Enormous quantities of lumber have been wasted through neglect and carelessness, but much is being done to eliminate waste and conserve the supply of lumber. (See p. 224.)

A good stand of western yellow pine, Coconino National Forest, Arizona. (Photo by A. Gaskill. Courtesy U. S. Forest Service.)

Principles of Woodworking

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PREFACE

During all ages wood has played an important and friendly part in the development of mankind. It enters, directly or indirectly, into the construction of more manufactured articles than any other material, and there is not an engineering project nor construction of any kind, in which wood is not used in some way.

A material, which enters so extensively into every phase of life, is of tremendous economic value to all civilized nations. The woodworking industries in this country, particularly the building and furniture industries, are among the most important, because they employ thousands of highly skilled workmen, designers, and artists, to produce useful as well as beautiful articles of wood. Other thousands are engaged in the distribution and selling of these products, and still other thousands in the manufacture of the numerous tools and machines used in woodworking.

This text is intended not only for the use of students in secondary and vocational schools, but also for adults who have taken up the study and practice of woodworking as a hobby.

Fundamental tool processes, common to all woodworking trades, have been compiled and arranged in family groups. With these as a basis, cabinetmaking has been emphasized throughout the book, because of its universal interest and appeal, and because this phase of woodworking is probably elected by most students.

All tool operations have been described and written in the form of instruction sheets. These have been further supplemented with related information about materials, tools, and machinery, and by a series of furniture projects, the construction of which has been carefully analyzed and described.

The teacher of woodworking will find the subject matter — both instruction sheets and related information — in convenient form for assignments.

Special attention is called to the method of planning and analyzing the various tool operations involved in the construction of an object. By following this method, any cabinet job may be analyzed and reference made by number to topics describing the various tool operations. After the students have become acquainted with the book, they should do their own thinking and planning, and should formulate their own job sheets for approval by the teacher.

The review questions at the end of each chapter should be of value to the student in testing his knowledge of a given topic, and to the teacher in checking up on his class.

The teacher of general science will find much helpful material on forest conservation, seasoning of lumber, and the physiological processes of the tree.

The teacher of physics will find the chapter on machinery helpful in illustrating the principles and practical applications of simple machines and the transmission of power.

It is the sincere hope of the author that the increasing number of "home woodworkers" will find this book helpful and stimulating, and that it will contribute to their interest and pleasure in craftsmanship. May they experience that satisfaction and joy of achievement which comes with a piece of work well done.

Grateful acknowledgment is hereby given to the following: Miss S. E. Sievers of Saunders Trades School for valuable help in reading and preparing the manuscript; Mr. J. Macdonald and Mr. H. A. Carlberg of Saunders Trades School for suggestions and criticisms; Mr. Arthur Wakeling, Home Workshop Editor of Popular Science Monthly, for permission to use the material on Wood Turning and Inlaying which was published in a series of articles in that magazine, together with some of the illustrations in topics 255, 325, 326, 327, 328, 330, 334, and 341, which were used in these articles; the Forest Products Laboratory, Madison, Wis., and the National Lumber Manufacturers' Association for most of the illustrations appearing in the chapter on Wood; the Oliver Machinery Company for the illustrations in Figures 97 and 118; and the Editor of the Industrial-Arts Magazine for permission to use material published in that periodical.

Yonkers, N. Y.
January, 1930

HERMAN HJORTH

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31. Name the most common chisels, and indicate the chief use of each.
32. How does a gouge differ from a chisel as to shape and use?

Boring Tools

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39. What is an auger-bit gauge, and how is it used?
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Miscellaneous Tools

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50. Name five jobs for which a woodworker may have to use one or more of the following tools: monkey wrench, tinner's snips, cutting pliers, gas pliers.

CHAPTER II

MACHINE TOOLS

During recent years there has been considerable progress in the field of woodworking machinery. Particular attention has been given to greater safety for the operator, and to convenience and ease in both the "setting up" and the operation of the machinery. Old types of production machines have been improved, and new types have been invented. Moreover, numerous types of bench and portable machines have been developed.

Since woodworking machinery is very dangerous to operate, improvements and inventions that will safeguard the operator are of the greatest importance. Some of the most notable advances have been cylindrical cutting heads on hand planers, safety switches, improved guarding devices, and the elimination of fast-moving belts through direct motor drives.

