
31. Describe two ways in which a nail set can be used.
32. Give three rules for the use of sandpaper.

33. Illustrate by a sketch how to construct an angle of 45 degrees with the try-square and ruler.
34. Name the different steps which are followed in framing a picture.
35. Illustrate by a sketch a half-lap miter joint.
36. Illustrate by a sketch an open dovetail joint.
37. Name a kind of work in which open dovetail joints are used.
38. Illustrate by a sketch a half-blind dovetail joint.
39. On what kind of work are half-blind dovetail joints used?
40. Illustrate by a sketch a haunched mortise and tenon joint. On what kind of work is this joint used?
41. Illustrate by a sketch the process called "dowelling."
42. Name two kinds of work in which dowelling is used.
43. Illustrate by a sketch the process called "chamfering."
44. For what is chamfering used?
45. What is meant by keying?
46. Illustrate by a sketch a keyed mortise and tenon joint.
47. Illustrate by a sketch the correct method of constructing an angle of 30 degrees and an angle of 60 degrees.
48. Illustrate by a drawing two methods of constructing an octagon (1) in a square, (2) in a circle.
49. Define the following terms: Radius; diameter; circle; circumference; arc.
50. Illustrate by a drawing the way to construct a hexagon in a circle.
51. What is beading? Illustrate by a sketch.
52. What is molding? Illustrate by a sketch showing four different kinds of molding.
53. Describe the process called matching. What does matching mean?
54. Name two places in which matching is used.
55. What is cleating? Illustrate two different methods of cleating, using sketches.
56. Define paneling. Illustrate by a sketch two different methods of paneling.

57. Describe the different steps in the construction of a drawing board made of two pieces doweled and glued together, and cleated to prevent warping. Number these steps in the order in which they are done, making a separate statement of each one.
58. Give a list of all the tools used in making the drawing board described, naming them in the order in which they are used.
59. Describe the process of making an open dovetail joint, naming the tools used in the order of their use.
60. Describe the different steps in the process of making a box 4″ deep, 8″ wide, and 12″ long, (outside dimensions) giving each step in its proper order and naming the tools used in the order of their use.
61. Illustrate by a sketch three different kinds of half-lap joints, naming a common use of each.
62. Illustrate by a sketch three different kinds of mortise and tenon joints, giving one common use of each.
63. Illustrate by a sketch three different kinds of joints used in drawer construction.
64. Give two rules for the selection and use of nails in box construction.
65. Illustrate by a sketch the process called housing, and name two places where it is used.
66. Describe three ways by which a mortise and tenon joint can be fastened, telling for what purpose each is used.
67. Describe the process called rabbeting. Illustrate by sketch.

[Based on Timber and Its Preparation for Use, Part. III.]

1. What is timber?
2. Name the three divisions of Philippine plants which produce wood, giving one example from each group.
3. Where do fern trees grow? For what are they used?
4. Describe the structure of a fern tree.
5. Describe the structure of a bamboo stalk.
6. Describe the structure of a tree.
7. What is the difference in growth between a palm tree and a narra tree?

8. Name the two divisions of the Exogen or tree group, giving a wood of each division.
9. Where do pine trees grow? In what part of the Philippines are they most abundant?
10. From what do "conifer" trees take their name?
11. What are deciduous trees? Are there any in the Philippines?
12. Define (1) pith, (2) wood, (3) bark. Where are they located in a tree?
13. Define sapwood and heartwood. Where are they located in a tree?
14. Upon what does the proportion of sapwood and heartwood in a tree depend?
15. Define pith rays. Name two Philippine woods in which they can be easily seen.
16. What are growth rings?
17. Describe the formation of growth rings. Name two conditions which might stop the growth of a tree.
18. Describe and give the use of pores.
19. Of what is wood composed? Describe the uses of the different cells.
20. Describe the circulation of sap in a tree.
21. What causes the heartwood of a tree to become darker colored than the sapwood?
22. Why is the grain of a knot harder than the wood around it?
23. Define "grain."
24. Describe two conditions that cause crooked or irregular grain.
25. From what part of the tree are "one-piece" table tops obtained?
26. What connection is there between color and grain in wood? Name two woods that have a beautiful color but not a beautiful grain.
27. What causes color in heartwood?
28. Name three Philippine woods which have an odor when freshly cut.
29. Describe the cutting regulations that govern the timber industry of the Philippine Islands.

30. Describe the process of felling a tree.
31. What is the minimum diameter of softwood and hardwood trees that may be cut down?
32. Why do trees grow taller in the forest than out in the open country?
33. Name in their order the different steps in the preparation of timber for the market, starting with a living tree and ending with a piece of matched flooring.
34. Give two reasons why the selling price of Philippine timber is very high.
35. Outline the different means of transportation used in getting a narra board from the forest to the trade school.
36. Give three reasons why Oregon pine is brought to the Philippines in large quantities.
37. What is the difference in meaning between "hard" and "durable?"
38. Name three durable timbers which are found in the Philippines in large quantities.
39. Name three softwoods of the lauan family.
40. Name two medium-hard woods of the Philippines and give two common uses of each.
41. Name two timbers that are used for salt-water piling.
42. Name three woods that the shipworm will not destroy.
43. Name three woods that white ants will not eat.
44. Name four woods used in shipbuilding.
45. Name four woods that are valuable for use as house posts.
46. Name four woods that are durable when buried in the ground.
47. What kinds of wood make the best paving blocks?
48. Name three woods used in carriage building.
49. Name three woods used for making wooden shoes.
50. Name two woods that are used for making matches.
51. Name all the woods of the first group.
52. Name four common woods of the second group.
53. Name two woods of the third group and three woods of the fourth group.

54. On what is the commercial grouping or classification of Philippine woods based?
55. What are the forest charges on the different groups?
56. Describe five woods of the first group, stating (1) where found, (2) quality, (3) common uses.
57. Describe three woods of the second group, stating (1) where found, (2) quality, (3) common uses.
58. Describe two woods of the third group.
59. Describe two woods of the fourth group.
60. From what source does most of the narra that is sold in Manila come?
61. Where do the following woods grow most abundantly: Ipil, molave, acle, tindalo, banuyo, calantas, guijo, palomaria, teak, tanguile, apitong?
62. What is meant by seasoning?
63. Describe the process called "air seasoning."
64. Describe the process of kiln-drying lumber.
65. Describe the process of water seasoning.
66. Describe the proper method of piling lumber for storage or for seasoning.
67. What is the most important principle in seasoning lumber?
68. What will happen if lumber is piled so that there is no ventilation?
69. Describe four essential things in building a lumber shed.
70. What changes take place when lumber is seasoned?
71. What change often takes place after seasoned lumber is taken from the dry kiln?
72. What will happen if unseasoned lumber is used in furniture or cabinet work?
73. Define shrinking.
74. Define swelling.
75. Define warping.
76. Define checking.
77. What is meant by rot?
78. What conditions cause wood to rot?
79. What causes wood to warp? Illustrate by a sketch.
80. Describe three conditions that will cause wood to warp.

81. Describe three conditions that will cause wood to check.
82. What is a knot?
83. In what way do knots injure the value of timber?
84. In what way to knots increase the value of timber?
85. What is meant by the term "shaky" as used in describing timber?
86. What causes "pin holes" in timber?
87. Describe two methods of preserving timber.

[Based on Wood Finishing, Part IV.]

1. What is the first important step in wood finishing?
2. Describe the process of filling, giving conditions of the wood that make filling necessary.
3. Why must wood be well seasoned before it is polished?
4. Describe the process of varnishing, giving the different steps from a raw surface to a finished surface.
5. What liquid is used for mixing filler?
6. What is turpentine made from and what is its source?
7. Give the formula for mixing shellac.
8. Why is it necessary to have a clean and dust-proof room in order to do good varnishing?
9. How is a varnished surface brought to a dull finish?
10. How is varnished surface brought to a high polish?
11. What materials are used in rubbing a varnished surface?
12. Describe in full the process called French polishing, giving the materials used, the order in which they are used, and the method of applying them.
13. In what way is varnishing superior to French polishing?
14. Why is French polishing the best method for use in school shops?
15. Why is wax finishing the best for use on some classes of work? Name two kinds of work on which it is the best.
16. Describe in full the method of applying a wax finish, giving the materials used, the order of their use, and the method of applying them.

17. Describe the method of repairing a surface, French polished, that has been damaged by water.

[Based on Systems of Measuring, Part V.]

1. Why are both the English and metric systems of measuring used in the Philippines?
2. Name two industries in which the English system of measuring is used in the Philippines.
3. Why must a woodworker understand both the metric and English systems of measuring?
4. What is the metric unit of lineal measure used in the machine shop? In the furniture shop? In building? In surveying?
5. What is the English unit of length used in the machine shop? In the furniture shop? In building? In surveying?
6. What is the equivalent in English measure of the following: 1 centimeter? 1 kilometer? 1 meter?
7. What is the equivalent in metric measure of the following: 1 inch? 1 foot? 1 yard? 1 mile?
8. Give three common metric units used in measuring surfaces.
9. Give four common English units used in measuring surfaces.
10. What is the equivalent in metric measure of the following: 1 square foot? 1 square yard? 1 acre?
11. What is the equivalent in English measure of the following: 1 square meter? 1 hectare?
12. Name three common metric units used for measuring volume.
13. Name three common English units used for measuring volume.
14. What is the equivalent in metric measure of the following: 1 cubic inch? 1 cubic foot? 1 cubic yard?
15. What is the equivalent in English measure of the following: 1 cubic centimeter? 1 cubic decimeter? 1 cubic meter?
16. What is the metric unit for measuring lumber? Where is it used and by whom?

17. What is the English unit for measuring lumber? Of what does it consist?
18. About how many board feet of lumber can be sawed from 1 cubic meter.
19. What is the equivalent in metric measure of 1 board foot?
20. What is the common method of transposing from metric to English in finding the number of board feet in a piece of construction?
21. How does a lumberman estimate the number of board feet of lumber that a tract of timber will produce?
22. Define the term "standard sizes" as used in the lumber business. Illustrate by naming ten standard sizes into which building materials are cut.
23. In what way do these standard sizes affect a builder in working to plans drawn to a metric scale?
24. What Philippine timbers are not cut to standard sizes, and why?
25. What is the metric unit for liquid and dry measure? From what is it taken?
26. Give the English table of liquid measure.
27. What is the equivalent in English measure of 1 liter?
28. What is the equivalent in metric measure of 1 quart? Of 1 gallon?
29. What is the metric unit of weight? From what is it taken?
30. Give three common English units of weight.
31. What is the equivalent in English measure of 1 kilo?
32. What is the equivalent in metric measure of 1 pound? Of 1 ton?
33. How many are 1 dozen? 1 gross?
34. How many sheets of paper make 1 quire? 1 ream?
35. What is the equivalent in metric measure of 1 vara? Of 1 cavan? Of 1 picul? Of 1 ganta?
36. What is the equivalent in English measure of 1 vara? Of 1 cavan? Of 1 picul? Of 1 ganta?
37. Name ten different commercial articles or products that come to the Philippines packed or measured by the English system.

MISCELLANEOUS PROBLEMS IN TRANSPOSING.

The problems which follow do not in any way supersede the book of "Supplementary Questions for Trade Schools and Trades Classes in the Philippine Public Schools" issued by the Bureau of Education and now in use. The practical questions in this book are taken from the subject matter in the book itself, and are intended as an aid in studying the text.

The systems of transposing explained herein are slightly different from those taught in the common school arithmetic, in that they have been simplified by the removal of small fractions and arranged for practical use in estimating. If they are taught or studied with reference to the explanation given, it will be seen that they do not conflict with any other text now in use.

The problems in estimating are merely additional to those already in use and can be used as such. They are so worded that they can be taught by actually placing the article of furniture before the student and allowing him to work from it in making his estimate.

In solving these problems, the directions given on page 177 should be followed, where reference is made to selecting the unit that is to be used.

1. What is the approximate equivalent in English measure of 3 meters?

Method of solving.—One meter equals about 39½″. Dividing this into feet, inches, and fractions of inches, we have the following: 1 meter equals 3 feet, 3 inches, ½ inch. Multiplying each of the above figures by 3, we find that 3 meters equals 9 feet, 9 inches, and 1½ inches, or 9′ 10½″.

The foregoing method is very easy to remember; and any ordinary problem of transposing from meters to feet can be done by mental arithmetic.

2. Find the approximate equivalent in English measure of 7 meters.
3. Of 21 meters.
4. Of 17 meters.
5. Of 8.3 meters (multiply by 39.5 and divide by 12).
6. Of 11 meters.
7. Of 37 meters.
8. Of 15.5 meters.

9. Of 10 centimeters. (Use $\frac{3}{8}''=1$ cm. for any number less than 30 cm.)
10. Of 19 centimeters.
11. Of 6 kilometers.
12. Of 25 kilometers.
13. Of 33.75 kilometers.
14. Of 57.25 kilometers.
15. Find the approximate equivalent in metric measure of $1\frac{1}{2}$ feet.
16. Of 2 feet 3 inches.
17. Of 29 inches.
18. Of 17 inches.
19. Of 24 feet.
20. Of 52 feet 10 inches.
21. Of 77 inches.
22. Of $1\frac{1}{2}$ inches.
23. Of 24 miles.
24. Of 40 yards.
25. The distance between two cities is 160 kilometers. How long would it take an automobile, traveling at the rate of 25 miles an hour, to make the trip?
26. A man can walk at the rate of 4 miles in one hour. How many kilometers can he walk in six hours?
27. Starting from a given point, how much is a mile in actual distance? A kilometer? (To answer this question, two local points should be given, such as the distance from the Luneta in Manila to the Pasig River, down Malecon Drive, which is about 1 kilometer.)
28. Walking rapidly, a man travels about 5 kilometers in one hour. How far is it from your home to the place where you study or work? (Give length of time required to walk this distance.)
29. The posts of a building are 20 centimeters square and 5 meters long. What standard size in English dimensions would need to be ordered?
30. The rafters of a building are $.05\times.15\times7$ m. What standard size English measure would be used?

31. Change the following list of building materials to the nearest equivalent in English standard sixes:

    6 pieces $.08 \times .08 \times 5.5$ m.
    6 pieces $.06 \times .09 \times 7.25$ m.
    6 pieces $.22 \times .30 \times 8$ m.
    6 pieces $.16 \times .25 \times 9.75$ m.

32. A table top is 76 cm. wide and 152 cm. long. What are its dimensions in inches?
33. How many meters in $\frac{1}{2}$ mile?
34. How many feet in .75 kilometer?
35. A building is 15 meters wide and 30 meters long. How many square feet in its floor?
36. A floor is 18 meters wide and 53 meters long. How many square yards of matting will be required to cover it?
37. What is the approximate equivalent in metric measure of 5 square feet?
38. What is the approximate equivalent in metric measure of 3 square yards?
39. Of 7 square feet?
40. Of 121 square feet?
41. Of a rectangle 3 feet wide and 4 feet long?
42. Of 16 square yards?
43. A building is 50 feet wide and 154 feet long. How many square meters are there in its floor?
44. A building is 6 meters wide and 10 meters long. How many square feet are there in its floor? How many square yards?
45. How many hectares are there in 39.52 acres?
46. How many hectares are there in 186 acres?
47. How many acres are there in 80.94 hectares?
48. How many acres are there in 93 hectares?
49. What is the approximate equivalent in metric measure of 12 cubic inches?
50. Of 18 cubic inches?
51. Of 4 cubic feet?
52. Of 23 cubic feet?
53. Of 9 cubic yards?

54. Of 57 cubic yards?
55. What is the approximate equivalent in English measure of 7 cubic meters?
56. Of 9 cubic meters?
57. Of 122 cubic meters?
58. Of 235 cubic centimeters?
59. Of 24 cubic centimeters?
60. Of 27.89 cubic meters?
61. A lumberman estimates that there are 456,234 cubic meters of timber standing in a forest. How many board feet can be cut from it?
62. How many board feet can be cut from 248 cubic meters of lumber in the log?
63. How many cubic centimeters of wood are there in 18 board feet?
64. In 47 board feet?
65. A contractor estimates that in making the foundations of a building he will need to move 20 cubic meters of earth. His wagons will carry 1 cubic yard at one load. How many loads will be removed?
66. A contractor has agreed to deliver 300 cubic meters of gravel. His truck will carry 6 cubic yards in one load. How many trips will be needed to make the delivery?
67. A concrete building requires 2,500 cubic meters of sand and gravel. The contractor must purchase his material by the cubic yard. How many cubic yards will he have to order?
68. A concrete building requires 3,900 cubic yards of sand and gravel. How many cubic meters will be used?
69. How many cubic meters of earth will be required to fill a hole 12 feet deep 18 feet wide and 90 feet long?
70. A city lot is 40 meters wide and 108 meters long. How many cubic meters of earth will be required to raise its level 1.5 meters?

71. How many board feet are there in 8 pieces of timber 4″×10″—18′?

The following method can be used where the length of timber is given in feet:

$$\frac{8\times\cancel{4}\times 10\times\cancelto{6}{18}}{\cancelto{\cancel{3}}{12}}=8\times 10\times 6=480 \text{ bd. ft.} \quad (\textit{Ans.})$$

72. How many board feet are there in 6 pieces 2″×12″—20′.
73. In 9 pieces 3″× 3″—16′.
74. In 12 pieces 4″× 4″—14′.
75. In 27 pieces 2″×14″—30′.
76. How many board feet are there in a table top 30 inches wide 70 inches long and 1 inch thick?

When all the dimensions are given in inches, the easiest method is to multiply all dimensions and divide by 144.

1×30×70=2100÷144=14.44 plus. (*Ans.*)

In actual practice about 15 board feet would be used, on account of the waste.

77. How many board feet in the following:
    4 pieces 1″× 4″×16″.
    6 pieces 1″×12″×22″.
    8 pieces 2″× 6″×35″.
78. The following pieces are required to build a table:
    4 pieces 4″× 4″×28″.
    2 pieces 1″× 4″×32″.
    2 pieces 1″× 4″×54″.
    1 piece 1″×30″×60″.

    How many board feet of lumber will be required to build 10 tables, allowing 10% for waste?

[NOTE.—In the making of estimates of building materials lumber is accounted for in two ways—by measuring the rough stock as it comes from the lumber pile or by adding a percentage for waste to the amount that is actually in the finished article. This percentage varies with the size of the job. If less than 10 board feet are used, about 30 per cent should be added; if more than 10 but less than 50 board feet, about 20 per cent should be added; if more than 50 but less than 100 board feet, about

10 per cent if more than 100 board feet, about 5 per cent should be added. This applies principally to furniture work. In building construction it is customary to order by standard sizes, giving the number of pieces required of each size. In the latter case there is no waste and therefore the whole amount of the order can be expended.]

79. What will the following bill of materials cost at ₱85 per 1,000 board feet?

12 pieces 6″× 6″—22′.
48 pieces 2″× 8″—32′.
184 pieces 2″× 4″—14′.
240 pieces 1″×12″—16′.

80. A floor is required in a building which is 12 meters wide and 48 meters long. The floor is to be laid on timbers 5×15 cm. placed about ½ meter apart from center to center. The flooring material is to be 2½ centimeters thick. What will be the cost of laying this floor with lauan, at ₱90 per 1,000 board feet?