Developments within the field of production machinery have completely revolutionized the furniture industry, and have made cabinet-making in its century-old form one of the disappearing trades. In large furniture factories, handwork has been reduced to a minimum, because machines have been invented which can be operated by semi-skilled workers. Such machines perform practically all tool operations faster, better, and more uniformly than the skilled workman can by hand methods.

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The development of the small bench and portable machines, on the other hand, is of interest to the manufacturer and the individual workman, as well as to students of woodworking, and the increasing number of amateurs, who find recreation, satisfaction, and joy in manual work. Large up-to-date factories have found it to their advantage to distribute a number of these small machines among their benchworkers, because they help to speed up production by eliminating practically all handsawing and planing.

For the same reasons, contractors and individual workmen use them in increasing numbers, not only for sawing and planing, but also for routing, shaping, boring, and sanding.

This type of machinery has also become very popular in schools, es-

Principles of Woodworking

CHAPTER I

HAND TOOLS

The woodworker uses a large variety of hand tools. Every workman should be familiar with the tools which he uses. He should know their proper names, the purpose for which each is used, and how they are sharpened and kept in good condition.

In this chapter a brief description is given of the most commonly used hand tools. In a later chapter the sharpening of tools is explained in detail.

1. The bench is a tool or appliance of the utmost importance to the woodworker. The best type of bench has a top that is constructed of narrow strips of hard wood, glued and bolted together. It usually has

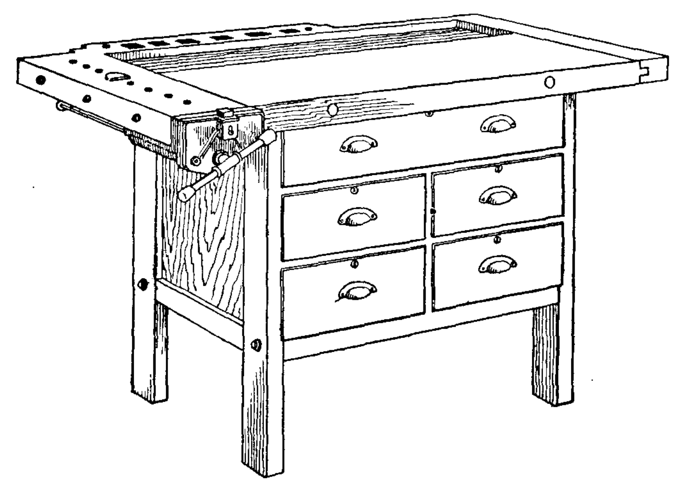

Fig. 1. Workbench

a recess or trough in which tools may be placed while working. The top is bolted to a frame consisting of four legs braced securely with crosspieces. This frame is often fitted with one or more drawers. (Fig. 1.)

The bench top is equipped with a side vise and sometimes also with a tail vise. These vises are made either of wood or iron. They have a central screw and parallel guide bars, one on each side of the screw. (Fig. 2.) Some iron vises are of the "continuous-screw" type and others of the "quick-acting" type. On some quick-acting vises a section of the screw thread is cut away throughout the entire length of the screw. This permits the movable vise jaw to be pulled in or out when the screw is in a certain position. A partial turn to the right tightens these quick-acting vises.

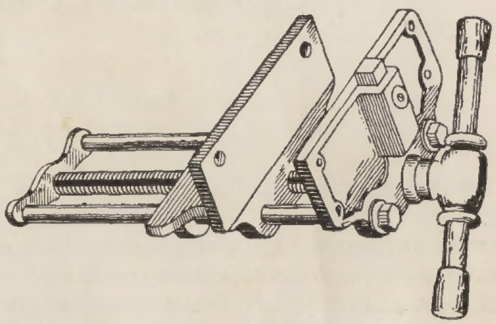

Fig. 2. Quick-acting vise

Some vises are equipped with an adjustable dog; i.e., a piece of iron which moves in a slot in the vise jaw. It can be set flush with the top of the vise jaw, or raised above it. A corresponding bench stop fits into holes bored in the bench top so that a piece of wood may be clamped firmly between the bench stop and the vise jaw.

A tail vise is a great convenience on a workbench, because it permits of clamping long pieces, such as table legs, for planing or mortising.

MEASURING TOOLS

2. **A rule** is generally the first tool used by the woodworker. Rules are made in different lengths and of different materials. Those used by the woodworker are usually of the folding type, and measure from 2 to 8 ft. in length. (Fig. 3.) Rules are generally marked off on both sides in inches and subdivisions of an inch, but they are also made with inch divisions on one side and metric divisions on the other.

Fig. 3. Folding rule

3. **Measuring tapes** are used by carpenters, contractors, and architects. They are made of steel or cloth, and usually measure from 25 to 100 ft. in length. (Fig. 4.) They are divided into inches and feet, or meters and centimeters.

4. **Try-squares** are used for testing the squareness of lumber, and in checking the squareness of work being assembled, especially in places where the framing square would be too large. Try-squares consist of two parts, the stock and the blade, which are firmly fastened together at right angles. The stock is thick and is made of wood or iron. The blade, which is thin, is made of steel and has an inch scale stamped on it. (Fig. 5.) Try-squares are made in sizes of from 4 to 12 in., measured from the end of the blade to the stock.

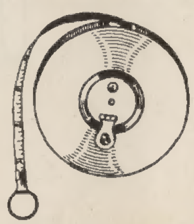

Fig. 4. Steel tape

5. **Miter and try-squares** (Fig. 6.) can be used at both 90 and 45 deg. Miter squares can only be used for angles of 45 deg.

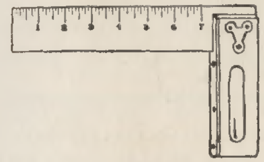

Fig. 5. Try-square

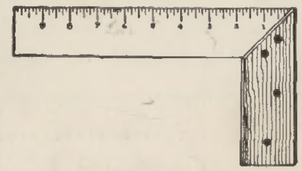

Fig. 6. Miter and try-square

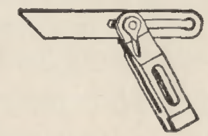

Fig. 7. Sliding T bevel

6. **Sliding T bevels** (Fig. 7) are similar to try-squares, but differ in that their blades are adjustable to any angle. They are used for laying out angles other than right angles, as for instance corner braces, dovetails, or side rails for chairs.

7. **The steel square** measures 16 by 24 in., or 18 by 24 in., and is of the same thickness, about ⅛ in., throughout. The 24-in. part is called the "blade" or "body," and is 2 in. wide. The 16- or 18-in. part is called the "tongue," and is 1½ in. wide. The "face" of the square is the side on which the manufacturer's name is stamped. The steel square is a very important tool, especially to the carpenter, who uses it in laying out the many different cuts employed in roof framing, stair building, oblique joints, etc. The cabinetmaker uses it mostly for testing the flatness of large surfaces (Art. 189) and for testing for squareness in gluing. The uses of the steel square are so numerous and varied that whole books have been written on this subject.

Besides the divisions of the inch into eighths, tenths, twelfths, sixteenths, and thirty-seconds, which are marked on the inside and outside edges on both sides of the square, the following tables are marked on it: brace measure, octagon measure, board measure, rafter table, and the divisions of 1 in. into 100 parts.

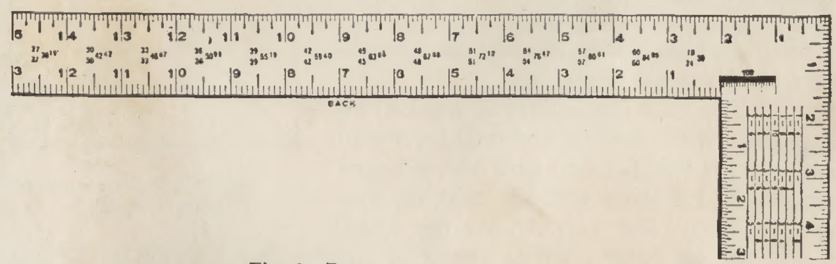

Fig. 8. Brace measure

Planes, like saws, are made in many different forms for different planing jobs. Some of the most common types are as follows:

34. **The jack plane** is the most useful, all-around plane in the woodworker's kit. (Fig. 36.) It is 14 or 15 in. long, and consists of an iron body to which the plane iron can be clamped. The bottom of the plane, which is either smooth or corrugated, is called the "sole." The front part of the sole is called the "toe," and its rear part, the "heel." A casting, called the "frog," is screwed to the iron body near its center. A wooden knob is screwed to the forward part of the body, and a handle to its rear part.