81. How many board feet of lumber will be required to make 100 drawing boards 2.3×55×75 cm.?

82. The gable ends of a house are 40 feet wide at the plate and 12 feet from the plate to the ridge. How many square meters of sawali will be required to cover them?

[NOTE.—It should be remembered that in making an estimate for building materials, a full unit must usually be purchased. To illustrate: If it is estimated that 4.7 square meters are required, 5 square meters must be purchased. If a piece of timber 15′ 6″ is required, a 16′ piece must be ordered. In working out these problems, the necessary change should be made after the exact result has been found.]

GENERAL SUGGESTIONS FOR ESTIMATING.

An estimate is a statement of the cost of producing a specified article or of doing a given amount of work. The word "estimate" is usually accompanied by an adjective which states what kind of an estimate it is. In this connection we say "rough estimate," "close estimate," "exact estimate," "liberal estimate,"—meaning how close to the exact cost the estimate must be.

An estimate does not always show cost in pesos and centavos. We may estimate the amount of time, or the amount of material, or the amount of labor required for a job. A good shopman can often give a very close estimate without making any calculation, because he carries a great deal of information in his head. He simply compares the problem at hand with other jobs of the same kind that he has done in the past.

In the questions given on estimating, a close estimate will give the correct answer. It is seldom safe to make an exact estimate. Many things may happen that will make a difference after a job is started. One single item of cost, overlooked in the estimate, may mean working at a loss. An experienced shopman will first make an exact estimate of the cost and then add a percentage, so as to be on the safe side. To illustrate: He is asked to estimate the cost of building a table. His figures show that it can be built for ₱12, but he tells the customer that the cost will not exceed ₱15. If this price is satisfactory, he goes ahead with the work. If any accident occurs, or if something has to be done that has been overlooked, he is thereby protected. On the other hand, if the job is actually done for ₱12, he can reduce the price and his customer will be pleased. This is the only safe method. If an agreement is once made to do a job for a certain amount, the price should not be raised, even if the shop loses money. Therefore the workman has a right to name his own price and should always be sure that it is enough.

The tables for transposing given in this book are not exact. Small fractions have been increased and all the equivalents thereby reduced to numbers that are easy to remember. Since an estimate should always be a little greater than the exact figures show, these equivalents can be used with perfect safety for estimating purposes.

When a student of woodworking first begins to make a study of estimating, he finds that there is a great difference between the exact arithmetic of the classroom and the practical arithmetic of the shop. To illustrate this point: Find the number of board feet in a table top 2 cm. thick and

1 m. square. Worked out in exact arithmetic, the answer would be 8.3 board feet; worked out practically in the shop, at least 12 board feet of lumber would be used.

ESTIMATING AND ORDERING LUMBER.

The shopman is often required to estimate the amount of lumber needed to run his shop for a given time, or to estimate the amount of lumber to be ordered for a piece of work. He must be able to write his order in language that the lumber dealer will understand. He must also order his lumber in dimensions that the lumber dealer can supply. He must, sometimes, even change his work, so that it will match the lumber he can obtain. The best plan is to visit the place where lumber is cut and get the information from the millman.

There are many statements made in American textbooks that do not apply to conditions in the Philippines. The woodworker must study the local systems for cutting timber and not depend on books for this information. American "standard sizes" are used here only on the cheapest woods. Our best furniture woods are not cut to standard sizes. Standard thickness is usually observed; but width and length depend on the size of the log from which the piece is taken. When ordering such lumber the best way is to state the required thickness and the minimum width and length that will be accepted.

Sample order:

200 board feet, narra, red, 1″×10″ up—8′ up.
300 board feet, narra, red, 2″×12″ up—8′ up.
400 board feet, narra, red, 4″×4″ random lengths.
200 board feet, camagon, 2″×8″ up—random lengths.

The word "up" written after figures indicating width and length explains to the lumber dealer that greater widths and lengths will be accepted, but not less. "Random lengths" means in any length that can be furnished. If exact dimensions are given for some high-priced wood, the dealer may refuse the order, as he might lose so much in waste that there would be no profit. If the order is a small one, he will either refuse it or charge a very high rate to cover the waste.

When standard sizes are ordered, they should be written as follows:

16 pieces 2″×4″—16′................ 171 bd. ft.
122 pieces 2″×6″—18′................ 2196 bd. ft.

The number of pieces is given first, as this is the first question that the millman considers.

A common mistake among beginners is that of thinking they have been cheated by the lumber dealers, when they have really received just what they ordered. When lumber is ordered to a given thickness, it is always understood as rough dimensions unless "full thickness" is specified. To illustrate: A piece is ordered 1″×12″—16′, planed on two sides. The millman will take a piece 1″ thick and plane it. When delivered it will be about 13/16″ thick. The millman uses about 1/8″ in surfacing the first side and 1/16″ on the second. If a full-inch thickness is wanted, the order should read "1″×12″—16′, planed two sides, full inch thick."

In the lumber business abbreviations are used to show planed work. S-1-S means that one of the broad sides is surfaced; S-2-S, that the two opposite sides are planed; S-3-S, two sides and one edge; S-4-S, both sides and both edges.

In writing the dimensions of a piece of lumber, several systems are used. One of the commonest is that which has been used throughout this book—thickness first, width second, and length last. The reason for writing dimensions in this order is easy to understand. From the time that the log enters the sawmill until it leaves the shop made up into furniture, the three dimensions are obtained in that order. A workman naturally looks first for the dimension that he is going to get first, therefore it should have first place. If all the dimensions of a piece are in inches, the multiplication sign is used between all three, as 2″×4″×18″. If the length is in feet, it is better to separate the width from the length by a dash (—). This indicates that the length is in feet and lessens the chance for mistakes, as 2″×4″—18′.

When dimensions are stated by the metric system, the decimal point is of particular importance. In furniture work it is customary to use the centimeter as the unit, omitting the decimal point, or using it only to indicate fractions of centimeters, as, 2×12×20.5 cm. If the sign indicating centimeters is left off, the dimensions will be taken as meters.

Other details in estimating: Besides the problem of finding the amount of lumber used, there are many other things which the workman must consider in making an estimate. The details of an estimate would be about as follows:

Amount of lumber, and its value.
Amount of nails and screws, and their value.
Glue and sandpaper, and their value.
Finishing materials—such as shellac, alcohol, paint, wax, varnish—with their value.
Cost of labor, either by the job or by the hour.
Miscellaneous hardware; such as handles, hinges, bolts, locks.

After finding the total cost, the workman adds whatever he thinks necessary to make his estimate a sure one for himself. This amount is the statement given to the customer. The shopman does not usually disclose anything but the total amount of his estimate.

PROBLEMS IN ESTIMATING.

1. Estimate the cost of making the dining table shown in Plate VIII, giving cost of production and estimate furnished to customer.

Bill of lumber:
4 pieces, 4"×4"×28", legs.
2 pieces, 2"×4"×40", cross pieces, bottom.
2 pieces, 2"×4"×56", cross pieces, bottom.
1 piece, 2"×60"×60", top.

Total number of board feet in finished table, 73 bd. ft., plus 10 per cent to cover waste, 80.3 bd. ft. As .3 is less than 1/2, it is dropped, making the estimated amount 80 bd. ft.

80 bd. ft. of lauan, @ ₱.09 per bd. ft.	₱7.20
Estimated value of labor	8.00
16 screws, @ ₱.05 each	.80
1/10 kilo glue, @ ₱1 per kilo	.10
5 sheets sandpaper, @ ₱.05	.25
1 pound filler @ ₱.60	.60
1 liter turpentine	.50
1 pound wax	1.00
Total cost	18.45
Plus 20 per cent profit or surcharge	22.14

Estimate furnished to customer: "This table can be built at a cost not to exceed ₱25."

The prices given in the above estimate cannot be used invariably. The value of materials differs in various localities and the shopman must keep a price list of his materials on hand at the figure he has to pay in his own town.

If the work is done in a Government school or shop, a percentage called "surcharge" is added to the cost of producing an article; if it is done in a private shop, the workman or foreman adds whatever he thinks best.

2. Make an estimate showing the cost of production and the selling price of the chair shown in Plate IV.
3. Estimate the cost of producing the book shelf shown in Plate VI.
4. Estimate the cost of making 10 school desks such as are shown in Plate IX. Material, lauan.
5. Estimate the selling price of 25 chairs such as are shown in Plate X. Material, lauan.
6. Estimate the selling price of a student's table such as is shown in Plate V. Material, tanguile.
7. Estimate the cost of making a rocking chair such as is shown in Plate XI. Material, red narra.
8. Estimate the cost of making 50 drawing tables like the one shown in Plate XII.

QUESTIONS FROM MISCELLANEOUS TABLES.

9. A tank measures $1\times1\times1$ m., inside dimensions. How many liters of water will it hold? How many gallons?
10. A dealer receives an order for 40 liters of turpentine. He receives his turpentine in 5-gallon cans and will not sell less than a whole can. How many cans does he deliver to fill the order?
11. How many 1-quart cans of paint will it take to fill an order for 50 liters?
12. 100 kilos of floor wax are ordered. The dealer must fill the order with cans containing 1 pound each. How many cans does he deliver?

13. The following order is given to a hardware merchant;

    25 kilos nails, wire, 2½″.
    16 kilos nails, wire, 3″.
    10 kilos paste filler.
    5 liters varnish.

    His nails are put up in 5-lb. packages, his filler in 1-lb. cans, and his varnish in 1-qt. cans. None of these quantities can be broken. How does he fill the order?
14. What is the equivalent in metric measure of 25 pounds?
15. Of 143 pounds?
16. Of 288¼ pounds?
17. What is the equivalent in English measure of 24 kilos?
18. Of 93 kilos?
19. Of 2,000 kilos?
20. How many liters in 1 barrel?
21. How many kilos can be carried on a 5-ton truck?
22. Write a sample order for the following:

    Common wire nails.
    Wire finishing nails.
    Flat-head, bright-wood screws.
    Carriage bolts.
23. Write a sample order for the following:

    Brass butts.
    Padlocks.
    Round-head, brass, wood screws.
    Cupboard locks.
24. Write a sample order for the following:

    Paint.
    Petroleum.
    Hammers.
    Auger bits.
25. Write a sample order for the following:

    Machine bolts.
    Four sizes of building timber.
    Corrugated-iron roofing.
    Common wire nails.

26. Write a sample order for the following:
    Red narra.
    Tanguile.
    Camagon.
    Ipil.
27. Write a sample order for the following:
    Stove bolts.
    Glass.
    Mirrors.
    Flat-head, brass, wood screws.
28. Write an order to a hardware firm in Manila ordering the following tools: Chisels, try-squares, backsaws, and bit braces.
29. Write an order to a firm in Manila ordering the following: Floor wax, paste filler, alcohol, shellac, paint.
30. How long is a 10-penny nail?
31. In using flat-head wood screws 2″, No. 14, what size of bit would be used to bore for the body of the screw?
32. What length of carriage bolts would be used to bolt together two pieces of timber, each 2 inches thick?
33. How are washers measured?
34. How are carriage bolts measured?
35. How is corrugated-iron roofing measured?
36. How are wood screws measured?
37. How are nails measured?
38. How are padlocks measured? Cupboard locks? Butts?
39. How are hammers measured? Auger bits? Handsaws?
40. How are try-squares measure? Bit braces? Nail sets?
41. How are chisels measured? Dividers? Planes?
42. How are drawknives measured? Gouges? Spokeshaves?
43. How are drill bits measured and how is the measurement shown?
44. How are gauges measured? Rulers? Scrapers? Oilstones?
45. How are grindstones measured? Oil cans? Files?
46. How are circular saws measured? Band saws? Turning saws?

Part VII.—WOOD TURNING.

The art of wood turning is very ancient and plays a very important part in connection with woodworking. The machine on which this work is performed is called a lathe. The tools used are somewhat like the tools of the bench, but are made in slightly different forms and have different names.

While wood turning is very difficult for a beginner in woodworking, it is very easily learned by one who has had considerable experience in using bench tools. Through such experience, the workman learns how to read the grain of wood and how to apply the tools in such a way that they will not follow the grain and split over the lines. One who understands the grain of wood thoroughly can easily learn to do practical turning in two months of daily work.

A beginner has much more difficulty. He has the problems of a lathe turning at a high rate of speed, material that he does not understand, and the possibly dangerous task of finding out by experience what will happen when he puts the tools against the work. He usually learns his first lesson by tearing the stock into splinters, and he may be considered fortunate if it does not break out of the lathe and injure him.

Lathe work should not be begun by any student until he has had at least one year's experience in bench work.

Wood turning is usually taught by a series of exercises which include all the common projects. The student must learn the names and uses of the different parts of his lathe, how to adjust them, and how to keep them in order; also the names and uses of the different tools, how to sharpen them, and how to keep them in order. The course which follows will begin with the first step and take up each important lesson in its proper order. Since it is assumed that the student has already learned how to sharpen and care for

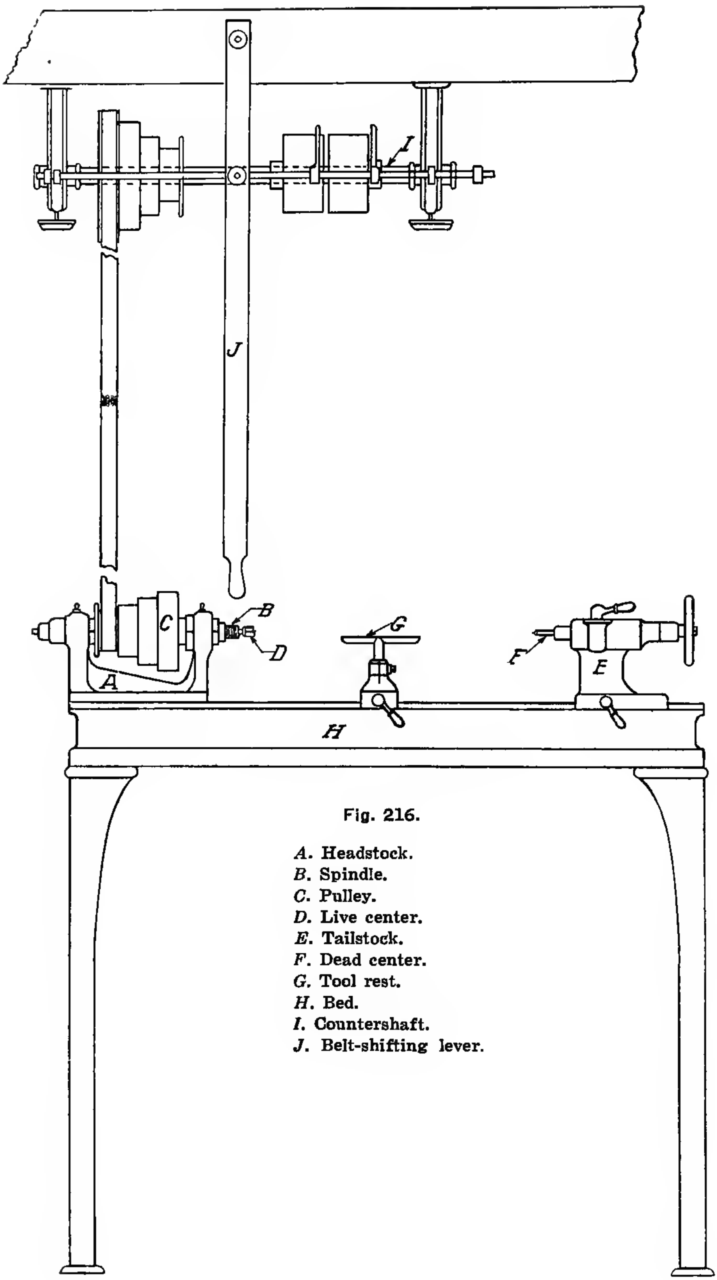


Fig. 216.

A. Headstock.
B. Spindle.
C. Pulley.
D. Live center.
E. Tailstock.
F. Dead center.
G. Tool rest.
H. Bed.
I. Countershaft.
J. Belt-shifting lever.

tools, and how to read working drawings, the lessons are arranged accordingly.

EQUIPMENT.

Turning lathe.—Figure 216 represent a turning lathe of a common form. The different parts are lettered and explained in the table which goes with it.

A study of the lathe should begin with the power which drives it. The power usually comes from the engine to a line shaft which runs through the shop and supplies power to all the machines. From the line shaft, the power is transmitted to the countershaft of the lathe. The countershaft is provided with a tight and a loose pulley. The belt which drives the lathe can be shifted from one pulley to the other by a shifting lever. When the belt is on the loose pulley, the lathe stops as this pulley turns free on the countershaft. The lathe is started by shifting the belt from the loose to the tight pulley.

The countershaft is provided with what is called a "cone pulley." The cone pulley has four wheels of different diameters. The headstock of the lathe has a corresponding cone pulley set opposite to the cone pulley of the countershaft. When the belt is on the largest pulley of the countershaft it is on the smallest pulley of the headstock. This gives the highest speed. When the belt is on the small pulley of the countershaft and the large pulley of the headstock, the belt gives the lowest speed. The different speeds are used for different diameters of stock, high speed being used for small stock, slow speed for stock of large diameter, and medium speeds for medium work. An ordinary wood lathe is made to turn small stock with safety at a maximum speed of 3,000 revolutions per minute.

Lathes are measured by the length of their beds and by their capacity. Capacity is measured by the greatest diameter that can be turned (this is commonly called the "swing") and by the greatest length that can be placed between centers.

The two centers or points which hold the stock are called the *"live" center* and the *"dead" center*. The live center turns the stock and the dead center holds it in position. The live center is held in the *headstock* and the dead center in the *tailstock*. Figure 217 shows a sectional view of the headstock. The spindle or shaft of the headstock is hollow. The live center, which turns the wood, is tapered in shape and is wedged into the hole in the spindle. It can be removed by driving it out with an iron rod through the hole in the spindle.

The end of the spindle which contains the live center or "spur," is provided with a thread to receive a face plate or chuck. Figure 218 illustrates two forms of face plates

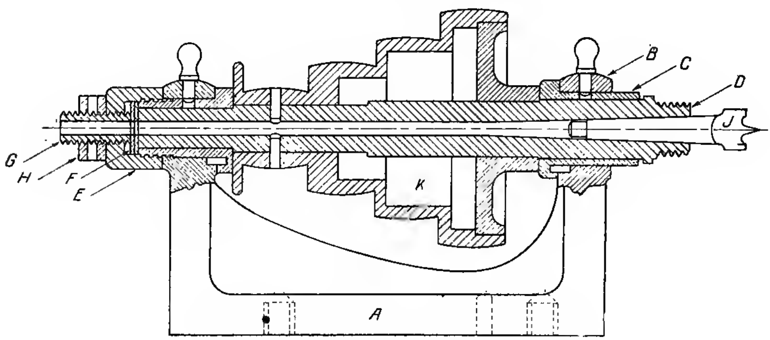


Fig. 217.

A. Headstock casting. *B*. Cap. *C*. Bearing. *D*. Spindle. *E*. Bearing locknut. *F*. Thrust bearing disks. *G*. Thrust bearing adjustment screw. *H*. Locknut for *G*. *J*. Live center. *K*. Cone pulley.

and a chuck. They are used for turning articles, such as hollow boxes and trays, that cannot be placed between the centers. The other parts of the head stock are explained on the drawing itself.

The tailstock is fastened to the bed of the lathe in such a way that it can be moved and adjusted to fit different lengths of work. Figure 219 shows a cross section of a tailstock. The different parts are named and explained on the drawing. In using the lathe, move the tailstock up close to the work and force the dead center into the end of the wood by turning the handwheel. Then tighten the set screw, which holds it in place. It will be noted that the tail-

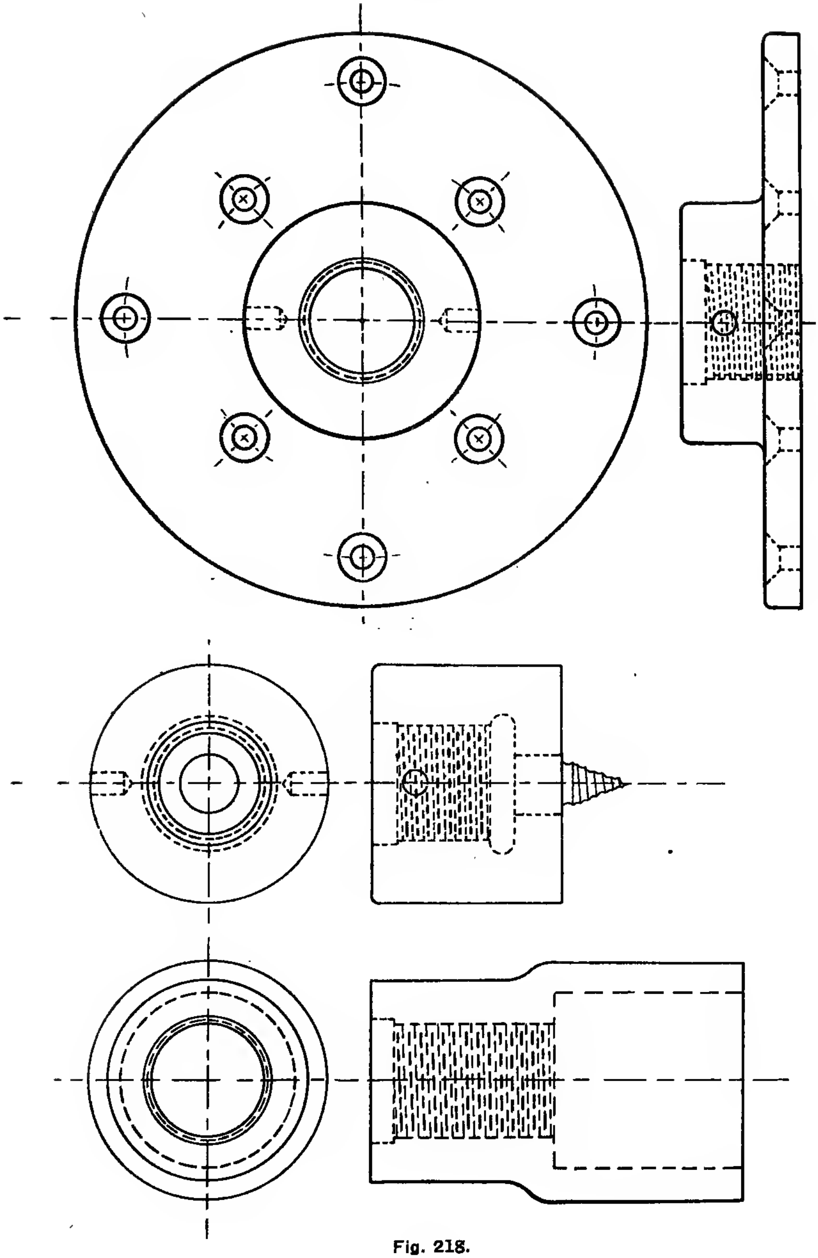


Fig. 218.

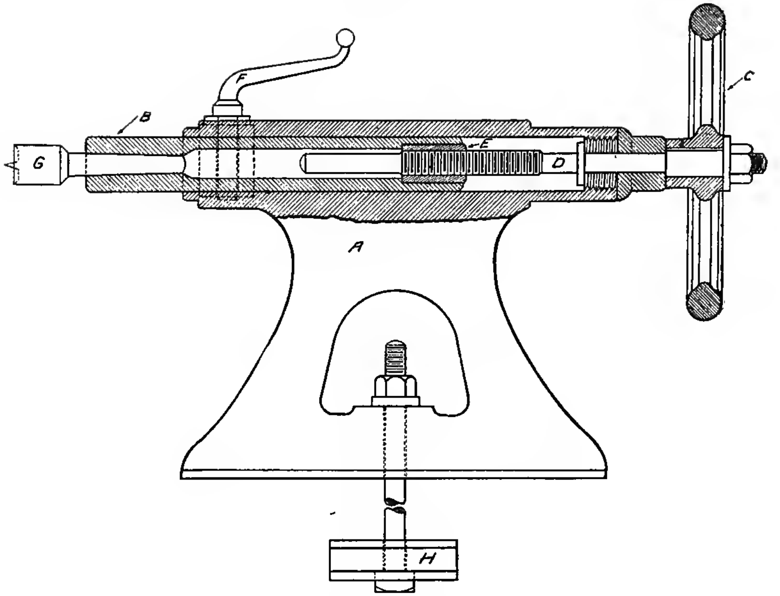
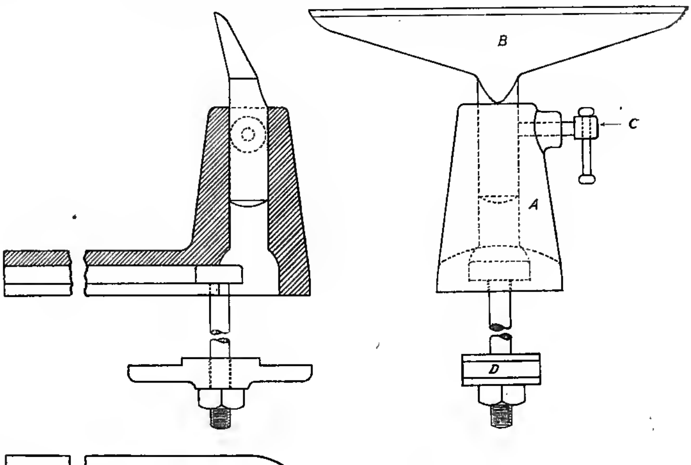
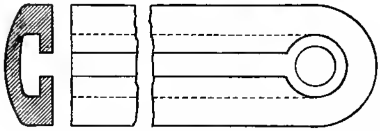


Fig. 219.

A. Tailstock. *B*. Spindle. *C*. Handwheel. *D*. Screw. *E*. Spindle nut. *F*. Clamp. *G*. Dead center. *H*. Tailstock clamp.





A. Bedplate and T-screw.
B. T-rest.
C. Rest clamping screw.
D. Bedplate clamp.

Fig. 220.

A. Bedplate and T-screw. *B*. T-rest. *C*. Rest clamping screw. *D*. Bedplate clamp.

stock spindle is also hollow. When the handwheel is turned until the screw is as for back as it will go, the end of the screw presses against the dead center and pushes it out of the spindle.

The *toolrest* (fig. 220) is also made up of several pieces. It is named from its use—that is, the tools rest against it when they are cutting. The tool rest can be loosened so that it can be moved along the bed of the lathe by turning a handle. At the same time that this screw is loosened, the socket which holds the tool rest is also released so that it can be moved in or out across the bed of the lathe. The tool rest is adjusted by means of a set screw. The different parts are explained in the drawing.

Tools used in turning.—In wood turning, as in every other trade, there are tools that go with the trade. Each of these tools is made for a special use; but, as in bench work, one tool is often made to do the work of another tool. The list of tools which follows is a satisfactory set for plain turning:

Measuring tools.—A 2-foot, English and metric rule; a pair of outside calipers; a pair of inside calipers; a pair of compasses.

Sharpening tools.—An oilstone, a slip stone, an oil can, and a piece of leather to use as a strop.

Cutting tools.—One ¼-inch or ⅜-inch turner's chisel; one ⅞-inch or 1-inch turner's chisel; one ¼-inch or ⅜-inch turner's gouge; one ⅞-inch or 1-inch turner's gouge; one ¼-inch to ½-inch round-nose scraping tool; one ⅜-inch or ½-inch square-nose scraping tool; one ⅜-inch or ½-inch diamond or spear point tool; one ⅛-inch or ¼-inch cut-off or parting tool.

Wood turners often use a sizing tool where a large number of pieces of the same diameter are to be cut.

Other tools used in connection with turning are the mallet, center punch, bit brace, small drills, screwdriver, and monkey wrench.

Grinding and sharpening turning tools.—The work of making a sharp edge on any cutting tool differs very little from the operations as already explained on pages 28–31. The angle shown on each tool illustrated is exactly what it should be when the tool is properly ground. As in sharpening chisels or other edge tools, the angle may be changed to suit the class of work on which the tool is to be used.

Turning gouges are ground on the grindstone and sharpened with a slip stone. If a regular slip stone cannot be obtained, a good substitute can be made by taking a broken

Fig. 221.

or worn-out oilstone and changing its shape. A hollow is made in one of its surfaces for sharpening the outside of the gouge, and one of its edges is rounded for sharpening the inside of the edge. The regulation slip stone (fig. 47) is much the best and should be used if possible. The same care should be used as in sharpening a chisel to keep the

Fig. 222.

flat or straight side from becoming rounded at the edge. After the tool has been sharpened, it can be brought to a still finer edge by honing or rubbing on a piece of leather.

Uses of tools.—In turning, the gouge takes the place of the jack plane in bench work and generally serves for all kinds of work, from the roughest to the finest. It is used for removing the greatest part of the waste in preparing the stock from square to round. Figure 221 shows a turner's gouge. The extra-long handle makes the tool steadier when in use.

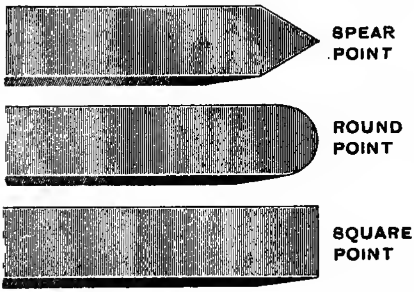


Fig. 223.

The turner's chisel (fig. 222) is used after the gouge to bring the surface down to the exact dimensions. Its sharp point is also used for making cuts into the work and for trimming ends. It has many other uses which will be explained as they occur in the work.

The round-point scraping tool (fig. 223) is used, as its name indicates, for scraping rather than cutting. Its uses will be explained as they occur in the work.

Fig. 224.

The square-point scraping tool (fig. 223) is used for scraping on flat surfaces. The different ways of using it will be explained as they occur. The spear-point tool takes

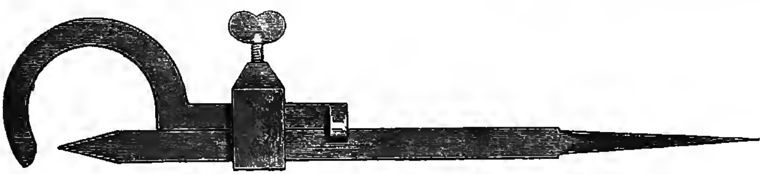


Fig. 225.

the place of the turner's chisel for inside work or on work where the chisel cannot be used to good advantage. Figure 223 shows the usual angle for this tool. The angle is sometimes changed to suit special work.

The cut-off or paring tool is shown in figure 224. It takes its name from its use in "cut-off" work, where a narrow space often prevents the use of a wider tool. It is also used for sizing as shown in figure 235.

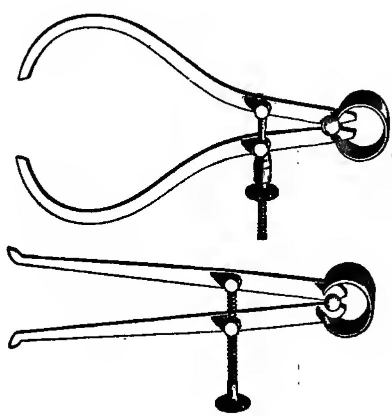


Fig. 226.

The sizing tool (fig. 225) is used on work where a number of pieces are to be made the same diameter. It is adjusted by means of a set screw.

Calipers.—Figure 226 illustrates the two forms of calipers used in wood turning The outside calipers are used for measuring outside diameters, and the inside calipers for inside diameters.

Dividers (fig. 13) are a common tool in bench work. Their various uses in turning will be explained as they occur.

EXERCISES IN WOOD TURNING.

Exercise 1.—TO TURN A CYLINDER.

Material required: Four pieces of square stock, lauan or some similar softwood, 2 by 2 by 12 inches.

To place the work in the lathe: The centers of each end are found by drawing the diagonals. Next, these centers are marked deeply with a center punch. Place the point of the live center in the punch mark at one end and then push the tailstock along until the point of the dead center is in the punch mark at the other end. Clamp the tailstock to the lathe bed. Next, turn the handwheel until the two centers are forced into the work; then loosen it just enough so that the lathe turns easily and clamp the hand screw. Then set the tool rest and clamp it into position. The rest is adjusted at different heights, depending on the diameter of the stock. For this exercise it should be about even with the centers of the lathe and as close to the stock

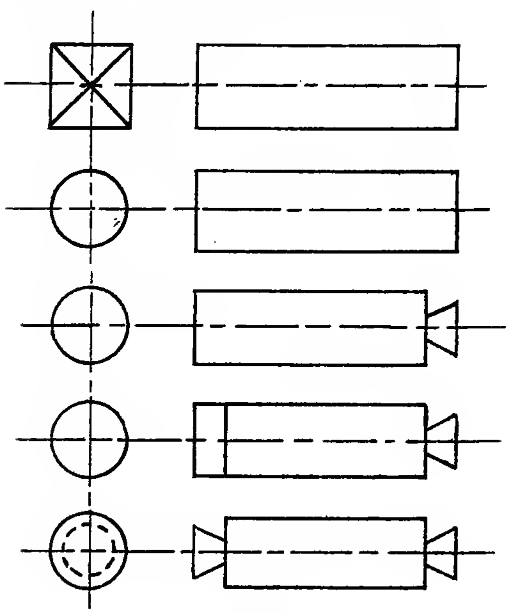


Fig. 227.

as possible. Lastly, a few drops of oil are put on the dead center and the work is ready for cutting.

The different steps to be taken in doing this exercise are shown in figure 227. The first step is called "roughing down" and is done with the gouge. Figure 228 illustrates the method of holding the gouge. The left hand is placed on top of the gouge in order to hold down the tool and guide it along the tool rest. The right hand is held at the end of the handle. The elbows should be kept as close as possible to the workman's sides, and he should stand in a natural, easy position, facing the lathe squarely, with the left foot a little advanced.

Fig. 228.

The cutting is commenced at the right-hand, or dead-center, end of the piece. The tool is made to cut by raising the handle with the right hand until the edge touches the work. The gouge is passed along the rest, stopping a safe distance from the left end. This removes the square corners. Great care should be taken not to make the first cut too deep as the tool is likely to "jump", and break the tool rest. This operation is repeated until the piece is round throughout three-fourths of its length. The lathe is then stopped, the rest is moved along, and the remainder of the piece is rounded. If the tool rest is long enough, the entire length of the piece may be finished in one continuous cut.

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In moving the tool along the work, the whole body is moved with the hands. This can be done without stepping out of position. A good workman will never try to make a long cut by moving the hands alone.

When the stock has been turned roughly round, the calipers are set to about $\frac{1}{8}$ inch more than the required diameter and the cutting is continued until the piece has the same diameter throughout its whole length. It is now ready for the paring, or finishing cut.

The paring, or finishing cut, is made with the chisel. This is the most difficult cut for a beginner to learn; but when he has learned it, the rest of his course will be easy.

Fig. 229.

The chisel is held in the same manner as the gouge. In applying it to the work, the bevel is held as shown in figure 229, the cutting edge being at an oblique angle to the axis of the cylinder. The sharp point of the chisel must be kept clear of the work and the short side of the chisel should be against the rest. Neither end of the cutting edge touches the surface of the stock, the cut being made with the middle of the edge. If the sharp point accidentally touches the surface, the student will usually find that he will have to take another piece of stock and start over again. The chisel is passed along the work in exactly the same manner as the gouge. Special care should be taken to keep it in the same position from start to finish. While the gouge may be swung from side to side while cutting, the chisel cannot. This does not mean that the gouge is to be swung in different positions, but the rounded edge of a gouge makes it possible to do so without accident. The edge of the chisel is straight, and the least change of angle is liable to tear the work.

Fig. 230.

When testing for dimensions with the calipers, hold them as shown in figure 230. The first attempt to turn an exact diameter is usually a failure. In this case, a new diameter can be taken and another trial made on the same piece. Cuts should be made from left to right and from right to left, working from the center toward the ends as much as possible. The workman must be able to use the tool in both directions and should practice until he is able to take the same position and work equally well either way.

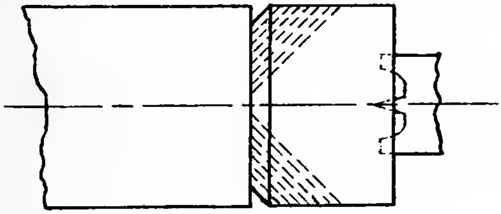


Fig. 231.

To cut the ends, use the point of the chisel. The first cut is made very light, simply to mark the length. The heavy cutting is then made a little distance away from the line and when the cutting is deep enough it is trimmed back to the line. Figure 231 illustrates the form of the first cut and the dotted lines represent the successive cuts thereafter.

The length of the cylinder is marked by holding the ruler against the work and marking it with a pencil while the lathe is in motion, or by setting the dividers to the required length and scoring the work with the sharp points. The dead-center end is cut first, as deep as safety will permit, the length is measured from it, and the live-center end is cut in the same manner. The cut should stop so as to leave about ½ inch of solid material in the center. The work is then removed from the lathe and finished on the bench. Sandpaper should not be used. When the first piece has been finished correctly, the same work should be repeated on the other three.

Exercise 2.—STEPPED CYLINDER.

Material required: One piece, 2 by 2 by 8 inches.

The stock is prepared to the required diameter, the length is marked off, and the end cuts made about halfway through to the axis.

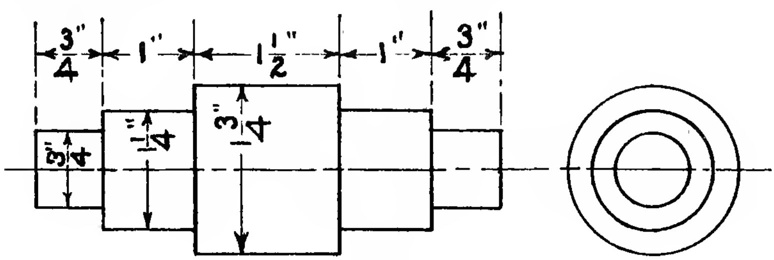


Fig. 232.

The drawing (fig. 232 shows the dimensions of the different cuts. They are spaced off on the cylinder with the dividers, very light marks being made, so as not to tear the wood.

The center section is the full diameter of the cylinder. The two cuts on each side of it are made first. A cut is made straight in at each line in the same manner as in cutting an end, the surplus, or waste material being removed with the gouge and the surface being finished down to dimensions with the chisel. On the surface thus made, the length of the next cut is marked off on each side of the center and the process is repeated. This completes the exercise. It is then taken from the lathe and finished on the bench by cutting off the waste ends with the saw and chisel.

Exercise 3.—BEADING (Fig. 233).