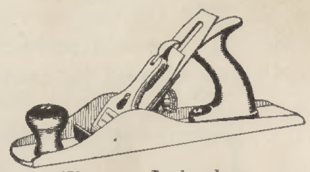

Fig. 36. Jack plane

The plane iron, which in a jack plane is 2 in. or 2¼ in. wide, consists of two parts, the cutter and the cap. The latter is screwed to the back of the cutter, and is used to stiffen it and to break up the shavings. The plane iron is clamped to the frog by means of another iron, corresponding to the wedge in a wooden plane, called the "lever cap." The plane iron can be adjusted to the depth of the cut by means of a brass screw engaging a wishbonelike casting. This is called the "Y adjustment." It can be adjusted laterally or level with the sole of the plane, by a lever riveted to the top of the frog. (Fig. 37.)

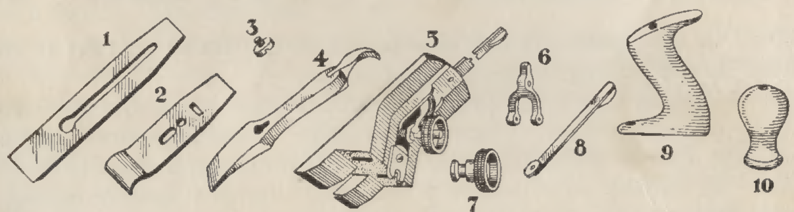

Fig. 37. Plane parts. 1, cutter iron; 2, plane-iron cap; 3, cap screw; 4, lever cap; 5, frog; 6, Y adjustment; 7, Y-adjustment screw; 8, lateral-adjustment lever; 9, handle; 10, knob

The sole of the plane keeps the thickness of the shaving uniform. If the board to be planed is uneven, it prevents the cutting iron from touching the hollow parts until all the high parts have been leveled off. Therefore, the longer the sole, the straighter the edge that is produced. The shavings enter through a narrow slit called the "throat" or "mouth." This slit is in the sole just forward of the cutting iron. The toe of the plane presses down on the wood in front of the shaving being taken, thus preventing it from splitting ahead. The width of the throat can be narrowed by moving the frog forward.

When planing an edge or a narrow board, the entire sole of the plane should be in contact with the wood to produce a straight edge. The tendency among beginners to hold the plane obliquely should be avoided and discouraged. Oblique cutting is a little easier, but it does not produce a flat surface, because only a small part of the sole is in contact with the wood.

35. **The fore plane** is built exactly like a jack plane, but is 18 in. long and has a plane iron 2⅜ in. wide.

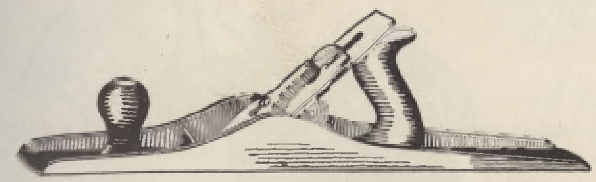

Fig. 38. Jointer

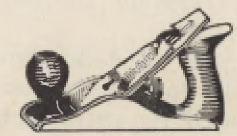

Fig. 39. Smooth plane

36. **The jointer** is also like the jack plane, but is 22 to 24 in. long, and has a plane iron 2⅜ or 2⅝ in. wide. (Fig. 38.) The latter two planes are used for leveling larger surfaces and for jointing the edges of boards to be glued.

37. **The smooth plane** is of the same construction as the abovenamed planes, but it is shorter, being from 5½ to 10 in. in length. (Fig. 39.) It also has narrower plane irons, from 1¼ to 2 in. It is used for planing smaller pieces and for very fine work.

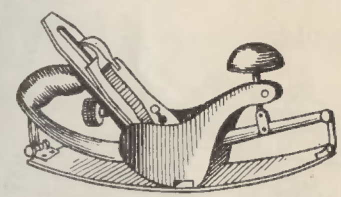

Fig. 40. Circular plane

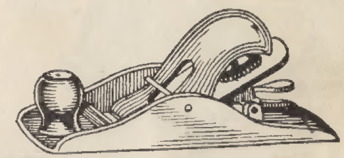

Fig. 41. Block plane

38. **The circular plane** differs from the others in that it has a flexible bottom 10 in. long, which can be adjusted to either convex or concave curves. (Fig. 40.) It is used on curved work, such as round table tops and aprons.