Material required: One piece, 2 by 2 by 10 inches. The stock is prepared to required diameter and length in the usual way, but the ends are not cut off. Next, the ruler is placed against the work while it is in motion and the spaces are marked with a pencil or the point of the divider. These spaces should be about ⅜ inch wide A pencil mark can be made in the middle of each space for use as a guide in making the cuts. The cutting begins by making a deep cut with the sharp point of the chisel at each of the space marks. No material is cut away in making this cut, the chisel being held on edge and pushed straight in so that is wedges or spreads the wood equally on each side of the line.

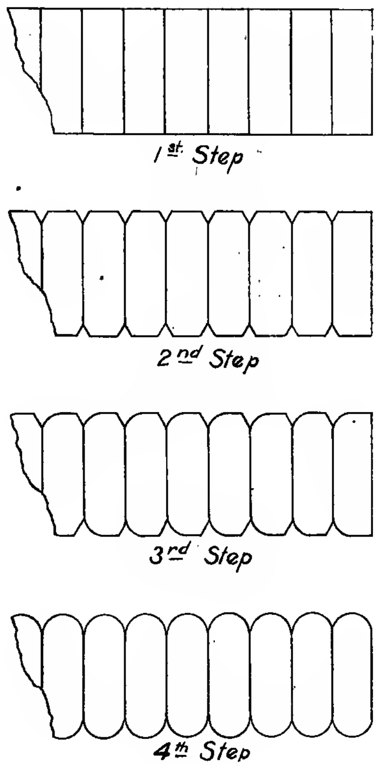


Fig. 233.

The next cuts are made with the chisel, though in an entirely different way. The chisel is first held flat and then turned, by twisting the wrist of the right hand, until the chisel is vertical. The cut is made with the "heel," or blunt angle, of the cutting edge. Each cut should be made complete with one continuous motion. All the cuts from right to left are made first, the chisel is then reversed and the cuts are made from left to right.

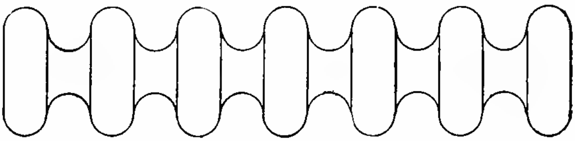


Fig. 234.

The figures on the preceding page describe the whole process. It is much easier to describe it than to do it; and a beginner will usually spoil one or two pieces of wood before he learns the right motions. The end cuts are finished last, and the wood is taken from the lathe and the ends finished on the bench.

Exercise 4.—HOLLOWING (Fig. 234).

Material required: A piece is prepared of exactly the same dimensions as for Exercise 3.

Next, the piece is spaced off in the same manner as in Exercise 3, and each alternate space is rounded with the

Fig. 235.

chisel. The remaining spaces are hollowed with the gouge in the following manner: A $\frac{1}{2}$-inch gouge is held exactly square with the axis of the work and pushed straight in until the waste material is removed almost to the line. The work is then cleaned out with the same gouge, but this time the wood is cut instead of scraped. The gouge is turned over until it takes the position shown in figure 236. The tool is slowly twisted back, cutting as it is turned, until one side of the cut is made; the position is then reversed and the opposite cut is made. Each space is cut out in the same manner, leaving the work in the shape represented in figure 234. Note that the outcurves and incurves are half circles in section. If two of these pieces are made correctly, they should match together, the outcurves on one fitting the incurves on the other.

Exercise 5.—CHISEL HANDLE.

Material required: One piece $1\frac{1}{2}$ by $1\frac{1}{2}$ by $7\frac{1}{2}$ inches; palomaria, camagon, tindalo, narra, or guijo.

Fig. 236.

All work that is turned between the centers is started in the same manner. The first step is always the same—that is, preparing a given diameter and marking off a given length—hence on the balance of these exercises this explanation will be omitted.

Figure 238 shows the chisel handle. The first step in making a chisel handle is to select a chisel from which to take measurements. The sockets of chisels are not always the same, so a chisel should be used as a model and the handle fitted to it.

The stock is first turned to the diameter of the largest part of the handle. The length is measured from the dead-center end and a cut started at the live-center end to mark the length. The dead-center end will not be cut as in the preceding exercises, but will remain on the finished work. The

Fig. 237.

next operation is to obtain the different diameters, as indicated in figure 239 in the manner depicted in fig. 235. The waste material is removed from between them with the gouge and the surfaces trimmed down with the chisel to exact size. The tapering end which enters the chisel socket

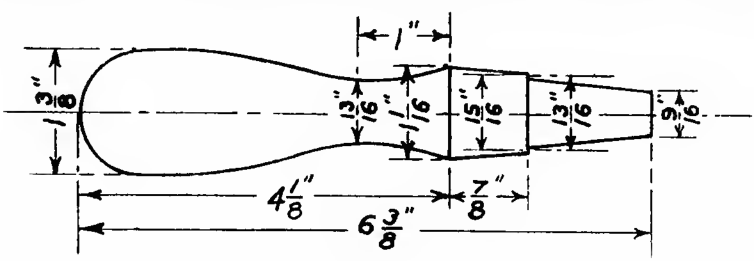


Fig. 238.

should be tested, by taking the work out of the lathe and trying it. It should be made slightly larger than the socket, so that it will wedge tightly when driven in.

Sandpaper the work thoroughly. Fold the sandpaper in a narrow strip and move it from side to side while the work turns. Start with sandpaper No. 1½ and finish with No. 0.

Finishing.—Give the work a coat of shellac, applying it while the lathe is at rest. Then start the lathe, and polish the work with a strip of dry cloth. The cloth should be

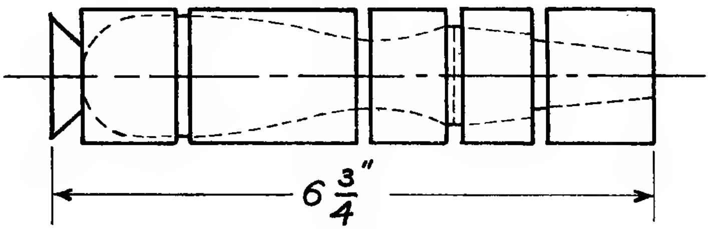


Fig. 239.

moistened with a few drops of oil and held as shown in figure 237. The cloth will wipe off the extra shellac and, if used correctly, will dry and polish the surface. If used too long or pressed against the work too tightly, the cloth will wear off all the shellac. This is a simple method of

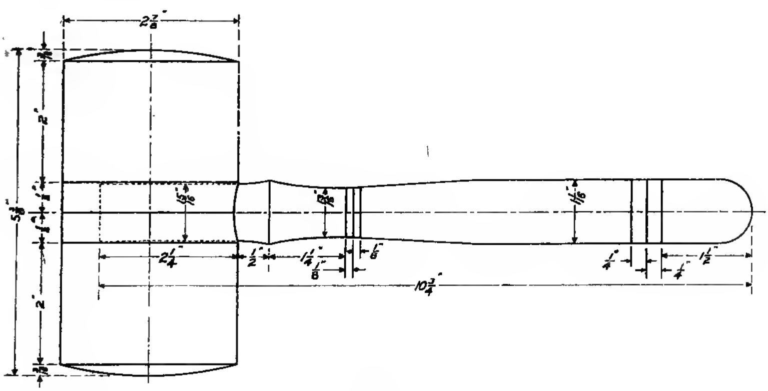


Fig. 240.

finishing and gives very good results. Floor wax can be used in place of the shellac, if desired.

When the polishing is finished, the cut at the left end is deepened as far as possible without breaking. The work is then removed from the lathe and finished at the bench.

Exercise 6.—MALLET (Fig. 240).

Material: one piece, $3\frac{1}{2}$ by $3\frac{1}{2}$ by 7 inches; one piece, $1\frac{1}{2}$ by $1\frac{1}{2}$ by 12 inches.

Several Philippine woods are good for making mallets; among the best are guijo, palomaria, camagon, and molave.

The work of turning the mallet is exactly the same as that of the chisel handle. A few special points, however, need to be mentioned. The part of the handle which enters the mallet head must be turned with great care, as it has to fit exactly into a hole bored with an auger bit. There is no way to cut the hole to fit the handle, therefore the handle must be made to fit the hole. The size of auger bits changes by sixteenths. Fifteen-sixteenths is a suitable size for this mallet.

The lines on the handle are for decoration only. The lines on the head are for decoration; they also serve as a help in putting the mallet together, as one of them is exactly in the middle.

Each part is polished on the lathe before the ends are trimmed off. In putting the parts together, the hole must be bored very accurately. It is better not to trust to the eye alone in this case, but to use a square as a guide in boring at right angles to the axis of the head. The handle is split as shown in figure 241 and a very thin wedge is made. The inside of the hole, and the handle are given a thin coat of glue and driven together. The handle should be driven in so that the wedge spreads toward the ends of the head; if it spreads sideways, it will split the head.

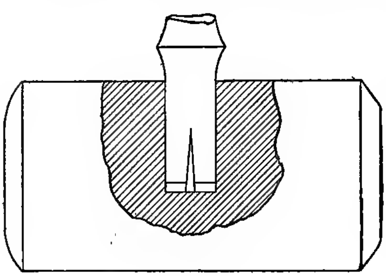


Fig. 241.

Exercise 7.—INDIAN CLUBS (Fig. 242).

Material required: Two pieces $3\frac{1}{2}$ by $3\frac{1}{2}$ by 20 inches, narra, acle, or any other suitable wood. If the pupil wishes to purchase the clubs when they are finished, he can use any material he likes best. If they are turned simply as an exercise to be kept by the teacher, soft, cheap wood will be preferable.

The same general directions that are given for turning the chisel handle apply here. The workman should proceed very carefully, as the clubs use large pieces of material and nearly 2 board feet of wood is wasted if one of them is spoiled.

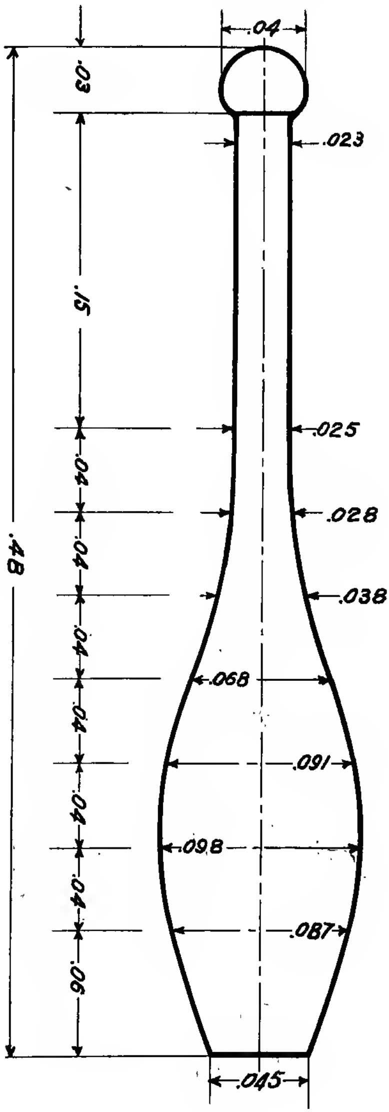


Fig. 242.

SPECIAL EXERCISES.

Dumb-bells fig. 243) can be turned after completing Exercise 7, if desired; gavel (fig. 244), after completing Exercise 6, if desired; turning tool handles (fig. 245), any time after completing Exercise 4; darning ball (fig. 246), any time after completing the mallet; spindles (fig. 247), any time after completing Exercise 7. (This sort of work is used in house construction in connection with stairways and railings); policeman's club (fig. 248), any time after completing Exercise 7.

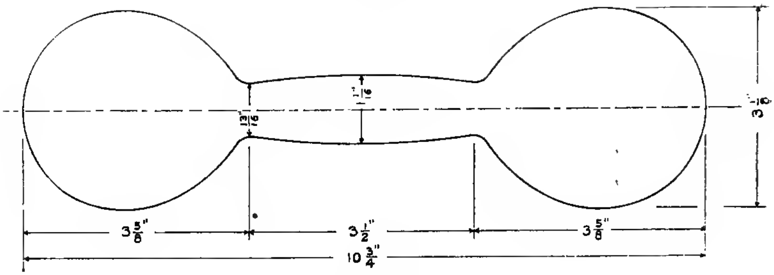


Fig. 243.

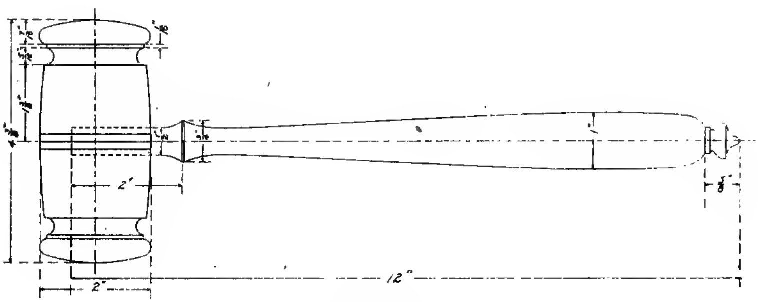


Fig. 244.

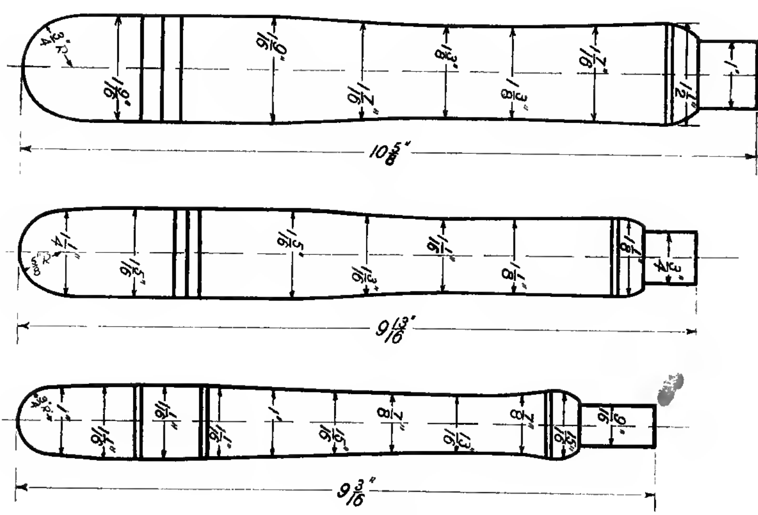


Fig. 245.

FACE PLATE AND CHUCK TURNING.

Exercise 8.—TURNED BOX, WITH COVER.

Figure 249 shows the completed exercise. Material required: One piece, 3 by 3 by 8 inches of any wood desired.

Figure 250 shows the method of fastening the stock to the face plate. The face plate with a central screw (see fig. 218) can be substituted if desired.

The work is started by cutting the stock to the required diameter. Although the stock is fastened securely to the face plate, it is advisable to push the dead center up against the free end to steady it while it is being reduced from square to round. After this is done, the tailstock is pushed

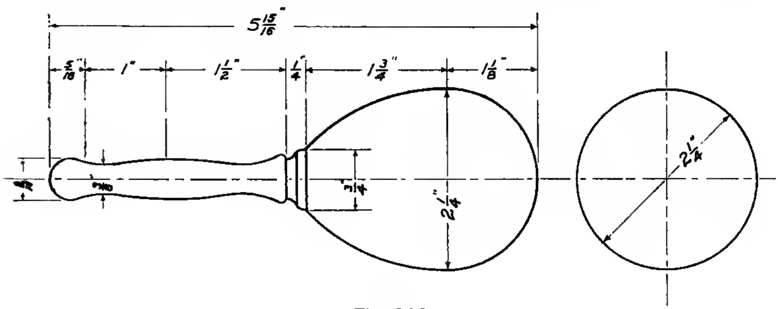


Fig. 246.

as far back as possible and the dead center is removed, so that its sharp point will not be in the way of the workman.

Next, the free end is squared or cut squarely off, the length of the box is measured, and a cut started which will serve as a guide while the inside is being hollowed. The tool rest is now swung around until it is squarely across the end of the piece and at such a height that the point of the small gouge strikes exactly in the center when held in a horizontal position. Figure 251 illustrates the position of the tool and rest.

The cutting is commenced by pushing the tool in slowly until the right depth is reached. This can be estimated by holding the tool on the outside of the work, marking the length that it should enter the work, and then using the mark as a gauge. The cutting is wholly on the side of the

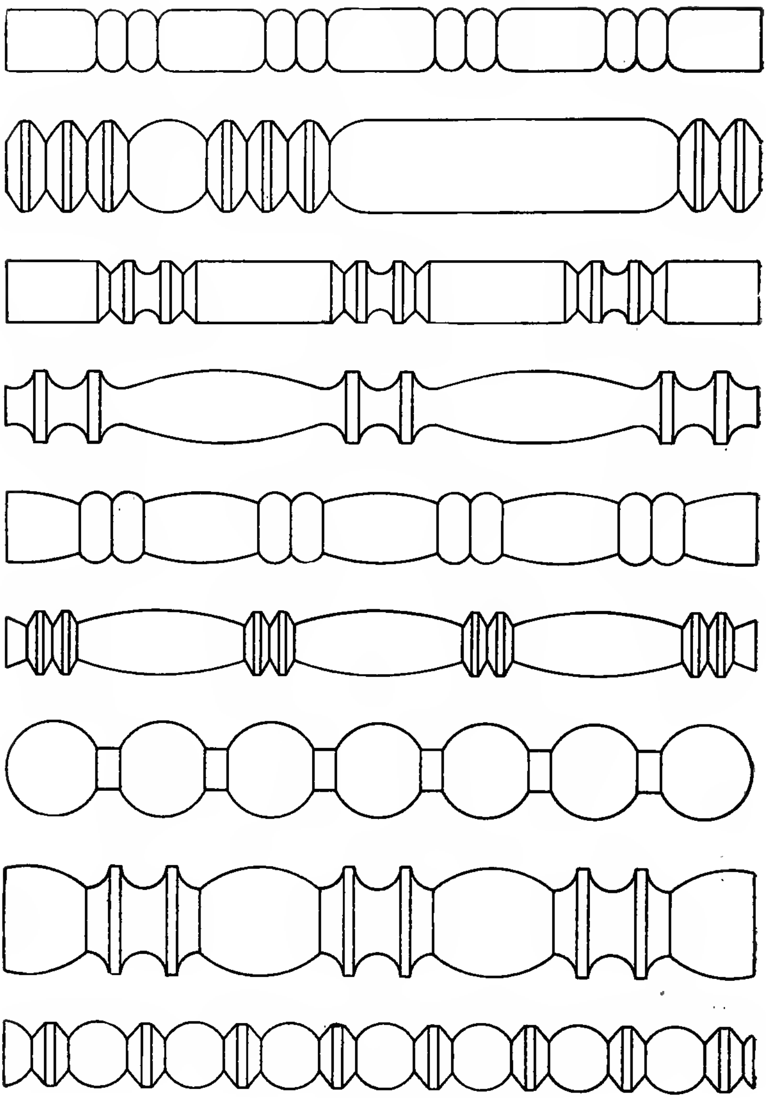


Fig. 247.

work that is toward the operator—that is, he works across the rest from the center to the side, in the direction in which the work turns. The chisel cannot be used as a cut-

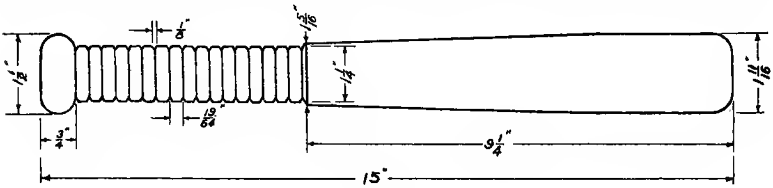


Fig. 248.

ting tool for smoothing the inside, because the shape of the work makes it impossible. The bottom can be scraped with either the square-nose scraping tool or the chisel swung around until its edge strikes across the bottom. The sides can be straightened up by passing the small chisel straight in, with its back against the side which is toward the front of the lathe. After the cutting is finished, the

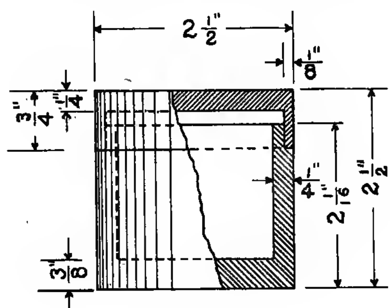


Fig. 249.

inside is sandpapered until smooth. The small, rabbeted edge which receives the cover is cut next. It is better to

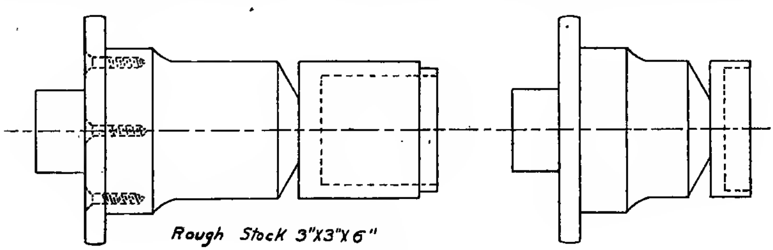


Fig. 250.

scrape down the edge with the chisel, as the process when finished leaves the material so thin that cutting in the usual way is dangerous. The end cut is finished next, then the box is cut off from the rest of the stock. Note that the outside of the box has not yet been sandpapered.