39. **The block plane** is a small plane from 4 to 8 in. long. (Fig. 41.) It has only a single plane iron, which is placed at a very low angle with the beveled side up. The lever cap is generally curved so that it fits smoothly within the hollow of the hand. This plane is used for planing end wood and in places where an ordinary plane could not be used.

40. **The bullnose rabbet plane** is about 4 in. long, and has the plane iron fastened to the extreme front of the body. (Fig. 42.)

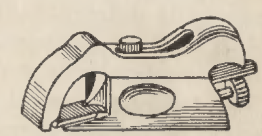

Fig. 42. Bullnose rabbet plane

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For the same reasons, contractors and individual workmen use them in increasing numbers, not only for sawing and planing, but also for routing, shaping, boring, and sanding.

This type of machinery has also become very popular in schools, especially those of junior grade where the work done is usually limited to size.

A special type of combination machine is very popular with the home craftsman. This machine usually consists of a small lathe as the basic tool, to which can be added attachments for boring, sawing, grinding, buffing, jig sawing, etc. (Fig. 90.)

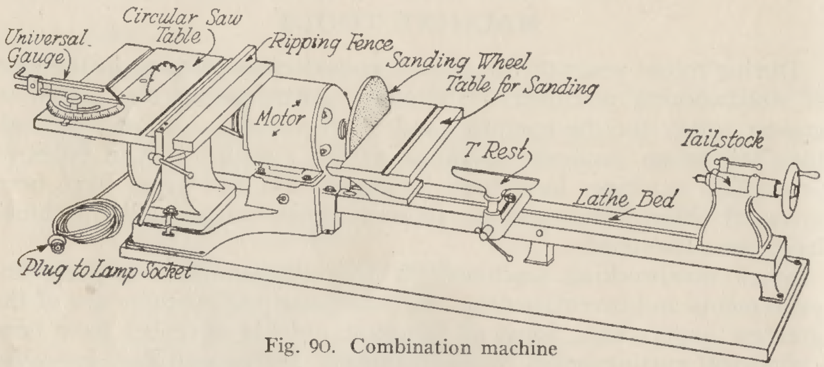

Fig. 90. Combination machine

A well-equipped woodworking shop contains the following machines: a swing cut-off saw, a circular saw, a band saw, a jig saw, a jointer, a planer, a mortiser, a shaper, a sander, a trimmer, a lathe, and sharpening machines.

89. Swing cut-off saws are of two general types, those which cut from above and those which cut from below.

Those of the first type consist of a hollow cast-iron column, suspended from two hangers fastened either to the ceiling or to the wall. A casting, the arbor frame, containing the bearings in which the saw arbor runs, is bolted to the end of this frame. Slots in the arbor frame permit a vertical movement. (Fig. 91.)

The motive power is transmitted in one of three different ways, by a countershaft, by a belted motor drive, and by a motor-on-arbor drive.

The countershaft has three pulleys, a tight and loose pulley of the same diameter, and a driving pulley of a larger diameter. (Fig. 267.)

A belt from the driving shaft runs on the loose pulley, which revolves on the countershaft without moving it. When the belt is shifted over to the tight pulley, which is keyed and bolted to the countershaft, the latter starts to revolve. The driving pulley, which is also bolted to the countershaft, drives the saw arbor by means of a belt at about 2000 r.p.m.

The belted motor drive consists of an individual motor mounted on the frame of the saw in place of the countershaft and belted to the saw arbor.

In these two machines, provision is made for tightening the belt

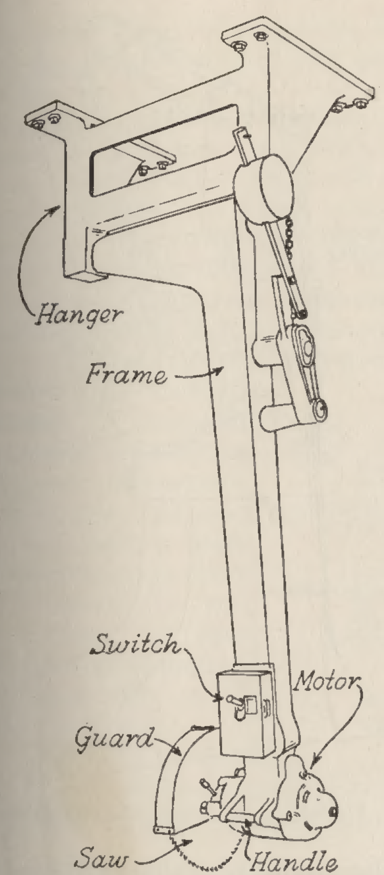

Fig. 91. Swing cut-off saw

by a vertical movement of the saw-arbor casting.