The cover (fig. 250) is turned next, there being enough stock left on the face plate to make it. The work is exactly the same as that of turning the box, except that special care must be taken in cutting the inside to fit the rim of the box. The cover should first be turned close to the required dimensions, then the box itself should be used as a measure. This can be done by stopping the lathe and

Fig. 251.

testing with the box, which is already finished. When the cover fits the box tightly, the lathe is stopped, the box fitted into the cover, and the dead center is pushed up against the work until it holds the box firmly in place. The box and cover are sandpapered at the same time. If any polishing is required, this is also done before the cover is cut off from the stock. Last of all, the cover is separated from the stock and finished at the bench.

By this time the workman will have learned his lathe and tools well enough to be able to practice what is rather a dangerous operation for a beginner, namely, that of cutting the work clear off while the lathe is in motion. A good strong center core should be left until all cutting, sandpapering, and polishing are finished. The belt is then shifted to the slowest speed. Cutting very carefully with the parting tool and holding the thumb and fingers of the right hand around the work as shown in fig. 252 the live-center end is cut clear off. This must be done very care-

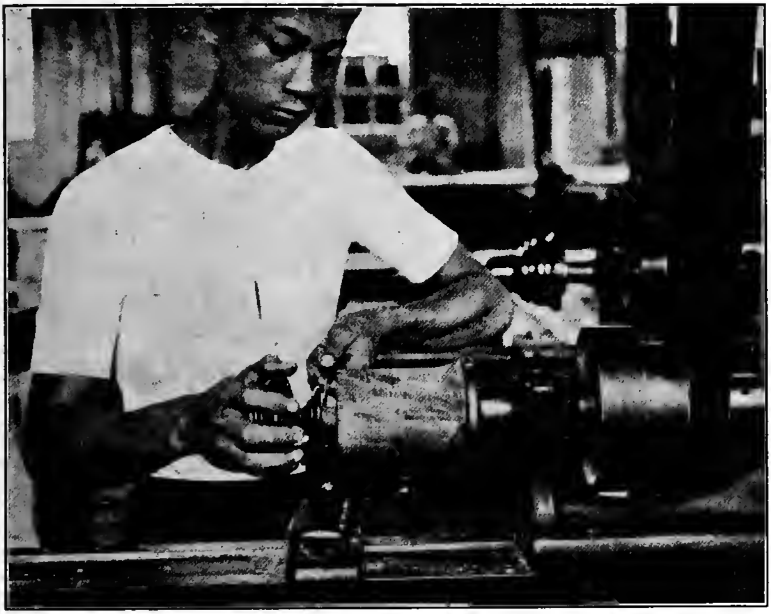


Fig. 252.

fully; if the wood breaks or twists off, it is liable to leave a hole in the center of the finished work. This process had better be practiced on a piece of scrap lumber before it is attempted on good work. The most difficult part is that of holding the piece when it is cut loose.

Exercise 9.—CUP (Fig. 253).

This exercise can be made of any desired material. There is little difference between it and the box, and the same general directions can be followed.

Figure 254 shows several different varieties of cups, boxes, and vases. These can be used as models, if desired, after the completion of Exercise 9.

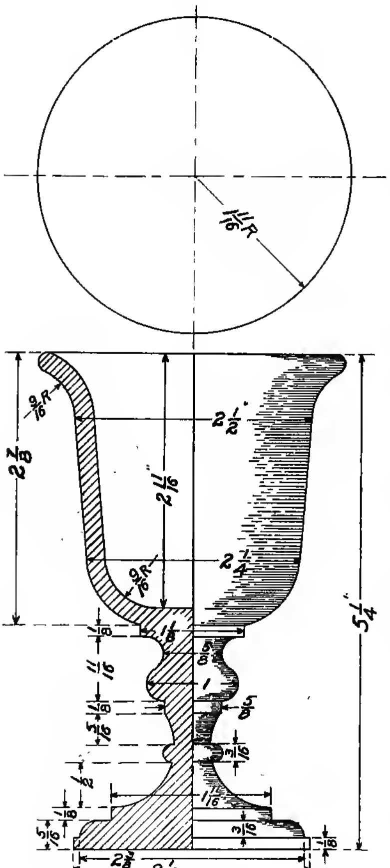


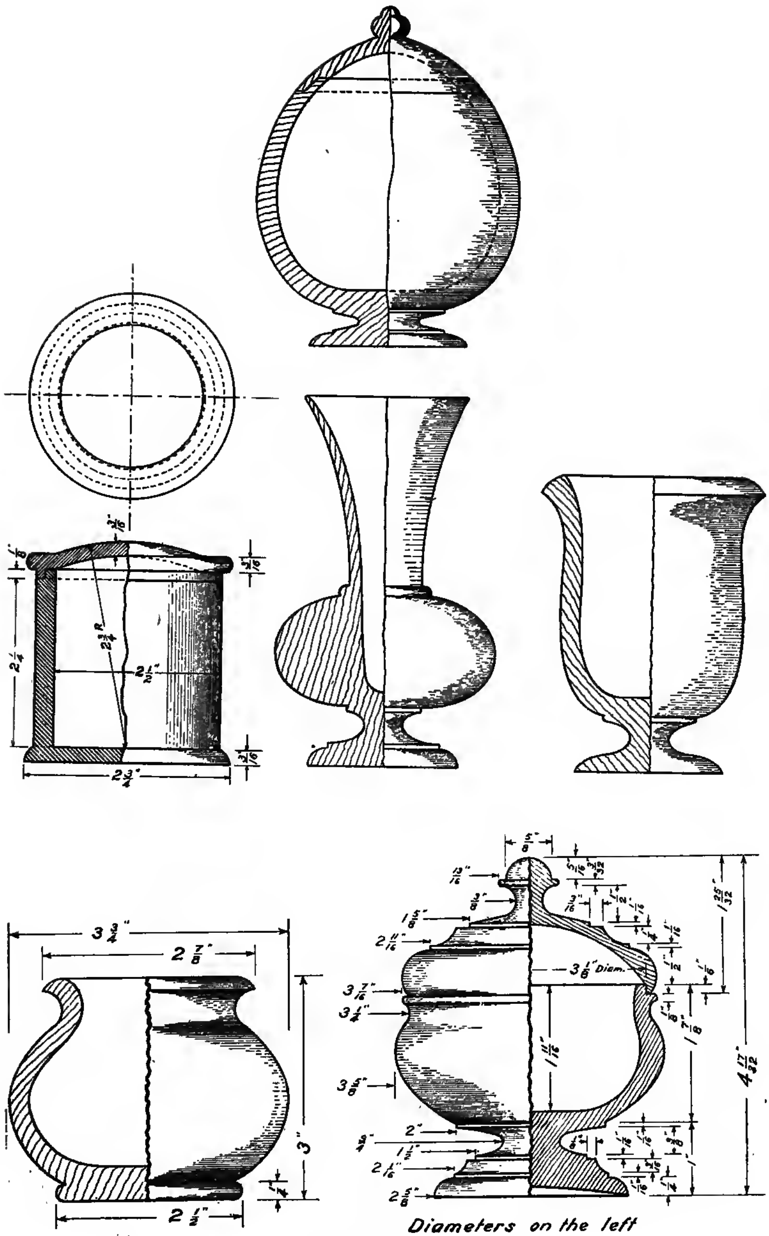
Fig. 253.

Exercise 10.—TURNED TRAY OR PLATE.[1]

This object is scraped, from start to finish as the direction of the grain makes cutting impossible. The tray can be made to any desired diameter, but it is better to make it small the first time to prevent waste in case of accident.

The stock is first fastened to the faceplate as shown in figure 255, and the outside, or bottom, is turned, sandpapered, and polished. As the stock projects beyond the faceplate, the edge, also, can be turned, and a small part of the inside hollowed out. The work is then taken from the faceplate and a chuck is made. Figure 256 shows the chuck and the method of fastening the tray to it. The chuck is made of dry, softwood and should have a margin of at least 1½ inches around the outside of the tray. The chuck

[1] The direction of the grain makes this project very different from any of the preceding exercises. The workman should practice first, on a test piece; and should study his wood carefully before commencing work.



3 3/4"
2 7/8"
3"
2 1/2"
2 3/4"
2 1/2"
3 1/8" Diam.
4 17/32"
1 25/32"
Diameters on the left

Fig. 254.

is hollowed out to exactly the same diameter as, and slightly deeper than, the total depth of the tray. The tray is then wedged into it and the turning is completed. A very large tray can be fastened as shown in figure 257.

Exercise 11.—TO TURN A BALL.

This exercise combines all the processes already described. It is started between the centers and cut in the

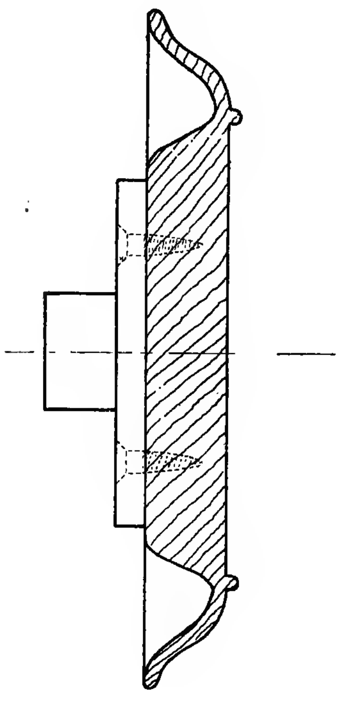


Fig. 255.

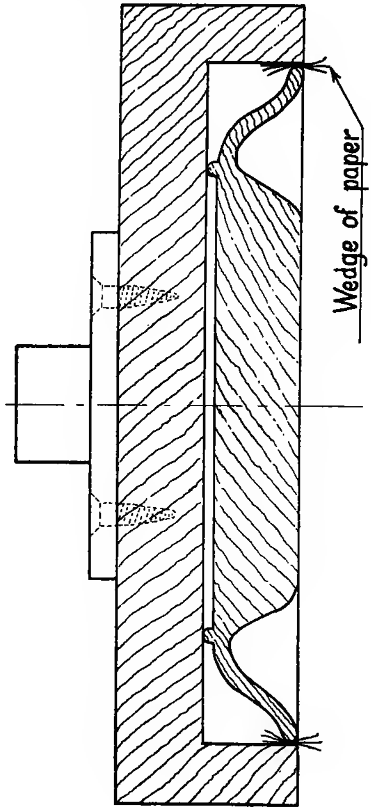


Fig. 256.

regular manner; the ball is then put in a chuck and scraped until it is perfectly round.

Figure 258 shows the different steps in the first part of the work. The stock is first turned to the required diameter. Enough stock is prepared for turning three balls.

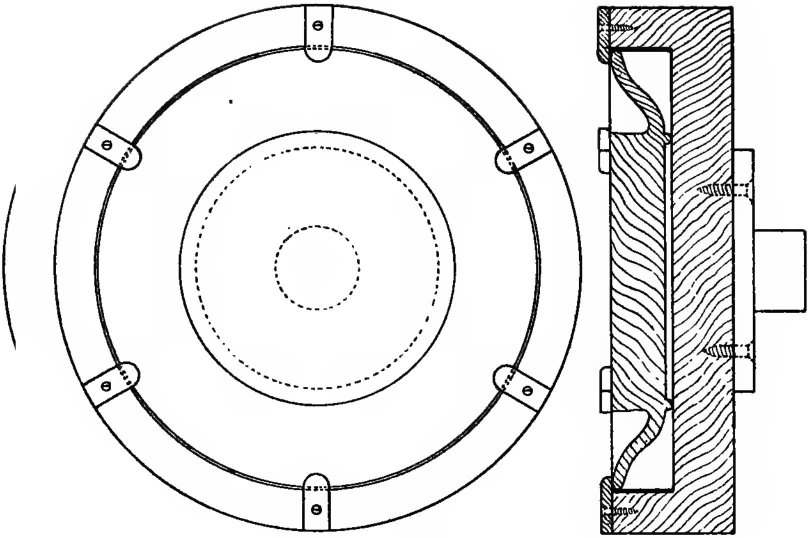


Fig. 257.

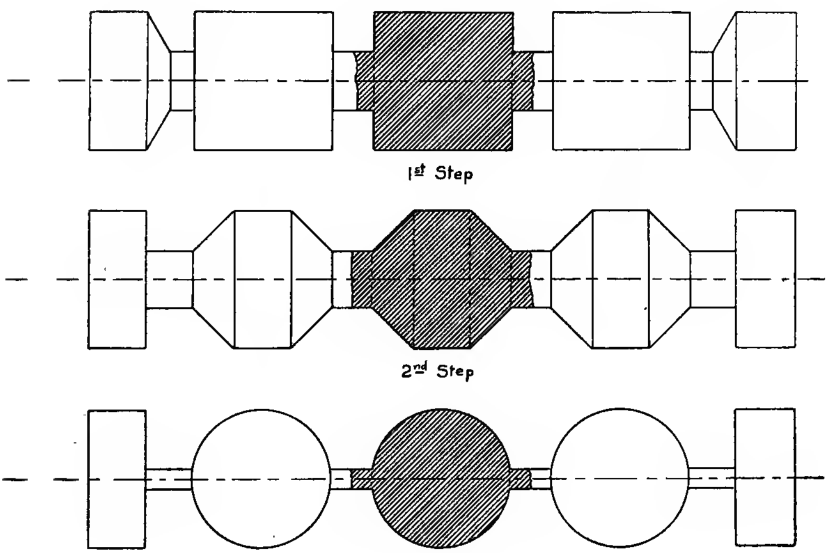


Fig. 258.

The lengths are next marked, the ends being cut as deep as safety will permit. Next, pencil marks are made at the points where the corners are to be taken off. A cross section of the stock taken during the different steps would appear; first, as three squares; second, as three octagons; third, as three circles. When the balls have been turned between the centers as nearly round as possible, they are cut off and finished in a chuck. Figure 259 shows a cross section of the chuck. It will be noted that the inside of the chuck hollows away under the edge. The opening is slightly smaller than the diameter of the finished ball, because in the scraping work which follows, the ball must project more than one-half of its body outside of the chuck. If the chuck is properly made of soft, springy wood, the ball will be held tightly enough to permit of finishing. It is first put in with the grain of the wood in the same position as when between centers; the rounded surface is then completed. This process is repeated on the other side. The ball is then shifted and is trimmed, by scraping, wherever needed to make it perfectly round. A good workman can finish the work in four positions—once for each end (across the grain) and once for each side (with the grain). This exercise is much easier to describe than to perform. The operation should be repeated until three perfect balls are completed, all of the same size.

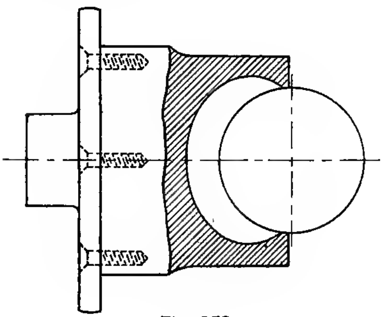


Fig. 259.

MISCELLANEOUS DESIGNS.

There are large variety of articles that can be made on a turning lathe. The preceding course gives a series of exercises which employ all the common processes, except those specially used in pattern making. When a workman once learns how to fasten his work in the lathe and how to hold the tools, the rest of his course is a matter of practice.

Commercial work has such an important place in our trade schools and school shops that all the work needed is usually supplied after a class has learned the ABC's of turning. The foregoing course can be taken as the minimum for preparing to do commercial work. Figures 260–266, inclusive, represent a number of articles which can be used or adapted to suit the needs of commercial orders.

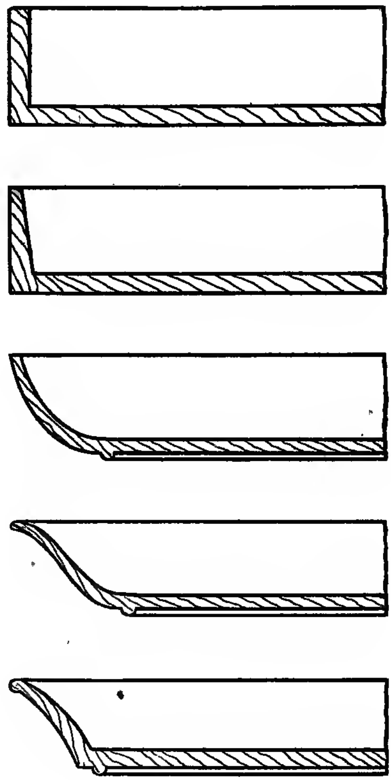


Fig. 260. Tray forms.

PARTED OR SPLIT WORK.

This form of work is used chiefly in pattern making, which is a trade in itself. A pattern is usually constructed in two or more pieces, to allow of removing it from the mold.

Split work is also used in making turned spindles and posts for decorative purposes where one half of a turned form is used against a flat surface.

The operation is usually performed by fastening two pieces together by one of the means shown in figure 267. The pieces thus fastened are put into the lathe and turned between centers until they are finished, when they are separated into their original halves. If the stock is large and heavy, the method shown in figure 268 is sometimes used.

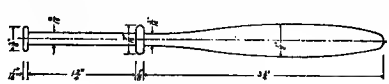


Fig. 261. Bobbin.

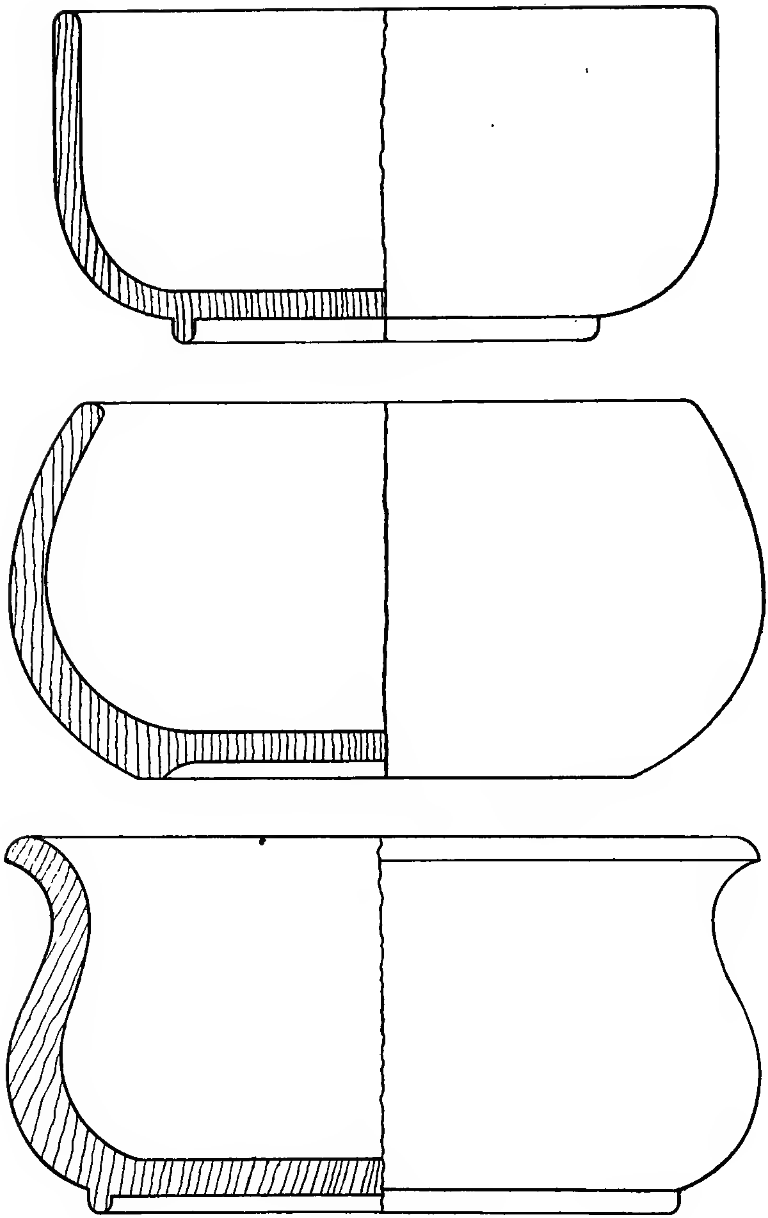


Fig. 262. Bowl forms.

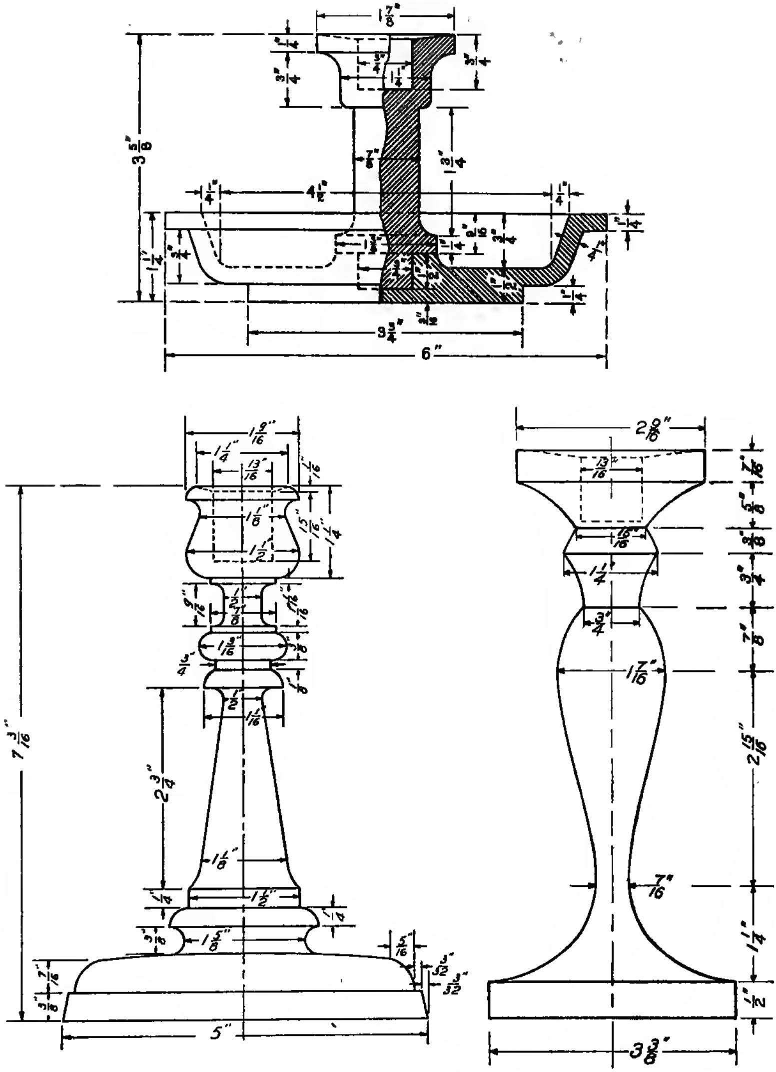


Fig. 263. Candlesticks.

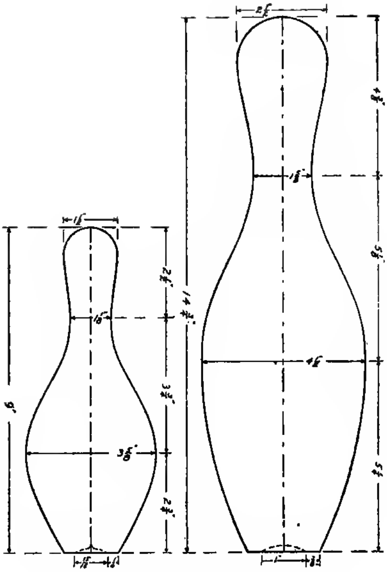


Fig. 264. Bowling pins.

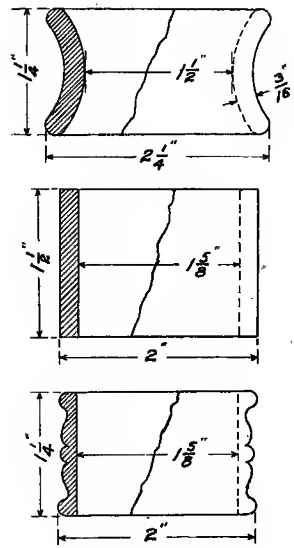


Fig. 265. Napkin rings.

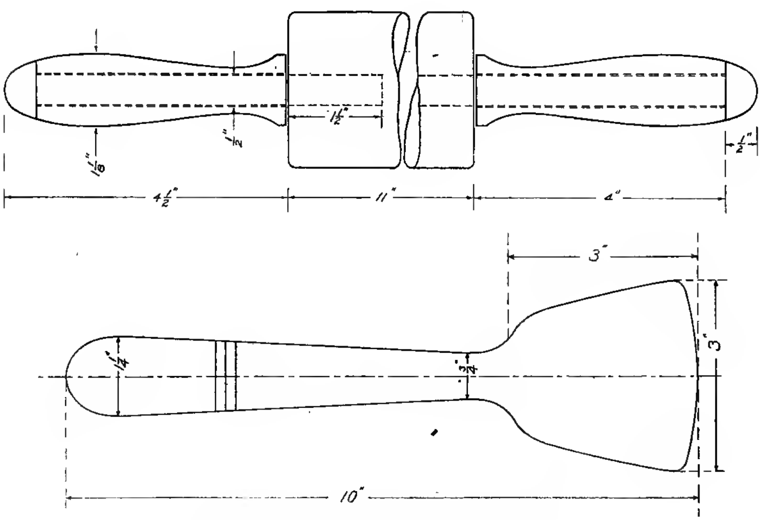


Fig. 266. Rolling pin and potato masher.

BUILT-UP STOCK.

The process of building up or gluing several pieces together to make one piece is often used in wood turning. This method is useful in pattern making, for two reasons—either to give greater strength, or because one piece cannot be obtained large enough to make the pattern. It is sometimes employed for decorative purposes, where several different kinds of wood are combined. A very pretty effect

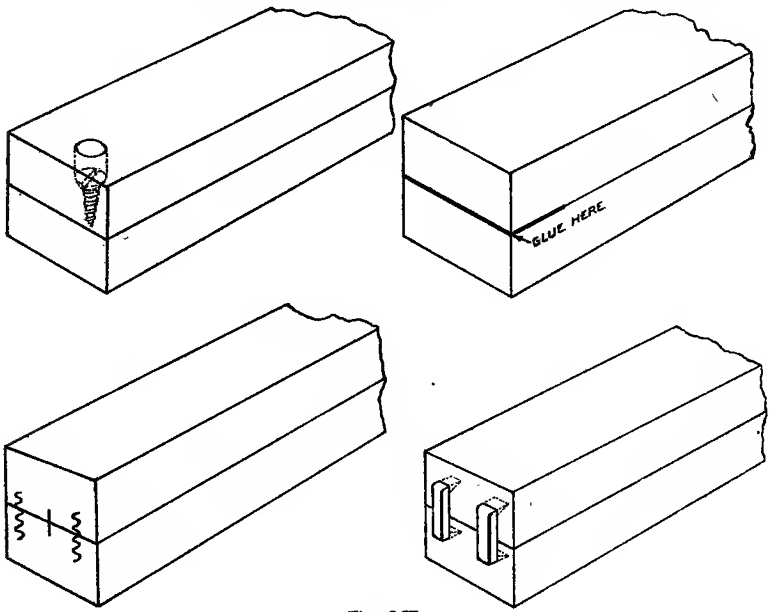


Fig. 267.

is produced; but as no two Philippine woods will "work" together, either in shrinking or in swelling, such combinations are not advisable.

GENERAL SUGGESTIONS AND RULES.

Use plenty of oil. A well oiled lathe turns easier; the full amount of power is obtained, and there is less wear on the bearings. A lathe in good running order should be oiled at least once every hour. If any of the bearings start to get hot, the lathe should be stopped at once and not started again until the trouble is found and corrected.

Keep the turning tools sharp and apply them to the work so that they *cut.* Anyone can *scrape;* it takes a skilled workman to make his tools cut.

The same rule as in working at the bench applies in turning—keep the same rate of speed from the beginning right up to the end. Many a good piece of work has been spoiled by one hasty or careless motion at the finish.

Do not try any "tricks" with the tools until their regular use has been thoroughly learned. A skilled workman will often use one tool in place of another, but a beginner cannot do so with safety.

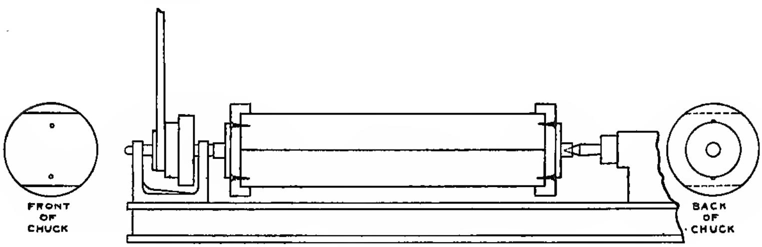


Fig. 268.

While working at the lathe, pay strict attention to business. If necessary to speak to anybody, or look away from the work, first remove the tool from the rest and stop the lathe.

Let the lathe slow down and stop itself. Never try to stop it by taking hold of the belt or cone pulley. Never *feel* of the work while it is in motion.

BELTS AND BELT LACING.

One of the commonest operations that occurs in the care and use of a lathe is that of lacing a belt; therefore every wood turner should understand the process. The directions which follow can be used either with wire or rawhide belt lacing, with variations as noted.

Trim off the ends of the belt so that they are perfectly square, using a try-square, a mallet, and a wide chisel.

Measure the thickness of the belt and draw a line across each end as far in from the end of the belt as its own thickness.

Put the two ends together so that one lies exactly on top of the other, and clamp them down on the bench in this position.

With a drill bit of suitable size (less than $\frac{1}{8}$ inch for wire and as small as possible for rawhide lacing) make the first hole tangent with the inner side of the line and exactly in the middle of the belt, boring through both parts of the belt at the same time. Next, measure in from the two edges a distance equal to the thickness of the belt and bore a hole on each side, just inside of the points thus located. Next, divide the space between the three holes into equal parts and bore the rest of the holes. The distance between each two holes should be about equal to the thickness of the belt. This distance can be made a little more, if necessary, but should never be less.

Cut a piece of lacing about eight times as long as the width of the belt.

Remove the clamp and place the two ends together in correct position. Pass both ends of the lacing through the two middle holes from the face side of the belt—that is, the side which runs against the pulleys. Working from the center both ways, pass the lacing over and over through the holes until the outer holes are reached. Double the lacing in the last two holes on each edge and then start back, doubling through every hole until the middle is reached. The lacing, if properly applied, will lie straight and parallel on the face side of the belt and will cross itself between holes on the reverse side. If wire lacing is used, the two ends are fastened on the back of the belt by simply twisting them together and cutting off the surplus wire. If rawhide lacing is used, the ends are fastened by boring a small hole in the center of each end of the belt a short distance back from the first center holes and by drawing the ends of the lacing tightly through them.

Lastly, lay the laced part of the belt on a hard surface, like the face of the pulley, and flatten the lacing with a mallet.

Rules to be observed:

1. The ends must be perfectly square.
2. There must always be an odd number of holes, the first one being exactly in the middle.
3. The lacings must lie parallel with each other, and must not overlap or cross each other on the side which comes against the pulley as this will make them wear out very quickly.
5. Use the pliers to pull the lacing tight as it is passed through each hole. The lacing must be tightened when it is put in, because it cannot be tightened afterwards.
6. Follow the directions for locating the holes exactly as given. An inexperienced workman often makes the mistake of thinking that a long lacing is stronger than a short one. This is not true. The lacing is the weakest point in a belt and the shorter it is made, the stronger it will hold. If a belt is in good condition, its own thickness can always be used as a measure in locating the holes.

Wire lacing is made in several gauges. The size is indicated by a number on the package in which it comes. No. 1 is the lightest, and is suitable for use on small belts not more than 2½ inches wide; no. 2 is suitable for belts between 2½ and 4 inches wide; and no. 3, for greater widths. On a very wide belt a lighter lacing is sometimes doubled to give the necessary strength. If the belting is of double thickness, the next larger size of wire lacing should be used throughout.

Rawhide lacing rots very quickly in this country and it is not advisable to use it if wire lacing can be obtained.

GENERAL INFORMATION FOR THE CARE AND USE OF BELTS.

For a long drive belt, whether narrow or wide, a double-thickness belt is the most satisfactory. It gives better friction and holds a lacing much better than a single thickness.

Nearly all good belting has a mark, put on by the manufacturer, indicating the side which should come against the pulleys; also an arrow point showing the direction in which the belt should run. These marks should always be observed.

When setting up a lathe, where the distance from the countershaft to the headstock is comparatively short, the best results can be obtained by placing the lathe at least a foot in front of the countershaft in order that there may

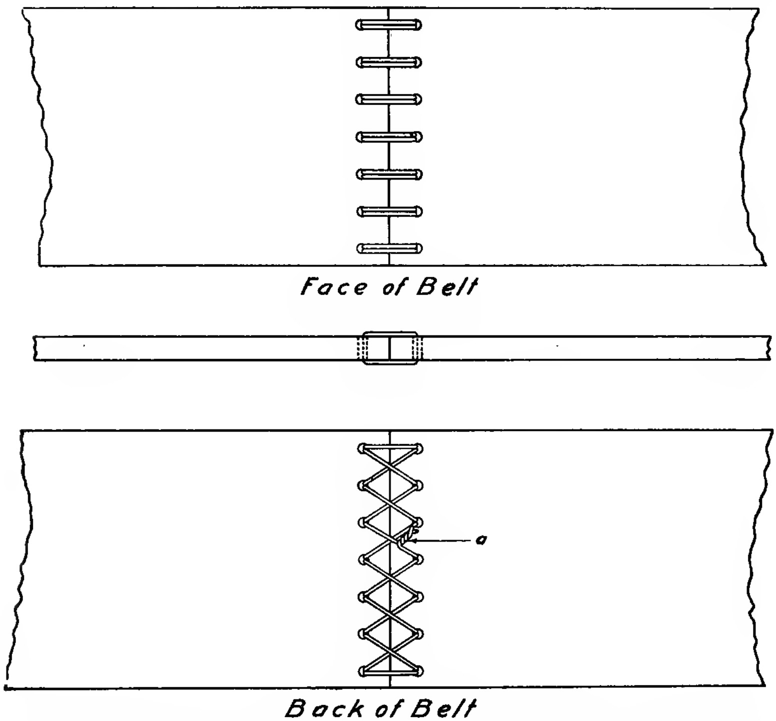


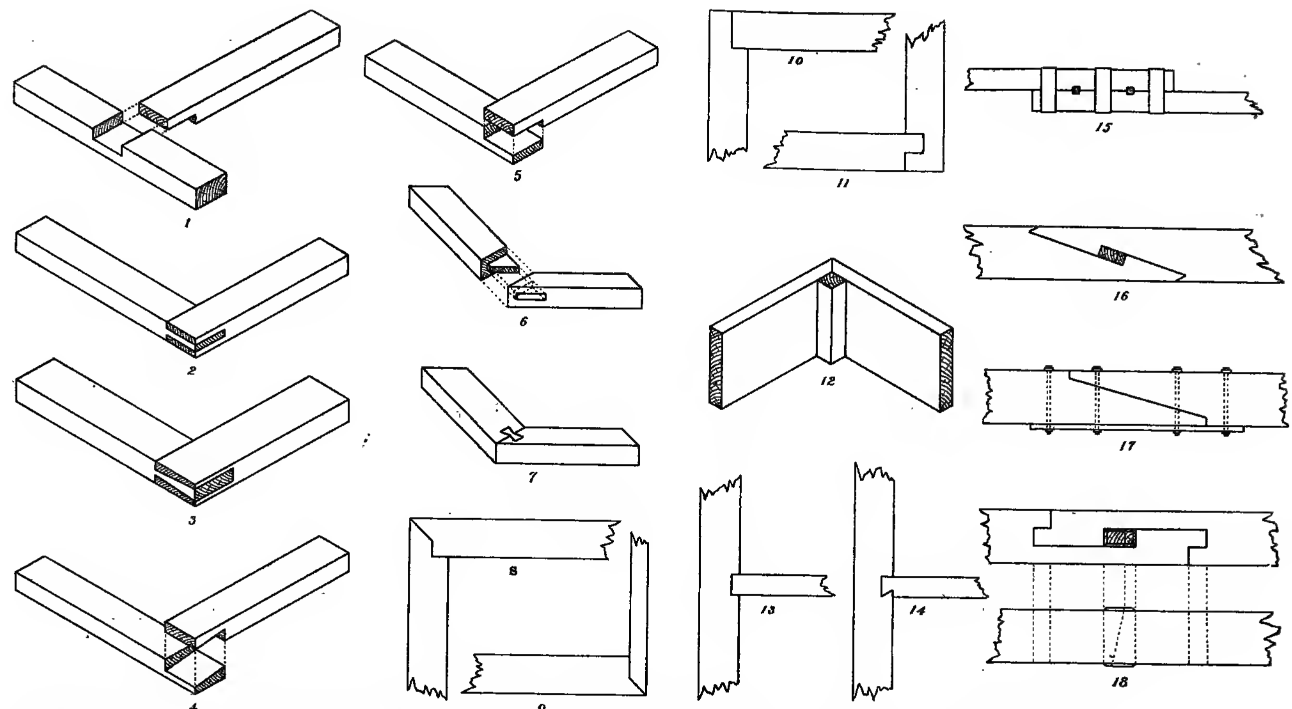
Fig. 269. Belt laced with wire lacing. Ends of belt are fastened by twisting together at point (a).

be a "rake," or slant, to the belt. If the lathe is placed exactly under the center of the countershaft, the belt has to be kept tighter and will, therefore, wear out faster.