The motor-on-arbor drive is one of the newest types. In this a ball-bearing motor is built on the arbor of the saw. A safety switch is conveniently mounted on the column above the motor. (Fig. 91.)

The saw table consists of two sections, each about 8 ft. long, 20 in. wide, and 30 in. high. The top usually is made of hard wood and is supplied with rollers to facilitate the moving of long planks or timbers. It also is furnished with a scale graduated in inches and feet, and iron stops. (Fig. 93.)

The saw swings in the narrow opening between the two tables, and is adjusted so that its teeth come just below the surface of the table. Readjustment is necessary after the saw has been worn and filed to a smaller diameter. Another type of swing cut-off saw, which also cuts from above, is mounted on a vertical cast-iron column somewhat resembling that of a mortising machine. (Fig. 92.) This machine is very rigid and accurate, and can be set to cut different angles.

90. Use of swing cut-off saw. This type of saw is used mainly for dadoing, and for cutting boards, planks, or timbers into required lengths. If a number of pieces are to be cut the same length, one of the iron stops is adjusted accordingly, and the lumber is pushed against it. By means of a handle bolted to the arbor casting, the saw is then pulled across the board or plank. A heavy counterweight causes the saw automatically to swing out of the way after the operator releases the handle.

The saws used are from 12 to 24 in. in diameter, and the capacity is 12 in. in width and as much as 9 in. in thickness. The saws are guarded

CHAPTER IV

PLANING AND SQUARING TO DIMENSIONS

Planing and squaring to exact dimensions is the ABC of all good woodwork. It must be thoroughly mastered before any other process can be undertaken successfully.

138. **To Square Small Boards to Dimensions.** (1) Select the best of the two widest sides, and plane it just enough to clean it off and make it perfectly flat. Test this surface with the try-square, holding

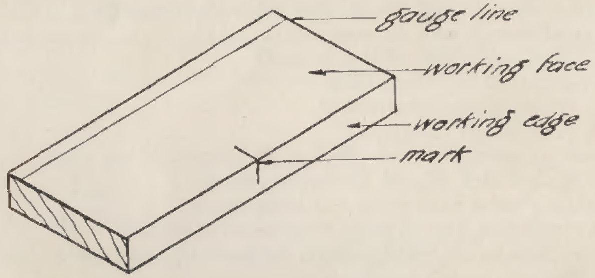

Fig. 154. Squaring board to dimensions. Steps 1 to 3

it lengthwise, crosswise, and diagonally at several points. This surface is called the "working face."

2. Select the best of the two edges, and plane it until the surface is true and square to the working face. This edge is called the "working edge." Mark the working face and working edge with a pencil. (Fig. 154.)

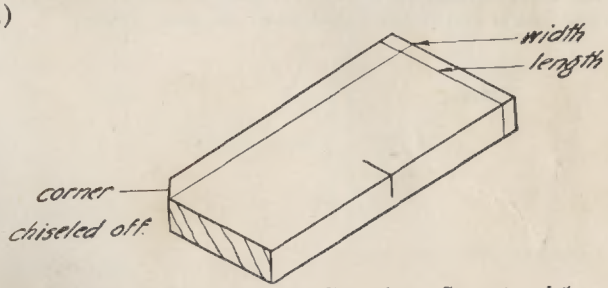

Fig. 155. Squaring board to dimensions. Steps 4 and 5

3. Set a marking gauge to the desired width. With a rule measure the width from the spur of the gauge to the block. Hold the block of the marking gauge against the working edge, and mark a line on the working face, pushing the gauge away from you.

If the width of the board is more than 5 or 6 in., the marking gauge cannot be used. If a panel gauge is not available, measure the width with a ruler at two points, one near each end. Then, draw a pencil line, along a straightedge, through these two points.

4. Chisel off the corner outside the gauge line, and plane the best end square to both working face and working edge.

5. Measure the length of the piece from the end just planed, and square lines all around, using the try-square and a knife or sharp pencil. (Fig. 155.)

6. Saw off the surplus lumber outside this line, using a bench hook, or clamping the piece in the vise. Chisel off the corner as before, and plane this end to the line marked, so that it is square to both the working face and the working edge.

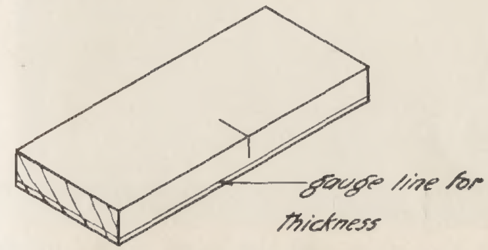

Fig. 156. Squaring board to dimensions. Step 8

7. Plane the edge opposite the working edge to the gauge or pencil line, and square to the working face.

8. Gauge the thickness from the working face on both edges and ends. (Fig. 156.)

9. Plane the last face, opposite the working face, to these gauge lines. In cases where the board is very narrow or already has the desired

Fig. 157. Planing end of narrow piece of wood

width, splitting of the end wood may be prevented if a piece of wood is placed in the vise behind the edge while planing the ends. (Fig. 157.)

139. **To Joint Boards for Gluing.** (1) Wide surfaces, such as

CHAPTER VIII

MORTISE-AND-TENON JOINTS

The mortise-and-tenon joint is without exception the most important and most used joint in cabinet construction. It is made with several variations for different purposes. Some of the most important of these are carcase framing, door and panel framing, table framing, and chair framing.

The carpenter uses the mortise-and-tenon joint in joining cross members to posts, and in the building of any heavy substantial framework.

164. To Make a Blind Mortise-and-Tenon Joint. (1) Square the pieces to dimensions, and mark their faces plainly.

2. Determine the length of the tenon; i.e., the distance it is to enter the other member, and square a line all around its end at that point which is the shoulder.

3. Mark the total width of the tenon member on the mortise member at the point where they are to be joined.

4. Determine the thickness of the tenon; it is usually from one third to one half the thickness of the stock. Set the points of a mortising gauge to this distance, and adjust the block of the gauge, so that the double lines will be marked in about the center of the piece.

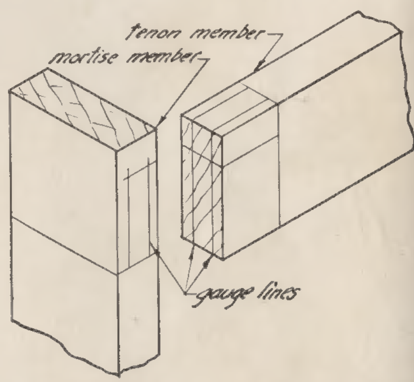

Fig. 194. Layout of mortise-and-tenon joint

5. Gauge *from the face* on the end and edges as far as the lines marking the shoulder. (Fig. 194.)

Mark and gauge all tenons in the construction in the same manner before proceeding with the work.

6. If the faces of the members are to be flush, gauge the mortise with the same setting of the gauge from the face of the piece. If the mortise member is thicker than the tenon member, as for example in a table leg, and the rail or tenon member is to be set in, for example ¼ in. from the face of the leg, the block of the mortise gauge must be moved accordingly, *but not the setting of the two points.*

Gauge all mortises with the same setting of the gauge. If a mortising gauge is not available, an ordinary marking gauge may be used. In this case, all the face cheeks on tenons and mortises are first gauged, and then all the back cheeks.

7. A tenon is rarely made the full width of the member, but an additional cheek cut is laid out, making it narrower. If the mortise is near the end of a piece, the corresponding cheek cut is made so that the end wood of the mortise will not tear out when it is chiseled. Lay out this cheek cut on both tenons and mortises.

Fig. 195. Sawing cheek cuts of tenon

8. The laying out is now completed, after which the mortise is made. This may be done either by chiseling alone or by boring and chiseling.