Avoid the use of belt dressing, except as a last resort, before shortening a loose belt. When a machine has stood still for several hours, the belts will often slip when first started, but will "take hold" when they have been in motion for a few minutes.

Much unnecessary wear on belts and lacings can be avoided by using care and judgment in starting the machine. It is easily understood by a thoughtful workman that a machine that turns at the rate of 3,000 revolutions per minute, cannot be started from a dead stop to full speed by a quick motion of the hand. Always start slowly, giving the belt a chance to take hold; and wait until the machine is running at full speed before commencing work.

APPENDIX.



1, Middle lap joint. *2*, Open mortise and tenon or slip joint. *3*, Dovetailed slip joint. *4*, End lap joint with beveled faces. *5*, End lap joint. *6*, Tenoned miter joint. *7*, Miter joint strengthened with a dovetailed key. *8*, Lapped miter joint. *9*, Miter and butt joint. *10*, Lapped butt joint. *11*, Tongue and groove butt joint. *12*, Miter joint strengthened by a block nailed or glued in the inside angle. *13*, Housed joint. *14*, Dovetailed housed joint. *15*, Lapped joint used in splicing timber. The two pieces are bound together with iron straps and the two keys prevent their pulling apart. *16*, Keyed scarf joint. *17*, Scarf joint strengthened with "fishplate" bolted to its lower side. *18*, Keyed scarf joint.

PLATE I.

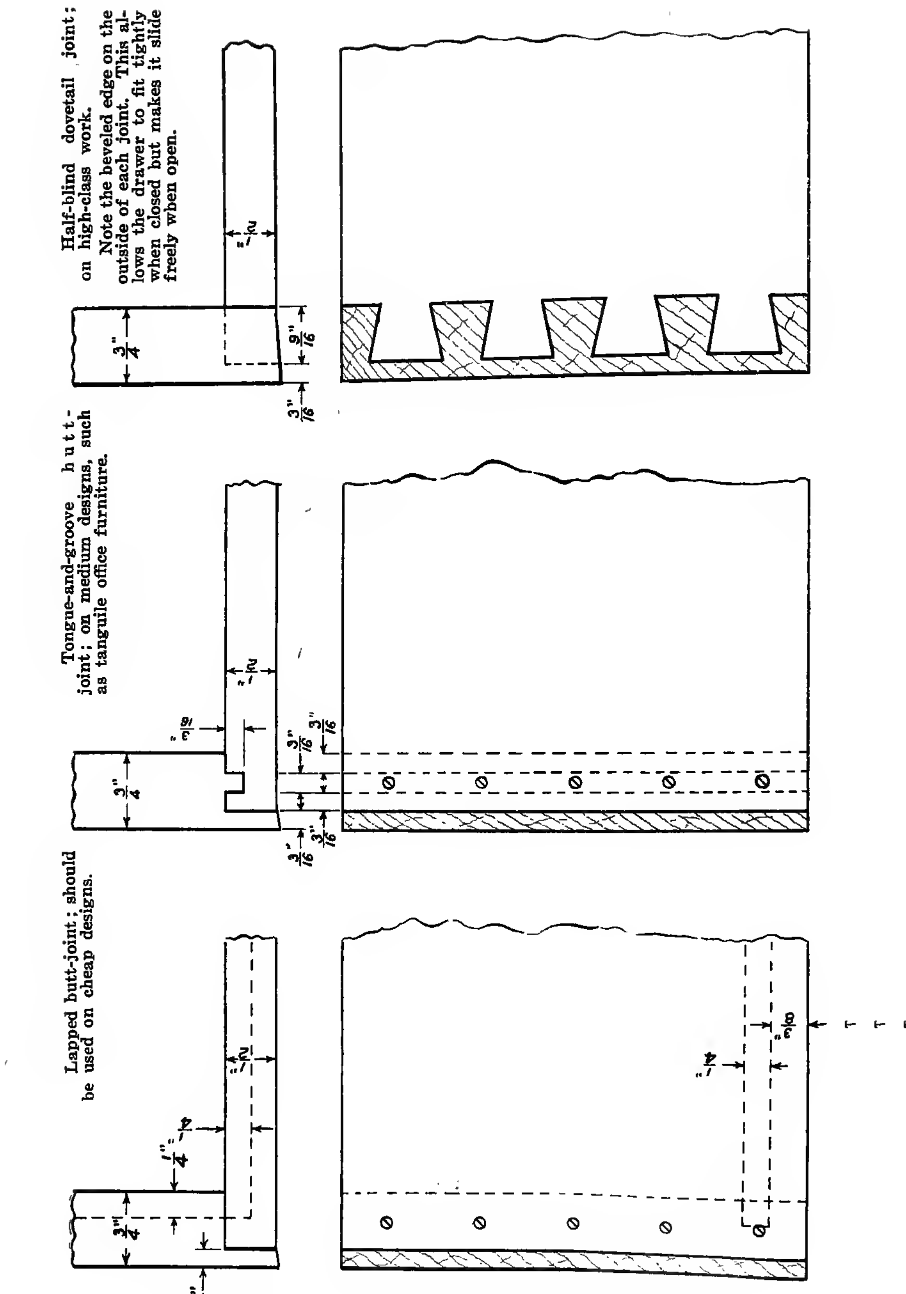


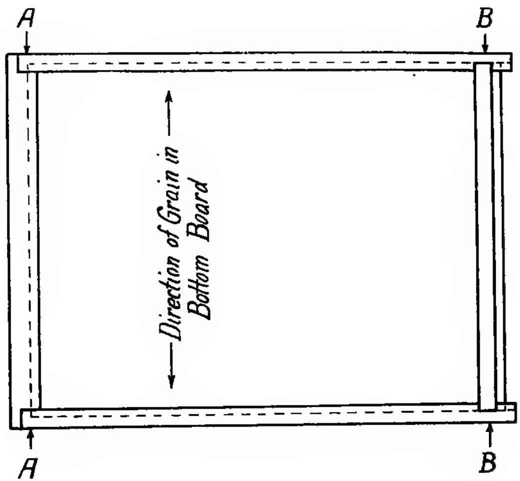
PLATE II. JOINTS USED IN DRAWER CONSTRUCTION.

(*a*) For suitable joints see figures on preceding page. (*b*) Backboard is housed into the side boards not more than one half of their thickness. Glued and nailed. (*c*) Nails hold bottom board in place. These nails should be left with the heads slightly projecting, so that they can be pulled if the bottom board needs tightening. (*d*) Groove in front board to receive the bottom board. (*s*) Groove in side boards to receive the bottom board. This groove should not be deeper than one half the thickness of the side boards. (*f*) Space below bottom board not less than two-thirds the thickness of the side boards.

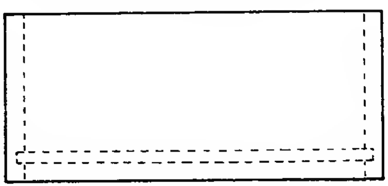
Notice the direction of the grain in the bottom board. It should always extend across the drawer from one side board to the other. This is to guard against shrinkage which occurs chiefly across the grain. As indicated in the drawing, the bottom board is made with a little extra width, allowing it to be tightened if it shrinks. If the bottom board is made of more than one piece, the pieces should be glued and sanded before being put in place.

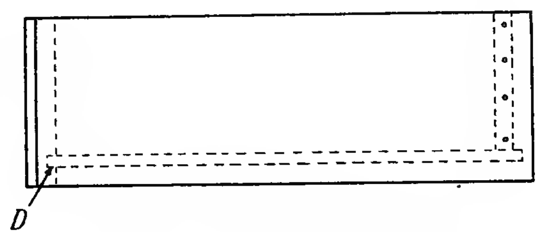
It may be taken as a general rule in drawer construction that a drawer should be as long as the space it occupies.

The width of a drawer is optional.



The depth of a drawer is determined by its use, but the depth is limited to a maximum of about 4 inches on any table of standard height (30 inches), as at least 26 inches should be left clear between the floor and the bottom of the rails.





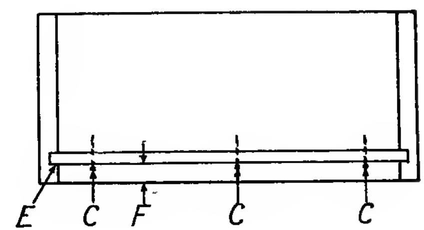
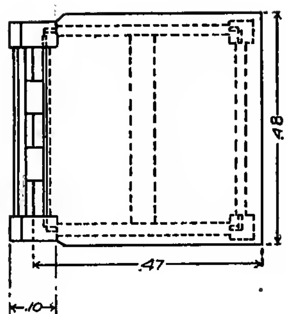
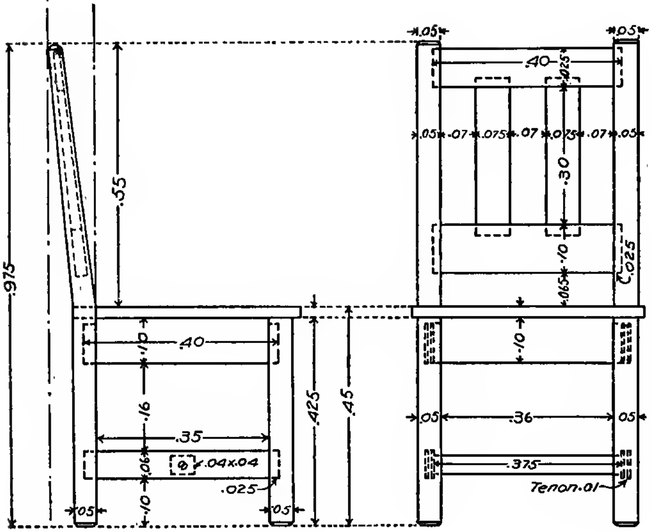


PLATE III. DRAWER CONSTRUCTION.

DINING CHAIR

All dimensions Metric
To find equivalent in English inches, divide by .025





Note:- *Six chairs are usually made with this set. If one armed chair is desired, widen the plain chair ten centimeters (4")*

PLATE IV.

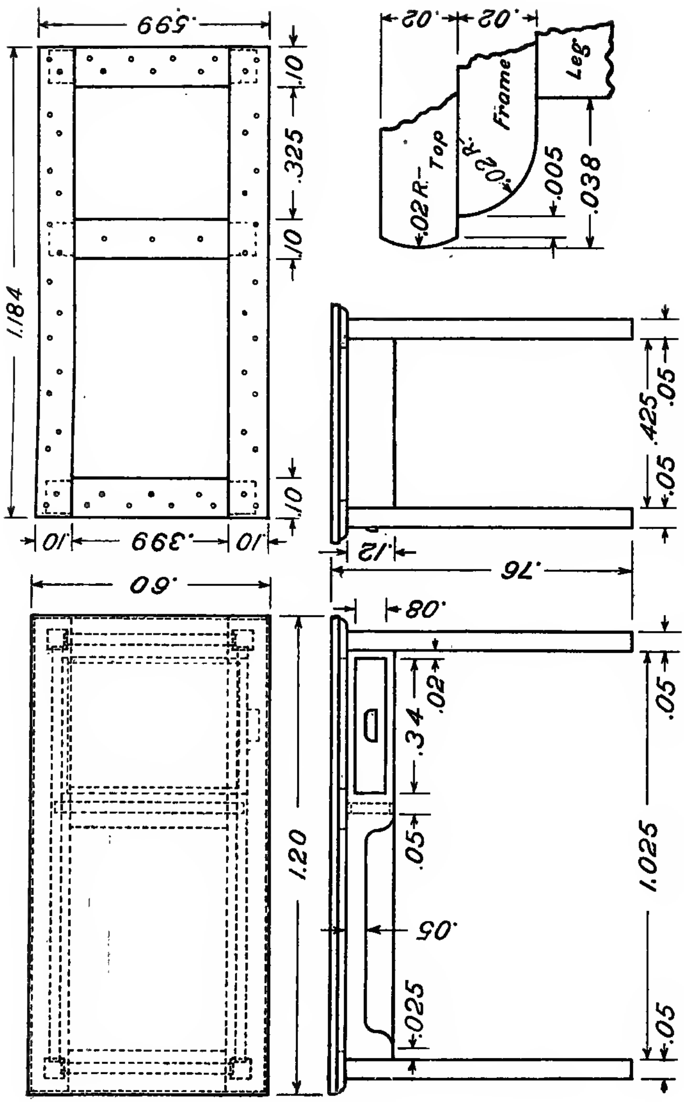


PLATE V. STUDENT'S TABLE.

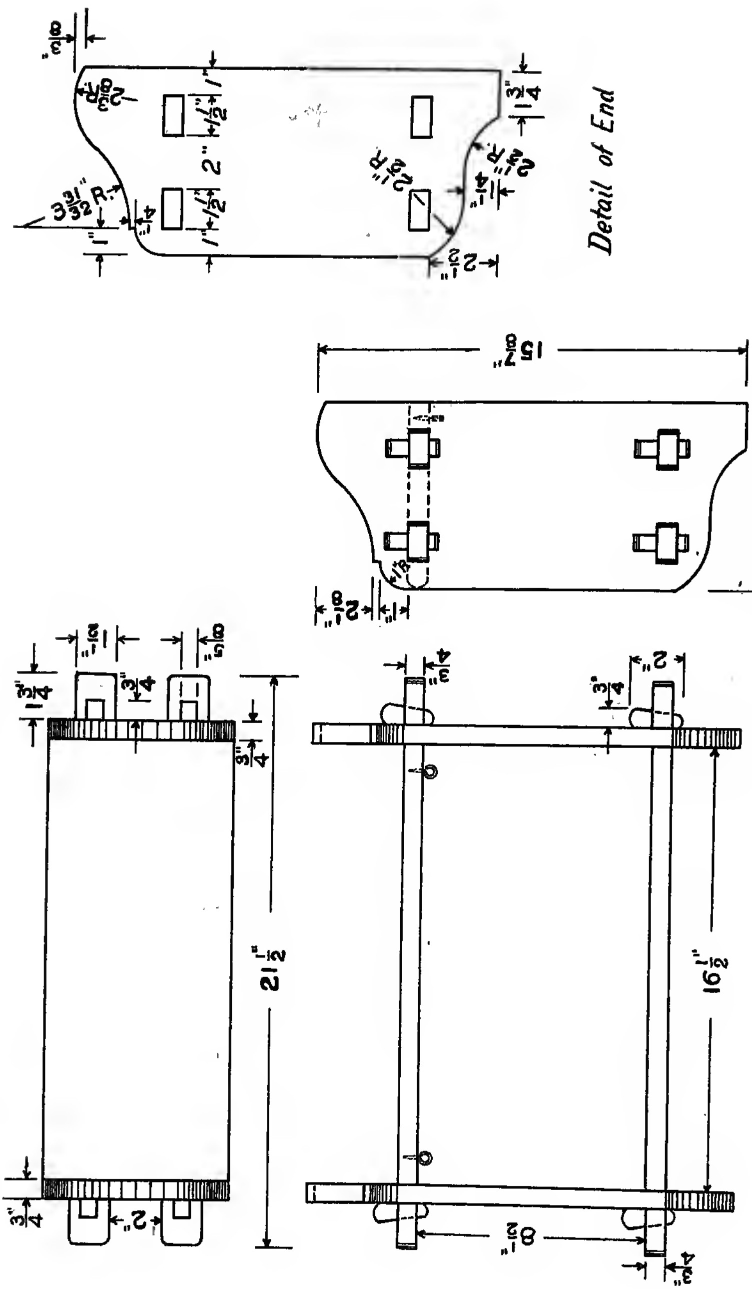
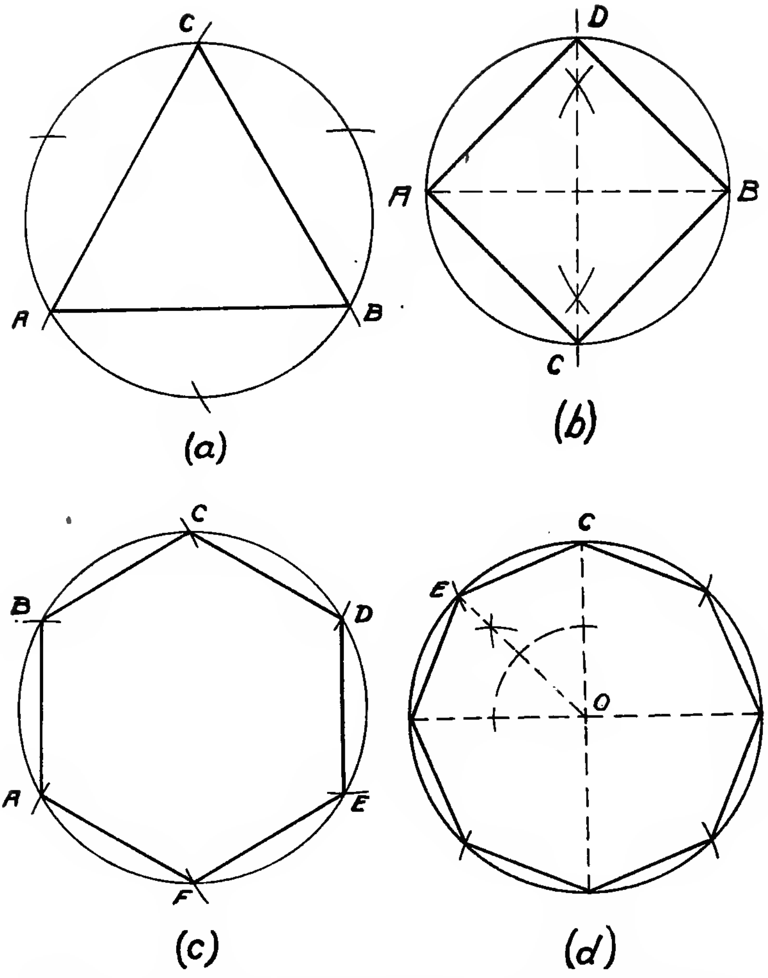


PLATE VI. HANGING BOOKSHELF.