9. In the first method, a mortising chisel of the same width as the mortise to be chiseled is used. Clamp the piece on top of the bench and begin by cutting out wedge-shaped pieces in the center of the mortise until the required depth is reached. This may be determined by gluing a strip of paper around the chisel. (Fig. 200.) Now make a series of perpendicular cuts toward both ends, holding the bevel of the chisel toward the cen-

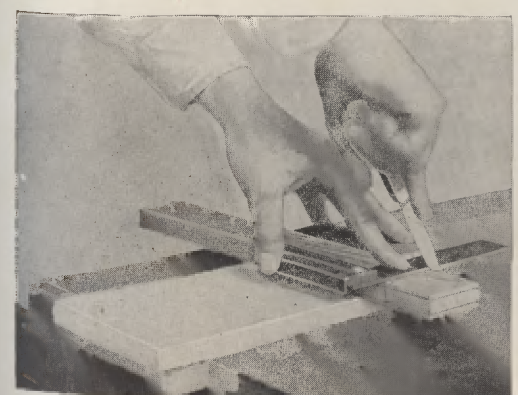

Fig. 196. Scoring line with knife

cut depending upon the sharpness of the cutter. The slight roughness appearing at the edges of grooves cut across the grain is removed when the inlaid surface is scraped and sanded, as directed in step 11 following.

6. For border lines up to and including ¼ in. in width, several parallel cuts may be made with a $\frac{1}{16}$-in. cutter as described herein.

7. For wider lines, it is recommended to gauge the width with a slitting gauge (Fig. 17) or a mortising gauge (Fig. 18), having the spurs filed to very sharp points. The material between the lines may then be removed with a router plane. To prevent the danger of the plane slipping outside the lines, a piece of wood may be screwed to its

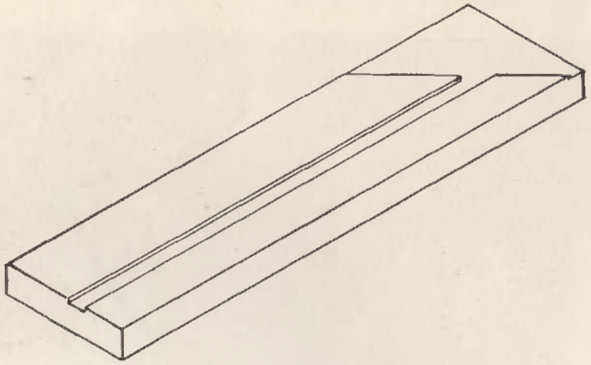

Fig. 304. Block for mitering bands of inlay

underside. This will bear against the edges of the surface to be inlaid, and act as a guide. (Fig. 310.)

8. Regulate any little unevenness in the corners with a sharp chisel, cut the lines to length, and miter them in the corners. This is best done with a very sharp chisel.

9. In a strip of wood about 2 or 3 in. wide and about a foot long, cut a groove $\frac{1}{16}$ in. deep and a little wider than the band of inlay. Near the end of the strip, lay off a line at an angle of 45 deg. Saw on this line to a depth of $\frac{1}{16}$ in., and cut a recess on the end of the wood to the same depth. This strip is used for mitering bands of inlay. (Fig. 304.)

10. When the lines have been cut to length and mitered, they are brushed with thin glue, and are forced into the grooves with a hammer, either by striking light blows on a block of wood laid over the inlay, or by running the hammer over the lines while exerting pressure on the head of the hammer. This must be done carefully so that the inlay will not be injured.

11. After drying about ten hours, the inlaid piece may be scraped with a very sharp veneer scraper until all glue has been cleaned off and

the lines are absolutely level with the surface. It is then ready for sanding and finishing.

Bands of inlay absorb some moisture from the glue which causes them to swell. As they cannot expand sidewise in the narrow grooves, they swell in an upward direction. When the water evaporates, they again shrink to their original thickness. It is, therefore, important to allow sufficient time before scraping them level with the surface. They

Fig. 305. Cutting grooves with router machine

will continue to shrink after a too early scraping, thus forming an unsightly hollow.

Grooves for line inlay can be cut very easily with a router machine. (Fig. 305.) This machine is furnished with a guide for both straight or curved work. The machine is fitted with a bit of the proper diameter and adjusted to the desired depth of cut. The guide is fastened at the correct distance and held against the edge of the piece while the groove is being cut.

235. To Inlay Insets. (1) Insets sold by manufacturers of mar-