To construct in a circle, an equilateral triangle, a square, a hexagon, or an octagon:

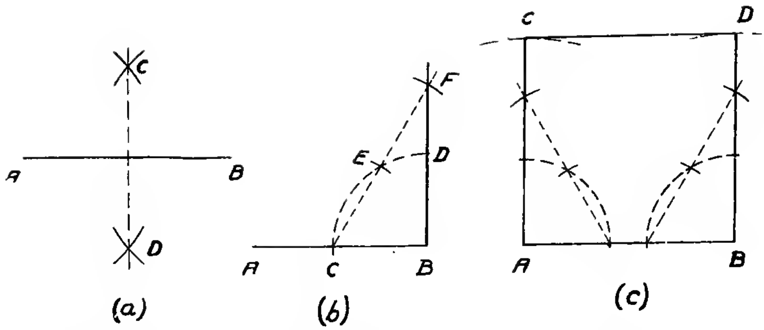
(*a*) Using the radius of the circle as a measure, divide the circumference into six equal parts. Connect the alternate points *A*, *B*, and *C*, and an equilateral triangle will be formed.

(*b*) Draw two diameters at right angles to each other and connect their ends, *A*, *D*, *B*, and *C*.

(*c*) Using the radius of the circle as a measure, divide the circumference into six equal parts. Connect the points thus found, and a regular hexagon will be formed.

(d) Draw two diameters at right angles to each other. This divides the circle into four equal angles. Bisect one of these angles and draw the line *O–E*. The distance *E–C* will be one-eighth of the circumference. Transfer this measurement, with the compass, to bisect the other parts. Connect the points thus found, and a regular octagon will be formed.

PLATE VIIa. GEOMETRIC PROBLEMS.



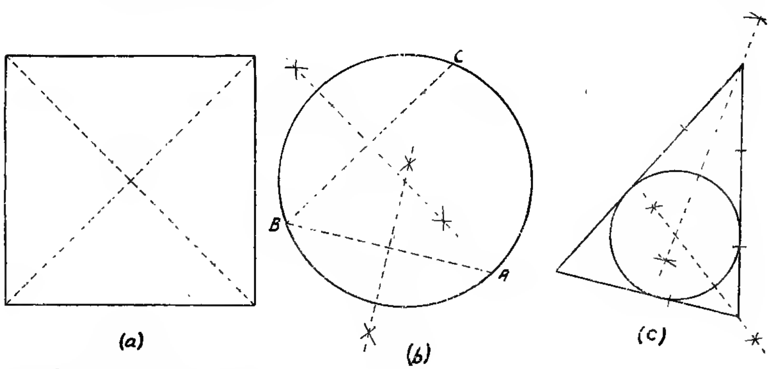
To bisect a line:

(*a*) Set the dividers to any convenient radius greater than one half the length of the line. Using the points *A* and *B* as centers, draw the arcs which cross or intersect at the points *C* and *D*. Connect the points *C* and *D* with a straight line. This will divide the line *A-B* into two equal parts.

To construct a right angle:

(*b*) Using any convenient radius and *B* as a center, draw the arc *C-D*. With the same radius, measure the distance *C-E*. Draw the line *C-E*, extending it as far as necessary. Using the same radius, measure the distance *E-F*. Connect the points *F* and *B*, and a right angle will be formed.

(*c*) This does not need any explanation, as it uses the same problem explained in (*b*). A square or a rectangle can be formed by measuring the required lengths on the lines.



To find the center of a square:

(*a*) Draw the diagonals as shown. The point where they cross or intersect will be the center.

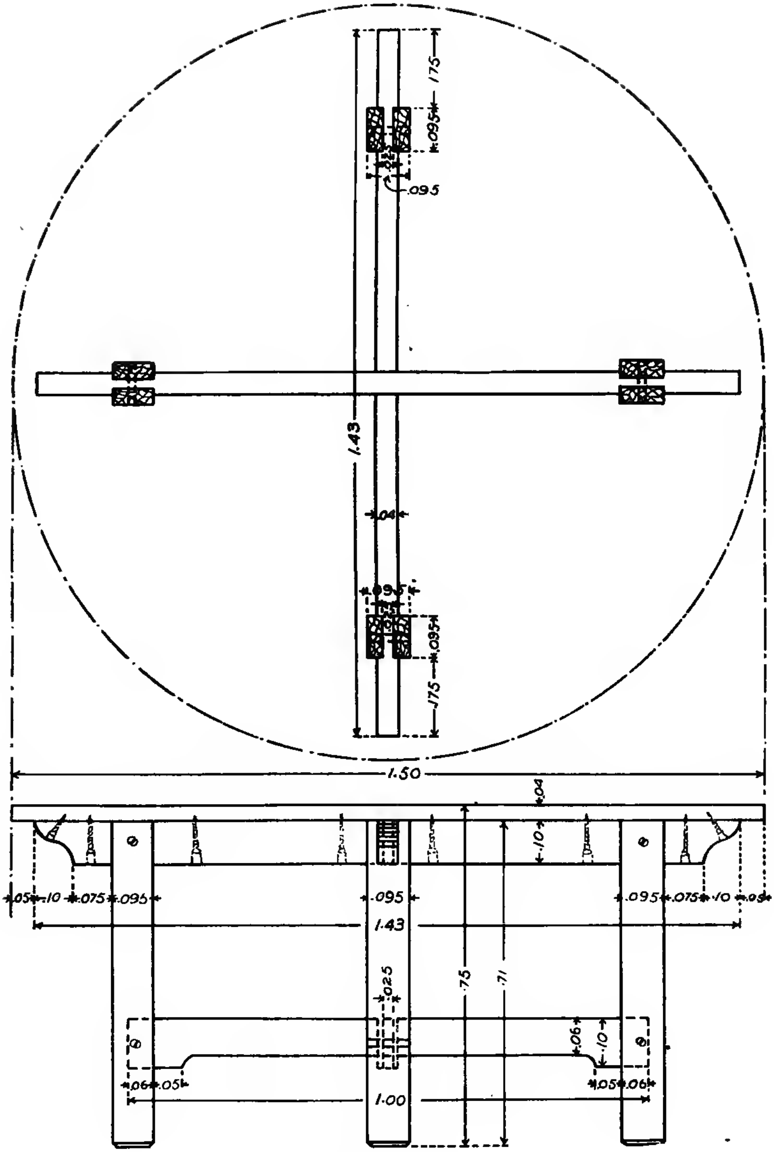
To find the center of a circle:

(*b*) Draw the two lines *A-B* and *B-C* meeting at the point *B*. Bisect these lines as shown. The point where the bisecting lines intersect will be the center of the circle.

To find the center of a triangle:

(*c*) Bisect two of the angles of the triangle. The point where the bisecting lines intersect will be the center of the triangle.

PLATE VIIb. GEOMETRIC PROBLEMS.



DINING TABLE

All dimensions Metric. To find equivalent in English inches, divide by .025

PLATE VIII.

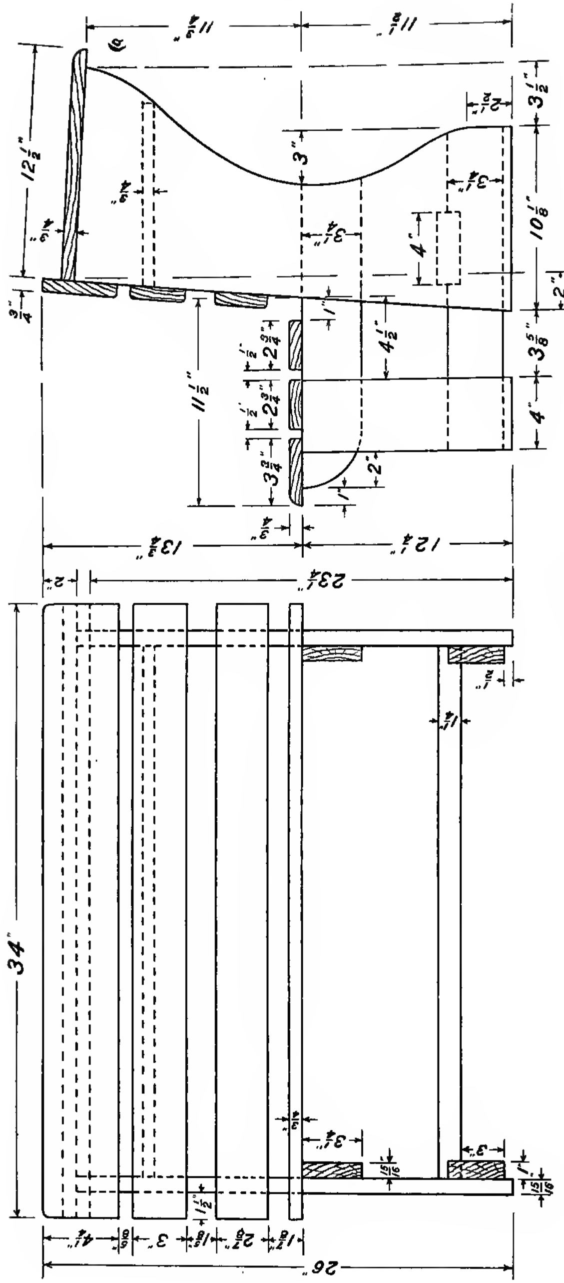


PLATE IX. SCHOOL DESK.

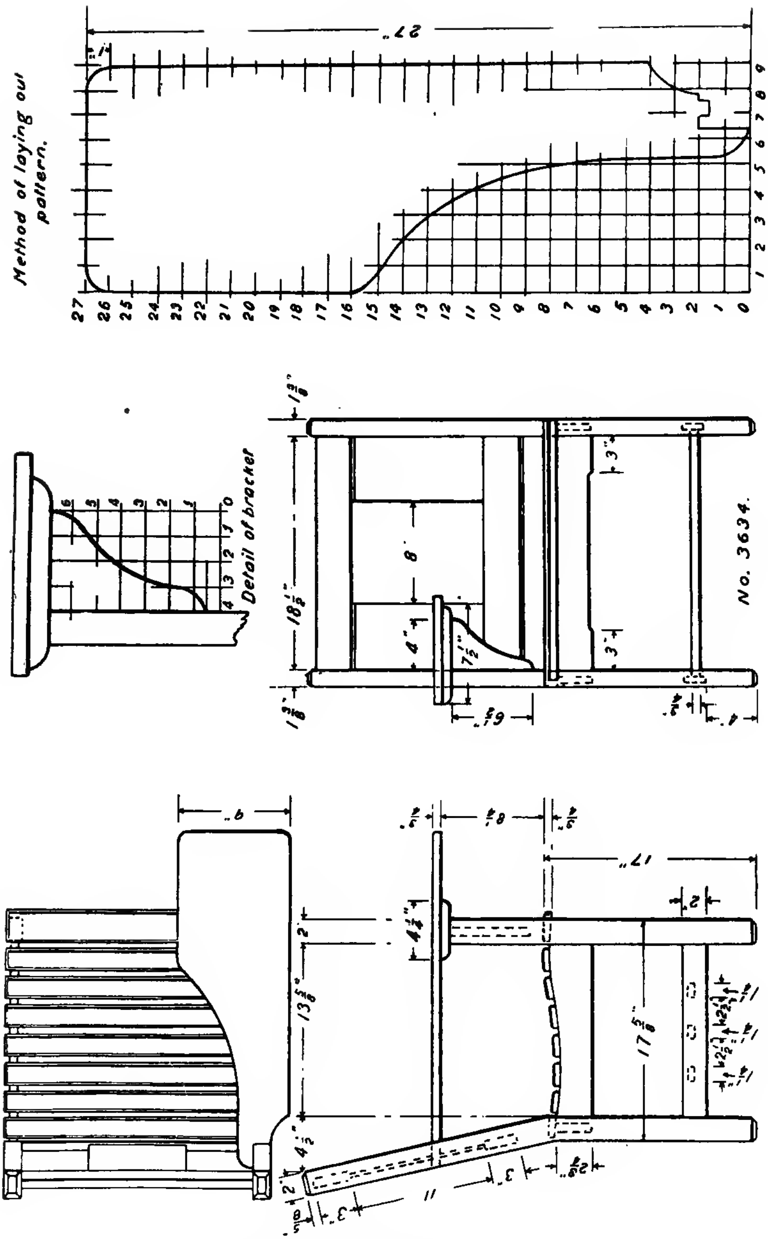


PLATE X. CLASSROOM CHAIR.

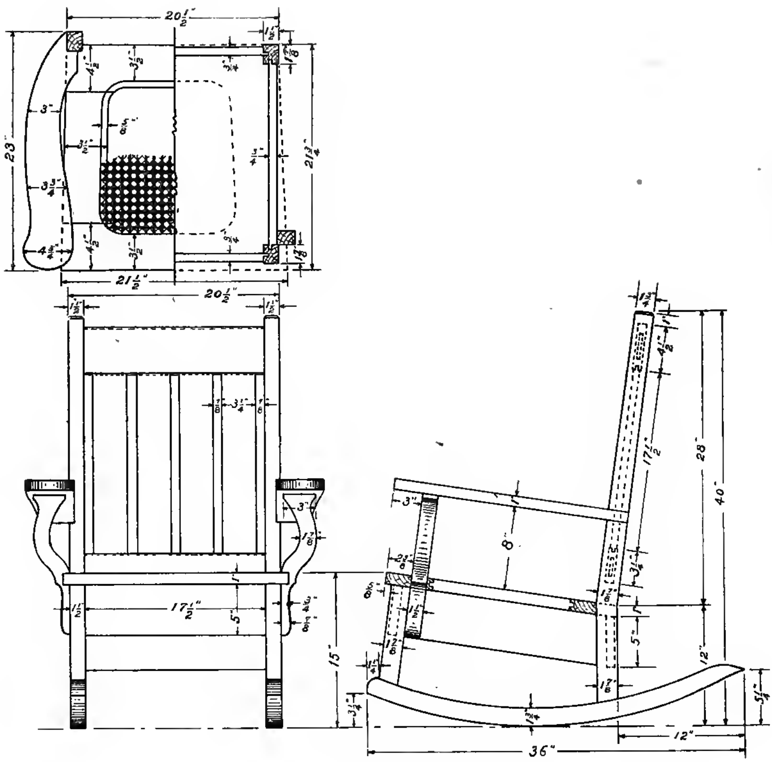


PLATE XI. ROCKING CHAIR.

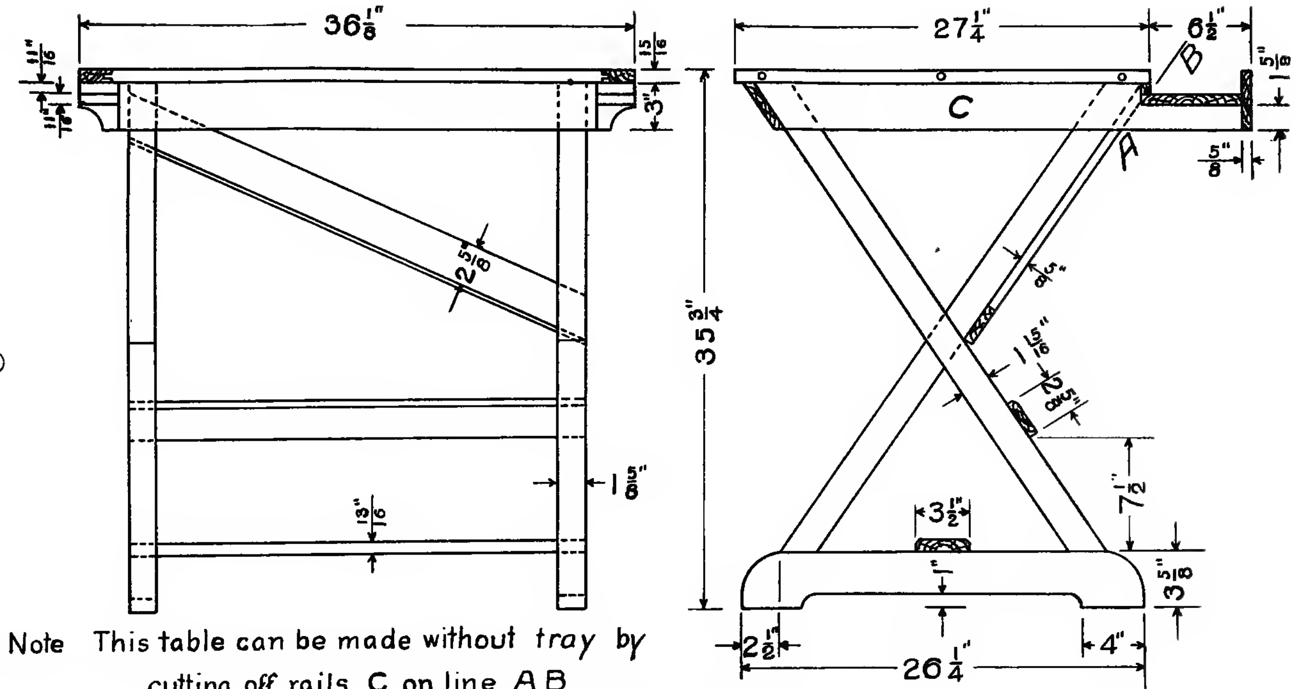


PLATE XII. DRAWING TABLE.

BUREAU OF EDUCATION PUBLICATIONS—Continued.

(Continued from second page of cover.)

THE PHILIPPINE CRAFTSMAN:

Volume I. 1912–13. (Supply limited.)
Volume II. 1913–14. (Supply limited.)
Volume III. 1914–15. (Supply limited.)

TEXTBOOKS:

Woodworking—A Manual of Elementary Carpentry for Philippine Public Schools. 1908. (Edition exhausted.)

Selected Short Poems by Representative American Authors. 1911. (Reprinted, 1913, 1915.)

Commercial Geography; the Materials of Commerce for the Philippines. 1911. (In course of revision.)

Samuel Johnson, Macaulay; Self-Reliance, Emerson; Gettysburg Address, Lincoln. 1911. (Reprinted, 1913.)

Supplementary Problems for Trade Schools and Trade Classes in the Philippine Public Schools. 1913. (Reprinted, 1915.)

Supplementary Problems for Domestic Science Classes. 1913. (Reprinted, 1915.)

Housekeeping—A textbook for Girls in the Public Schools of the Philippine Islands. 1914. (Reprinted, 1915.)

Economic Conditions in the Philippines. 1913.

Woodworking for Beginners. 1915.

Supplementary Problems for Classes in Agriculture. 1915.

Free-hand Drawing for Primary Grades, Grades I and II. (Supply limited.)

Free-hand Drawing for Primary Grades, Grades III and IV. (Supply limited.)

Phonics, A Five Weeks' Course for Primary Grades. 1915. (Supply limited.)

MISCELLANEOUS:

Domestic Science—A Guide to Practical Instruction in Housekeeping, Sewing, Cooking, and Laundering in Grades III and IV of the Philippine Public Schools. 1908. (Supply exhausted.)

Some Recipes for Preparing Jellies, Preserves, Pickles, and Candies from Philippine Fruits. 1911. (Supply exhausted.)

Second and Third Annual Reports on Private Schools and Colleges of the Philippine Islands. 1911 and 1912. (Supply exhausted.)

A Statement of Organization, Aims, and Conditions of Service in the Bureau of Education. 1911. (Several editions printed at Manila and Washington.) (Supply exhausted.)

A Talk on Health Conditions in the Philippines. Dr. Victor G. Heiser, Director of Health. 1912.

Local Geographical and Historical Notes. 1915. (Not completed.)

PHILIPPINE CRAFTSMAN REPRINTS: