KING'S WOODWORK AND CARPENTRY

ELEMENTS OF WOODWORK AND CONSTRUCTION

KING'S SERIES IN WOODWORK AND CARPENTRY

ELEMENTS OF WOODWORK
ELEMENTS OF CONSTRUCTION
ELEMENTS OF WOODWORK AND CONSTRUCTION
CONSTRUCTIVE CARPENTRY
INSIDE FINISHING
HANDBOOK FOR TEACHERS

W. P. 2

PREFACE TO THE SERIES

This series consists of six volumes, five of which are intended as textbooks for pupils in manual-training, industrial, trade, technical, or normal schools. The last book of the series, the "Handbook in Woodwork and Carpentry," is for the use of teachers and of normal students who expect to teach the subjects treated in the other volumes.

Of the pupils' volumes, the first two, "Elements of Woodwork" and "Elements of Construction" (or the combination volume, "Elements of Woodwork and Construction"), are adapted to the needs of students in manual-training schools, or in any institution in which elementary woodwork is taught, whether as purely educational handwork, or as preparatory to a high, or trade, school course in carpentry or vocational training.

The volumes "Constructive Carpentry" and "Inside Finishing" are planned with special reference to the students of technical, industrial, or trade schools, who have passed through the work of the first two volumes, or their equivalent. The subjects treated are those which will be of greatest value to both the prospective and the finished workman.

For the many teachers who are obliged to follow a required course, but who are allowed to introduce supplementary or optional models under certain conditions, and for others who have more liberty and are able to make such changes as they see fit, this series will be found perfectly adaptable, regardless of the grades taught. To accomplish this, the material has been arranged by topics, which may be used by the teacher irrespective of the sequence, as each topic has to the greatest extent possible been treated independently.

The author is indebted to Dr. George A. Hubbell, Ph.D., now President of the Lincoln Memorial University, for encouragement and advice in preparing for and planning the series, and to George R. Swain, Principal of the Eastern High School of Bay City, Michigan, for valuable aid in revising the manuscript; also to Assistant Professor of Forestry, C. L. Hill, of the University of Michigan, for his careful revision of the chapter upon the growth of wood in Elements of Woodwork.

Acknowledgment is due various educational and trade periodicals, and the publications of the United States Departments of Education and of Forestry, for the helpful suggestions that the author has gleaned from their pages.

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PREFACE TO ELEMENTS OF WOODWORK AND CONSTRUCTION

In preparing this book, it has been the author's purpose to present, in as complete and concise form as possible, the knowledge which every woodworker should possess regarding the care and use of his tools and materials, the simpler forms of construction used in fastening wood together, and the reading and understanding of simple drawings.

Whether tools, materials, or forms of construction are used by an amateur, apprentice, or skilled workman, by a carpenter, cabinetmaker, boat builder, pattern maker, or wood carver, the elementary knowledge of the construction of tools, of the principles upon which they operate, of sharpening them, and of their adjustment and manipulation is practically the same. The structure of wood, and the necessity of applying its peculiarities of grain and texture to the advantage of the work in hand, also is the same upon all forms of woodwork.

While innumerable tools and cutting devices have been invented to enable the woodworker to accomplish special results economically both as to time and material, a study of them will prove that they all operate upon a few simple principles, a knowledge of which is not difficult to acquire, though skill and judgment in the application of the tools can be attained only by continuous and properly directed practice.

It would be both impossible and unnecessary in a book of this sort to describe these various devices, though in a schoolroom it is a great advantage to have as many of them as practicable, not for their use only, but that the students may become familiar with their purposes and the applications of the fundamental principles upon which each is based.

The actual use of tools may be considered the A B C of woodwork, as it bears the same relation to the finished product of the workman as the alphabet bears to literature, the space between the mere mechanical facility in the use of either tools or alphabet, and the finished product, being the result of the judgment, skill, and individuality of either the workman or the author.

Thus, if a student acquires the facility to use the tools described in this volume, he will have little difficulty in using other and more complex tools; and when he has mastered the principles involved in the constructive exercises, he has acquired a knowledge of the fundamental principles which must be applied in all construction in wood.

The problems in elementary construction are intended to familiarize the pupil with their various uses, and one or more of these problems, bearing upon the work he is to do, should precede the undertaking of any really important work.

Students should be encouraged to create new models or exercises for themselves, following those shown only as a guide to the degree of difficulty or for suggestions as to methods of construction.

The arithmetic problems in this volume are intended to be used in connection with the class work, the teacher adapting them to his uses as may seem best. They are of the same nature as those with which the workman will come in daily contact, and should be used as the basis for mental drill as much as possible and for the teaching of the short cuts which the man in business should acquire.

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CHAPTER I

Growth of Wood

1. **Kinds of trees used for lumber.** — (**A.**) The classification of trees here considered is based upon the method by which the trunk, or stem, of a tree is formed. The term *exogenous* is applied to outside growers, around which a layer of wood grows each year, and from which is cut the lumber of commerce. As the wood-worker is interested mainly in trees which grow by this method, we will do no more than mention the *endogenous*, or inside-growing, trees or plants of the nature of palm trees, cornstalks, etc., in which the woody fiber is formed upon the inside of the stem.

(**B.**) The new wood formed each year upon exogenous trees is known as the *annual layer*, or *ring;* the separate layers being more prominent in open-grained woods, such as oak, ash, and chestnut, than in close-grained woods, such as maple, cherry, poplar, and birch. It is the difference in the character and structure of these layers which makes some woods hard and others soft, some with open and others with close grain, and which also, with the coloring matter peculiar to each kind of wood, causes its individuality and adaptability to certain uses.

(The color and odor of wood are caused by chemical combinations, and are not part of the substance of the wood.)

Each of these annual layers is composed of two parts, the formation being shown in Fig. 1, in which the grain of yellow pine is depicted. The visibly porous, or open grain, *a*, is formed as the sap moves upward in the spring, and the hard, compact grain, *b*, is formed later in the year. In soft woods the open grain predominates, while in hard woods the compact grain is more in evidence.

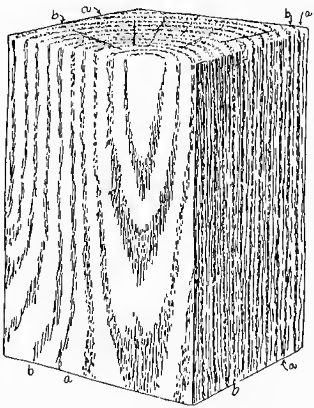

FIG. 1. — SECTION OF YELLOW PINE.

a, visibly porous, or open grain; *b*, hard, compact grain.

The age of a tree may be determined by counting these annual rings upon the stump, though a drouth during the growing season may have at some time so affected its growth as to make some layers indistinct, rendering it impossible to be absolutely sure of the count. In a young tree the annual layers are thicker than when the tree becomes more mature.

(C.) The different kinds of wood in common use are taken from *deciduous*, or broad-leaf trees, and from *coniferous*, or needle-leaf, trees. This classification is based upon the character of their foliage, the former kind furnishing woods similar to the ash, oak, walnut, beech, birch, poplar, and linn. The coniferous, or evergreen, trees furnish the cedar, pine, hemlock, spruce, fir, and redwood.

The above classification is a popular one, but it cannot be strictly applied to the larch (tamarack) and cypress, which shed their foliage after the manner of deciduous trees; they are conifers since they have cones and foliage similar to other conifers, and their wood has the usual structure of coniferous woods. These woods have a resin which is always present, no matter how old or dry the wood may be, which explains their superior weather-resisting qualities.

2. **The formation of wood.** — (**A.**) In the spring the sap ascends by way of the sapwood. This crude sap consists of water, having dissolved in it a very small amount of mineral constituents of the soil. (**B.**) In the leaves, by the process of photosynthesis, carbon dioxid, taken from the air, is broken up and its carbon is combined with hydrogen and oxygen of the water to form sugar or starch. This process can be performed only in the presence of light, by the minute green chlorophyll bodies, as they are called, which give color to the leaf. (**C.**) The elaborated plant food, in the form of sugar, is then carried downward, through the inner bark, until it is used in the growth of the tree, in the cambium, or, if in excess, it is carried inward through the medullary rays and stored until it is needed. (**D.**) In the delicate tissue known as the cambium, which lies between the wood and the bark, the growth of exogenous trees takes place. The cambium cells divide parallel to the periphery of the stem and form new cells; those formed on the inner side of the cambium become sapwood, while those on the outer side become part of the bark, this new growth forming the annual layer for each. (**E.**) In many kinds of trees, after a number of years, varying for different species, and even in the same

species under varying conditions, the wood changes color, becomes darker, more durable, and is then spoken of as "heartwood" in distinction from sapwood, the younger, lighter colored part of the stem.

(**F.**) In all unseasoned lumber from 20 to 60 per cent of its weight is moisture, which must be evaporated before the lumber has its highest commercial value. This may be done by weather drying or by artificial means, the lumber being treated in a specially constructed kiln.

3. **Parts of the woody stem.** — (**A.**) The trunk of a tree may be roughly divided into two main parts: wood and bark. The wood includes the *pith* (Fig. 2, *a*), the *heartwood* (*b*), and the *sapwood* (*c*); from this part of the tree is taken the commercial lumber. The bark includes the *bast* or inner bark (*e*), and the corky outer bark (*f*). The *cambium* (*d*) is a thin layer of soft growing tissue, between the sapwood and the bark, which annually forms the new layer for both.

(**B.**) The heartwood (*b*) of most trees is the part generally used by carpenters upon the best work. It is firm, compact, and of the color and character by which the best grades of the wood are recognized commercially.

(**C.**) The sapwood (*c*) is generally light-colored, and in most building woods its presence is considered a defect, though not in hickory, ash, maple, or yellow pine, and a few other woods; in fact, in these woods it is often preferred to the heartwood for many kinds of work on account of its color. The sapwood of most trees does not make as good lumber as the heartwood, as it usually absorbs moisture more readily, and is more easily attacked by decay; exceptions to this will be mentioned later.

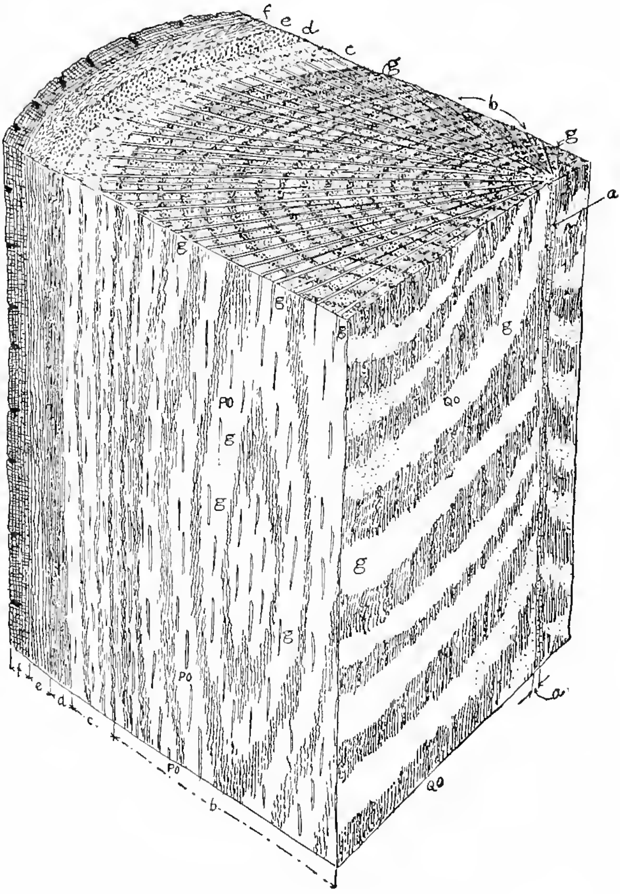

FIG. 2.—SECTION OF OAK TREE TRUNK.

a, pith; *b*, heartwood; *c*, sapwood; *d*, cambium; *e*, bast, or inner bark; *f*, outer bark, or corky layer; *g*, medullary rays, or silver grain; *po*, plain oak; *qo*, quartered oak.

Many of the cells of the sapwood are active, and assist materially in the functions of the tree, until by absorption of chemical substances, and by other processes not yet entirely understood, the cell walls become darker and eventually part of the lifeless heartwood. The time required for sapwood to attain maturity ranges from thirty to one hundred years, according to its kind and age.

(**D.**) Outside of the sapwood (Fig. 2, *c*) is the cambium (*d*), which furnishes the substance upon which the life of the tree depends. Here, nourished by the richest sap, new cells are formed, which become either sapwood or a part of the bast. (**E.**) At (*e*) is shown the bast or inner bark, which is composed of a woody fiber combined with a tissue of cells. This is elastic, which allows it to expand as the wood grows beneath it. Outside of the bast is the bark (*f*), or outer covering, which is of a corky nature, and protects the delicate vital parts of the tree.

4. **The medullary rays.** — The *medullary rays* (Fig. 2, *g*) are usually spoken of by woodworkers as the "silver streak" or "silver grain." They are found in all trees, but are more prominent in oak, beech, and sycamore than in most other woods. It is to take advantage of the beauty which these medullary rays impart that so much quarter-sawed lumber is used, though lumber sawed in this way is preferred for other reasons, which will be discussed later.

In many woods these rays are so small as to be invisible to the naked eye, as in pine, for instance, which has fifteen thousand to the square inch. Aside from adding much to the beauty of the lumber, they also give strength; if lumber is dried out too rapidly by artificial heat, it is apt to *check*, or crack, upon the line of the medullary rays.

5. The grain in trees. — Trees growing in open or exposed situations usually have short trunks, and are generally of little value for anything but cordwood; for though short pieces will often have a handsomer grain than lumber cut from a straight trunk, their strength will be less, and they will have a greater tendency to warp and twist in seasoning. The lower branches of trees growing in a dense forest become more and more shaded, and are thus prevented from receiving the necessary nourishment. These slowly die and fall off, and in due course of time the trunk grows around and over the stub or wound, after which the tree produces first-class lumber. The living branches are at the top where they can obtain the light needed for the growth of the tree. These trees have straighter trunks than those which grow in the open, and few cross-grained places, because the lower branches disappeared while they and the tree were small.

When the annual rings are large, the grain is said to be *coarse*, and if the rings are fine, the term *fine-grained* is used to describe it. When the direction of the fibers is nearly parallel with the sides and the edges of the board, it is said to be *straight-grained;* when the lumber is taken from a crooked tree, it is said to be *cross-grained*, as the grain follows the shape of the log, while the board is sawed straight.

6. Defects found in lumber. — (A.) Some of the most common defects found in lumber are *wind shakes*, or *cup shakes* (Fig. 3, *a*), which are cracks following the line of the porous part of the annual rings. These are caused by the action of severe winds. (**B.**) *Heart shakes* (Fig. 3, *b*) are cracks wider at the pith of the tree from which they radiate, along the line of the medullary rays. They may be found in any wood, as they are caused by the shrinkage in opposite directions of the pith ray, and body cells of the wood. (**C.**) *Star shakes* (Fig. 3, *c*) are caused by the shrinkage of the tree upon the outside, which is the result of a long dry spell, of intense cold, or of the deficient action of the sap. Star shakes differ from heart shakes in being larger upon the outside of the tree; the heart shakes are larger at the center.

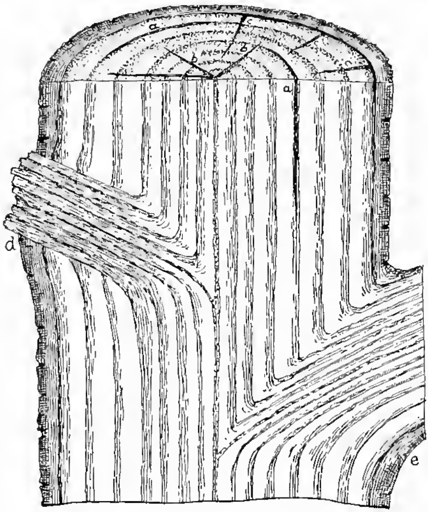

FIG. 3. — DEFECTS IN LUMBER.

a, winds shakes or cup shakes; *b*, heart shakes; *c*, star shakes; *d*, branch broken off, showing the method by which the annual layers gradually cover broken branches; *e*, hard knot.

Shakes of all kinds are common defects and sometimes are so numerous as to make the log worthless.

(**D.**) *Discolorations* are caused by decay which has at some time gained a foothold, but which the tree was sufficiently vigorous to overcome; or they may be due to imperfect or insufficient nutrition, which generally results in the entire tree being affected instead of small places upon it.

(**E.**) Timber grown in a damp, marshy locality is usually of a poorer quality than that grown upon higher ground, as more water is taken up by the roots than can be well assimilated, which prevents the formation of healthy compact wood. Some woods are adapted to such soil, the poplar or whitewood, willow, basswood, buckeye, and cypress being denizens of moist or swampy places.

Trees growing where they are exposed to winds from one direction are apt to assume a spiral growth, which renders the timber almost worthless, as it is weak, and twists badly in drying.

(**F.**) Trees which have lumps appearing like growths upon them are usually unhealthy. These lumps, or tumors, may be caused by defective nutrition, checks, or shakes, or by the depredations of animals or insects.

(**G.**) *Clefts* or *splits*, often caused by extreme cold, are wider at the outside. They may extend into the tree several inches, and while the blemish will always remain, showing a discoloration or other defect, nature often repairs it so that the strength of the timber is but slightly affected. If these clefts are not healed, the spores of fungi find lodgment there, and rains furnish sufficient moisture to encourage their growth; this causes the timber to decay, and will eventually destroy the tree.

(**H.**) Eggs of certain insects are also deposited in these clefts, the larvæ of which bore into the wood and destroy it. (**I.**) If it were not for the birds and other natural enemies of these insects, they would increase so rapidly that the lumber supply would be seriously affected, and, as it is, there are very few trees which are not injured to some extent by wood borers. The United States Bureau of Entomology estimates that the damage to trees by these pests amounts to at least $100,000,000 annually.

(**K.**) The dying and breaking off of branches (as at *d*, Fig. 3) opens an avenue by which rain will often find access to the heart of the tree, thus creating conditions favorable to the growth of fungi, and the decay of wood. In this case, birds and other denizens of the forest may dig out the rotten wood and thereby hasten the destruction of the tree. If this does not happen, the wood may grow over the break after several years and leave a loose knot in the heart of the tree, which will be a decided blemish when the log is made into lumber. The sketch shows the endeavor of nature to repair the defect, as the annual rings will eventually close over the break.

The hard knot at *e*, Fig. 3, is not a serious defect, unless the wood is to be used for finish or where great strength is required.

7. When to cut lumber. — Wood cut during the summer is not so reliable as that cut during the colder months, for the reason that exposure to the sun and the higher temperature causes checks which both reduce the strength of the wood and favor the entrance of moisture and fungi. If the wood is sawed and kiln-dried as soon as it is cut, there is no difference between the summer- and the winter-felled wood. Owing to the scarcity of lumber, or from avarice, trees are often felled at any time of the year, and no special pains are taken to prevent deterioration.

When a tree shows signs of dying at the top, it should be cut down, as the quality of the lumber it contains will soon be affected.

Suggestive Exercises

1. What is meant by exogenous trees? In what kinds of wood are the annual layers most prominent? Describe the formation of annual layers. What causes the difference in the degrees of hardness of wood? In the color and odor of wood? How may the age of a tree be determined? Are the broadest annual layers found in young or in old trees? From what class of trees does soft wood come? Hard wood?

2. Describe the composition and motion of sap. What is the function of the leaves in tree growth? What becomes of the plant food thus formed? What forms the sapwood? Compare sapwood and heartwood. What is the percentage of moisture in unseasoned wood? By what method is this moisture extracted?

3. Describe the parts of the woody stem of a tree. Describe the inner bark.

4. What are the medullary rays? In what woods are they most prominent? How do they affect the strength of timber?

5. What is the nature of trees which grow in exposed situations? Where are the straightest trees found? Why does the location of a tree affect the grain? What is meant by *coarse*, *fine*, *straight*, and *cross-grained* lumber?

6. What causes wind shakes? Heart shakes? Star shakes? How may they be distinguished from each other? What causes discolorations? What is the usual character of timber grown upon marshy ground? What woods are adapted to low ground? What sometimes causes spiral growth? What do lumps and excrescences upon a tree generally signify? What causes clefts in trees? What are the results of clefts? Does nature perfectly repair the cleft? What is the usual result of a branch being broken off?

7. At what time of the year should trees be cut? Why? How may the top of a tree show when it should be felled?

CHAPTER II

Lumbering and Varieties of Wood

8. The manufacture of lumber. — **(A.)** There are two distinct processes in the preparation of lumber for commercial purposes, *logging* and *sawing ;* the former includes all the steps from felling the tree to the delivery of the logs at the sawmill; there the logs are sawed into boards, planks, and timbers of certain dimensions, which are piled and exposed to the sun and air for a sufficient time to allow a large part of the water in them to evaporate, when the lumber is said to be "weather dried," and ready for shipment to the consumer.

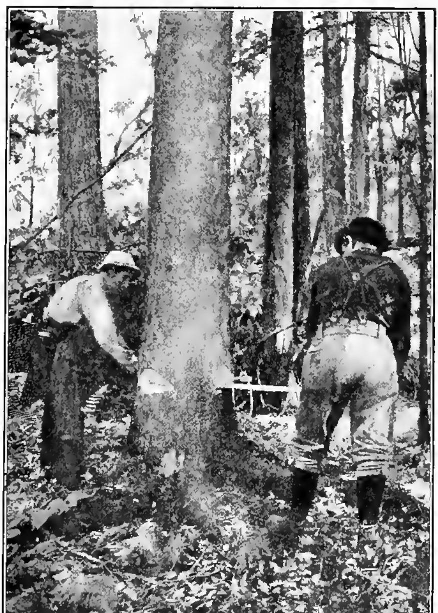

Fig. 4. — Felling a Tree.

FIG. 5.— CUTTING SMALL BRANCHES FROM FELLED SPRUCE.

(B.) If a lumber concern desires to begin operations in one of the great forest areas, a "land-looker" or "timber-cruiser" is sent to spy out the land, and to report upon the probable yield of timber within certain areas, and the conditions which would aid or retard the work of getting out the logs. If the report is favorable, the standing timber may be purchased by "stumpage," which means that a certain price will be paid for each thousand feet of lumber cut, or the land may be purchased outright, though in the early history of lumbering cases have been known where these little formalities were omitted.

Camps are located at convenient points throughout the boundary, roads are made through the woods, and foundations, or "skidways," built at right angles to them, to receive the logs as they are hauled down the "travoy" roads, which are narrow trails cut through the woods at frequent distances for this purpose.

(C.) The above preparations completed, the work of

FIG. 6.—SKIDWAY OF SPRUCE LOGS.

FIG. 7.—LOAD OF WHITE PINE LOGS.

felling the trees is begun (Fig. 4); this part of the work requires nice skill and judgment, as it is necessary that the tree should fall so that it will cause the least damage to itself and to surrounding trees. After the tree is down, the branches are cut close to the trunk (Fig. 5) and carried to one side so that they will not be in the way of the horses. The trunk is then sawed into logs, twelve, fourteen, sixteen, or eighteen feet in length, as the imperfections and the length of the tree trunk may allow. Longer or shorter logs are rarely cut except for special purposes.

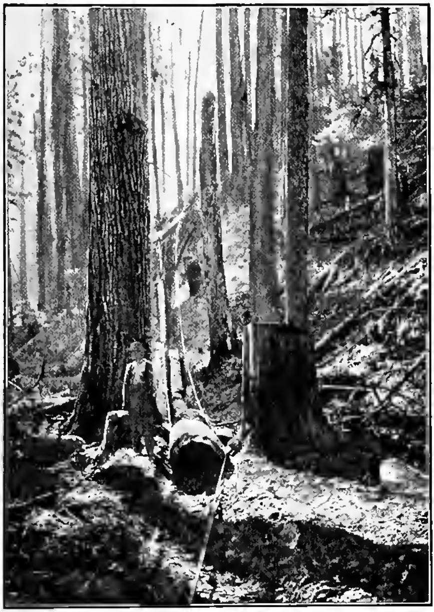

Fig. 8. — Hauling Logs by Steel Cable.

(**D**.) One end of the log is placed upon a drag, or is gripped by a pair of tongs, and hauled to the nearest travoy road and skidway, where it is piled (Fig. 6). (**E**.) From the skidway the logs are loaded upon trucks, cars, or sledges (Fig. 7), and carried to the cable (Fig. 8), which is a method of hauling logs used in some parts of the country, or to the railroad (Fig. 9), or floated down a river (Fig. 10). If either of these latter methods of

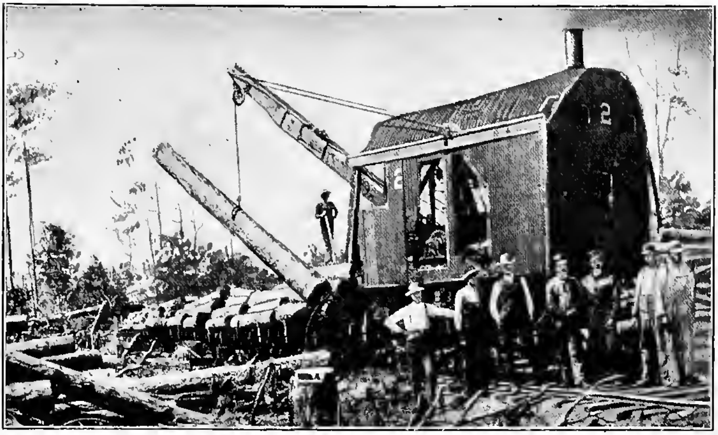

Fig. 9.—Loading Logs from Skidway to Train.

Fig. 10.—Boom of Logs.

transportation is employed, the logs are generally piled upon another skidway until there is enough for a train load, or until the conditions upon the river are favorable for them to be floated to the mill.

(**F.**) Figure 11 illustrates a jam of logs, which is generally the most dangerous obstacle the lumberman has to

FIG. 11.—LOG JAM.

face. A jam usually depends upon one key log, which, if loosened, will allow the jam to break instantly. The work of loosening the key log is frequently done by one or two men, who must be men of spring steel nerves and muscles, and possessed of the highest possible skill and activity, or they cannot hope to break a large jam and escape with their lives.

(G.) The mill illustrated by Fig. 12 is one which receives its logs by both rail and river. In this case the logs which come in by rail are rolled into the river, as they can be more easily placed upon the chain feed of the mill. In winter, a small pond of water is heated, in which the logs are soaked before they are taken into the

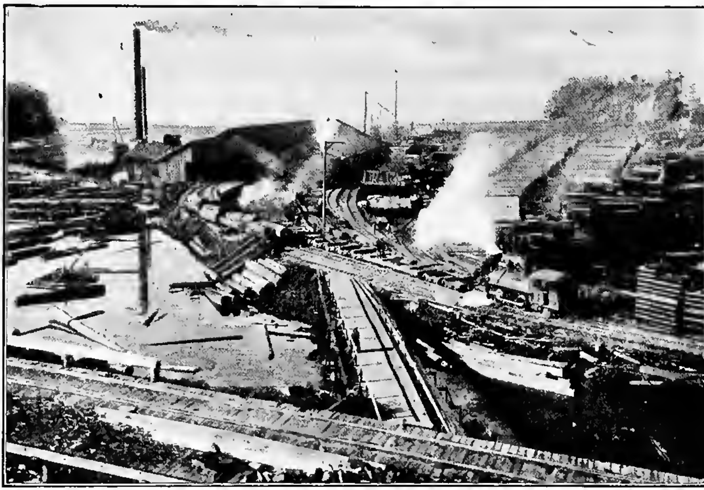

Fig. 12.—Sawmill in the Big Tree District.

mill; this draws the frost out of them, and allows them to be worked much more easily.

(H.) There are different types of sawmills, in which the logs are worked into commercial shapes. The small enterprises use portable mills, which are moved into the woods and located upon a tract of land, remaining until all the desirable timber in the vicinity has been sawed, and then moved to another locality and the process repeated.

Large operations are conducted upon a different plan; mills of a permanent type are erected as near the forest as practicable, roads are built, tracks laid, and the logs brought from the woods by one of the methods previously illustrated; or, where it is feasible, flumes are built, and the logs floated in these to the mill. In erecting a mill of this sort, a location is selected upon a waterway if possible, as the logs may be floated more cheaply than by any other method of transportation, though some of the heavier woods will not float, and have to be handled on land. (**I.**) The immersion of logs in water also improves the quality of the lumber, as the action of the water upon the sap prevents to some degree the tendency to decay, and also facilitates the seasoning of the manufactured product. If the log is left in the water until it becomes water-logged, it will sink, and while it is not injured for many purposes, the wood loses some of the strength which it is supposed to have. In many localities, the salvage of sunken logs has become an industry.

(**J.**) In modern large lumbering operations, the timber to be cut is selected by trained foresters, thus insuring a permanent supply, and in the near future all extensive lumbering operations will, beyond doubt, be conducted upon a scientific basis, as it is apparent that unless lumbering is carried on differently than it has been in the past, the supply for the future will be entirely inadequate for the demand.

(**K.**) In the smaller sawmills, the logs are usually sawed into lumber of various dimensions by a circular saw (Fig. 13); but in the larger mills, the band saw generally is used. Figure 14 illustrates a double cut band sawmill, in which it will be seen that the saw makes a cut each time the log is carried either way.

9. To saw lumber of irregular dimensions. — (**A.**) Besides sawing dimension timber, joists, scantlings, boards, and planks of different thicknesses are sawed, as follows: 1″, $1\frac{1}{4}$″, $1\frac{1}{2}$″, 2″, $2\frac{1}{2}$″, 3″, $3\frac{1}{2}$″, 4″; and thicker, if desired.

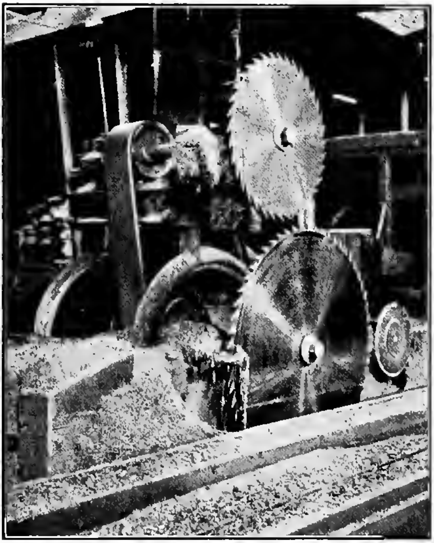

Fig. 13.—Circular Saw.

(**B.**) If lumber is cut again from its original dimensions, it is said to be *resawed*. When boards or planks of the above dimensions are dressed on both sides, they will be about $\frac{1}{8}$″ thinner; thus, a board sawed 1″ thick will, when seasoned and dressed, be but $\frac{7}{8}$″, and a 2″ plank will be but $1\frac{7}{8}$″ or $1\frac{3}{4}$″, though still classed by their sawed dimensions.

Thicker lumber than that above-mentioned usually comes under the head of dimension timber, which is not used to the extent that it was formerly, as steel and concrete are replacing it upon heavy work.

If $\frac{1}{2}$″ boards are wanted, $1\frac{1}{4}$″ or " five quarter " lumber is usually resawed to furnish it, and after resawing, is planed upon each side to the desired thickness. Boards

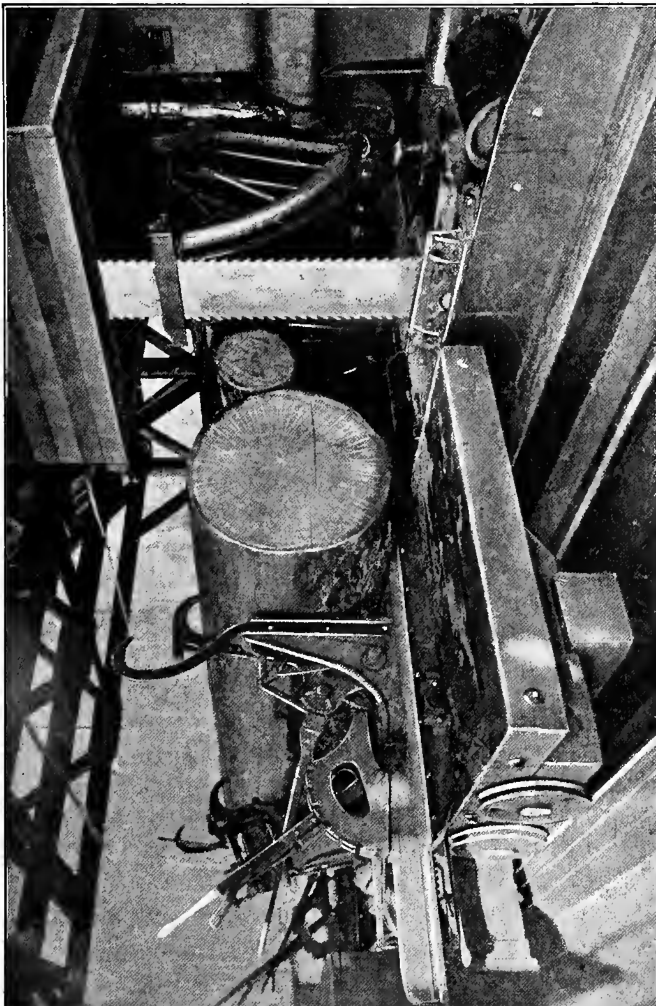

Fig. 14.—Double Cut Band Saw.

for box stock and other special purposes are sometimes sawed as thin as $\frac{1}{4}''$.

(**C.**) The method of cutting a log illustrated by Fig. 15 is known as *plain*, *slash*, or *bastard sawing*, and is the cheapest way to cut logs, both as to time and waste. The log is first squared to secure a bed upon which it may lie while being sawed, which also makes it unnecessary to run each board by the edging saw to straighten the edges. The slabs at *a* are sawed into boards as the log is squared, and the bark, or "live edges," sawed off afterward. These make an inferior grade of boards, as they are nearly all sap, but they are well worth saving, if large logs are being cut.

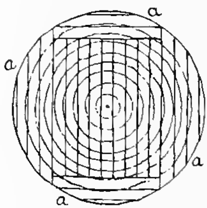

Fig. 15. — Plain, Slash, or Bastard Sawing.

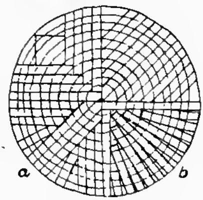

Fig. 16. — Four Methods of Quartering.

In sawing dimension timber, or "bill stuff," good judgment is necessary to cut a log so that the greatest amount of marketable lumber can be made from it. This is done by cutting various sizes from a log, if it will not cut all of one size without too much waste.

(**D.**) In cutting woods which have prominent medullary rays or silver grain, the log is sawed by one of the methods shown in Fig. 16, the object being to bring the rays as nearly parallel to the surface of the board as possible, thus giving the broad silver, or quarter, grain which is so highly prized.

The best results are obtained from sections *a*, *b*; this method also gives the most waste. In plain sawed lumber, the boards from the middle of the log will have the quarter grain; these are usually culled and sold as quarter-sawed.

Neither of these methods results in economy of time or material, as about 25 per cent of each is used in excess of that required in plain sawing; hence, quarter-sawed lumber is more expensive than the plain, or bastard, sawed.

(**E.**) Quarter-sawed lumber (Fig. 16) is preferred not only on account of its handsomer grain, but because it holds its shape better than lumber sawed in any other way, as the annual layers are approximately square with the surface of the board. As the board shrinks in the direction parallel with the annual layers, from two to three times as much as from the center to the outside of the tree, it is obvious that there is much less shrinking and warping in quarter-sawed lumber than in that which is sawed plain.

The best grades of flooring are quarter-sawed, and stand usage without the surface splintering much better than does the common plain sawed material. Quarter-sawed lumber is known also as "rift-sawed," "vertical grain," and "comb grained."

10. **The grading of lumber.** — Custom varies somewhat in different localities as to the grading of lumber, but there are generally four grades, which are often subgraded into qualities suitable for various uses.

"Number 1" lumber should be practically perfect, though in large dimensions, small and unimportant blemishes may be allowed. These blemishes in a board are usually restricted to not more than one inch of sap, a small sound knot, or small discoloration, and but one blemish to a board is allowed.

"Number 2" lumber is generally allowed two sound knots, an inch of sap, and one other blemish.

"Common boards" are allowed three or four sound knots, but two thirds of one side must be clear stock.

"Culls," the lowest grade, are used only upon the cheapest work. One half of the board must be usable.

In many cases the boards are graded by the width of clear stock which can be taken out. There are tables published by the different associations of lumber manufacturers which give the gradings under which their lumber has been measured and shipped, but as these vary from time to time no permanent list can be given.

The principal reason why there can be no permanent grading of lumber is that the forests from which the finest timber can be cut in marketable quantities are being destroyed faster than they can be replaced by nature. In anticipation of this condition, the Division of Forestry of the Department of Agriculture is actively engaged in organizing government forest preserves, in educating the people, and in promoting legislation aimed at the husbanding of our forests. When we consider the abundance of high grade lumber a few years ago, and the fabulous prices which the same grades now bring, it is evident that this movement should have begun during the days of our grandfathers, instead of waiting until nearly all the best lumber in the great forests east of the Mississippi had been cut, and inestimable damage wrought by forest fires.

11. **The testing of lumber.** — **(A.)** Dry, sound stock, if struck with the knuckles or with a hammer, will give a

clear ringing response, while a wet or decaying piece will give a dull response to the blow.

(**B.**) Every kind of lumber has its peculiar odor, by which, as well as by the grain, the student should learn to distinguish the woods in common use. This may be more easily done before the wood has been thoroughly seasoned. Wood in general has a sweet and pleasing odor; if a sour or musty smell is perceptible, it indicates that decay is present.

(**C.**) If there is much variation in the color of timber, or black and blue spots, the stick is probably diseased.

(**D.**) Decay is a disease, which may be prevented by dryness or ventilation, and frequently may be cured by soaking the wood in water for several days, or by steaming. The disease of decay is cured also by chemical preservatives being forced into lumber by pressure; this at the same time prevents insects from boring into the tree.

Alternate wetting and drying will produce rot, but most lumber, if permanently submerged or if kept perfectly dry, will last almost indefinitely. Dry rot spreads to adjoining timbers, and even to those which have no connection with the one originally infected.

12. **Surveying or estimating lumber.** — (**A.**) It is the custom to consider any board less than one inch in thickness as an inch board, and anything over one inch is measured as so many inches and fractions of an inch. For instance, a board $\frac{3}{4}''$ thick is surveyed as a full inch, while one which is sawed $1\frac{1}{2}''$ in thickness is estimated by obtaining its surface measure, and increasing it by one half. Thus, a plank $12'$ long, $8''$ wide, and $1\frac{1}{2}''$ thick would have twelve feet board measure in it.

In some localities there is a sliding scale of prices which varies with each quarter inch in thickness of resawed lumber, but this is not universal.

(**B.**) In surveying joists or scantling, it is customary to obtain the fraction of a foot, board measure, for each lineal foot. Thus, a piece of 2×4 (inches understood) has two thirds of a foot for each foot in length; a 2×6 has one foot, and a piece of 2×8 has one and one third feet of lumber for each foot in length of lumber measured. If a joist is 2×12, doubling its length gives the number of square feet, board measure, that the joist contains.

(**C.**) In measuring a common board, the widest parallel piece which can be cut from it is the width of the board being measured; therefore the board should be surveyed at the narrowest place. In measuring more expensive lumber, it is customary to average the width of the board.

(**D.**) In estimating all kinds of lumber in common use, the lumber scale shown in Fig. 17 is used. It is made of thin, cleft hickory, about three feet long, with one end large enough for a suitable handle; on the other end is a metal head, which is held against the edge of the board while the scale is being read.

The length of the board is marked near the handle, and at the end of the socket of the metal head, as at *a*.

In using this scale, the hooked end, or head, is held against the edge of the board, as at *b*; the eye follows along the same line of figures upon which the length of the board is found, reading those figures nearest the width of the board. Thus, a scale laid upon a board 16′ long would, without further measuring or calculating, show that the board contains 17′ board measure. If the board were

12′ long, it would contain 13′; and if 14′ long, by reading the middle line of figures, the board would be seen to contain 15′.

In using this scale, it is customary to read to the nearest figure, and when there is no difference, to alternate between the lower and the higher figures upon different boards. Thus, a board 12′ long and $8\frac{3}{4}''$ or $9\frac{1}{4}''$ wide would be read as having 9′ board measure in it. Two

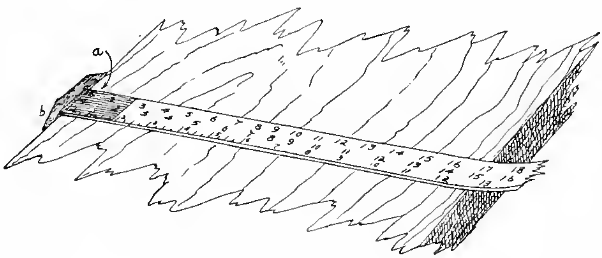

FIG. 17.—LUMBER SCALE.

boards $8\frac{1}{2}''$ wide, of the same length as the above, would be measured as having 8′ and 9′, respectively, in their surfaces. In short, the fractions of a foot are not considered in surveying the lumber in common use.

13. Qualities of wood. — (**A.**) Certain kinds of wood are adapted for some purposes better than are others; the wood-worker, therefore, should be familiar with the qualities which conditions demand, and the kinds of woods which have these qualities.

Lumber for framing should be strong and durable; it should be cut from trees which grow to a size that will allow large dimensions to be cut from them.

For outside finish, the material should be wood which will stand the weather, can be easily worked, and will hold its shape well.

Timbers that are to be buried must possess the quality of durability, and should be of sufficient strength to resist the strain which will be put upon them.

Flooring should wear well, hold its shape, and be of good appearance. In providing lumber for inside finish, care should be used that it has good grain and color, is not too soft, and that it will hold its shape well. Almost any wood may be used as far as strength is concerned, but lumber which shrinks and warps badly is unfit for finishing.

Shingles should be of wood which will resist decay, and which has the least tendency to warp and split.

Boards which are to be used for siding should hold paint well, and be as free as possible from the tendency to warp, split, and twist when exposed to the weather.

(**B**.) All material used in framing a building should be weather-dried in good drying weather for at least thirty days for each inch in thickness, and that used for inside and outside finish and floors should be thoroughly kiln-dried, and kept in a dry place until ready for use. These conditions are not always obtainable, but if the best results are desired, they should be followed as closely as possible.

The woods hereafter described comprise the principal varieties used by the wood-workers of the United States.

(**C**.) *Ash* (deciduous, or broad-leaved) is an open-grained, light-colored wood, in which the porous portions of the annual rings are quite prominent, thus making it somewhat coarse-grained.

It grows in the Northern states, and is a wood of medium weight and hardness. It is tough and elastic, the young growth being much used in the manufacture of wagons, machinery frames, and for similar purposes, as it is not expensive, quite easily worked, and very strong. It has a tendency to decay, and is often badly infested with insects; therefore it is not suitable for building construction or for contact with soil.

Ash grows in forests with other broad-leaved trees, and is plentiful in many localities. There are two kinds of this wood recognized in commerce: the *white*, which is light-colored, and the *black*, which is of a brownish tinge, though there is little difference in the grain of the two. Sap is not considered a defect, but is regarded as the best part of the tree for some purposes. The wood grown in the Northern states is generally tougher than that grown farther south.

The wood from the older and larger trees is not so tough and hard as that from the younger growth, and is much used for cabinet work and for interior finish. It should be filled with a paste-filler, after which it may be brought to a fine polish. The wood holds its shape well and is useful for the purposes mentioned.

(**D.**) *Apple* (dec.) is not used for construction, as the proper dimensions cannot be secured, and as it is very stubborn to work. It is one of the best woods known to resist splitting, and is much used for chisel and saw handles.

(**E.**) *Basswood*, or *linden* (dec.), is a soft, porous wood, which shrinks considerably in drying. It is used for the backing of veneer work, for drawer bottoms of the common grades of furniture, for case backs, and similar purposes, and is also much used in the manufacture of spools and other small articles which are made in large quantities. In building construction, basswood is used for ceilings, and for other work where strength is not needed, though for use in such places it should be thoroughly seasoned, or the joints will open.

If steamed, basswood may be bent to almost any form. Steaming also cures to a great extent the tendency of this wood to shrink and swell.

(**F**.) *Beech* (dec.) is adapted for use in places where the ability to resist a heavy strain or hard wear is necessary, as in plane stocks, tool handles, and parts of machinery. In building work, it is used to some extent for flooring and for inside finishing. It is used also for furniture, though the difficulty of working it makes it more expensive than other equally desirable woods.

If exposed to alternations of dryness and dampness, it decays rapidly; if submerged, it gives fair satisfaction.

Beech trees are common through the Ohio and Mississippi valleys, and are found to some extent in all of the states between the Great Lakes and the Atlantic seaboard.

(**G**.) *Birch* (dec.) is one of our most useful hard woods. It is found in abundance in the broad-leaved forests of the Eastern states and Canada. There are two varieties recognized in commerce, the *red* and the *white birch.* The former is used considerably for inside finish and for furniture. It takes a stain well, and may be made to imitate cherry or mahogany so exactly as to deceive any one but an expert. When finished in its own natural color, it is a satisfactory wood for the above uses, but as it ages, it turns to a muddy brown; as it is a stubborn wood to work, it is not popular.

Fig. 18. — Beech and Sugar Maple Forest.

Canoe, or *paper, birch* is softer than the red variety, and is used to some extent by paper pulp makers, and for the manufacture of spools, dowels, and a large variety of small articles.

(**H.**) *Butternut* or *white walnut* (dec.) has a good grain and color; it is quite soft, though not so easily worked as are some harder woods, for it has a tendency to string while being dressed to a fine surface. It does not absorb moisture readily, and holds its shape under trying conditions.

Butternut does not split easily, takes a fine polish, and is used considerably for furniture and for interior finish.

(**I.**) *Cedar* (coniferous, or needle-leaved) is of two varieties, the *red* and the *white*. The former is used considerably for cooperage and veneers, lead pencils, and for lining moth-proof drawers and chests, as its strong odor and bitter taste protects it from the ravages of insects. The supply of red cedar is becoming limited, and it is now too expensive for common use, though our forefathers used it for shingles. The unwise and avaricious cutting of this valuable timber and of others, notably white and Georgia pine, has destroyed what would have been a supply for all time, if the cutting had been properly controlled.

White cedar is much more plentiful, and a much inferior wood; it is used for shingles, water tanks, boat building, and in the manufacture of barrels and cigar boxes. It is a very durable wood, and shrinks but little in drying. It is well adapted for burying, though not strong enough to resist a very heavy strain. It grows faster than the red cedar, and makes a larger tree.

(**J.**) *Cherry* (dec.) is one of the best of our native woods. It is much used for fine finish and for cabinet work, as it holds its shape well, if thoroughly seasoned, and takes a fine finish. Its grain is of fine, even texture, of reddish color, and often stained to imitate mahogany. When well ebonized, it cannot be distinguished from the genuine wood except by weight.

Cherry is used by pattern makers for parts of patterns which are to stand rough usage. The tree is found in all of the states east of Texas, and in the Mississippi valley, but it is becoming too scarce for common use.

(**K.**) *Chestnut* (dec.) is a soft, open-grained wood, adapted to use in exposed situations. It is used a great deal for inside finish, as it will take a fine polish, and as the figures formed by the grain make it a very handsome wood for the purpose.

Not being a strong wood, it will not stand a heavy strain, and will shrink and crack badly in drying.

(**L.**) *Cypress* (con.) is similar to cedar. It is one of our most durable woods, and perhaps the best we have for outside work. It is used extensively for shingles; roofs covered with cypress shingles have been known to last for more than seventy-five years. The wood is light, straight-grained, and soft; it is easily worked, and holds its shape well. It is to great extent taking the place of white pine in the manufacture of doors, sash, and blinds, and is considered by many to be equal, if not superior, to that wood. It is much used in building small boats, and for use in places where it will be exposed to dampness. Eaves, troughs, and tanks made of it give better satisfaction than those made of any other woods except redwood and cedar, which are the only woods having anti-decaying qualities equal to cypress.

Cypress may be obtained in boards of almost any dimensions, and if it were stronger and harder, it would be one of our best woods for framing and finishing. It is used for the latter purpose to a considerable extent, as it has a handsome grain, and will take a polish well; if thoroughly seasoned, it will hold its shape as well as any wood. If it is seasoned slowly, it does not crack to an appreciable extent, but if forced, it is apt to be filled with fine shakes. Sap is not considered a blemish.

Cypress grows in the swamps and along the rivers of the Southern states, the best of it coming from those bordering on the gulf.

(**M.**) *Elm* (dec.) is a moderately hard wood, difficult to split. It warps and checks to some extent in drying, but when well seasoned it holds its shape as well as most woods in common use. It is susceptible to a good polish, and is used a great deal for interior finish and furniture, as it takes a stain well. Much of the quartered oak used in the manufacture of cheap furniture grew upon an elm stump. It is used largely in cooperage, and stands contact with the soil satisfactorily.

The elm is found in nearly all parts of the United States, but is more abundant east of the Mississippi river.

(**N.**) *Gum* (dec.), or, as it is more generally known, *sweet gum*, is extensively used for interior finish upon the better class of buildings. It warps and shrinks badly unless thoroughly seasoned, in which condition it is a very satisfactory wood. It is tough and strong, cross-grained, and of fine texture; its color is a warm, reddish brown, and it finishes handsomely. The gum tree grows abundantly in the Southern states.

(**O.**) *Hemlock* (con.) is found in most of the Northern states, and is used for scantlings, rough boards, under floors, and for boarding preparatory to siding. It is a fairly durable wood, but splits easily, and is apt to be full of wind shakes. It holds nails firmly.

(**P.**) *Hickory* (dec.) is the hardest native wood in common use, and the toughest wood that we have; it is too hard to be used for building material. It is flexible, and its principal use is for wagon and carriage work, and for other purposes where bent wood and great strength is required. As it does not split easily, it is much used in the manufacture of tool handles. It is liable to attacks from boring insects, and these pests often destroy much valuable timber.

Sap is not considered a defect, and the sapwood is in fact the most desirable part of the tree, on account of its creamy whiteness and great strength.

(**Q.**) *Locust* (dec.) is found in nearly all parts of the country, and is a useful and durable wood. It is much used for fence posts and, in damp locations, for railway ties, and sometimes for furniture, as it has a yellowish brown color which takes a polish well.

(**R.**) *Maple* (dec.) is a heavy, strong wood, nearly white, with a yellow or brownish tinge. There are several kinds of maple, but the kind generally used for commercial purposes is the *sugar* or *rock maple.* It does not shrink excessively, seasons without serious checking, and from it a very fine surface for polishing may be obtained. It is much used in places where it is exposed to wear, as in floors, butchers' tables, etc., and to a considerable extent as a cabinet wood, and for interior finish. Maple does not resist decay as well as do some other woods.

Sap is not considered a defect, and on account of its whiteness the sapwood is often preferred to the heartwood for many uses.

Bird's-eye maple is of this wood, but some peculiarity in the growth of certain trees, believed by many to be caused by woodpeckers, has caused the tree to have what seem to be numerous small knots, known as curls or eyes. The presence of these imparts a beauty which is possessed by no other wood, and has never been successfully imitated.

(**S.**) *Mahogany* (dec.) is an imported wood, and is much used in the finish of fine buildings and in the manufacture of fine furniture. It is of a rich red color, and has a beautiful grain and other desirable qualities which make it the finest wood for finish in use. It holds its shape remarkably well, unless it is very cross-grained, and is in every respect an ideal cabinet wood. Its cost is all that prevents it from being universally used.

(**T.**) *Oak* (dec.) is our best all-round native wood. It is found abundantly in nearly all parts of the country, and forms the larger part of our broad-leaved forests. There are a number of species of oak, but they are in general known to commerce as the *red* and the *white oak*. Nearly all these trees are cut for commercial purposes, but the white oak is the finest. The wood of some varieties of oak is so similar to the white oak that the difference cannot be distinguished after the work is finished, therefore they are all put together and sold as a medium grade of white oak for purposes where the strength of the genuine is not required. This will generally account for the difference in the grain and the color which is noticed in handling the commercial white oak.

Red oak is a coarser wood, and is more apt to give trouble in seasoning than white oak, though they both have to be dried very carefully, or there may be checks and cracks to such an extent that the wood will be ruined. Both the red and the white oak are used extensively in finishing and cabinet work, but the red oak is used commonly upon the cheaper grades, as it is easier to work.

The two varieties should never be used upon the same job, unless the wood is to be stained a dark color, as there is a marked difference in their appearance when finished. White oak is much used for flooring, quartered oak resulting in a beautiful floor, if the work is well done.

Oak is not a suitable wood for exposure to trying climatic conditions, though if buried deeply, or in water, where there is no alteration in moisture or dryness, it gives satisfaction. White oak is used to great extent for railroad ties, but what these are to be made of in the future is causing much speculation, as the end of the present supply of white oak is already in sight.

(**U.**) *Pine* (con.) in its different varieties is used more than any other kind of wood. It is found in nearly all parts of the United States and in Canada. Certain sections of the country which were once covered with virgin pine forests have, however, been so denuded of their wealth, and so many of their young trees destroyed, within a few short years, by the depredations of lumbermen who cared more for their immediate profit than for the prospective good of the nation, that instead of a permanent and continual supply of this valuable wood, there are now nothing but barren hillsides, and the moss-grown ruins of the lumber camps and sawmills by means of which this irremediable wrong was perpetrated against posterity.

White pine is soft, easily worked, and when thoroughly seasoned will hold its shape better than any other wood except mahogany. For these reasons, and on account of its adaptability to gluing, it is used almost exclusively by pattern makers. It is found in the Northern states and in Canada. Farther south is the belt in which grows the grade of pine known as "Carolina," the *bastard* or *yellow pine*. This belt extends from the Mississippi valley to the Atlantic coast, and is of a width to include Virginia and the Carolinas. This pine is harder to work, and has a more pronounced grain than has the white pine, but it makes a handsome wood for interior trim, as it is capable of a fine finish. Carolina pine is neither so hard nor so strong as "Georgia" pine, which is also known commercially as *long-leaved pine*, *pitch pine*, or *hard pine*. This wood is found from Virginia to Texas, in the states bordering upon the ocean and the gulf.

Pitch pine has a finer, closer grain than has either of the two above described, being much stronger and more dense. This is the wood which is used for heavy timbers of large buildings, and the above described grades should never be confused with it, the Carolina pine resulting in work of less strength, for instance, if used where the pitch pine was intended. Although this wood is very hard and strong, and is the best wood for heavy construction, as has been stated, it should never be used in any place which is not dry and well ventilated, as it will decay rapidly if placed in a damp location, or where it will come in contact with the earth.

Fig. 19.—White Pine Forest.

There are several varieties of pine besides those above mentioned. These are generally less desirable for finish or for construction than is the white, yellow, or Carolina pine, but they are used extensively for the common work of light building, and by box factories.

(**V.**) *Poplar* or *whitewood* (dec.) is cut from the tulip tree, and is found principally in the Middle West and in some parts of the South. It is of light weight and color, with few knots, and is soft and easily worked. It is used for the common grades of cabinet work, inside finishing, veranda posts, etc. It takes a stain remarkably well, and its even texture makes it a favorite with wood carvers. It warps and shrinks considerably in seasoning, and unless held in its place, it is apt to twist.

(**W.**) *Redwood* (con.) is taken from the big trees on the Pacific slope; it is straight-grained, soft, and free from knots, and may be obtained in boards of any size which it is possible to cut. It has the reputation of being one of the best woods for use in trying conditions, or where it will be exposed to alternations of dryness and moisture.

It has a very coarse grain and takes a finish well, but it is not apt to become very popular for inside finish, as it is easily marred, and, although very soft, will, when thoroughly dry, destroy the edge of tools quicker than many harder woods. It turns to a dull, unattractive brown as it ages, if it is finished in its natural color.

It is claimed by many to be the best wood for shingles, as it resists decay indefinitely. It shrinks both ways of the grain, and burns very slowly.

(**X.**) *Spruce* (con.) is moderately hard and strong, and in New England is used generally for framing light build-

Fig. 20. — Douglas Spruce Forest.

ings and for rough boarding. Its color is almost pure white, and it has the valuable quality of holding nails firmly. There is little difference between the heart and the sap wood, and its texture is sometimes such that it is difficult to distinguish it from white pine. It warps and twists badly in seasoning, and on that account is not suitable for framing trusses, unless seasoned lumber is used.

Spruce is used also for a cheap grade of clapboards, for flooring, ceiling, and laths, and also by paper pulp manufacturers in immense quantities. It is a fairly satisfactory wood for immersion, but if exposed to alternations of dryness and moisture, it decays rapidly.

(**Y.**) *Sycamore*, or *buttonwood* (dec.), is found in nearly all parts of the Mississippi valley and in the Eastern states. It is a moderately stiff and strong wood, coarse-grained, and quite difficult to smooth to a surface, as the grain seems to run in all directions at once. It has also a disagreeable habit of warping and twisting as it seasons, but if well seasoned and properly handled, it will give no more trouble than do other woods. It takes a good polish, and is a desirable wood for inside finish.

(**Z.**) *Walnut*, or *black walnut* (dec.), is found in all the Middle and Eastern states. It is heavy, firm, and strong, of a chocolate color, and takes a fine finish. It is well adapted to inside finish and to furniture work.

At one time nearly all the best work was done in this wood, but at present it is out of style, as oak and other woods are more in favor. Like other varieties of our best woods, this has been cut out, and is now too expensive to be considered as anything but a fancy wood.

White walnut is described under butternut.

FIG. 21. — RED SPRUCE AND BALSAM FIR KILLED BY FIRE.

Suggestive Exercises

8. How are small lumbering operations conducted? Large operations? What is the favorite method of bringing logs to the mill? Why? Compare the circular and the band saw as to economy. Why is scientific forestry a necessity?

9. What are the usual thicknesses to which planks are sawed? How much thinner is dressed than sawed lumber? How are $\frac{1}{2}$ boards usually sawed? How should a log be sawed to get the most out of it? To furnish dimension lumber? Describe the advantages and the methods of quarter-sawing. Compare plain and quarter-sawed lumber as to economy. Compare and give reasons for their different shrinking qualities. What are the different names by which quarter-sawed lumber is known?

10. Describe and demonstrate the four grades of lumber as they are commonly graded.

11. What will be the nature of the sound if a dry, perfect piece of timber is struck with the knuckles? A wet or decaying piece? What does it usually signify if there is a great variety of color in a board? How may decayed lumber be detected by its odor? How may incipient decay be stopped? How may decay be prevented or cured?

12. How is lumber less than 1″ in thickness surveyed? Lumber over 1″ in thickness? How are joists and scantlings measured? To what lengths are logs sawed in the forest? In surveying, where should a common board be measured? A quarter-sawed board? Demonstrate the use of the lumber scale.

13. What should be the qualities of a good framing timber? Of timber for outside finish? To be buried? For floors? For inside finish? For shingles? For siding? How long should lumber be dried before using? How should lumber for inside finish be cared for while waiting for use? Describe the qualities and the uses of the following kinds of lumber: ash, apple, basswood, beech, birch, butternut, cedar, cherry, chestnut, cypress, elm, hemlock, hickory, locust, maple, mahogany, oak, pine, poplar, spruce, sycamore, walnut.

CHAPTER III

Care of Lumber

14. **The piling of lumber.** — (**A.**) To the uninitiated it may seem that the piling of lumber is work upon which it is not necessary to expend much skill, but there are few operations in which carelessness or ignorance will cause more loss to a wood-worker.

(**B.**) The front end of a lumber pile should be higher than the back, therefore it is a good plan to locate it upon ground which falls away to the rear, or to build the ways which support the pile so that the water which drives into the pile will run out at the back end, and not stand upon the boards, as this will cause discolorations.

15. **Permanent lumber ways.** — These should be built by some method similar to that shown in Fig. 22. It is not a good plan to lay timbers upon the ground, as they will decay rapidly, and there will not be sufficient room for air to circulate under the pile to allow the boards of the lower courses to dry out properly. The pile is also apt to settle when the frost comes out of the ground in the spring. Lumber should not be stacked above wet or marshy ground; if necessary to stack it where the weeds are of rank growth, the latter should be kept down.

The ways should be built with a solid foundation, well below the frost line, though this is rarely done except for permanent lumber storage. This is shown at *a*, Fig. 22, in which it will be seen that the ways are built to stand a heavy load; the space between the centers of the ways should be about five feet, as multiples of this distance will accommodate any length of boards.

16. To minimize the warping of lumber. — (**A.**) Do not place lumber piles less than one foot apart, as it is

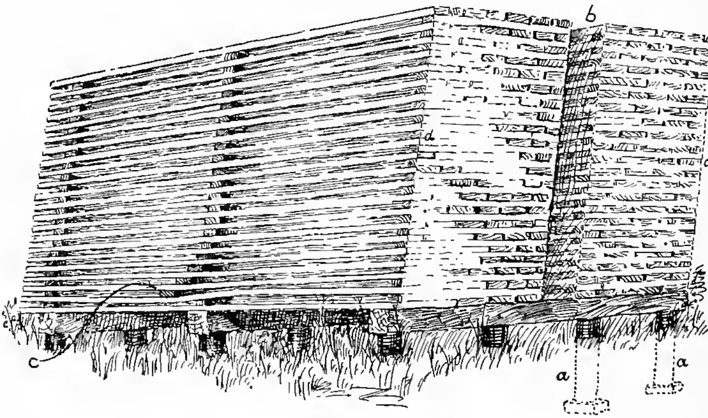

FIG. 22. — PERMANENT LUMBER WAYS.

necessary that there should be a continuous circulation of air through the pile in all directions. (See *b*, Fig. 22.)

(**B.**) Lumber piles are usually four feet in width, and should be built up with sticks of that length, which are placed between the courses of boards. It is important that these be placed directly over each other and the ways; otherwise there will be short kinks in the boards, as shown at *c*. It is such carelessness as this that causes a great deal of loss. In piling very expensive lumber, the front sticks should be laid so as to project a little over the course of boards below, and the boards of the course above should project the same distance over the stick, in order to give the front of the pile an inclination to the front, as shown at *d*, which will allow most of the rain-water to drop clear of the boards below, instead of running down the front and finding its way into the pile.

(**C**.) Square piles are sometimes built, but in these the boards should be laid with large spaces between them, to allow perfect circulation of air. It is obvious that in a pile of this sort, the boards in the center of the pile will not come in contact with the air as much as those on the outside, and that consequently, unless carefully piled, the boards may be damaged by the moisture souring instead of drying out, which usually results in decay.

(**D**.) During the drying out process, all boards change their form more or less, depending upon the shape of the tree trunk, the kind and quality of the wood, the part of the tree from which the log was cut, as well as its size and age, the relation of the annual rings and medullary rays to the surfaces of the board, the length of time since the log was cut before being made into lumber, whether it had lain in water for several months, and the method of piling. Thus it will be seen that in every stage of preparing lumber for market, a high degree of skill and judgment is necessary to insure the best results.

The greatest deterioration in lumber, after it has been cut and properly piled, is generally due to the tendency to warp, the cause of which is indicated in Fig. 23, and which may to great extent be minimized by skillful piling. If this sketch is studied carefully, it will be noticed that the middle board is thicker in the middle than it is at the edges, and that the curves of its top and bottom sides are practically uniform. This is because the annual layers are at nearly a right angle with the sides of the board, which causes the board to shrink in thickness, and very little in width. This is due to the tendency of lumber to shrink around, or parallel with, the annual layers. This tendency also causes the star shakes, as at *c*, Fig. 3, which is because the inner layers of the log, being less than the outside layers in circumference, and less exposed to the dry air, do not shrink so fast nor so much. This tendency is again illustrated in Fig. 23, in which it will be seen that because the outer annual layers shrink faster, they cause the outside of the board, or the part which grew toward the outside of the tree, to become narrower, and to assume a concave shape, while the side nearer the center of the tree, or the inside of the board, becomes convex. This is also the reason why boards cut near the outside of the log will shrink in width more than those cut nearer the center, which shrink in thickness proportionately more than in width.

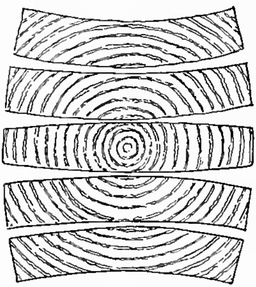

Fig. 23.—Warping of Lumber.

(**E.**) For the purpose of taking advantage of the tendency to warp, and applying it to its own remedy, boards should be piled with the side which grew nearer the center of the tree uppermost. This will help to correct the tendency of the board to warp, as explained above, as the side which would naturally assume the concave shape will be underneath, and less likely to warp than if it were uppermost. This is not generally observed in stacking common lumber, since it needs care and judgment to do it properly, but it should be done if valuable lumber is being handled.

Boards of practically the same width, if less than 7″ wide, are sometimes stacked in double courses, as shown in Fig. 24, the outside of the boards, or the sides which grew nearer the outside of the tree being placed together, thus allowing the inside of the boards, or the sides which grew toward the center of the tree, to receive more air than the sides which are placed together, and therefore to dry out faster, which will reduce the warping to a minimum. After a pile is completed, it should be covered with old boards to protect the top courses from the weather.

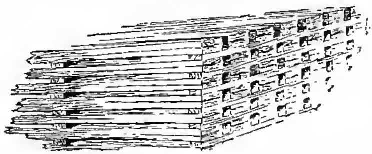

Fig. 24. — Lumber piled in Double Courses.

(**F.**) A pile of valuable lumber should be restacked every six or eight months, as the boards are apt to become discolored where the lumber sticks are placed; in this rehandling, the warped boards should be placed with the concave side underneath.

(**G.**) Lumber may be cut at any time of year, and if properly cared for it is not apt to be injured by rain driving into the pile, providing there is free circulation of air. Lumber, cut in winter, is not so liable to decay as that cut in summer. (See topic 7.)

17. Weather-dried lumber. — Lumber which has been dried in the stack out of doors is not dry enough for use in the manufacture of inside finish or furniture, as it has dried out only to the degree of moisture in the outside air. If it is then worked up and placed in an artificially heated house, the heat will cause more moisture to evaporate, the wood to shrink, and the joints to open. For material to be used in the frames of buildings, in wagons, or in other places where the greatest possible strength is required, not less than two years weather-drying is preferred, as the material retains its full strength.

18. Kiln-dried lumber. — Lumber for furniture or for inside finish should be seasoned by the process known as "kiln-drying." This means that lumber is exposed to a temperature of from 120° to 200° F. by which the moisture is extracted and evaporated. Lumber thus treated is apt to be more or less weakened by the action of the heat upon the fibers of the wood, which causes thousands of minute fractures, and in many cases the life and the elasticity of the lumber is destroyed. The results of kiln-drying depend largely upon the kiln, and upon the skill with which the lumber is piled, the heat applied, and the rapidity of evaporation of the moisture regulated.

For these reasons, much kiln-dried lumber is suitable for use where but little strength is required and where the color and the grain are the important points to consider.

19. Moist air kilns. — (A.) There are two types of dry kilns in common use: the *natural draft*, or moist air, kilns, and the *induced draft* kilns. These two types are made by different manufacturers, nearly all of whom use certain devices of which they control the patents, and which constitute the chief difference between their kiln and those made by other manufacturers.

(**B.**) The moist air kilns are so constructed as to allow the freest possible circulation of the heated air, and to provide opportunities for the moisture to be expelled in accordance with certain natural laws, which results are obtained by a carefully planned and managed system of ventilation. These kilns operate upon the principle that heated air circulating naturally through lumber will become charged to a much greater degree with moisture than if it were forced through rapidly, as in the induced draft kilns. Thus, heated air by passing slowly through a pile of lumber may become charged with moisture nearly to the dew point.

If the humidity of the heated air is maintained at that point, by allowing the moisture to pass out as it accumulates, with a small amount of heated air, which is replaced with fresh air from the outside, it is claimed that the boards will dry out from their centers. (**C.**) As the warm, moist air which circulates through the pile will keep the outsides of the boards moist, it will prevent case hardening, or the hardening of the outsides of the boards. This is caused by very warm dry air, which "cooks," or closes the pores of the surface of the boards, and this prevents the outsides from shrinking, while the insides will be so badly checked and discolored as to destroy the boards.

After the moisture is all out of the lumber, that held in suspension will gradually pass out of the kiln, and the air inside will become perfectly dry.

(**D.**) It is claimed that all kinds of lumber in common use may be put into this type of kiln perfectly green, except oak and other very hard woods, which should have at least thirty days' drying under good drying conditions for each inch in thickness. It is also claimed that the moist air kiln is simply weather drying accelerated, — the moisture being thoroughly extracted from the lumber, the result being the same as though it were stacked out of doors for several years, — and that the lumber has lost none of its strength, elasticity, or characteristic color.

(**E.**) This method sometimes is applied by steam pipes extending between each course of boards, and in this way the lumber is dried out very rapidly. Lumber used in this sort of kiln should be thoroughly weather-dried, or otherwise the high temperature will cause it to check badly. In certain forms of these kilns, the lumber is saturated with live steam after it is piled in the kiln, before the heat is turned on.

20. **Induced draft kilns.** — (**A.**) This system of kiln-drying consists of a power-driven fan, which forces the heated air at a high rate of speed through the spaces between and around the lumber piled in the chamber.

(**B**). Manufacturers have different devices for extracting the moisture from the air after it has passed through the lumber piles. It may be passed over condensing plates, or through coils of pipes in which cold water is continually circulating, both of these devices being for the purpose of extracting the moisture from the heated air. If the moisture is separated from the air by condensation, it runs away, but if not, a certain per cent of the heated air is expelled out of doors, being replaced by fresh air. The air in the kiln, somewhat cooled from contact with these cooled surfaces, is returned to the heater, reheated, and again forced through the kiln, which operation is repeated continuously and automatically. Thus the heated air becomes charged with a small percentage of moisture each time it passes through the kiln chamber; this moisture is extracted and the air is again heated before beginning another circuit, instead of slow circulation which allows the heated air to become saturated with moisture before it is discharged, as in the moist air kiln.

The induced draft dry kiln requires quite an expensive equipment, as the blower and the appliance which drive it are necessary in addition to the equipment of the kiln itself, which would be similar in either of the types of kiln described. Lumber to be dried in this form of kiln must be well weather-dried before it is exposed to the high temperature of the kiln.

21. **Results of the two systems.** — While it is not the province of this book to pass judgment upon the results of the different methods or forms of dry kilns, it is obvious that the induced draft kiln is the more expensive to operate, as the expense of running the blower is avoided in the moist air system. In this latter type of kiln the steam simply passes through the pipes, the condensation being returned to the boiler to be reheated, so the only expense is that of maintaining the fire to keep up a low pressure. In the daytime, or while the engine which furnishes the power for the plant is running, the kilns of either type may be heated by exhaust steam.

Many users of one or both systems seem satisfied with the results obtained from either, while others are decided in their preference.

22. **Filling a kiln.** — In doing this, care should be used that there is plenty of room for the air to circulate

freely around and through the pile — not less than 3″ between the edges of the boards horizontally and vertically, and one foot between the lumber and the wall or adjacent pile. Each course of boards should be so planned as to bring the same width over those of the course below, if possible, in order to keep a vertical air space through the pile. In some cases the kiln is filled by placing the boards edgeways.

23. **Length of time lumber should be left in the kiln.** — No one should undertake to operate a kiln unless he understands perfectly the particular make of the kiln that he is handling, for if the ventilation is not correctly regulated, the entire charge of the kiln may become mildewed, casehardened, checked, discolored, or dried unevenly. No rule can be given for the time which lumber should be left in the kiln, as it depends upon the condition of the lumber, temperature, kind of lumber, dimensions, and ventilation. Generally speaking, if the kiln is properly constructed and operated, from two to four days for each inch in thickness of soft wood, and from two to three times as long, at a lower temperature, for hard wood, is usually enough to extract the moisture. It is, however, best to allow the lumber to stay in the kiln, at a moderate temperature, from three days to two weeks after the moisture is extracted, in order to harden and cook the solids of the sap, as by so doing the lumber is not so liable to be influenced by moisture in the future; this is the effect that long weather-drying accomplishes.

24. **The care of kiln-dried lumber.** — It is a common mistake to allow lumber to lie in an open shed or other place where it will absorb moisture from the atmosphere, and still call it kiln-dried. Lumber of this sort should

be kept in a place where heat can be applied in damp weather, and should be stacked in a close, compact pile, so as to prevent the air from coming in contact with it.

25. Steaming wood. — This process makes wood pliable, and adds to its durability by destroying the germs which may cause decay; it also neutralizes, to a great extent, the effect of the presence of sap. Steaming or immersing wood in boiling water minimizes its tendency to shrink and swell, and wood thus treated is not so apt to check in seasoning. Steamed wood loses some of its original strength on account of the effect of the high temperature upon the fibers.

26. Preserving wood. — In order to preserve wood, it is sometimes treated with creosote or other chemicals, which are forced into the wood at a sufficient pressure to cause them to permeate the wood thoroughly. This treatment enables the wood to resist better the elements and to keep away insects, which do a great deal of damage, frequently honeycombing the wood with holes, with little or no evidence of their presence upon the outside.

Suggestive Exercises

14. What are some of the results of piling lumber carelessly? Should the back and the front of the lumber pile be upon the same level? Why?

15. How should lumber ways be built? What kind of places should be avoided in seeking a location for lumber piles?

16. Should the piles be placed close to each other? How wide should the piles be made? What is the objection to a square pile? How thick should the lumber sticks be? How should they be placed? What is the result if they are not carefully placed? How should the sticks and the ends of the boards be placed at the front of the pile?

Why? What causes lumber to warp? Describe methods of piling lumber to minimize warping. Should a lumber pile be allowed to stand indefinitely? What is the proper time to cut lumber? Does it injure lumber to allow a little rain to beat into the pile?

17. What is meant by weather-dried lumber? Why is it not suitable for furniture and for inside finish? How is this remedied? For what purposes is weather-dried lumber the best?

18. What is the chief objection to kiln-drying lumber?

19. What are the two methods of kiln-drying? Describe the principle of the moist air kiln. What is claimed of it? How should hard wood lumber be treated before being kiln-dried?

20. Describe the induced draft system. What devices are used to extract the moisture from the heated air? What are the main points of difference between the two systems?

21. What is the difference in the condition of lumber which may be put in the two forms of kilns? Which is the more expensive system to install and operate? How do users of the two systems compare them?

22. How should lumber be stacked in the kiln?

23. How long should lumber generally remain in the kiln to allow the moisture to be extracted? How long to insure most permanent results?

24. How should kiln-dried lumber be cared for?

25. What is the effect of steaming wood?

26. How is wood sometimes treated to preserve it from the elements and from insects?

CHAPTER IV

Tools

27. How to purchase tools. — (**A.**) The quality of the tools used by the mechanic is of the greatest importance. They should be selected carefully, and while it is the poorest economy to buy anything but the best, the best are not necessarily the most finely finished.

(**B.**) In purchasing tools, it is well to remember that those made especially for some dealer, and bearing his name, if sold for a less price than the best, are usually not of the highest grade, and should be shunned. It is wisest to buy standard makes, examining them carefully to be sure that there are no visible defects. The temper of steel may be discovered only by use, and any defects in the best grades of tools is made good upon complaint to the dealer.

28. Benches. — (**A.**) Figure 25 shows the type of bench used in the most up-to-date carpenter and cabinet shops, while that used by carpenters for ordinary work usually is of the type shown in Fig. 26.

(**B.**) In many manual-training schools, the benches are of the former type,. and in the most completely equipped schools, are fitted with locked drawers and closets for the reception of tools, not only to keep the latter in condition for use, but to insure that the set of tools is complete, and to be able to place the responsibility for damage or loss.

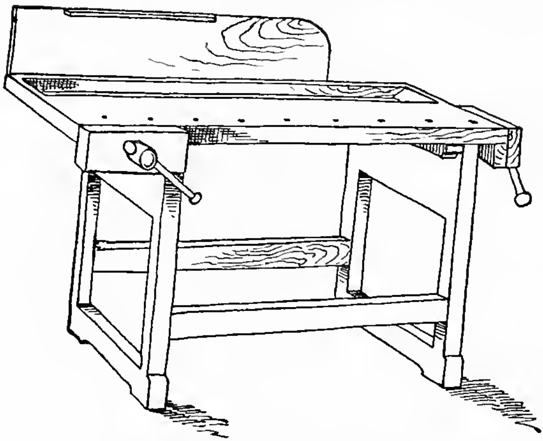

FIG. 25.—MANUAL-TRAINING BENCH.

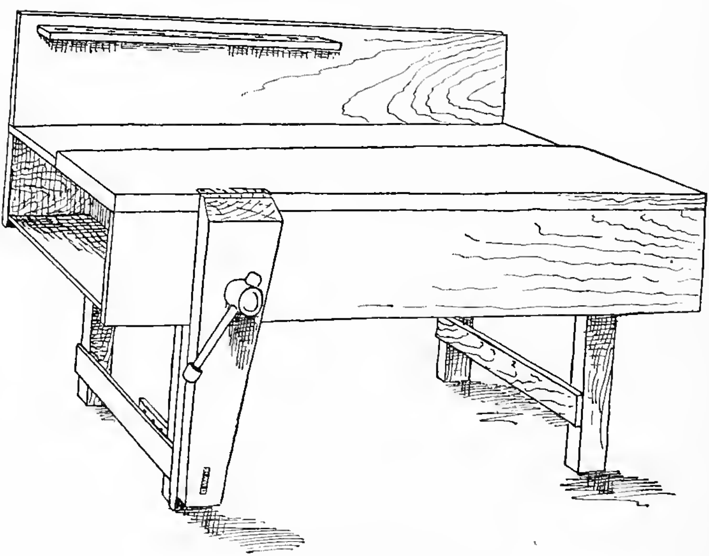

FIG. 26.—CARPENTER'S BENCH.

(C.) The *vises* should be of the modern, quick action design, which, on account of the rapidity with which they work, are superseding the old-fashioned wooden and iron screw vises.

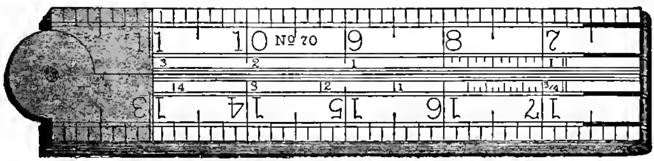

FIG. 27.—TWO-FOOT, FOUR-FOLD RULE.

29. **Rules.** — The two-foot, four-fold *rule* (Fig. 27) is the one generally used by carpenters. It is made of different grades, the more expensive makes being divided into 16ths, 8ths, 10ths, and 12ths, and having the $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$, $1\frac{1}{2}''$, and $3''$ scales upon them. Although the cheaper rule is just as accurate, it is divided usually into 8ths and 16ths only. The form of rule shown in Fig. 28 is becoming quite popular, as it is longer. Since rules are easily lost or broken, many workmen have a good rule for scaling, and a cheaper one for general work.

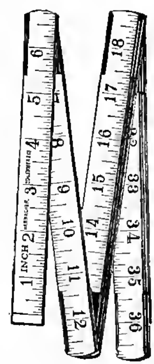

FIG. 28.—ZIGZAG RULE.

30. **The try-square** (A.) consists of the beam (Fig. 29, *a*), which is generally of metal-lined wood, and the blade (*b*), which is a thin piece of steel.

(B.) Too much care cannot be exercised in the selection of this tool, as one which is not perfectly true may

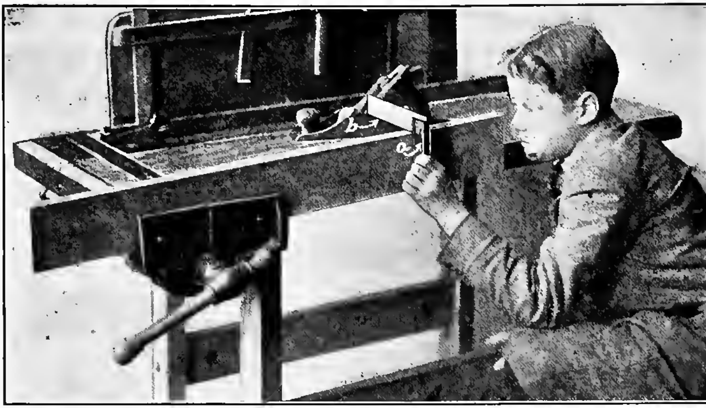

FIG. 29.—POSITION OF TRY-SQUARE IN SQUARING AN EDGE.

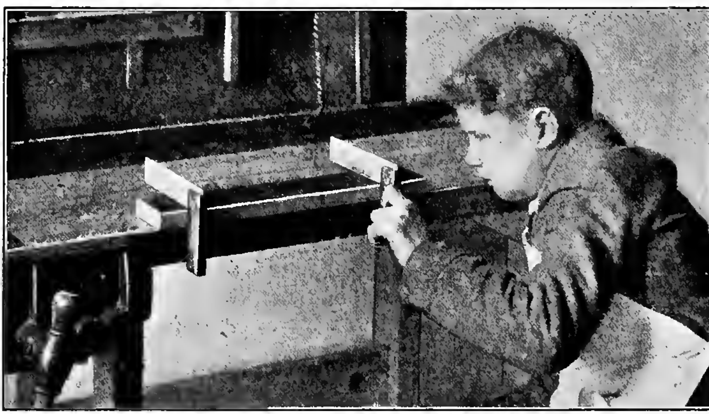

FIG. 30.—USE OF TWO TRY-SQUARES TO SEE IF PIECE OF WOOD IS "OUT OF WIND."

cause much trouble. To test a square, hold the beam against a perfectly straight and square edge of a board which is wide enough to allow a knife line to be made the entire length of the blade. Then turn the square over, the other side up, and, holding the beam against the same edge, move the blade to the line. If the jointed edge of the board and the square are perfectly accurate, the knife line and the edge of the blade will perfectly coincide.

(**C.**) The use of this tool in squaring an edge is shown in Fig. 29. The piece being squared should be in such a position that the try-square will be between the eye and the light; in this way, the slightest inaccuracy may be detected. In Fig. 31 is shown the position of the try-square when used to make a line by the edge of the blade. If working from the edge indicated, hold the beam against the edge with the thumb, and at the same time hold the blade down with one or two fingers, using the others to steady the square in its place upon the board. (**D.**) Two try-squares may be used to see if a piece of wood is "out of wind" (*i* sounded as in kind) by the method indicated in Fig. 30.

Fig. 31.—Position of Try-square when Making Line.

Two pieces of wood known as *winding sticks*, of exactly the same width and perfectly parallel, are often used in manual-training schools for this purpose; they are rarely used in a shop, however, as a workman generally will use two steel squares if the piece is too large to be sighted accurately without some aid of this sort.

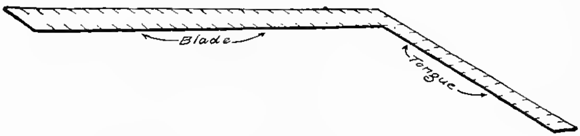

FIG. 32.—STEEL, OR FRAMING, SQUARE.

31. The steel, or framing, square (Fig. 32) is often used as a try-square upon large work, though its most important use is in framing, or roof construction. It is indispensable in finding the lengths and the angles of rafters, braces, etc. Its use for this purpose will be explained in "Constructive Carpentry." The long side of the framing square is known as the "blade," and the short side as the "tongue."

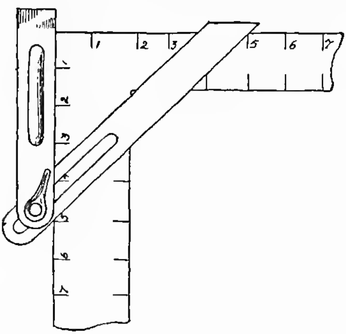

FIG. 33.—BEVEL AND STEEL SQUARE.

The bevel is set at an angle of 45°.

32. The bevel (Fig. 33) may be set for use in marking and testing any angle, in the same manner that the try-square is used upon rectangular work. The sketch shows the bevel and the steel square in position for setting the bevel at an angle of 45°. It will be noticed that the blade of the bevel rests upon the same figures upon both the blade and the tongue of the square.

33. **The gauge** (**A.**), Fig. 34, is for the purpose of making lines parallel to the face or working side or edge. Usually it is made in four pieces: the "head" (*a*), which is held against the face side or edge; the "stick" (*bb*), upon which the head moves; the "thumbscrew" (*c*), which holds the head firmly in its position upon the stick; and the "point" (*d*), which makes the desired mark upon the wood.

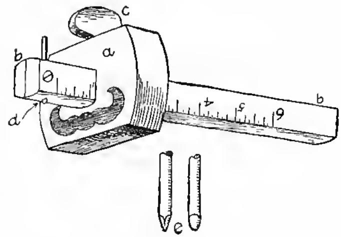

Fig. 34. — Marking Gauge.

a, the head; *bb*, the stick; *c*, the thumbscrew; *d*, the point.

(**B.**) A rule should be used in setting the gauge, unless one is certain that the point is located accurately with regard to the graduations upon the stick.

The point should be sharpened to work with either a push or pull cut, as at *e*.

(**C.**) The gauge should be grasped as shown in Fig. 35, and generally used with a push, though it is occasionally pulled toward the worker. One should always work from the face side of the piece.

If the point enters the wood too deeply, it may be set back, or the gauge carried on the corner of the stick as indicated, which will govern the depth of the cut. Do not use a dull gauge, or one with a round point like a pencil, as it will tear the wood, instead of making a clean cut or scratch.

34. **The hammer** (**A.**) is used by the average woodworker more than any other tool. The "face" (Fig. 36, *a*) and the "claws" (*b*) should be tempered carefully, as they will either bruise or bend if too soft, or

break if too hard. The eye (*c*) is made longer than it is wide, to prevent the head from turning on the handle, and larger at the outside of the head than it is at the neck,

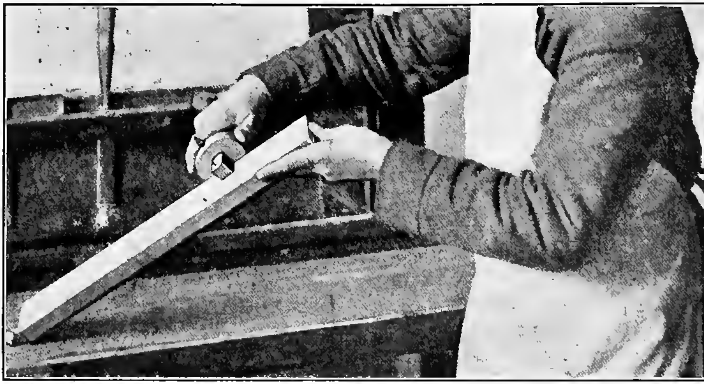

Fig. 35. — Marking Gauge in Use.

so that the handle may be firmly wedged in the eye or socket. The neck (*d*), by extending upon the handle as it does, adds much to the strength of the connection.

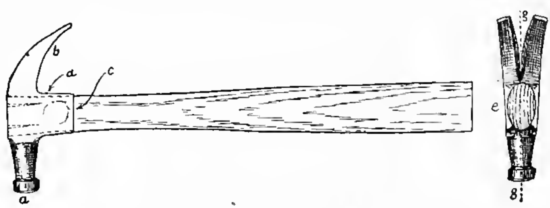

Fig. 36. — Claw Hammer.

a, the face; *b*, the claws; *c*, the eye; *d*, the neck; *e*, grain of neck.

The handle should be of young, tough, straight-grained hickory, elliptical in section, and of a size to be grasped easily.

The grain should be perfectly straight at the neck, and the annual layers should show lengthwise of the ellipse at the end, as at *e*. The handle should be fitted and wedged, or " hung " in such a way that a nail may be driven home in a flat surface without the knuckles striking, which means that the center of the handle should be about parallel with the flat surface. A line lengthwise of the head through the eye should exactly coincide with the long, or major, axis of the ellipse at the end of the handle, as at *gg*, or pounded fingers will result.

The *bell-faced* hammer is to be preferred to the *flat-faced* type, as it will not mar the wood so badly if the nail is missed, though more skill is required to use it. Upon rough work, the bell-faced hammer will sink the nail beneath the surface without bruising the wood badly. Upon inside work, the nails should be sunk beneath the surface with a nail set.

(**B.**) In nailing, the young workman should acquire the habit of grasping the handle of the hammer at the end, as this will give greater force to the blow. Upon light work, the hand will naturally slip a little toward the head Nails should generally be driven in a slanting direction, as they hold better than if driven straight. When nails are driven as shown at *a*, Fig. 37, it is called " toenailing," and when driven sufficiently to hold, but not driven home, as at *b*, they are said to be "tacked." Nails are driven this way when they are to be pulled out again, as in stay laths, and in fastening pieces temporarily.

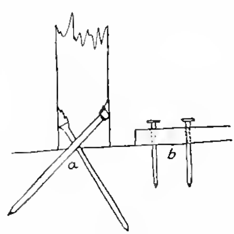

FIG. 37.
a, toenailing; *b*, tacking,

In forcing matched boards together, do not pound directly upon the tongue edge of the board, but upon a waste piece of the same material, as the tongue will be bruised so that the next board will not form a good joint. Care should be used that the hammer does not strike the edge of the board when the nail is driven home. To guard against this, a nail set should be used to sink the head beneath the surface, as in Fig. 38, so that the next board will come to its place without trouble. This is called "blind nailing."

FIG. 38. — BLIND NAILING AND USE OF A NAIL SET.

35. The hatchet (**A.**) is used for hewing light work, for shingling, and as a heavy hammer, though the face is rarely tempered to stand very heavy usage (Fig. 39, *a*).

(**B.**) A *hand axe*, or broad hatchet (Fig. 39, *b*), usually is a better grade of tool than the hatchet, and as it is of greater weight, is better adapted for heavy work. A hatchet or hand axe for general use should be sharpened as at *c*; but for hewing only, an edge like *d* will give the best results.

36. **The mallet.** — This tool should be used upon chisel handles, as a hammer will destroy the handle in a very short time. Mallets are of two shapes, the *square-faced* (Fig. 40, *a*) and the *round* mallet (*b*), the latter being preferred by many workmen as it will always strike a fair blow upon the chisel handle, while the square-faced mallet sometimes will miss, and inflict a painful blow upon the hand. In general, the handle of a square-faced mallet is round, which allows the mallet to turn in the hand; if the handle were made elliptical, like a hammer handle, there would be less likelihood of missing the chisel.

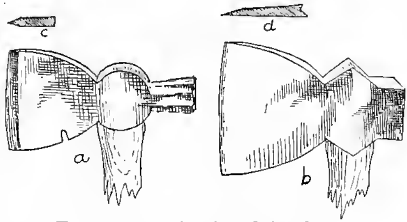

Fig. 39. — *a*, hatchet; *b*, hand axe. (For explanation, see text.)

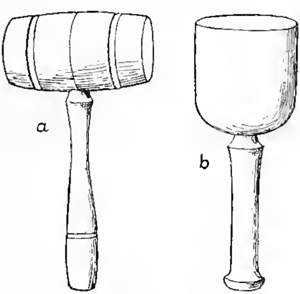

Fig. 40. — Mallets. *a*, square-faced mallet; *b*, round mallet.

37. **Saws.** — (A.) The saws used by the carpenter are for cutting parallel with, or across, the grain, or a combination of the two, and all are composed of two parts, the "handle" and the "blade."

The teeth of a *ripsaw* (Fig. 41, *A*) are suitable for sawing in a direction parallel with the general direction of the grain. The points of different saws may be from one third to one seventh of an inch apart, and form a series of chisels, the cutting edges of which are filed so that they are at right angles to the sides of the blade. In action, the saw is pushed against the wood, each tooth cutting a little deeper than the one preceding it.

The *cutting-off* or *crosscut saw* (Fig. 41, *B*) has from 6 to 12 teeth to an inch, the cutting edges of which are filed at an angle of from 60° to 70° with the sides of the blade, as in Fig. 92. The teeth are set alternately from right to left.

In all except the finest saws, the teeth are set; that is, the points are bent a very little in such a way as to make the cut wider than the thickness of the blade, so that the saw may cut through the wood without binding, which it could not

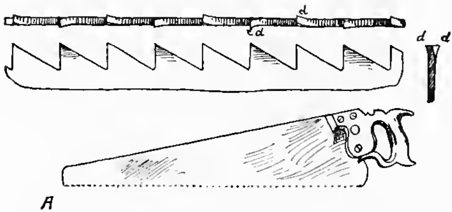

Fig. 41, *A*. Ripsaw.
dd, view and section of setting of teeth.

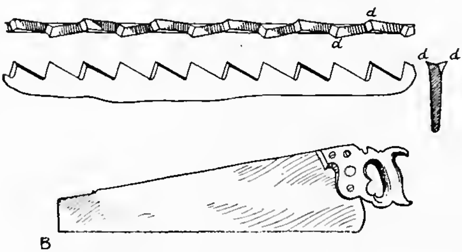

Fig. 41, *B*. Cutting-off Saw.

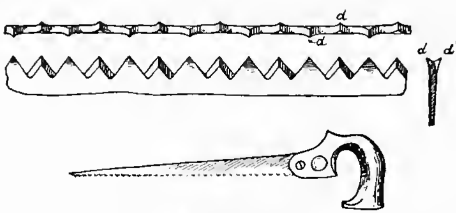

Fig. 41, *C*. Compass, or Keyhole, Saw.

Fig. 41. — Saws.
(In each of the three varieties of saw teeth shown in Fig. 41, the set of the teeth is exaggerated.)

do if the cut were the same thickness as the blade. The blades of all high grade saws are thinner upon the back than upon the cutting edge, but if the saw is to be used upon the finest work, this difference in the thickness of the two edges of the blade is supposed to make the setting of the saw unnecessary. For general work, it will be found that the saw will be much more efficient if it is given a set adapted to the size of the teeth, or to the nature of the work it is expected to do.

The *compass*, or *keyhole, saw* (Fig. 41, *C*) is used where a larger saw is impracticable or where it is necessary to cut both with and across the grain, as in sawing curves. It is also used in starting a cut within the edges of a board. Its point is inserted into a hole bored through the piece, and a cut is made of sufficient length to admit the rip- or cutting-off saw. In order to allow it to cut around curves easily, the cutting edge is considerably thicker than the back, and is given a heavy set. The blade is made of softer steel than the ordinary highly tempered saw, as the nature of its work is such that it should bend without kinking and allow of straightening without breaking.

Some carpenters working upon job work, where it is desirable to carry as few tools as possible, have a narrow 20″ or 22″ saw sharpened like a compass saw, which for ordinary work is quite satisfactory as either a cutting-off or a ripsaw, thus making another saw unnecessary.

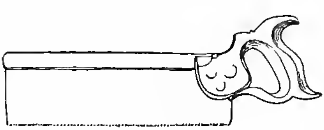

FIG. 42.—BACKSAW.

The *backsaw* (Fig. 42) is used upon fine work; it is filed like a cutting-off saw, but the teeth have rather more hook, and it often has as many as fifteen teeth to the inch, though a twelve-tooth saw is as fine as is generally used. The thick back is to stiffen the blade of the saw; if it works loose, the blade is apt to spring out of shape, but a light blow upon the back will drive the blade into its place, and usually will straighten it.

(**B**.) In buying a saw, select one which is thicker upon the cutting edge than upon the back; this allows the saw to be used upon very fine work with little or no setting. See that the handle fits the hand, and that the saw hangs to suit, or "feels right." This is a matter concerning the balance and the weight of the tool, which cannot be described, but which any one accustomed to using tools will miss if a tool not possessing this quality is placed in his hand.

A saw blade, unless very short and thick, should bend so that the point may be put through the handle, and upon being released, instantly resume its shape. It should bend evenly in proportion to the width and the gauge of the saw, and should be as thin as the stiffness of the blade will permit, as a saw of this sort cuts less wood, and therefore runs with less resistance. A compass saw, being softer, is not expected to stand the above test.

A 26″ or a 28″ blade is best for a heavy rip or cutting-off saw to be used upon coarse work; but for fine work, a 22″ blade, commonly known as a "panel saw," is a convenient size, though a 20″ or a 24″ blade is preferred by many workmen.

(**C**.) A hard saw is best for fine work, but for general work most workmen prefer a saw of medium hardness, as the teeth of a hard saw are apt to break in setting, and its edge, if it comes in contact with metal, requires filing just about as quickly as that of a soft saw, and is much more difficult to sharpen. If always filed by an expert filer, a hard saw is superior in every way to any other.

(**D**.) The handle of the saw should be grasped firmly by three fingers, as in Fig. 43, with the forefinger extended along the

Fig. 43.—Use of the Saw.

Showing the method of using a try-square to insure accuracy.

side, thus making more room for the three fingers, and giving better control of the saw. Very little strength should be used in forcing a fine saw to cut, as its own weight generally is sufficient; if the saw is forced, it will not run smoothly, but will bind, and if a thin board is being worked, it is apt to split. The saw should be used from the face side of the material, so that any splinters or variation will be upon the back side and out of sight.

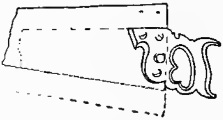

FIG. 44. — RESET SAW HANDLE.

(E.) It is the custom of some carpenters to reset the handles of their heavy saws by drilling holes through the blade so that the handle may be fastened as close to the cutting edge as possible, as in Fig. 44. This brings the force of the stroke nearer the direct line of the cut, which obviously allows a more economical application of force. Never leave a saw in a cut, for if the piece of wood falls off the trestles, the saw is apt to be broken. (Saw-filing will be discussed later.)

38. **The knife blade** used by the wood-worker for general work is similar to that shown in Fig. 45, at *A*. That shown at *B* is the form of blade in most common use in manual-training schools, as it is better adapted for whittling, its shape assisting the student to some extent to prevent the knife from following the grain.

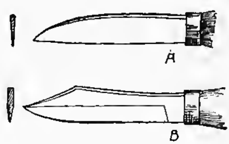

FIG. 45.—KNIFE BLADES.

A, used by wood-worker; *B*, used in manual-training schools.

39. **Planes.**—(**A.**) The *plane* is the most complex, as well as one of the most important, tools which the wood-worker uses, and a high grade of

skill is necessary to keep it in order, as well as to use it properly.

(**B.**) The only plane in use until recent years had a wooden stock, and the iron was adjusted by blows with a hammer; this form of plane has changed very little since the first types were invented, as planes of ancient

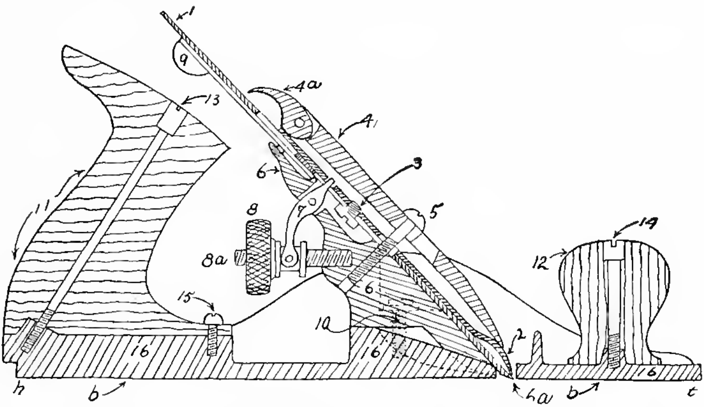

FIG. 46. — SECTION OF IRON PLANE.

1, cutter, iron, or bit; 2, cap iron; 3, plane iron screw; 4, cap lever; 4 *a*, cam; 5, cap screw; 6, frog; 6 *a*, mouth; 7, Y lever; 8, vertical adjusting nut; 8 *a*, vertical adjusting screw; 9, lateral adjustment; 10, frog screws; 11, handle; 12, knob; 13, handle bolt and nut; 14, bolt knob and nut; 15, handle screw; 16, bottom, or stock.

times have been found which in all essentials are practically the same as those in use to-day.

(**C.**) Our modern planes are more easily adjusted and more convenient to use, though they will do no better work than the wooden planes of our forefathers, which are still preferred by many of the best workmen. The face of an iron plane holds its shape permanently, while it is necessary that the wooden plane should be jointed occasionally.

(**D.**) There are planes for every conceivable purpose, all constructed upon the same general principle as the common bench plane which we shall discuss later. These planes are adjusted by screws and levers, which are very simple, and any one understanding them may easily comprehend the more intricate molding or universal planes.

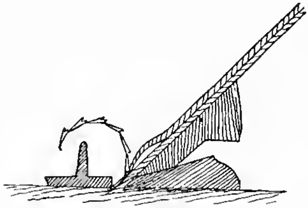

Fig. 47. — Result of Using Plane with Improperly Adjusted Cap Iron.

The adjustment of the modern plane may be understood by a careful study of Fig. 46 and by comparing it with the plane itself. The "cutter," "iron," or "bit" (1) and the "cap iron" (2) are the essentials of the tool, and it is upon their condition and adjustment that the efficiency of the plane depends. If the cap iron is set too far from the edge of the iron, and if the cut is made against the grain, the shaving will not break before it leads the iron into the wood, as shown in Fig. 47. If the cap iron is set somewhat less than $\frac{1}{16}''$ from the edge of the cutter, according to the wood being planed, it will break the shaving nearly as soon as it is cut, as in Fig. 48, and will result in a smooth, clean surface. The closer the cap iron is set to the edge, the smoother the iron will cut, as the breaks in the shaving are thereby made shorter.

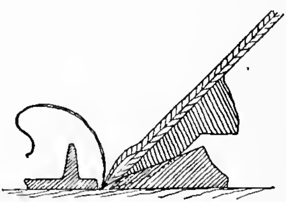

Fig. 48. — Result of Using Plane with Cap Iron Adjusted Properly.

It will be seen that the closer the bottom of the cap iron (2) is set to the edge of the cutter (1), the shorter the breaks will be, as in Fig. 48, and the more smoothly the plane will cut. The plane "iron screw" (3) holds the edge of the cutter (1) and the bottom of the cap iron (2) in their desired relation. The "cap lever" (4) being pressed against the under side of the head of the "cap screw" (5), by the "cam" (4 *a*), holds the iron in its place, and presses the cap iron (2) firmly against the top of the cutter (1). Unless the cap iron fits the face of the cutter perfectly, the plane will not work satisfactorily. The "frog" (6) carries all the adjusting mechanism of the plane, and may be moved backward or forward to reduce or enlarge the "mouth" (6 *a*), which should be no larger than is necessary to allow the shavings to pass freely. The frog rarely will require readjusting after it has been properly located.

The "Y lever" (7) forces the plane irons (1 and 2) in or out simultaneously, which governs the projection, or "set," of the edge of the cutter (1) beyond the face, or "sole" (*b*) of the "plane stock," and thus the thickness of the shaving which the plane will cut. The "adjusting nut" (8) moves freely upon the "screw" (8 *a*) and operates the Y lever (7). The "lateral adjustment" (9) is for the purpose of forcing the iron to cut in the exact center of the width of the face (*b*) of the plane. The two "frog screws" (10) hold the frog rigidly in the position which will make the throat (6 *a*) of the desired size.

The above illustrates all the adjusting mechanism; the other parts of the plane are as follows: "handle" (11); "knob" (12); "handle bolt" and "nut" (13); "knob bolt" and "nut" (14); "handle screw" (15); "bottom," or "stock" (16).

The face, or sole, of the plane (*b*) must be kept perfectly flat, or good work cannot be done. The ends of the plane (*h* and *t*) are called the "heel" and "toe," respectively. The "mouth" of the plane (between 6 *a* and 2) must be kept clear of shavings, or it may become clogged.

FIG. 49. — SETTING A PLANE.

(E.) In setting a plane, do not pass the fingers over the face, or sole, as cut fingers may result. Hold the plane as shown in Fig. 49, and look toward the light, when the exact projection of the cutter may be seen. Notice the position of the fingers of the left hand, and that the eye glances from toe to heel. This leaves the right hand free to make the adjustments. This is a workmanlike way of setting a plane, and in this, as in all handling of tools, awkwardness should be avoided.

40. **Sharpening a plane.** — (A.) An important part of this process is *the grinding of the cutter.* Set the cap back about $\frac{1}{8}''$ from the edge of the iron, and use it as a

guide by which to grind the iron perfectly square, as at *A*, Fig. 50. The cap iron should be kept perfectly square, and never touched except to fit it to the cutter, or, if it is too thick to allow the shavings to pass freely, to file the top of it to the proper thickness. If the tool is kept in order skillfully, the cap will need care only upon rare occasions.

The cutter should be held firmly to the grindstone or emery wheel and kept moving from side to side to prevent wearing the stone in one place. The grinding should all be done upon the beveled side of the cutter, which should be held upon the stone at an angle of about 20° (as at *B*, Fig. 50), more rather than less, as a thinner edge is apt to "chatter," or vibrate, if it strikes a hard place in the wood. Many workmen use a rest when grinding; this insures a true bevel. Any device which holds the tool firmly at the same place on the stone will do for a rest.

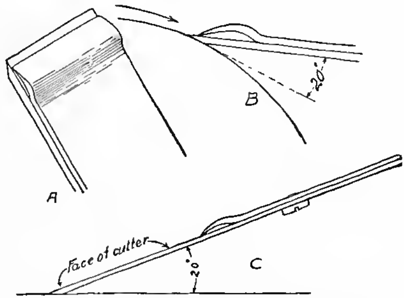

FIG. 50.—GRINDING AND WHETTING OF A PLANE IRON.

The slightest glint of light upon the edge of an edged tool indicates the need of whetting. In whetting a plane iron the cap iron should be carried back until the screw stops at the top of the slot as at *C*, Fig. 50. The screw may then be tightened to hold the cap in place; this gives a better grasp of the iron, though some workmen prefer to take the cap off entirely while whetting.

The bevel of the iron should be held exactly upon the surface of the oilstone, as shown at *C*, Fig. 50, the iron being grasped as in Fig. 51. Keep the right wrist rigid and allow the arm to swing from the shoulder, bending only at the elbow. In this way the rocking motion may be reduced to a minimum; this is necessary to preserve the bevel. Though the bevel may be maintained better

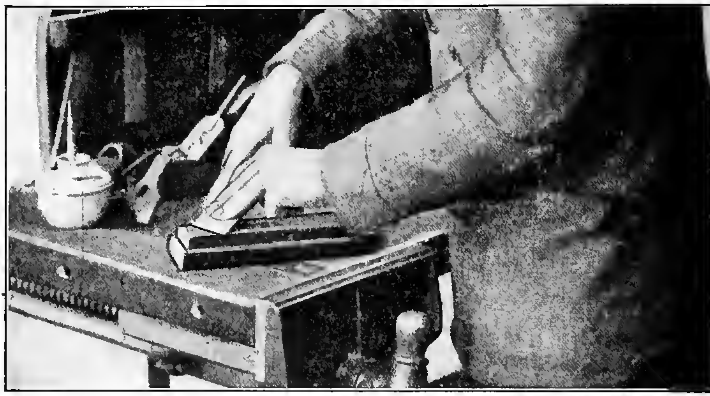

Fig. 51.—Whetting or Oilstoning the Beveled Side of a Cutter.

by imparting a short circular motion to the plane iron, or to any edge tool which is being sharpened, it seems an awkward and fussy method of work, and rarely is used by an expert workman. By long practice the mechanic finds that a stroke made nearly the entire length of the stone will impart an edge quicker, and after the knack has been acquired, the bevel will be preserved just as well.

Turn the whetstone end for end frequently, and work upon the farther end, as in this way the stone may be kept true much longer than if one place upon it is used all the time. This will also minimize the danger of pulling the tool off from the nearer end of the stone, which will generally make regrinding necessary.

When the beveled side has been whetted, lay the face, or the top of the iron, perfectly flat upon the stone, as in Fig. 52, holding it down with the fingers of the left hand,

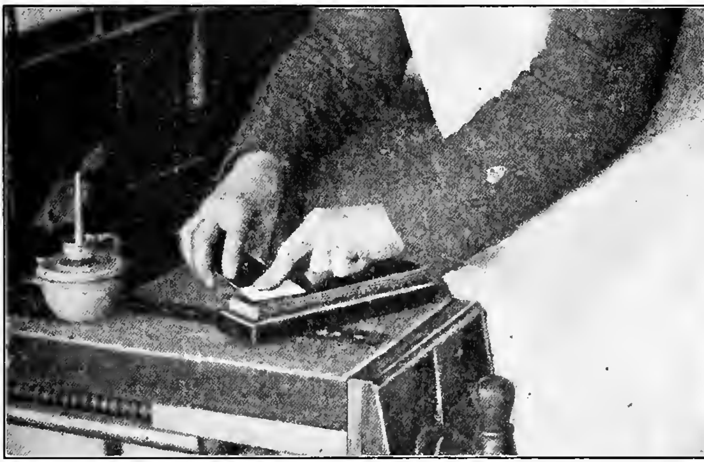

FIG. 52.—WHETTING OR OILSTONING THE PLAIN SIDE OF THE PLANE IRON.

using the right hand only to move the iron back and forth. Care should be used that under no circumstances is the face of the iron lifted the slightest degree from the stone. At this stage of sharpening a plane iron, the utmost care is necessary that the face of the cutter does not lose its perfectly flat surface at the edge, since the slightest deviation from absolute accuracy at this place will prevent the cap iron from fitting properly, which will cause end-less trouble, as the shavings will be forced between the cap and the face of the iron (see **C**. of this topic).

(**B**.) The shape of the cutting edge of the plane cutter has an important influence upon its efficiency. Imagine the edge divided into three equal parts: the middle part should be perfectly straight, or almost imperceptibly rounded; the two outside thirds should be slightly and gradually rounded until the corners of the iron are so short that there will be no danger of their projecting below the face of the plane. This gives the edge an elliptical shape, as shown in Fig. 53, which is somewhat exaggerated, as the shape shown is about that which would be seen if a moderately coarse jack plane were held as in Fig. 49.

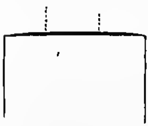

Fig. 53.—Shape of Edge of Plane Iron.

(**C**.) In order to insure fine work, the cap iron must be fitted so carefully to the face and the edge of the cutter that, if necessary, it may be placed less than $\frac{1}{64}$th of an inch from the cutting edge, though this would rarely be required except upon very cross-grained wood.

In fitting the cap iron to the top of the cutter, a very fine, sharp file should be used. The filing must all be done upon the under side of the cap iron, at the places where it rests upon the face or top of the cutter; or, if preferred, the cap may be very carefully bent, but unless there is considerable fitting necessary, and unless the joint is perfected by the use of a file, this method is not recommended.

If sufficient care and skill are exercised, a plane may be sharpened and adjusted so finely that a veneer of .01″ or less in thickness of bird's-eye maple, burl walnut, ash, or similar wood may be smoothed. It is not wise, however, to spend the time necessary to keep a plane sharpened and adjusted to do this sort of work, as a scraper and sandpaper, or the latter alone, is the most economical way to smooth woods of such nature.

(**D.**) To remedy clogging of the mouth, remove the conditions which cause it; simply digging out the shavings is useless. An improperly fitted cap iron is one of the principal causes of trouble; the cutter may be ground so thin that when it is forced against a knot or hard place, the iron chatters, which allows the shavings an entrance under the cap iron. In this lies the only real advantage of a wooden plane over the modern iron plane, as in the former the iron is much thicker and stiffer. The cap iron may be so thick that it causes the shavings to curl too much, or the frog may be set too far to the front, which will make the mouth too small. This latter may be remedied by moving the frog back, but in a wooden plane, the mouth and the throat would have to be cut larger in order to allow the shavings to clear themselves properly.

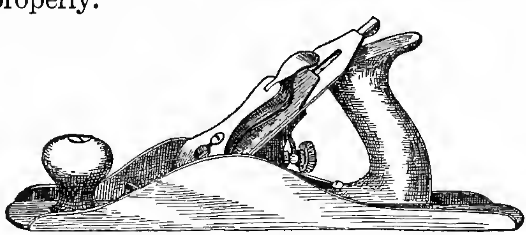

FIG. 54.—JACK PLANE.

41. The jack plane (Fig. 54) generally is 15″ long, and its ordinary use is for the purpose of roughing out a piece of wood for jointing or smoothing. If it is properly sharpened, it may be used as a smoothing plane, or as a jointer upon small work, as it is capable of doing as good work as any plane.

The jack plane generally is ground more rounding, and the cap set farther back than in the other planes, especially if it is to be used upon rough work.

42. The jointer. — (**A.**) This tool is from 20″ to 26″ long, and is used to straighten edges and surfaces, or to fit them together. The shape of the edge of the cutter of this plane should be but slightly elliptical, less so than the jack plane or the smoother, unless the two latter are fitted for doing very fine work.

(**B.**) In using a jointer for squaring or jointing an edge, it should be carried to one side or the other of its face as may be necessary to take advantage of the elliptically shaped edge of the cutter, by cutting a shaving thicker on one edge than on the other, thus making the edge of the board square with the face side.

To make a perfectly square edge, the cut should be made in the center of both the iron and the width of the face of the plane. The plane should be held as shown in Fig. 55, the fingers under the face of the plane, the tops of the finger-nails touching the board lightly, guiding the plane, and keeping the bit cutting in one place upon its edge.

43. The smoothing plane (**A.**) is of the same type and mechanism as those described above, though it is but 9 or 10″ long; if satisfactory work is expected from it, it must be kept in good order, with the cap iron perfectly fitted. For general work, it is not necessary to spend the time to insure that the plane should be continually in readiness to work upon hard, tough, cross-grained wood, as a plane to do the latter kind of work well is unnecessary upon softer or straight-grained wood. For ordinary work, the cap iron should be set from $\frac{1}{32}''$ to $\frac{1}{16}''$ from the

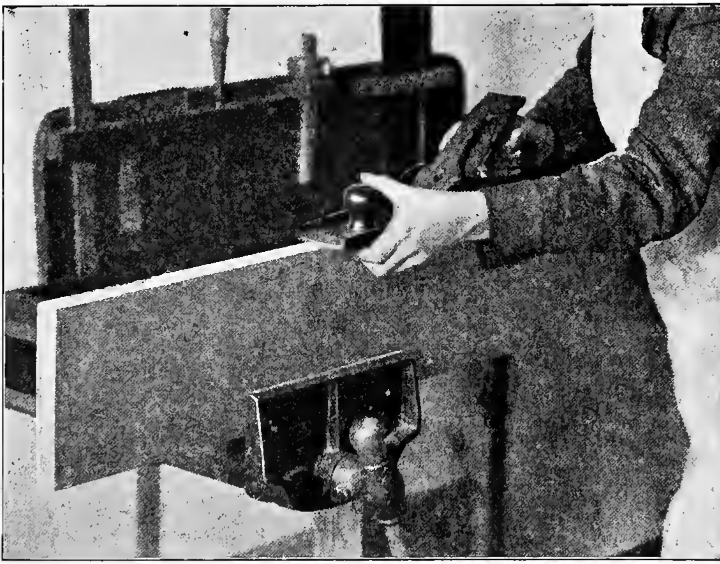

Fig. 55.—Method of Guiding a Jointer.

edge of the bit, but for the finest work, the closer to the edge it will fit and allow a shaving to be taken, the finer the work that may be done. No wood used upon ordinary work is so cross-grained or knurly that it cannot be smoothed economically, if a properly sharpened and adjusted plane is used.

(**B.**) A smoothing plane should cut a shaving as nearly the entire width of the bit as possible, therefore a very flat, elliptically shaped edge must be maintained. In using a plane or any kind of cutting tool, the direction of the grain of the wood should be carefully studied, and every advantage taken of it to facilitate the work.

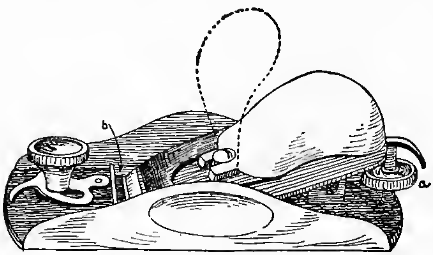

Fig. 56.—Knuckle Joint Block Plane.

44. The block plane (knuckle joint cap, Fig. 56) (**A.**) is constructed upon a somewhat different principle than the planes above described, as the adjusting nut (*a*) under the cutter at the rear end of the plane is raised or lowered to withdraw or advance the bit, and thus govern the cut of the tool. The size of the mouth is controlled by a movable section of the face at *b*. This plane has no cap iron, as the use for which it is intended makes it unnecessary. The block plane is used across the end of the wood, at right angles with the general direction of the grain. The iron, or cutter, is so placed in the stock of the plane that its cutting angle is as nearly in line with the cut as possible,

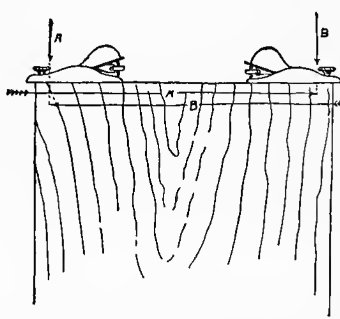

Fig. 57.—Use of the Block Plane.
(For explanation, see text.)

with the beveled side of the iron uppermost. By this method of construction, the iron is given more stiffness to resist the chatter, or vibration, caused by planing end wood.

(**B.**) In using the block plane, do not make the cuts from edge to edge, or chips will be broken off at the corners; instead, plane from one edge, and stop the stroke before the other edge is reached; reverse the plane and work from the other direction, as shown at *A*, *B*, Fig. 57. Another and workmanlike way of using the block plane upon small pieces is shown in Fig. 58. Work from each edge as described above, turning the piece over for each stroke. In sharpening the block plane iron, the edge should be made slightly elliptical, and the bevel carefully maintained.

Fig. 58.—Using Block Plane upon Small Pieces.

45. **The correct position.** — (**A.**) In using planes or any edge tools, a position should be taken which will furnish sufficient resistance to the pressure required for making the cut, as the pressure should be applied firmly

and steadily. With experience, the correct position will be taken involuntarily, but the beginner should be continually upon the watch to overcome his awkwardness.

(**B.**) The habit of bending from the hips is acquired easily, and the young workman should learn to work in as nearly an erect position as possible, for if the bending of the shoulders is persisted in, a permanent stoop will result. Stand facing the work and clear of the bench in order to prevent unnecessary wear of the clothing.

FIG. 59.—INCORRECT USE OF JACK PLANE.

(**C.**) Do not allow the plane to drop over the end of the board at either the beginning or the end of the stroke, as indicated at *A*, *B*, Fig. 59. To prevent this, the hand should be kept upon that part of the plane which is upon the board; at the beginning of the stroke, the weight should be upon the front end of the plane, as in Fig. 60, and at the end of the stroke upon the rear end, or upon the handle, as in Fig. 61. Begin and end each stroke with a lifting motion instead of allowing the plane to drop as it leaves or enters the wood. The plane should be held firmly, not rigidly; do not allow it to jump; this is caused generally by an attempt to take a shaving heavier than the plane should cut, or, if the cap iron is fitted and adjusted properly, by a dull iron. A cutter will jump or chatter if it does not fit solidly against the frog. In drawing the plane back after making a stroke, carry it upon the toe, or upon one corner; do not drag it flat upon its face, as the iron is thereby dulled as much as when it is cutting, or possibly more.

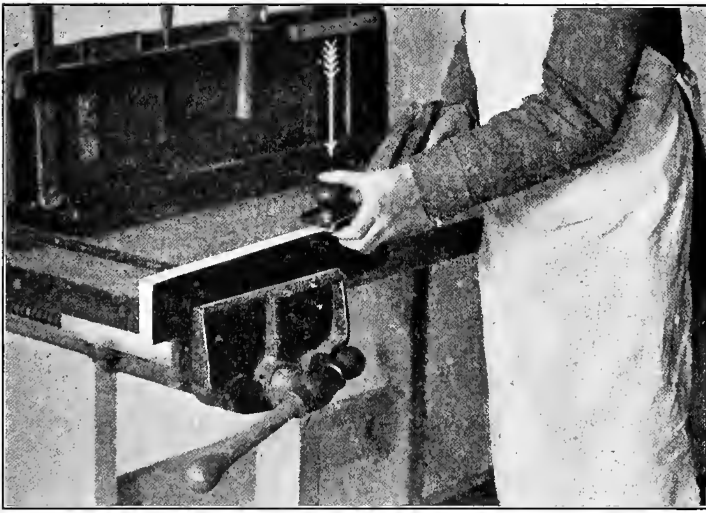

Fig. 60. — Beginning the Stroke with a Jack Plane.

Fig. 61. — Ending the Stroke with a Jack Plane.

(**D.**) Carry the plane parallel with the grain when it is possible, and take no more shavings off than is necessary to attain the desired results. The young workman should make a study of the grain and the peculiarities of the different kinds of lumber upon which he works, losing no opportunity to experiment upon and compare the qualities of every available wood.

(**E.**) In using edge tools of every kind, little is gained, and much is often lost, by working with dull tools; tools should be sharpened often and thoroughly. This is of the utmost importance, for even with the tools in the best possible order, it will require much care and skill to do good work.

46. Chisels. — (**A.**) Carpenters' chisels are used for paring and mortising; the paring chisel should be light, smoothly finished, and ground with a sharper bevel than that used for mortising, for which the heaviest chisel is none too strong.

(**B.**) Chisels are "tanged" or "socket," according to the method by which the blade and handle is joined. The tanged firmer chisel (Fig. 62, *A*) is the older form, and is not so strong as the more recently designed socket chisel (*B*). For light work, the tanged chisel is preferred by many, but more commonly the socket chisel is used, as it is stiffer, not so easily broken, and has no shoulder to catch upon the edge of the wood when the tool is used. The beveled-edge chisel (*C*) is a favorite tool with pattern makers; and the mortise, or framing chisel (*D*), is designed for heavy use. A set of chisels consists of one each of the following dimensions: $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{5}{8}''$, $\frac{3}{4}''$, $\frac{7}{8}''$, $1''$, $1\frac{1}{4}''$, $1\frac{1}{2}''$, $1\frac{3}{4}''$, $2''$.

(**C.**) A large, heavy chisel, $3\frac{1}{2}''$ or $4''$ in width, called a "slice" or "slick," is used, like a paring chisel, upon heavy work.

(**D.**) Handles for paring chisels may be of any hard wood and of any convenient shape, as these should not be pounded upon. Although they are occasionally used for cutting small mortises, it is not a good practice unless the tops of the handles are protected by leather or fiber tops. Mortising chisels should have handles of the toughest wood obtainable, preferably hickory, with leather nailed with small brads upon the top to protect the wood. If a leather washer is fastened to the handle by a pin or dowel, the wood will in time pound down and the leather be broken out and destroyed, while if bradded upon the handle, the leather may be renewed as often as necessary. An iron ring, or ferrule, is used by many to prevent the handle from splitting, but this will bruise the face of the mallet. A hammer should never be used upon any sort of wooden handle, or the handle will be very quickly destroyed, but a mallet will injure it comparatively little. In fitting the handle to the chisel blade, care should be used that they are in perfect alignment, as otherwise a sharp blow may break the blade.

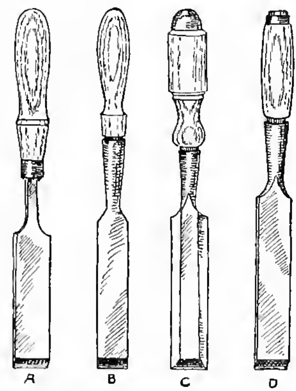

FIG. 62.—CHISELS.

A, tanged firmer chisel; *B*, socket chisel; *C*, beveled-edge chisel; *D*, mortise, or framing chisel.

(**E.**) In sharpening a mortise chisel, it should be ground at an angle of not less than 30°, as a thinner edge would be apt to break upon coming in contact with a knot. A paring chisel may be ground as thin as 20°, as it does not have to stand heavy blows, and a better edge for the purpose may thus be obtained. In whetting a chisel, the bevel must be carefully maintained, and the back be kept perfectly flat, like the face of a plane iron, or it will be impossible to work to a line.

FIG. 63.—DRAWSHAVE.

47. **Gouges** may in general be described in the same way as chisels, except that they are curved instead of flat. The terms "inside" and "outside," used in describing them, indicate whether they are ground upon the inside or the outside of the curve.

48. **The drawshave** (Fig. 63) is often used in cutting curves, in chamfering, and for roughing out work. The patent drawshave, with folding handles, is a safer tool to keep in the tool box, as the edge is protected, but it is not as satisfactory for general work as the ordinary rigid-handled tool. If the latter is used, a piece of wood should be fitted over the edge to protect both it and the hands when the tool is not in use.

49. **The spokeshave** (Fig. 64) should not be used in any place where a plane can be used, but only upon concave or convex surfaces; when used, it may be either pushed or pulled.

FIG. 64.—SPOKESHAVE.

50. **Bits** (A.) are of many different types, the most common being the *auger bit* (Fig. 65). The use of the "worm"

(*a*) is to draw the bit into the wood, thus making a heavy pressure upon the bit unnecessary. The "lips" (*bb*) make an incision on the wood below the cut made by the "cutters" (*cc*), which take the shavings out and into the "twist," which in turn lifts them out of the hole.

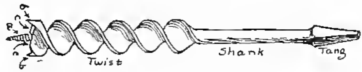

Fig. 65.—Auger Bit.

(**B.**) Care should be used when boring a deep hole that the bit is removed before the shavings clog in the twist, which will happen if the hole becomes full of shavings which cannot be lifted out. Should clogging occur, do not use a great deal of strength in trying to back the bit out, or its "shank" may be twisted off; it is better to pull it out with a straight pull by means of a lever, if sufficient strength cannot be otherwise exerted, the pull being straight over the center of the bit from the "chuck," not from the head of the bitbrace.

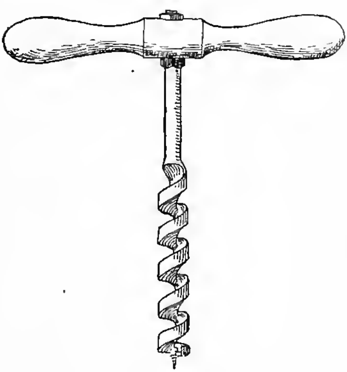
Fig. 66.—Cross-handled Auger.

After boring the hole to the desired depth, do not turn the bit backward to remove it, as shavings will be left in the hole, but give it one turn back to loosen the worm, then turn as though boring the hole deeper, lifting under the head of the bitbrace in the meantime, by which process the shavings will be lifted out. These bits are numbered from $\frac{3}{16}$ths to $\frac{16}{16}$ths inch by 16ths of an inch. Sizes larger than these are known as augers.

(**C.**) Large auger bits generally are fitted with cross handles, as in Fig. 66, as a bitbrace will not give sufficient leverage to make the bit cut the wood; these are called augers. The form shown is known as a "Ford auger."

FIG. 67.

A, German bit; *B*, twist drill.

(**D.**) The *German bit* (Fig. 67, *A*) is used for boring small holes for screws and nails, and has entirely supplanted the gimlet of our forefathers, as its action is much more rapid. Its progression in sizes is from $\frac{1}{16}''$ to $\frac{12}{32}''$ by 32ds of an inch; this tool is also called a *screw bit.*

(**E.**) The *twist drill* (Fig. 67, *B*) is a valuable tool; every carpenter should own an assortment of twist drills for use in places where other bits may come in contact with iron. The sizes range from $\frac{1}{16}''$ to $\frac{5}{8}''$ by 32ds. The round shank drill may be purchased in any size up to 3″, by 64ths of an inch.

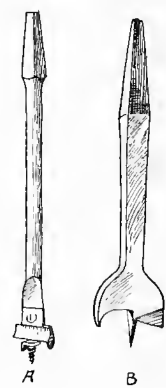

FIG. 68.

A, extension bit; *B*, center bit.

(**F.**) The *extension bit* (Fig. 68, *A*) is a very convenient tool for boring a hole of any size within certain limits, and is at times extremely valuable.

(**G.**) The *center bit* (Fig. 68, *B*) is often used in boring holes through thin material which would be apt to be split if an auger bit were used.

(**H.**) The filing of an auger bit offers an opportunity for the exercise of both judgment and skill. The tops of the cutters and the insides of the lips may be filed with but little trouble. It is very essential to see that all cutting edges are kept thin and not filed to a blunt angle.

In filing the under side of the cutter, as shown in Fig. 69, lies the danger of destroying the efficiency of the tool. The metal, back of the under side of the edge, should be filed at a greater angle than the pitch of the worm, so that it will clear the wood as the bit simultaneously turns and advances. Unless this is skillfully done, the under side of the cutter, back of the cutting edge, will bear upon the wood underneath and so prevent the bit from advancing.

FIG. 69. — FILING AN AUGER BIT.

(I.) If the lips (Fig. 65, *bb*) are filed off, an auger bit bores into the end wood easily.

51. **The bitbrace, or stock.** — (A.) This tool is used to hold the bit, and to furnish sufficient leverage to turn the bit into the wood. Bitbraces are made of different sizes, and with different devices for holding the "tangs" of the bits. A workman should own an 8″ and a 10″ swing bitbrace, as it is often necessary to use different sizes or kinds of bits alternately.

(B.) The *ratchet bitbrace* (Fig. 70) differs from the ordinary brace only in the ratchet attachment. It is an indispensable tool to an up-to-date workman, as it may be used in many places where an ordinary brace would be useless; for general work, however, being heavier, it is less convenient than the plain brace.

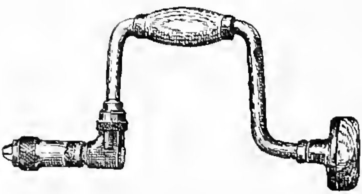

Fig. 70. — Ratchet Bitbrace.

52. The screwdriver (A.) is one of the most important tools in a carpenter's kit, and to be of use should be of finely tempered steel, for if too soft, it will turn over, and if too hard, it will break. The edge should be as thick as the slot of a screw will allow, in order to have as much strength as possible.

(B.) A round-handled screwdriver is not so satisfactory as one with an elliptical or polygonal handle, as it is impossible to obtain as good a grip upon the former as upon the latter; a round handle, planed flat upon the two opposite sides, is quite commonly used.

(C.) *Ratchet screwdrivers* are useful in many places where it is difficult to use two hands, and there are patent quick-action screwdrivers on the market which are suitable only for certain kinds of light work, as what is gained in speed is lost in power. The screwdriver bit is a short screwdriver blade, tanged to fit a bitbrace; it is essential in doing economical work, as screws may be driven much more rapidly than by hand, and it is also valuable on account of its greater leverage in driving heavy screws.

53. **Compasses, or dividers** (Fig. 71), are used to draw circles and curves, and for spacing and scribing, by which is meant the process of fitting a piece of wood to an uneven surface. *Calipers* (Fig. 72) are used to measure the outside of a round or oval object. Those shown are known as "outside" calipers; "inside" calipers, or those used for measuring the inside of a hole, have straight legs. These tools ordinarily are not considered a part of a carpenter's kit, as they are generally used upon work requiring more exact measurements. Wood-workers' tools are graded to sizes, generally nothing finer than 16ths of an inch; hence, the ordinary methods of measuring will usually give sufficiently accurate results.

FIG. 71.
COMPASSES.

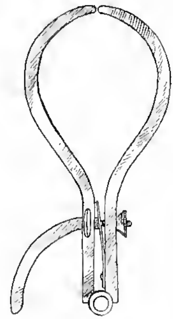

FIG. 72.
CALIPERS.

54. **Pliers.** — (**A.**) These are indispensable little tools (Fig. 73), and every workman should own a pair. Those combining several tools are most useful; cheap tools of this sort are usually worthless.

FIG. 73.
PLIERS.

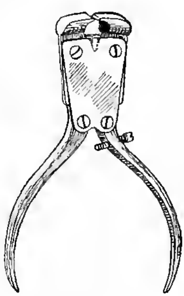

FIG. 74.
NIPPERS.

(**B.**) *Nippers* (Fig. 74) are made to cut wire, but not to pull nails. Being tempered for cutting, those of good quality are hard and brittle, lacking the toughness necessary to pull nails, for which work a cheap pair of nippers may be purchased.

55. **The scraper** is one of the most useful tools in the kit of the carpenter who works upon hard wood. This tool may be purchased, or made of a very hard saw; it must be of hard, tough steel, or the edge will not last. A scraper should be about 3″ × 5″, which is a convenient size for grasping with the hand. Many workmen make handles for their scrapers (Fig. 75, *A* and *B*), but cabinet makers, and others who use them continually, generally prefer to use them without handles. If a large surface is to be scraped, it is well to have a handle of a leather palm (Fig. 75, *C*). This is a piece of leather of suitable size and shape to protect the hand from the heat generated by the action of the scraper in cutting; the thumb is passed through the hole, and the broad part of the palm hangs between the scraper and the thick of the hand. For scraping floors, a scraper plane (Fig. 75, *D*) will be found valuable, though if much of this work is to be done, it will be the best economy to purchase one of the forms of floor-scraping machines.

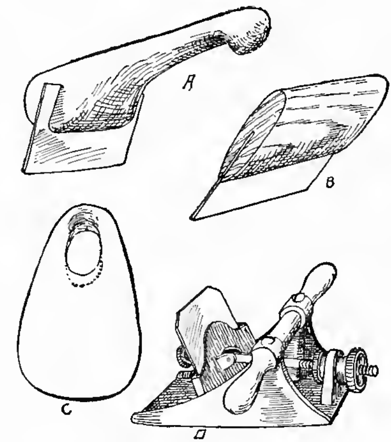

FIG. 75.—SCRAPER.

A, *B*, handles for scraper; *C*, leather palm; *D*, scraper plane.

56. Edges. — There are two forms of edges used in sharpening scrapers, — the *square* and the *beveled* edge; in sharpening either of these, the edge should be filed, whetted, and turned with a burnisher, which imparts a wire edge, indicated in Fig. 76, *A* and *B*, which shows enlarged views of the two forms of edges of scrapers. If the eye glances along the edge of a properly sharpened scraper, the edge will appear slightly curved; this edge must be given it by filing. After the scraper is filed, each corner which is to be turned must be whetted to a perfectly keen edge upon an oilstone, as the object of sharpening a scraper is to "turn" this edge at an angle with the sides of the scraper.

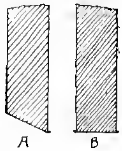

FIG. 76. — EDGES OF SCRAPERS.

A, beveled edge; *B*, square edge.

By "turning" the edge of a scraper is meant pushing the particles of steel which form the corner over so that they will form a wire edge which will stand at an angle with the sides of the scraper. When the edge has been skillfully turned, it will cut like a very finely sharpened and adjusted plane, and will work either with or against the grain without tearing the wood.

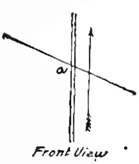

FIG. 77. — ANGLE OF BURNISHER WITH SIDES OF SCRAPER.

Notice carefully the angle of the burnisher with the sides of the scraper, as at *a*, Fig. 77, and as in Fig. 78, which indicates approximately the angle at which it should be held across the edge when seen in the view illustrated of either a square or beveled-edge scraper, the vertical lines indicating the scraper. The stroke must be from the bottom, up, as indicated. At *A*, Fig. 79, is shown the top view of the burnisher as it makes each of the strokes in turning the edge of a square edge scraper; notice that the burnisher swings in an angle of about 15°, one stroke only being made at each angle.

At *B*, Fig. 79, is shown the method of turning the edge of a bevel edge scraper; the student will notice that the angles are similar to those shown at *A*, except that the first stroke is made at nearly the same angle as the bevel of the scraper. An edge may often be turned at one stroke, and more than three should rarely be necessary. If more than three are made, the edge may be turned too far, which is worse than not being turned enough. The strokes should be made in the order indicated by the figures of the angles of the burnisher; otherwise it will be difficult to obtain satisfactory results.

Fig. 78. — Method of Grasping Scraper for Sharpening.

The amount of pressure necessary to apply at this stage of the work cannot be described, but can only be discovered by practice. A steady, moderate pressure is all that is needed, but care should be used that the angle of the burnisher does not change during the stroke. This will give an edge suitable for common counter or table tops, hardwood floors, and similar work, if the skill to use the burnisher properly has been acquired.

The burnisher should be slightly lubricated with oil or with the end of the tongue, as this assists it to slide over the edge of the scraper without scratching.

If a scraper is to be used upon very fine work, a different shaped edge should be made; it should be whetted to four perfectly square and keen corners, each of which will furnish an edge. This is a more difficult method of sharpening a scraper, but it gives four edges suitable for fine work. The edge should be turned by carrying the burnisher as shown at *A*, Fig. 79, making the strokes at the different angles in the order indicated by the numbers. In sharpening any scraper, care should be used that no strokes are made back of the square, as stroke *bc* of Fig. 80. Keep the burnisher pointing down all the time, as indicated at *a*, Fig. 77, as in this lies the chief difficulty. Two or three strokes should be sufficient to sharpen the scraper.

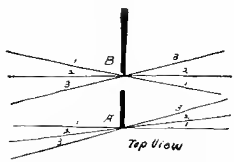

Fig. 79. — Top Views of the Angles of the Burnisher.

As stated at the first of this section, a burnisher is necessary. This tool should be made of the hardest steel, and is often made by the workman himself of an old file, ground perfectly smooth and polished. Perhaps the most satisfactory burnisher within easy reach of the wood-worker may be made from a nail set, which may be fitted to a handle and ground to an awl point. The back of a narrow chisel or gouge may be used, though these are rather clumsy. The burnishers found in stores are generally unsatisfactory, as they are apt to be soft, and any steel which can be cut with a file is useless as a burnisher for sharpening scrapers, as the scraper will cut into it, instead of turning over.

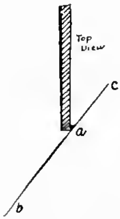

Fig. 80. — Angle to be Avoided in Sharpening Scraper.

If satisfactory results are not obtained, there may be several causes: the scraper may not be of just the right temper or texture; the burnisher may be soft or rough; the edge may not have been turned over evenly, or it may have been turned over too far, as indicated in an exaggerated way at *a*, Fig. 80, which is the result of carrying the burnisher around too far, as shown by the line *bc*. This may be remedied by using the awl point as shown at *d*, Fig. 81, holding the scraper and burnisher in about the same relative positions as indicated, guiding the burnisher by the thumb, which should be carried on the square edge of the scraper, moving with the burnisher its entire length. In this way the edge may be turned back to its correct angle, when a very light touch in the usual way will generally make the desired edge.

Fig. 81. — Turning Back the Edge of a Scraper.

If either the scraper or the burnisher is not of the right texture, throw it away, as it is worthless. If the burnisher is rough, it may be made smooth upon an oilstone. If the edge of the scraper is rough, it may be turned back again by laying the scraper flat upon the bench, the rough side up, and the burnisher passed over it several times; then proceed as with a new edge. In general, this is not so satisfactory as it is to file, whet, and sharpen the edge all over

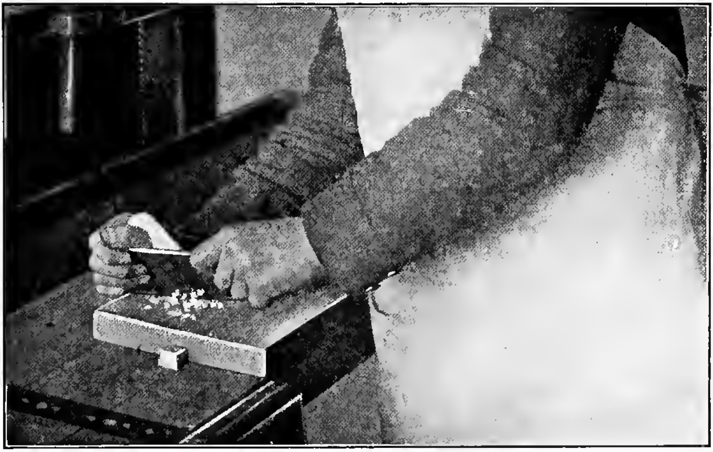

Fig. 82.—Method of Grasping the Scraper when Working upon a Broad Surface.

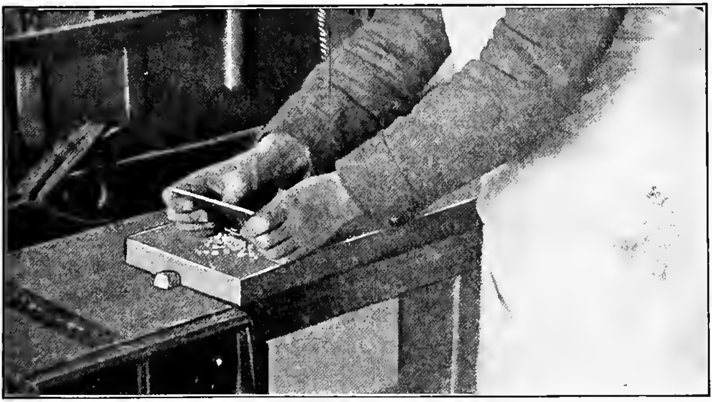

Fig. 83.—Method of Grasping the Scraper when Working within a Small Area.

again, especially if the corner has been turned several times.

Though it may seem from the above explanation of the methods of sharpening scrapers that it is a very complex operation, it will be seen that it is not a difficult matter, if it is onee worked out; usually it requires a little time and practice to acquire the knack that will make it possible to do it surely and well.

Fig. 84. — Method of Grasping Scraper when Working upon an Edge.

In using a scraper, it may be grasped as shown in Figs. 82, 83, 84, as best suits the work being done, and the strokes should be with the grain. In using this tool, as in the use of most others, the easiest way generally is the most efficient. As the young workman gains experience, he will gradually acquire the correct methods to use his tools for all the various purposes within their scope.

57. **Nail** sets are for the purpose of "setting" the nails, or for sinking them below the surface of the wood; and to stand the hard usage to which they are subjeeted, they must be very carefully tempered. The best form of nail

set is that which has a cupped or hollow point, as it is not so apt to slip off of the head of the nail.

58. **Wrenches** are of many kinds and patterns and of every conceivable use, but that known as the "monkey," or "Coes," wrench (Fig. 85) is perhaps the most convenient for general work and has not been supplanted by any of more recent invention.

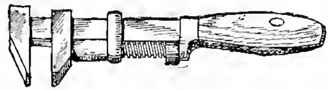

FIG. 85.—MONKEY WRENCH.

59. **Handscrews** (**A.**), if of good material and well made, will stand any legitimate use, and if properly used and cared for, will last a lifetime. However, a novice or a careless workman often destroys them rapidly by allowing the jaws to be under strain while in the position shown in Fig. 86, which will probably break the middle screw, and perhaps both.

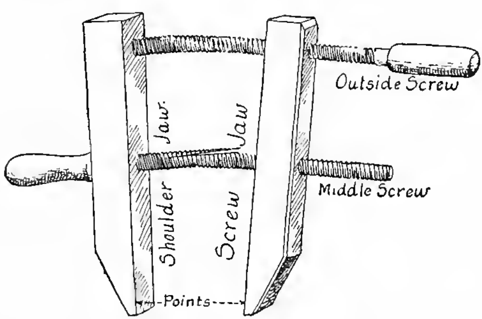

FIG. 86.—EFFECT OF THE UNSKILLFUL USE OF A HANDSCREW.

(**B.**) In using handscrews for gluing, the jaws should be set to nearly the size of the material which is to be placed between them, before the glue is spread. In placing the handscrews upon the work, the outside screw should be turned back so that it will not prevent the jaws from being slightly closer at the outside screw than at the points. This will allow the strain which is applied in setting up the outside screw, to bring the jaws parallel, which is the only position in which handscrews should be allowed to remain.

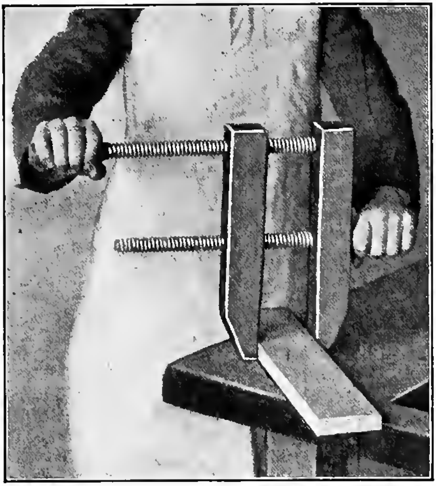

Fig. 87.—Correct Use of Handscrew.

In opening or closing a handscrew, the middle screw should be held in the left hand, and the outside screw in the right, as in Fig. 87; the screws should then be grasped so that they will not turn in the hand and the handscrew revolved in the desired direction. Never put unnecessary strain upon handscrews, nor leave them with a heavy strain upon them for a very long time.

If the work is well fitted, no more strain should be used than is necessary to bring the joints well up, and no work should be glued unless the joints fit well. In any case, the outside screw should be turned back a quarter or a half a turn after the glue has set; this will relieve the strain, and add much to the life of the handscrew.

In gluing work which requires several handscrews to hold it while the glue is setting, the handles of the outside screws all should point one way, which allows the work to be handled much more easily, as the handles of the middle screws will form an even bearing upon the floor. If this is not done, the outside screws will be apt to be broken when a heavy piece of work is being glued and handled, as the weight of the work will rest upon the screws which bear upon the floor.

(**C.**) Before using new handscrews, the screws should be treated with beeswax and beef tallow, or with black lead mixed with oil or with wax. The latter compound is very dirty; the former lubricates the screws perfectly. The screws should be heated, and the lubricant applied hot.

60. (**A.**) **A grindstone** of good quality, from 20″ to 26″ in diameter, is indispensable to a woodworking shop, and should be used frequently, as the efficiency of cutting tools is much increased if they are kept well ground, and much time may be saved in whetting them.

(**B.**) In selecting a grindstone, be sure that it is true and round, and of a coarse, even grit, which can be quite satisfactorily determined by examining several and selecting the coarsest, as that will doubtlessly be a fast cutting stone.

(**C.**) The stone should be carefully centered and mounted upon a frame; the face may be kept true by means of a file or other hard steel being held against it as it revolves, or a piece of ½″ or ¾″ gas pipe revolved from side to side of the stone as it is turned. Never allow a stone to rest with one side in the water, as it will be made softer and heavier upon that side, and soon worn out of true.

(**D.**) Do not use one place upon the surface of the stone continually, or a groove will quickly be worn there; instead, keep the tool moving from side to side. If properly cared for, a stone will hold its face indefinitely.

61. **Emery, corundum, carborundum**, and other artificial abrasive wheels have in many cases supplanted the grindstone, as they cut much more rapidly. Any one not accustomed to using them must be careful that the temper of the tool is not destroyed, as the wheel runs at a high rate of speed, and a tool in unskillful hands is easily burned. To avoid this, the tool should be held lightly but firmly against the stone, and frequently dipped in water to cool it. If an emery wheel burns badly, it may be because it needs dressing; for this purpose a diamond emery wheel dresser is the best, but on account of its cost, various devices have been patented to accomplish the same result, one of which is illustrated in Fig. 88.

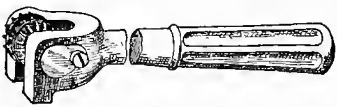

Fig. 88.—Emery Wheel Dresser.

62. **Whetstones.**—(**A.**) These are used to give to a tool the keen edge necessary to cut wood smoothly. The natural stone in most common use is the "Washita stone," which is quarried in the Ozark Mountains, and is thought by many to be the best natural stone for the general use of the wood-worker; it is fast cutting, and when of the best quality is of even texture.

(**B.**) Many workmen prefer an "Arkansas stone," as it is finer and harder than the Washita. It is also more expensive, however, and is better adapted to the use of woodcarvers and engravers than to the use of wood-workers in general. It is usually not so fast cutting as the best of the Washita stones, but a finer edge may be obtained by its use. There are other natural stones, but none so generally used as the above. The purchase of a natural stone is to a great extent a lottery, as only about one stone in ten has a perfectly even texture, is free from cracks, and has reasonably good cutting qualities.

(**C.**) If a stone needs truing, lay a piece of coarse sandpaper upon a board, and rub the stone over it until it has been ground down. The best place, however, to true up a whetstone is upon the horizontal stone of a marble worker; this is a large grindstone, several feet in diameter, mounted on a vertical shaft, upon which are placed pieces of marble to be ground to a flat surface.

(**D.**) *Artificial oilstones*, made of emery, corundum, carborundum, and other artificial abrasives, are coming rapidly into use, and, as in the case of grindstones, eventually will supplant all others in many occupations, as they cut faster than any natural stone, may be made of any degree of fineness, and are of absolutely even texture. They are also able to resist many accidents which would destroy a natural stone.

(**E.**) An *oblong stone*, $8'' \times 2'' \times 1''$, is the size of stone in most general use by the wood-worker, and should be fitted into a box or piece of wood with a cover to keep it clean. It may be laid either flat or on its edge, as suits the workman, though the stone may be kept true more easily if it is set on its edge. *Slip stones* are used to sharpen gouges and curved tools of all kinds, and may be made in any desirable shape.

(**F.**) The use of the oilstone is described under topic **40, A.** The oil used should be a kind that will not gum; its purpose is to prevent the particles of steel, worn away by the friction of the tool over the surface of the stone, from entering the pores of the stone and causing a glassy surface. Common machine oil is used by many, lard oil by others, and kerosene, or coal oil, is claimed by many workmen to be the only oil suitable for use upon an oil-stone. Any one of these oils will give satisfactory results, but kerosene keeps the stone cleaner, thereby adding to its efficiency.

63. (**A.**) **Files** are used for many purposes by wood-workers. An assortment consisting of 4″ and 6″ slim taper, or three-cornered, files; 8″ and 10″ flat, or bastard, files; 8″, 10″, and 12″ round files; and 8″ and 12″ half round wood files and rasps should be in every carpenter's kit. The 4″ slim taper files should be used upon the finer saws, and the 6″ upon the coarser ones, though the latter are used by some workmen for both saws. Upon jobbing work, it is necessary to have a few warding and knife files to use upon keys and odd jobs, and also to sharpen bits.

Files and rasps are made of every shape and size, and for every purpose. Wood files usually are tempered to stand lead or soft brass, and should never be used upon anything harder.

In drawing a file back between the cuts, do not allow it to drag, as it is injured thereby about as much as when it is cutting.

(**B.**) There are a great many other tools and appliances used by the wood-worker with which the workman should be familiar, but it is not necessary to describe them, as the above-mentioned are the most essential tools common to all forms of woodworking. There is no important principle involved in the construction, care, and use of woodworking tools which is not discussed in this chapter, and the student who becomes thoroughly familiar with the matter treated will have little trouble in learning to handle other tools.

64. Saw filing. — (**A.**) This is an accomplishment which every young wood-worker should master, as its

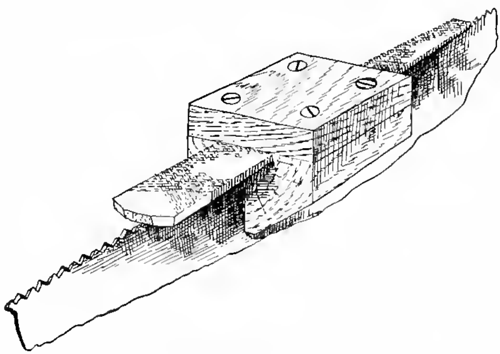

FIG. 89. — JOINTING A SAW.

possession will save expense and inconvenience, and add much to his efficiency as a workman.

(**B.**) The first step in sharpening a saw is to examine the edge carefully to see if the teeth are of an even length; if they are not, they should be jointed. This is done by using a flat file held perfectly square in a block, as shown in Fig. 89. One or two light strokes usually will be enough to make all the teeth of the same length. The edge of the saw should round slightly in the middle, say about $\frac{1}{8}''$ for a $24''$ or a $26''$ saw. If the edge is perfectly straight, it should not be jointed to this shape at once, but a little at each time for several filings.

(**C.**) After jointing the saw, be sure that it is properly set. This may be done by a *saw set*, of which there are several patterns in use; these are all of two types, the *hand set* (Fig. 90), and the *anvil set* (Fig. 91). Either of these forms is efficient, but as it is more convenient, the hand set is more commonly used. Do not give the saw too much set, or it will not cut smoothly, but will break the wood badly on the back side of the cut; there is also greater danger of breaking the teeth, and as more wood is cut out, more muscle must be applied. The set should not extend more than half the length of the tooth, and care should be used that the blade of the saw is not sprung, which will be apt to result from setting the teeth too far from the point.

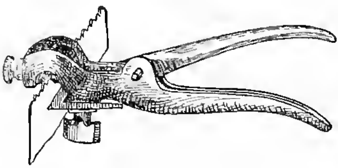

Fig. 90.—Hand Saw Set.

A saw to be used upon green lumber should have coarser teeth and more set than one which is to be used upon thoroughly dry, seasoned wood. A panel saw intended for use upon fine finishing work usually is ground so thin upon the back that it needs little or no set. Some workmen set a saw so heavily that it will do for several filings; while this is satisfactory for a soft saw to be used upon common work, it is not a good plan to treat a fine, hard saw this way, though the latter may be touched up once or twice.

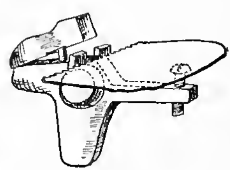

Fig. 91.—Anvil Saw Set.

(**D.**) In filing, it is important that the file should be carried at the same angle the entire length of both sides of the blade. For a cutting-off saw, the file should be carried at an angle with the side of the blade of from 60° for soft wood to 70° for hard wood, as shown in Fig. 92; and for general work, at an angle about halfway between the two. The file may be carried horizontally, as at *aa*, Fig. 93, which makes all the teeth of the same size; as at *A*, Fig. 94; or it may be carried as at *bb*, Fig. 93, which will make the teeth of the shape shown at *B*, Fig. 94. The latter method is preferred by many workmen, as it allows the file to run more smoothly, thus lengthening its life a little. There is no difference in the efficiency of the saws filed by these methods, but if filed as at *bb*, Fig. 93, it is more difficult to keep the teeth of the same size, and to make a good-looking job.

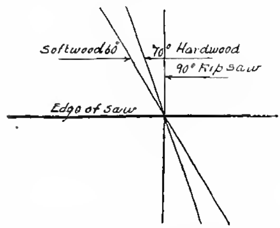

FIG. 92.—ANGLE OF THE FILE WITH THE EDGE OF THE SAW.

In filing a cutting-off saw, the top of the file should be held more or less slantingly, as shown in Fig. 95, according to the hook which it is desired that the teeth shall have. The more hook a saw has, the faster it will cut, but the cut will be rougher in proportion. Experience is necessary to discover just the right angles at which the file should be held; after considerable practice, the file will naturally drop into the correct position.

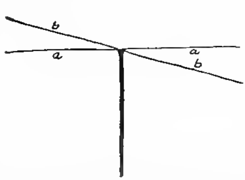

FIG. 93.—ANGLE OF THE FILE WITH THE SIDES OF THE SAW.

File every tooth upon each side of the saw to a perfect point, one half of the filing being done from each side; file the entire length from one side, then reverse the saw and file from the other side. This cannot always be the exclusive practice if a saw is in very bad shape, because if the teeth are of uneven sizes, care must be used, and more filed from some teeth than from others. It may, in such a case, be necessary to go over the saw two or three times, but it should be done very carefully, so that the bevel of the teeth may be preserved and their length kept the same. Observe each tooth, and press toward the point or the handle of the saw, as may be necessary. The file should be carried with its point toward the point of the saw, filing the cutting or the front side of the tooth of the farther side of the saw, and the back of the tooth next ahead on the nearer side with the same stroke. If the point of the file is carried toward the handle of the saw, it makes the teeth chatter, and upon a hard saw, may make them break. It also causes an excruciating noise, and shortens the life of a file, as the continuous chatter against its teeth will soon break them, and destroy the file.

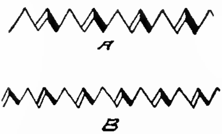

FIG. 94.—RESULTS OF FILINGS AS AT *aa* AND *bb*, FIG. 93.

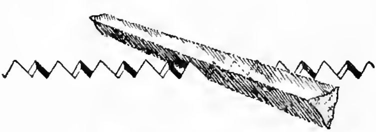
FIG. 95.—METHOD OF CARRYING A FILE TO OBTAIN THE HOOK OF A CUTTING-OFF SAW.

A ripsaw requires more set than a cutting-off saw, and if, as usual, the file is carried square with the blade both ways, the saw may be filed from one side.

After a saw is filed, it should be laid upon a perfectly flat surface, and given a light touch with a flat file or a whetstone, to remove the burr caused by the file, as in Fig. 96.

The teeth of the compass saw should be a combination of the rip- and the cutting-off saw, as it does the work of both as occasion requires. The teeth should be nearly as hooking as those of a ripsaw, and the front teeth filed

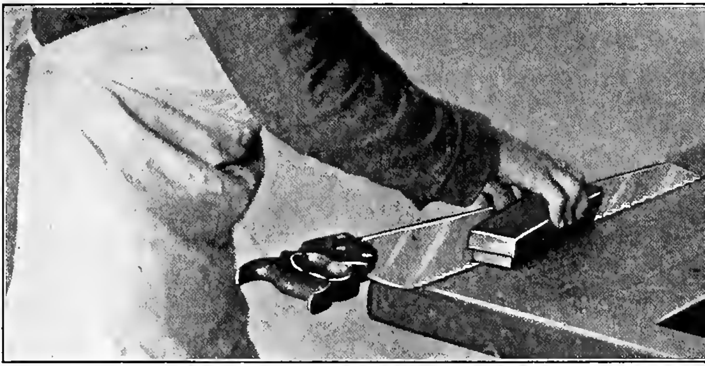

Fig. 96.—Removing the Burr after Filing a Saw.

at an angle of about 80° with the side of the saw. In filing the back of the teeth, the hand should be carried a little lower than horizontal. Figure 41, *C*, shows three views of the teeth of a compass saw.

Suggestive Exercises

27. What should be the quality of all mechanics' tools? Is a good, serviceable tool always finely finished? Are tools made especially for some dealer always reliable? What is the safest method to follow in buying tools? How may the efficiency of a tool be known?

28. Describe two forms of benches. Describe a modern vise.

29. Describe the rule in common use.

30. For what is the try-square used? Why should special care be used in purchasing one? How may a square be tested?

31. Compare the steel square and the try-square.

32. Describe the bevel and its use.

33. For what is the gauge used? Should the graduations of the gauge be depended upon in setting it? What special form of gauge is useful?

34. What will be the result if the head of a hammer is not properly tempered? Why is the eye shaped as it is? How is the handle fastened to the head? Describe the wood necessary for a hammer handle. How should a hammer be hung? How should nails be driven so that they will hold the best? What should be guarded against in driving up ceiling or matched boards? How and why should nail heads be sunk below the joint surface?

35. For what is a hatchet used? Describe two ways of sharpening a hatchet.

36. What is the principal use of a mallet? Describe and compare two forms of mallets.

37. What are the two parts of a saw? Describe the use of a ripsaw. After what tool is it modeled? After what tool are the teeth of a cutting-off saw modeled? What kind of saw combines the teeth of both? For what is it used? Why is it made of softer metal than are other saws? Describe a saw adapted to jobbing work. Describe the backsaw. How can the blade be straightened if it is sprung? What kind of saw is used for fine work? How should the thickness of the back of a saw compare with its cutting edge? What is gained by this? What test should the blade of a high-grade saw be able to stand? What are the best sizes for saws? Compare the practical features of a hard and a medium hand saw. How should a saw be held? How much force should be used upon a saw? How do some workmen change the handles of their saws to make the saws run more easily?

38. Describe the knife commonly used by the wood-worker. Why is the form of blade used in manual-training schools more suitable for whittling than the form used by the wood-worker?

39. Compare the old-fashioned and the modern planes. Describe the mechanism of the modern plane and its action. What should be

the condition of the face of a plane? How should a plane be held so that one may see the adjustment of the cutter?

40. Of what use is the cap iron in grinding a plane bit? How may a grindstone be prevented from wearing unevenly? Upon which side of the bit should all the grinding be done? At what angle should it be ground? What is the objection to grinding a bit too thin? Where should the cap iron be while whetting? How should the bevel of the bit be held upon the stone? Describe the correct action of the arm while whetting. How should the whetstone be prevented from wearing unevenly? What motion should be avoided in whetting? What is the correct shape of the edge of a plane iron? What is the use of the cap iron? What is apt to result if the cap iron is too thick?

41. What plane is used generally for rough work? In what way does the edge of its iron differ from that of other planes?

42. What plane is used for straightening edges and surfaces? What should be the shape of the edge of the iron of this plane? How should a plane be carried to joint an edge square?

43. What plane is used in smoothing fine work? What should be the position of the cap in smoothing hard, cross-grained wood? How should edge tools of all kinds be used in relation to the grain?

44. Compare the construction and the use of the block plane with the above planes.

45. What position should be taken when at work with edge tools of any sort? Should the workman bend from his hips or from his shoulders? What should be guarded against at the beginning and the end of the strokes of a plane? Is it ever economy to work with dull tools? How should a plane be drawn back after a stroke?

46. What are the two forms of chisels? Describe the peculiarities and uses of each. Describe a durable form of chisel handle. Should a mallet or hammer be used in pounding upon a chisel handle? Why? Describe and give reasons for the difference in the grinding of the paring and the mortising chisel. Describe a set of chisels. What is a slice, or slick?

47. Describe a gouge. What is the difference between an inside and an outside gouge?

48. Describe the form and uses of a drawshave. Compare the utility

of the rigid- and the folding-handled drawshaves. How should the edge of a rigid-handled drawshave be protected?

49. Describe the form and the use of a spokeshave.

50. What is the form of bit in most common use? Describe the different parts of an auger bit and their functions. How may the clogging of a bit be prevented? If a bit should become clogged in a hole, how should it be drawn out? Describe the form and the use of a German bit; of a twist drill; of an extension bit; of a center bit. Describe the method of sharpening a bit. Demonstrate. What part of a bit should never be filed? Why?

51. Describe the form and the use of bitbraces. Describe the ratchet brace. Which is the more convenient brace for common use?

52. What should be the shape and the temper of the point of a screwdriver? What should be the shape of the handle? What is the value of a screwdriver bit?

53. Describe the use of compasses; of calipers.

54. Describe the use of pliers. What is a good form for common use? Should wire-cutting nippers be used to pull nails? Why?

55. For what is a scraper used? What is the best size for a scraper? Describe handles for scrapers. Describe a leather palm and its use.

56. Describe a burnisher. How should a scraper be sharpened for rough work? For fine work? How may a burnisher be used when the edge of the scraper has been turned over too far, or when the edge is not sufficiently keen? How should the scraper be used in relation to the grain?

57. Describe the best form of nail set.

58. What is the form of wrench in most common use?

59. How long ought handscrews to last? What should be the position of the jaws when in use? Which screw should be set first? How should handscrews be treated to make them work more easily?

60. What are the characteristics of a good grindstone? How should a grindstone be trued?

61. Compare emery wheels and grindstones. What should be guarded against in the use of an emery wheel?

62. Why is it necessary to use a whetstone? What kind of stone is commonly used? What is a finer kind of stone? Compare the two

kinds. How may whetstones be trued? What kind of stones are coming into use? Compare the wearing qualities of stones laid flat and edgeways. What forms of stones are used for gouges? What kinds of oils are used for oil or whetstones?

63. What kinds of files are used for saw filing? Describe the files generally used by wood-workers. Describe wood rasps and files.

64. Describe the jointing of a saw. What should be the shape of the cutting edge of a saw? Describe the purpose, and demonstrate the process, of setting a saw. Compare the set of saws for coarse and fine work. At what angle with the sides of the blade should a file be carried in filing a cutting-off saw? Compare the results of carrying the file horizontally and with an upward inclination. At what angle with the sides of the blade should the file be carried in filing a ripsaw? If the saw is in bad shape, should the attempt be made to bring it to a finished point when going over it the first time? What should be the direction of the point of the file while it is cutting? Compare the set of the ripsaw and that of the cutting-off saw. Compare the teeth of the compass saw with those of others.

CHAPTER V

Glue and Sandpaper

65. Different kinds of glue. — (**A.**) Wood-workers use both *liquid* and *sheet* or *stick* glue, but as the former requires little skill in its use, we will deal principally with the latter, which is made of hides, sinews, bones, and waste material of slaughterhouses. Different grades of glue are made of various kinds of refuse, but the processes of treating them all are similar.

(**B.**) The material from which glue is to be made is steeped in lime water at low temperature, or subjected to a chemical treatment for a sufficient time to separate the fat from the fiber. The latter is then washed in clean water and boiled down to gelatin, which is spread upon wires to dry and harden, when it is ready for use.

(**C.**) *Ground glue* makes up more readily than that which comes in sheets, and therefore is preferred by many workmen. It is frequently adulterated, but if made upon honor, it is as good as the glue from which it is made, and does not deteriorate unless kept for a long time in a damp place. As it is not possible to apply certain tests to ground glue which may be used upon that in sheets or sticks, many workmen prefer not to use it unless sure of its quality.

(**D.**) The highest-priced glue is not always the best for all purposes, and a dealer who handles different grades can generally advise which should be used, though the medium grade in common use is usually satisfactory for general work.

(**E.**) It is impossible to give infallible rules for testing glue in the stick, or to say that glue should be of any special color, or that it should be either transparent or opaque; but, in general, glue suitable for ordinary work will be of a reddish, yellowish, or light brownish color, clear and transparent, and not offensive to either taste or smell, though some of the best makes of glue are absolutely opaque. Good glue will swell in cold water, but will not dissolve until it has nearly reached the boiling point. It will also absorb more water than will poor glue, and is therefore more economical. Any test which depends upon the brittleness or dryness of the glue is not reliable, as a somewhat damp, good glue will not stand this test as well as a poor glue that is very dry. If conditions are the same, and comparison is possible, it is fairly safe to assume that if a good glue is cut with a sharp knife, a hard, elastic shaving will result, while a poor glue will give a shaving which is extremely brittle, and will break into little pieces.

A safe way to test glue is to prepare a number of pieces of the same kind of wood, 1″ square and about 12″ long, fit them perfectly end to end in pairs, and glue as many of them together as there are samples of glue to be tested. After the glue is thoroughly hard, clamp one of the pieces of each pair to a bench top, with the joint coinciding with the edge. Hang a pail about 10″ from the joint on the piece which projects over the edge of the bench, and allow sand to run into it slowly, until the joint breaks. Repeat this process with each pair which has been glued up, and the amount of sand necessary to break the joint will furnish a basis of comparison between the different varieties of glue tested.

(**F.**) Glue should be soaked in cold or lukewarm water before being put into a glue pot, which should be a double vessel, with the glue in the inside pot, and the hot water or steam in the outer jacket. In making up glue, it should be brought to the boiling point until melted, and then removed from the heat, for if kept continually hot, it loses much of its strength by being cooked too much, as this makes continual thinning necessary.

If time will not permit, the preliminary soaking may be dispensed with, and the hard glue put at once in the hot water, in which case it must be stirred frequently while melting, or it will form a mass. If the water boils out of the outside kettle, and the glue burns, throw it away, as it is worthless.

Glue should be thinned with cold water, after which it should be allowed to become thoroughly heated before using; in the shops, this is not always done, as there may not be time to allow the glue to become heated again; therefore it is quite the common custom to thin the glue with hot water.

(**G.**) Paint brushes, or other brushes in which the bristles are set in glue, are not suitable for use in hot glue, and those made especially for this purpose should be purchased. For very small brushes, a strip of basswood bark may be soaked and pounded about half an inch from the end; these are satisfactory for small work.

66. How to use glue. — (**A.**) Glue should be used as hot as possible, and of about the consistency of cream.

The pieces to be glued should be heated thoroughly and the gluing done in a warm room.

(**B.**) In factories, where it is possible, the gluing is done in a specially fitted room which contains all necessary appliances. Vertical and horizontal coils of steam pipes surround the room, both to furnish heat for the room, and for the purpose of heating the material to be glued, which should be so hot that the hand cannot rest upon it for more than a few seconds. In a room of this sort, the temperature is maintained at from 110° to 130° F.

(**C.**) If the best possible results are wanted, a *scratch or tooth plane* should be used. This is a tool similar to a smoother, only its cutter is nearly vertical, and it has teeth like a fine saw which will scratch the wood, thus giving a better hold for the glue.

(**D.**) It is important that all clamps, handscrews, and other appliances which are likely to be needed should be set as nearly as possible the desired size, and so arranged as to be reached easily, for when the glue is applied, there should not be the slightest hesitation or delay in getting the work together and the clamps on. The utmost speed and surety of motion is absolutely necessary in using hot glue; therefore everything during the process of the work should be foreseen and provision made for it before the glue is applied, for if the glue is even slightly chilled, the work will not be so well done, and the efficiency of the glue will be greatly diminished. A novice should never attempt more than the simplest work, unless working with a competent man.

(**E.**) The glue should be spread rapidly and evenly with a brush of suitable size,—a large one for broad surfaces and a small one for small work. Glue should not be thrown about wastefully; enough should be used to cover the surface completely but not thickly.

(**F.**) In using handscrews, it is of the greatest importance that the jaws be kept parallel as described in Topic 59; care must be used that more strain is not placed upon the handscrews and clamps than is necessary to bring the joint together.

(**G.**) Cold or liquid glue has supplanted hot glue in furniture repairing, gluing up intricate work, and in places where it is impracticable to use hot glue either on account of its setting too rapidly, or where heat is not available. Liquid glue does not hold as well nor as permanently as hot glue when properly used, but for many kinds of work it is perfectly satisfactory.

(**H.**) In gluing rosewood, or other woods of a greasy nature, the glue should be thinned with vinegar, which will cut the grease. Another method of making glue hold on wood of this sort is to chalk both members of the joint thoroughly, and let it stand for two or three hours, when it should be wiped off. This absorbs the grease on the surface of the wood, which allows the glue to take hold. In all gluing, do not allow the bare hand to touch the joint any more than necessary, as the grease and perspiration will prevent the best results from being obtained.

67. The testing of sandpaper. — (**A.**) Sandpaper is made by covering paper with a thin layer of glue, over which is spread evenly a layer of ground flint or glass; over this is spread another coating of glue, which firmly fastens the sand to the paper.

(**B.**) In buying sandpaper, pass the finger over it to see if the sand is firmly fastened. Be sure that the paper is neither flimsy nor brittle. Coarse particles of sand are sometimes found upon sandpaper which renders it worthless; these can be detected only by use, unless they are very prominent.

68. **How to use sandpaper.** — **(A.)** Sandpaper is made in numbers, 00, 0, $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3. Numbers 00 and 0 are very fine, and are used in rubbing down shellac and varnish. Numbers $\frac{1}{2}$ and 1 are used in sandpapering mahogany and other fancy woods, and number $1\frac{1}{2}$ is used upon all building finish but the finest; the coarser numbers are used upon floors, outside finish, and other coarse work which is to be painted, though for a very nice floor, $1\frac{1}{2}$ is used, rarely anything finer. It is a fallacy to think that the finer the sandpaper used, the finer the job will be, since upon some kinds of woods fine sandpaper will make a glassy surface in spots which will not take the finish like the rest of the work. Sandpapering is as apt to detract from the work as it is to improve it, for unless used very skillfully, the character of angles and small surfaces will be changed, though it may seem that the damage is so slight as to be imperceptible. In using sandpaper, the workman should guard against rounding off square corners or destroying the form of surfaces; a raw corner, however, should be removed with a few light, careful strokes, as a perfectly sharp corner will always be more or less ragged.

The one who knows will always notice the omissions of details of this sort, and will attribute such imperfections to lack of skill or knowledge on the part of the workman. It is for the one who knows, that all work should be done — not for the casual observer — and these apparently insignificant details, rather than the part of the work which may seem of more importance, form the basis by which one workman judges the work of another. In nothing do small things count more than in making or destroying a workman's reputation.

(**B.**) Keep the sandpaper dry, and stored in a dry place, as moisture softens the glue so that the sand may be easily

Fig. 97.—Use of Sandpaper upon a Broad Surface.

rubbed off. In handling sandpaper, care should be taken that the sanded sides are not rubbed together.

(**C.**) In preparing to sandpaper a flat surface, or for general work, a sheet of sandpaper should be torn in halves the short way of the paper, and one half should be folded back to back, and held (not tacked) around the block with the hand, as in Fig. 97. The act of grasping the block for the work will hold the sandpaper, and any device for holding the sandpaper on the block is worthless, being considered by the workman as a mark of the novice. The block should be about $3'' \times 4'' \times \frac{7}{8}''$, and may be made of wood, cork, fiber, or any material which suits the taste of the workman.

If there is much sandpapering of moldings to be done, it is best to make blocks which will fit the contour of them, as it is very hard on the hands to do this work for very long at a time, though nothing has ever been invented which fits irregular forms as well as the fingers. A piece of sandpaper *should never be used on a piece of work until all the cutting by edge tools has been done*, as the particles of sand will enter the grain of the wood, and any edge tools used upon it afterward will be quickly dulled. Do not use a piece of sandpaper so large that any part of it will not be under perfect control, as loose ends will scratch the wood, and it has an awkward and unworkmanlike appearance. Always work parallel with the grain, and be sure that all plane marks and rough places are thoroughly rubbed down. In order to do this well, it is often necessary to use considerable muscle. This part of the work calls for good judgment, for unless sandpapered enough, there will be places which will show when the finish is spread on the work, though they may have been invisible before. No one can tell as well as the workman himself when sufficient sandpapering has been done, though it may be evident to any one who knows the signs whether or not the work has been done judiciously. Upon a coarse job it is usually allowable, and sometimes desirable, to sandpaper across the grain, especially if the work is to be painted.

In order to impress it upon the student, we will repeat that *too much care cannot be taken in the use of sandpaper*, for much oftener will an amateur injure a piece of work than improve it.

(**D.**) In sandpapering panel work, as in Fig. 98, the panels (*a*) should be smoothed, scraped, and sandpapered, and the edges of the stiles (*b*), rails (*d*), and muntins (*e*) should be treated the same way before the panel work is put together; an exception to this in regard to the panels may be made if the panel frame is constructed in such a way as to allow the panels to be put in place after it is together, in which case the panels may be smoothed at any time. Upon very fine work the panels are sometimes polished before being fastened in, as it is difficult for the finisher to work into the corners after the panels are in place. After the faces of the stiles, rails, and muntins have been planed and scraped, they should be sandpapered in the order named, working with the sandpaper over a sharp-cornered block close to the edges of the pieces, being careful not to drag the paper over the face of the pieces which join at right angles. The stiles, rails, and muntins should be sandpapered in the order in which they are mentioned. If the sandpaper runs over the rails a little when sandpapering the muntins, or over the stiles when sanding the rails, it will do no harm, as a couple of light, careful strokes parallel with the grain will be sufficient to remove any scratches which may be made.

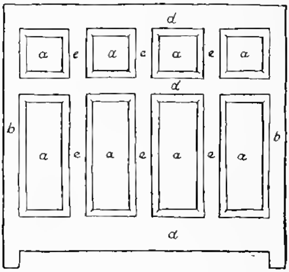

FIG. 98.—SANDPAPERING PANEL WORK.
(For explanation, see text.)

In sanding mahogany, or any wood of which the grain rubs up, make the strokes in one direction only, instead of back and forth. Sometimes wax is rubbed in to hold the grain down upon cheap work, but this is not recommended, as that place will not take the stain or the finish like the rest of the wood. A very thin coat of shellac is used for the same purpose; this is less objectionable, but should be avoided if possible.

Suggestive Exercises

65. Of what material is glue made? Describe briefly the process of making glue. What kind of glue is best for general work? Is ground glue always reliable? What is the chief advantage in its use? Is high-priced glue always the best for all purposes? What should be the appearance of good glue? How should it act in cold water? When cut with a knife? When broken? Compare the amount of water absorbed by a good and a poor glue. How should a glue pot be constructed? What will be the result if the glue pot boils dry? Describe brushes suitable for use in gluing. What kind of bark makes a good brush for small work? How is it prepared for use?

66. Describe the condition of glue when ready for use. What tool is used to increase the strength of the joint? In preparing for gluing, what preparations should be made? How should wood be treated for use in gluing up wood of a greasy nature?

67. Describe the manufacture of sandpaper. What is used for sand? How select sandpaper?

68. For what kind of work is sandpaper numbers 00 and 0 used? Numbers ½ and 1? What number of sandpaper is used upon general work? What will be the result if sandpaper is kept in a damp place, or becomes wet? What should be the size of the piece of sandpaper used upon flat surfaces, and for general work? How should moldings be sandpapered? What should be guarded against in working around sharp corners? Should sandpaper be carried with or across the grain? What exceptions? How should panel work be sandpapered? How should panels and the edges of stiles, rails, and muntins be treated before gluing up? How should sandpaper be used upon grain which rubs up? How are panels sometimes treated upon fine work? Why?

CHAPTER VI

Wood Finishing

69. Filling. — (**A.**) After wood has been smoothed and made ready to receive the finish, it is prepared by *filling,* by which is meant the process of filling the grain so that the finish itself will not soak in. This, if well done, makes it possible to do as good a job of finishing with two or three coats as could be done on some kinds of wood with from five to eight coats without the filling. Open-grained woods, such as oak, ash, etc., especially need filling, as before the process of filling was discovered, the open grain, or cellular part of the wood, had to be filled by shellac, or other expensive material, before there was a surface suitable to receive the polish. (**B.**) There are two forms of filler — *the paste,* which is for use upon open-grained woods, and *the liquid,* which is adapted to filling the pores of close-grained woods like pine, poplar, cherry, etc., and which takes the place of one coat of the more expensive shellac or other finish. The paste may be purchased ready-made, and colored to suit the taste, or it may be made by using whiting, silex, or corn starch, and any dry colors necessary to secure the desired stain. The ingredients should be well ground, and thoroughly mixed with boiled linseed oil to a thick paste; to this should be added as much japan drier as there is of the oil, or one quarter as much as there is of the paste. The whole may then be thinned with turpentine, benzine, or gasolene to a consistency which will allow it to be spread easily, but it should still be quite thick.

(**C.**) Filler need not be spread very smoothly, but the surface of the wood must be covered, and the filling thoroughly worked into the grain. After this has been done, the wood should be allowed to stand a few minutes, until the filler has become dull or powdery, and seems to stick to the wood if rubbed lightly with the finger, when it should be rubbed off with shavings or excelsior, rubbing across the grain wherever possible. Do not use cloth until cleaning up after the filler is all off, as it is more apt to take the filling out of the grain than either excelsior or shavings. The corners should be cleaned out with a sharp stick, after which the work should stand for several hours, or over night, before the finish is applied, as otherwise the moisture in the filler may cause the finish to bubble. Care should be used that the filling does not stand too long before rubbing off, or it will be very difficult to remove it; hence, it is best not to spread any more than can be cleaned off before it gets too hard. Be sure that there is enough filling mixed to do the job before any is applied, as it is difficult to match colors.

(**D.**) Liquid filling should be spread as smoothly and as evenly as possible, as the laps will be apt to show through the finish which is spread over it.

70. Staining wood (**A.**) is for the purpose of imparting some other than the natural color to the wood.

(**B.**) In finishing open-grained woods, they are sometimes given an equal color by a coat of stain, and then filled to match the stain; but ordinarily, the filling only is colored.

This does not make the work all of one color, as the cells of the wood will retain more filling than will the harder part of the grain. By this method the quarter grain may be made more prominent. If an open-grained wood is being treated, it should be filled after being stained. Close-grained woods are ready for the finish as soon as the stain has dried. Stains which will do the work satisfactorily may be made of various chemicals. There are also many satisfactory stains upon the market, which can be purchased in as small packages as desired, offering the student a large range of colors from which to select.

(**C**.) Stains for close-grained woods may be made by mixing dry colors with turpentine or benzine, and a little boiled oil and japan to bind the color. These stains should be applied the same as the filler, but not allowed to become so hard before cleaning off, or there will be light places rubbed in the finish. The rubbing or cleaning off should be done with a soft cloth, care being used that there are no places left uncleaned, especially in the corners, as the finish will make them muddy.

(**D**.) A very good *old cherry* stain may be made by mixing Venetian red and rose pink until the desired shade is produced.

(**E**.) *Black walnut* may be imitated by mixing burnt umber with turpentine, oil, and japan, and if a reddish tinge is desired, a little burnt sienna may be added; this is a much better color than can be produced by umber alone. Asphaltum, thinned to the desired color, makes a good walnut stain.

(**F**.) Many of the best stains are mixed with water as a vehicle, as a depth and brilliancy of color may be obtained which is impossible with any stain that has oil in it. The objection to using water is that the grain of the wood is lifted by the moisture, and has to be sanded smooth before it can be finished. Even with this serious objection, water stains are used extensively upon the best work.

(**G.**) The rich mahogany stain which is so much admired may be made by mixing the same colors as mentioned in (**D.**), and adding carmine until the desired color is obtained. An oil stain will not give the best results, therefore a water stain should be used, with a piece of gum arabic about twice the size of a pea dissolved in a pint or less of the stain for a binder, or about the same proportion of mucilage. This stain should be cleaned off the same as the oil stain above described.

(**H.**) Cherry may be darkened by applying nitric acid; other woods may be darkened or aged by using ammonia, potash, or a strong solution of tobacco or coffee. Nitrate of silver, if exposed to the sunlight, gives a beautiful brown.

(**I.**) A rich brown may be produced by using equal parts of permanganate of potash and sulphate of magnesia, dissolved in water; as many coats as desired may be applied, sanding with number 00 sandpaper between the coats. Better results are obtained if the stain is applied hot.

(**J.**) A beautiful green of any intensity may be produced by mixing verdigris and indigo in hot vinegar, and applying hot. Several coats may be necessary, sanding between the coats. The indigo should be used cautiously, or the green may have too much of a bluish cast.

(**K.**) A rich brownish black may be obtained by using a solution of logwood (pulverized) and sulphate of iron, applied in coats in the order named. Each solution should be hot.

(**L.**) *Ebony* may be obtained by giving any close-grained wood, cherry preferred, a coat of sulphate of iron, using a weak solution, and after that has dried and been sanded, a coat of solution of nutgalls. If the iron is too strong, a white efflorescence will appear, which in open-grained woods will bring out the grain in strong relief. If this is objectionable, the grain should be filled with a black filler.

(**M.**) *Shellac* (see **71**, **A.**) and boneblack, if well mixed, make an ebony finish which is often used upon common work; black varnish sometimes is used the same as black shellac, but for the best work these are not satisfactory, as they do not strike into the wood to the same extent as do acid, turpentine, or water stain.

71. Shellac. — (**A.**) This is the manufactured product of a resinous excretion of the lac insect, which infests tropical trees. The insect is often buried beneath its own excretions to the depth of a quarter of an inch. The gum thus formed is gathered, and after various refining processes becomes the shellac known to commerce. It is cut or dissolved by either wood or grain alcohol, when it is ready for use. Some of the best furniture is finished with shellac, and unless continuously exposed to moisture or hard usage, the finish is practically everlasting.

(**B.**) Shellac finish does not crack as varnish is liable to, neither does its luster dim by exposure to the various gases present in every house, which are due to domestic causes, though most varnishes will do this after some years.

Upon ordinary work, two coats of shellac may be satisfactory, though three coats generally will improve the work sufficiently to make it advisable to apply the extra coat. Shellac should not be laid in too thick coats, or it will pit badly in drying, and make work in rubbing to a surface, which can be avoided if moderately thin coats are spread, though perhaps the greatest advantage in laying thin coats is that the wood may be covered more evenly, and there will be fewer runs and laps visible. Shellac should always be laid with quick strokes, never working over a place already covered; for this work, use a brush as large as possible to do the work without clumsiness.

(C.) In applying shellac finish, one coat is laid upon the other, each coat being rubbed down with number 00 sandpaper, or with pulverized pumice stone before the next coat is spread. For this purpose, a sheet of sandpaper should be cut into eighths, and one of these pieces folded in the center of its long dimension, and held in the hand as shown in Fig. 99, which keeps its edges from scratching the surface. If it is desired to rub the shellac down to a surface with pumice stone, it should be applied with haircloth, or with harness maker's felt, moistened with oil or water; but for ordinary work, sandpaper will give satisfaction, and as it is more convenient, it is much used.

If the best results are desired, the last coat should be rubbed with pumice stone and sweet oil, applied as above, though boiled oil is satisfactory; and for ordinary work, number 00 sandpaper is used, though it is liable to show scratches. After the rubbing is done, the oil should be wiped off with a soft rag, and very fine rotten stone dusted on and polished with a clean, soft cloth. Many finishers use the palm of the hand in putting on the finishing touches. If a dead, or mat, finish is desired, the final rubbing should be done with water, used sparingly, as oil imparts a high gloss, if the work is well done.

(**D.**) Care should be used on any kind of work upon which waste or oily rags are used; these rags should be gathered and burned unless they are wanted again soon, in which case they may be spread out separately; since, if crushed together and thrown, as they often are, into

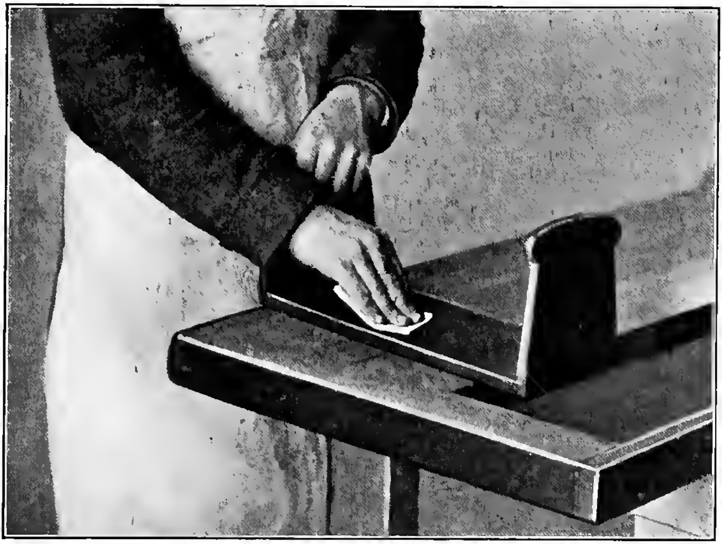

FIG. 99.—METHOD OF GRASPING SANDPAPER IN RUBBING DOWN SHELLAC FINISH.

a waste box, they furnish the necessary conditions for a case of spontaneous combustion.

(**E.**) The gloss upon dried shellac and varnishes of all kinds is very showy, and lacks the finish and the texture of a rubbed finish. Moreover, any dust settling upon moist varnish is held, giving the surface an effect of countless minute points; rubbing removes these, and gives the smooth, glossy surface desired upon most work. Upon the most artistic furniture, a gloss, which is the result of a built-up polish, is not considered good taste; the use of muscle and a very little oil, applied at intervals during a term of years, gives a polish and a beauty which can be obtained by no other method, and it is to attain this ideal in a few days that so many varieties of finish exist.

(**F.**) In rubbing, be sure that the corners are not rubbed through, as the pressure will naturally be more upon the corners than upon a broad surface. This may be avoided by using care that the pressure is not applied so as to bear on the corner; grasp the rubbing material in such a way that no loose edges will be beyond control, as in Fig. 99, or the finish may be badly scratched; this applies especially to the corners. The rubbing should always be in the direction parallel with the grain of the wood.

(**G.**) If the finish is rubbed through to the wood, it may be repolished or patched by sandpapering the bare wood with fine sandpaper, and staining it to bring it to the same condition as the rest of the wood before the first coat of finish was applied. Using the same finishing material as the finish of the rest of the piece, lay a very thin coat, a little larger than the place to be patched, being careful to avoid a ridge at the edge of the patch. This ridge may be drawn out by a small camel's-hair brush, and the patch left until thoroughly dried; then apply another patch a little larger than the first one, treating the edge as in the first patch. Continue this until the finish is built up to the same thickness as that of which it is a part. This should be rubbed very carefully to bring it to the same finish as the rest of the surface, using care not to rub through the old finish at the edge of the patch. As it is the corners which are most liable to be rubbed through, this process will not generally be difficult of application; all that is necessary to secure a successful patch is to use care at each step, and not to hurry the drying of the different patches.

72. **Wax finishing** is a good method of finishing any kind of hard or dark-colored wood; (**A.**) it does not give as satisfactory results, however, as do some other methods of finishing, upon soft or light-colored wood. There are a number of different kinds of wax finishes which can be purchased in almost any desired quantity, (**B.**) but an economical and satisfactory wax finish may be made by dissolving as much pulverized resin as may be picked up on a cent in a half pint of turpentine or gasolene heated in a water or steam double vessel. After this is clear, cut up and add a piece of beeswax as large as a thimble, and allow the finish to simmer slowly, until it is clear, when it is ready for use. This may be mixed in larger quantities by using the same proportions. If placed in an air-tight vessel, it will keep indefinitely.

(**C.**) This finish should be applied hot, with a brush, as smoothly and as evenly as possible, and allowed to stand until it has become quite hard, when it should be polished with a soft rag which is free from lint. As many coats as desired may be applied, each coat being treated in the same way, and adding to the beauty of the finish. Another method of applying this finish, and which gives satisfactory results upon broad surfaces, is to make a pad of a rag, and rub the wax on the wood, rubbing until it is dry. This is not as satisfactory as it is to use a brush upon work where there are many corners to finish around.

One of the advantages of this wax finish is that it may be brightened if it becomes dim by going over it with a soft cloth, or it may be renewed and improved by another coat at slight expense and little trouble.

This is also a satisfactory method of finishing a dark floor made of a wood which will not splinter when it is rubbed.

73. (A.) **Oil finish** is perhaps the most simple way to finish a piece of furniture; it is best adapted to hard, dark woods. The material is made by mixing a quarter of a pint of turpentine with seven eighths of a quart of boiled linseed oil. It should be spread evenly over the surface to be finished, and should stand until as much of it as will, has soaked into the wood, when the surface should be brought to a finish by rubbing. This will require muscle, as the finish should stand about ten hours, during which time a thin film or skin will form, which must be removed by rubbing. Only a soft rag, free from lint, should be used, and be sure that the folds of the cloth do not leave their marks upon the surface. Rub with the grain.

(**B.**) Oil finish is a very durable finish, easily taken care of, and is used to some extent in finishing the most artistic furniture, being especially adapted to finishing mahogany. It has a character peculiarly its own, and exposure to moisture and heat affects it less than almost any other form of finish. As it should be occasionally oiled, it improves with age and care. This finish was used in olden times, and the care of generations gives a polish attainable by no other method.

74. **Varnish** forms the finish which is used most commonly upon all grades and kinds of work. (**A.**) The different grades are made of various vegetable gums and

resins, cut in turpentine and mixed with boiled oil. A cheap grade of varnish or hard oil may be made by boiling resin, turpentine, and boiled oil together. Other gums may be treated the same way; the varnish used upon the best work, for instance, is made from copal, a vegetable product of the tropics. By a very careful process of boiling, straining, and ripening, extending over months, copal is made into the product which is used so extensively upon furniture finishing, carriages, etc.

(**B**.) Varnish should be applied in a room heated to about 80° F., the dust should be laid by sprinkling, and there should be no drafts of air, nor flies or other insects to light upon it, if the best results are desired.

(**C**.) In flowing varnish, instead of laying a thin coat as in shellac, a thick coat should be applied. This may be done by using a thick, heavy brush; some prefer a heavy, round brush, and others think they can obtain the best results from a broad, flat brush. The finer the hairs, the better the results obtained.

The brush must be taken up full of varnish, enough to cover the entire surface, if possible, and spread or flowed very quickly. The brush should then be wiped out in the varnish pot. With the brush thus dried, go over the surface, picking up all that the brush will absorb; wipe this out in the pot, and repeat the operation until nothing is left but a thin film of varnish. If this is done properly, it will prevent all runs and streaks which result from unskillful workmanship.

When this coat is thoroughly dried, rub with number 00 sandpaper, pulverized pumice stone, or a smooth block of pumice stone (carriage painter's method), and repeat the process until the desired body of varnish is obtained. Rub down last coat with oil and polish. Allow as much time between last coats as possible, as the harder the varnish is, the better and more durable the work will be when completed.

75. Polishing. — This term applies to the process by which a polish is built up by rubbing, or "ragging" as workmen sometimes call it. The piece to be polished should receive two or three coats of shellac or varnish, which should be rubbed down to a surface, when it is ready for the polish.

To make a pad of convenient size for polishing, fold a piece of old, soft cloth, free from lint, and fill it with cotton waste; or the end of a roll of cloth may be covered by the piece which is to do the actual polishing. Provide a cup of moderately thin shellac and another of boiled oil, of which about one quarter is turpentine; or better, a cup of sweet oil without turpentine. Dip the pad into the oil and allow it to soak in completely, then do the same with the shellac. Now dip the pad again into the shellac, and with the finger put on a single drop of oil, and rup lightly upon the work, with a circular motion, or if the work is large enough, the stroke may be longer. If the work is done with a straight stroke, do not stop at the end of the stroke, as the instant between the end of one stroke and the beginning of the return may be enough to allow the shellac to stick and make a hole in the surface, which will be difficult to repair; begin and end the stroke with a sweeping motion. The idea of this method of polishing is to bring the shellac to a polish, using as little oil as possible for lubricating, as the less oil used, the better will be the polish.

76. Brushes. — (**A.**) If brushes are to be used for stain or for filling, a cheap brush of any suitable size will do, a flat brush being preferred upon ordinary work. For shellac and varnish, the finer the brush, the better the results usually obtained. Ordinarily it is the best practice to use as large a brush as the nature of the work will permit, as it will hold more, and cover more surface, than a smaller brush, and have fewer "laps." Chisel-pointed, flat brushes, from $1\frac{1}{2}''$ to $2\frac{1}{2}''$ in width, will be found satisfactory for the work of schools and amateurs, but upon professional work, brushes from $3\frac{1}{2}''$ to $5''$ often are used.

(**B.**) The care of the brushes is an important part of the work of those who use them, as neglect or carelessness may destroy a valuable brush overnight. Unless a brush is going to be used again the next day, it is always best to clean it thoroughly. If a stain, filling, paint, or varnish brush, use gasolene or turpentine, but if a shellac brush, use wood alcohol, cleaning off all the small particles. To obtain the best results, all brushes should be washed in hot, soapy water, and afterward rinsed in clean water; in general, however, this latter precaution may be dispensed with, unless the brushes are to be laid away indefinitely. Unless the above precautions have been taken, care should be taken that shellac and varnish brushes are not changed from one to the other. Never allow a brush to stand on its side for more than a few minutes at a time, as a wrong direction is easily given the bristles, and the brushes may be quickly destroyed by a little carelessness or negligence.

Old brushes, well broken in and cared for, will give better results than new brushes; therefore they should be treated with every possible consideration.

Varnish brushes often are left in the varnish pot, and if they are hung up so that they will not rest upon their bristles, this is the best way to keep them when they are in almost constant daily use.

Suggestive Exercises

69. Why is wood filler used? Describe paste filler. Describe the process of spreading filler and of rubbing it off. Describe liquid filler and the process of spreading it.

70. Why do we stain wood? What is the difference in the results of staining and filling and of filling alone? How may stains for open-grained woods be mixed and used? Describe a simple cherry or mahogany stain. Describe black walnut stain. What is the objection to a water stain? How may a rich mahogany stain be mixed? How may woods be darkened? Describe the composition of a rich brown stain; of a good green stain; of a brownish black. Describe ebonizing. For what purposes are shellac and lampblack and black varnish used?

71. Of what does shellac finish consist? What is the source of supply of shellac? Compare shellac and copal varnish. Demonstrate the application of shellac. Are thin or thick coats of shellac the better? Why is rubbing down necessary? Demonstrate. What precautions should be taken in regard to oily rags? Why? What should be guarded against in rubbing? What is a convenient size for a piece of sandpaper? Describe and demonstrate patching.

72. Describe the preparation of wax finish. Describe and demonstrate two methods of applying wax finish.

73. Describe oil finish and its application. Describe its qualities.

74. Describe briefly the manufacture of varnish. Describe ideal conditions for flowing varnish. Describe and demonstrate the method of flowing varnish.

75. Describe and demonstrate the process of polishing.

76. Describe the kinds of brushes suitable for different kinds of work. How should brushes be cleaned? What should be the general treatment of a brush? How may varnish brushes be kept ready for use?

ELEMENTS OF CONSTRUCTION

CHAPTER VII

Working Drawings

77. Use and purpose of working drawings. — **(A.)** It is essential to the success of a workman of the present time that he should be able to read ordinary working drawings readily, and to take measurements from them intelligently. He should also understand the relation between the scaled drawing and the work that he is to produce from it.

(**B.**) The difference between a photograph, or a perspective view, and a working drawing, lies in the fact that the former shows the object approximately as it appears to the eye, and is an end in itself; while a working drawing is made with but slight regard for artistic effect, and is simply a means to an end. In other words, the purpose of a working drawing is to convey to the mind of the workman, in the plainest and simplest manner possible, the idea which is in the mind of the draftsman.

78. Three-view drawing. — Any object to be drawn may be shown generally by three views; for instance, let us assume that the perspective sketch of the cross in Fig. 100 represents the idea, or the mental image, conceived in the mind of the draftsman, and of which he wishes to make a drawing as a means to the end of having the cross built.

In his mind he takes a position directly in front of the cross, and imagines that every part of its face is at exactly right angles with a line from his eye. This eliminates perspective, and he proceeds to draw the sketch shown in the front view of Fig. 101.

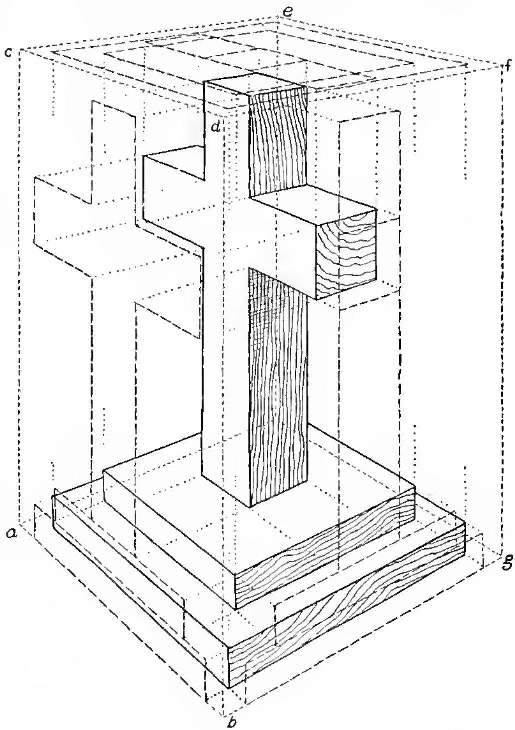

FIG. 100.—PERSPECTIVE VIEW OF A CROSS, ILLUSTRATING THE THREE PLANES OF PROJECTION COMMONLY USED.

In doing this, he imagines a transparent plane between his eye and the mental image of the cross, at right angles with the line of vision, which we will represent by the plane *abcd* of Fig. 100. Using his paper as that plane, he draws upon it the lines, which, in his mind's eye, he sees projected there from the cross, as illustrated in the front view of Fig. 101. This completes the front view, and he must perform the same operation for the top view, imagining himself above the cross and looking directly down upon it, using the transparent plane *c d e f*, as his basis. The resulting lines are shown upon the top view of Fig. 101. The same method is followed in drawing the right side view of Fig. 100, working to plane *b d f g*. This same process could be continued around the six sides of the transparent

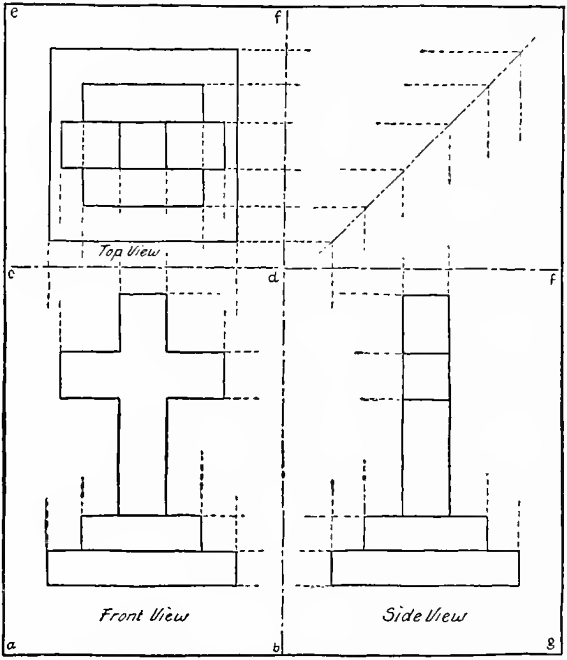

Fig. 101.—Working Drawing of Cross, Illustrating Method of Showing Three Views upon One Plane.

box inclosing the cross, but these, as well as the drawings showing the sections of the object, are necessary only when three views will not describe the object sufficiently. The elevations and floor plans of a house, and its sections, are an instance where more than three views are essential.

Frequently two views will adequately convey the draftsman's ideas, as in Fig. 102.

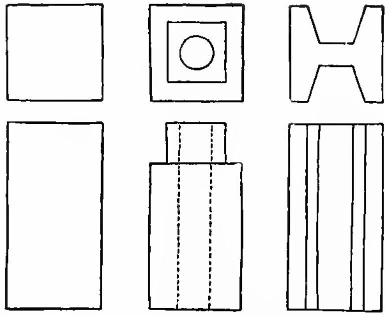

Fig. 102. — Two-view Working Drawing.

Figure 103 shows three views, and indicates the dimensions of a well proportioned table. The dimensions extend from arrow point to arrow point. The corner of the table top is cut away to show the detail of the connection between the leg and the rails. The dotted lines, representing the top view of the rails and the legs, illustrate one method of indicating construction.

79. Sections. — (A.) In order to show the

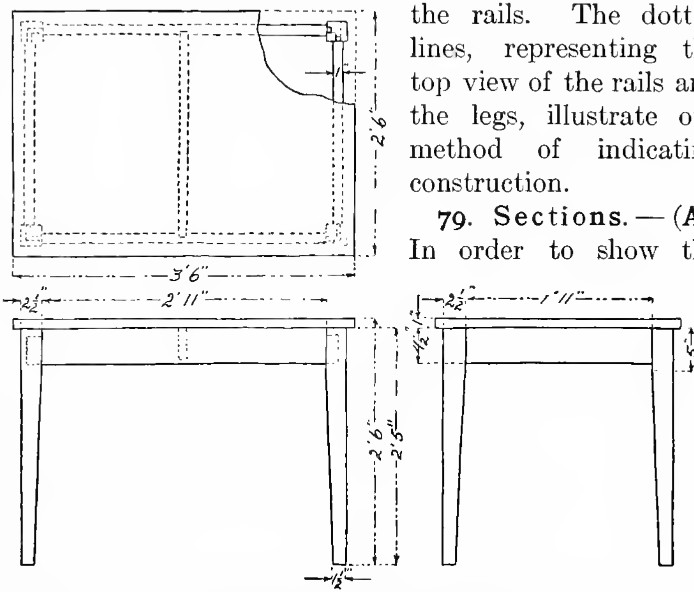

Fig. 103. — Three Views of a Table. — Methods of Indicating Construction; Dimensioning.

construction of details which cannot be indicated upon any of the three views of the object, a drawing of the

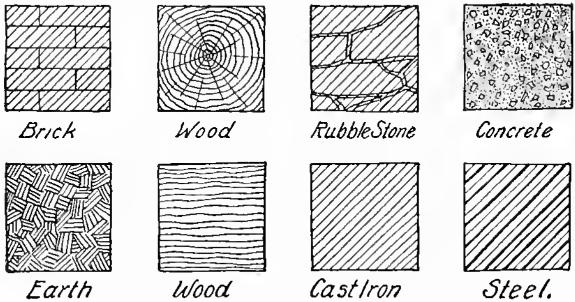

Fig. 104.—Conventional Sections.

detail may be made separate from the main drawing, consisting of three views, or more, as required. It is often necessary also, in order that the construction may be shown adequately, to make a sectional view; this is a drawing representing the plane which would be seen if a cut were made at any suitable place in the object.

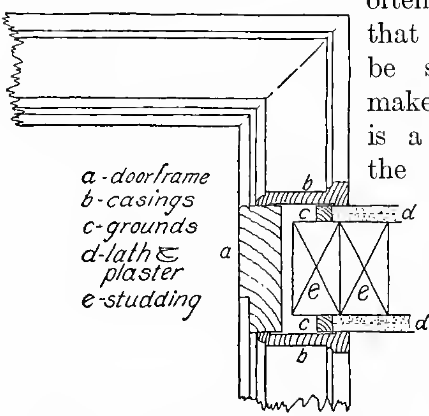

Fig. 105.—Section of Construction—a Door Frame.

The drawing of a plane thus made should include the section of all the different pieces through which such a cut would pass. A section is always indicated by line or tint shading, the nature of the lines, or the color of the shading, suggesting conventionally the material of which the section actually consists, as in Fig. 104, in which is shown the character of the lines generally used to represent the various building materials. If the section is colored, woodwork is illustrated by yellow; iron, by dark gray or black; brickwork, by red; and stonework, by light gray. Section lines running in different directions indicate that different pieces form the section.

Figure 105 shows the horizontal section of a door frame, its finish, and a part of the partition in which the frame is set.

(**B.**) It frequently happens that a detail may be too large in one or more of its dimensions to be drawn in the desired scale; in such a case, if the shape of the detail permits it, the entire length may be shown by *breaks* being introduced in places where the part broken out is of the same dimension and detail as at the breaks, as shown in Fig. 106.

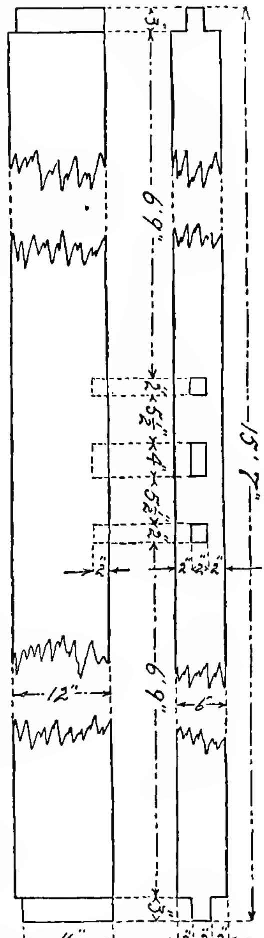

Fig. 106. — Method of Showing a Large Detail.

80. Center lines. — Figure 107 shows a piece of panel work with breaks, as it is too large to be drawn to the full scale. As both sides of the center line are alike, there is no need of drawing more than one half

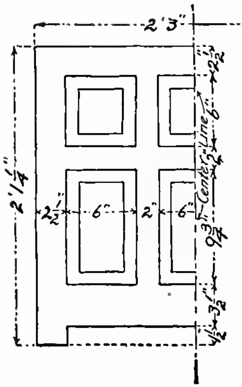

FIG. 107.—USE OF A CENTER LINE.

of it; thus the figure indicates the common method of showing an entire view by drawing one half of it. Notice that the horizontal dimensions are for the entire width, as though the full drawing were shown; therefore but one arrow point is necessary. The center line is often used as indicated in the front and sectional view of the music cabinet, Fig. 108, one half of the outside and the vertical section being shown.

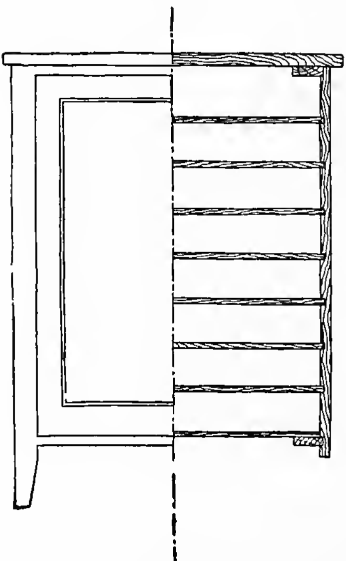

FIG. 108.—USE OF A CENTER LINE TO SHOW OUTSIDE VIEW AND SECTION.

81. Radii and centers.—Figure 109 shows the method of indicating the radii and centers.

82. Notes and dimensions.—In studying plans, it is important that every reference and explanatory note should be read and carefully considered; every line should be followed its entire length, as what may seem to be of little importance may be the key to a knotty question. In using plans, the workman should invariably follow the figures or dimensions given, and not depend upon scaling, because a mistake may have been made in the drawing, or a change made after the drawing was finished. In such cases the draftsman would not change the drawing, but would simply alter the figures, knowing that the workman will follow the figures instead of scaling the drawing. If drawings are properly made, every essential dimension is plainly noted.

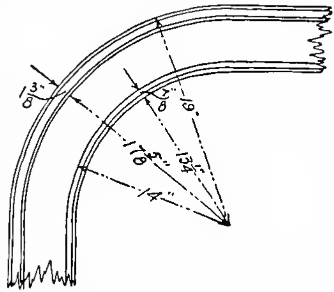

FIG. 109. — METHOD OF INDICATING RADII AND CENTERS.

Instead of using the words *feet* and *inches*, or their abbreviations, *ft.* and *in.*, it is the usual custom to make the symbol (′) for feet and (″) for inches; therefore, instead of writing 6 ft. $9\frac{1}{2}$ in., it would generally be expressed, 6′ $9\frac{1}{2}$″.

83. Using the scale. — In using a scale, the workman must *learn to think in feet and inches.* It is a great temptation to the novice, because it seems the easiest way, to reduce the desired measurements of feet and inches to inches and fractions of an inch. For instance, if in working with a three quarter inch scale, or $\frac{3}{4}'' = 1'\ 0''$, the desired dimension is 6′ 8″, the easiest way seems to be to reduce it to standard inches, and to say five inches. This is wrong; for, when working with an intricate fraction, or an unusual scale, say, $1'' = 1'\ 0''$, it will be hard to measure or reduce it to a workable fraction if using an ordinary rule.

The 1″ and the $\frac{1}{2}$″ scales are awkward, as the ordinary rule is divided into sixteenths of an inch, and therefore hard to adapt to measuring twelfths of a foot; thus the scales most generally used are those which are adaptable to a sixteenth of an inch, for instance, the $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{3}{4}''$, $1\frac{1}{2}''$, and $3''$ scales.

In a $\frac{1}{8}''$ scale, $\frac{1}{16}''=6''$. This scale is adapted only to work upon large buildings, and is the smallest which the average woodworker is likely to use, though on large, general, or assembled drawings of a group of buildings, the $\frac{3}{32}''$ or $\frac{1}{16}''$ scales are sometimes preferred. The $\frac{3}{16}''$ scale is occasionally used, in which $\frac{1}{16}''=4''$. The $\frac{1}{4}''$ scale is the usual scale for small and medium-sized buildings in drawing the floor plans and elevations. In this scale, $\frac{1}{16}''=3''$. The $\frac{3}{4}''$ scale is frequently used in showing details and sections of construction. These are often placed upon the same sheet of drawings as the smaller drawing that they are to explain, references being made between them either by letters or figures. In this scale, $\frac{1}{16}''=1''$.

The $1\frac{1}{2}''$ scale is used for the same purpose as the $\frac{3}{4}''$ scale, and this, or any large scale, may be used for making drawings of furniture and other fittings. In this scale, $\frac{1}{8}'' = 1''$. The $3''$ scale is used for the same purpose as is the $\frac{3}{4}''$ and the $1\frac{1}{2}''$; but, being larger, it allows more accurate drawing and scaling. In this scale, $\frac{1}{4}'' = 1''$. Full-sized drawings are usually made of important details. Figure 110, *A*, shows a part of a $\frac{1}{4}''$ scale, and *B*, a part of a $\frac{3}{4}''$ scale. The distance indicated at *A* is $4'\ 5''$; and at *B*, it is $2'\ 9''$. In using a scale to measure an unknown distance from a drawing, — for instance, either of the above spaces, — place the graduation 0 on the line at one side of the space, as at *c*; then move the scale to the nearest smaller graduation of feet at the other extreme of the distance to be measured, as at *d*. In measuring the distance at *A*, move the scale to the right, and at *B*, to the left, a distance equal to that between *d* and the smaller graduation of feet; then read the feet and inches as shown upon the scale.

In using an ordinary rule as a scale, the workman will find it more convenient to use the edge which is divided

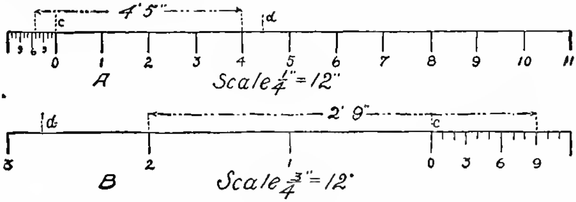

Fig. 110.—Use of Scales.

into sixteenths, as indicated in Fig. 111. In using the rule for this purpose, it is tipped upon its edge to bring the graduations nearer the work, and the end of the rule is placed upon the line at one end of the space being measured. The number of feet and inches are then computed, we will

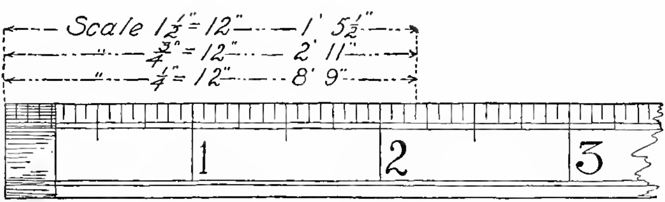

Fig. 111.—Use of the Rule in Scaling.

say to a $\frac{1}{4}''$ scale, the distance $2\frac{3}{16}''$ being reduced to feet and inches by the following mental process: $\frac{1}{4}'' = 1'$; $8 \times \frac{1}{4} = 8'$; $\frac{3}{16}'' = \frac{3}{4}$ of $1' = 9''$; thus we obtain $8'\ 9''$. In working with a $\frac{3}{4}''$ scale, by applying the same mental process, we obtain $2'\ 11''$. If a $1\frac{1}{2}''$ scale is being used, it will read $1'\ 5\frac{1}{2}''$. The rule commonly used by most woodworkers is adaptable for scaling by the above method, but a brass-bound rule, which is generally scaled, or some other form of a scaled rule, is preferred by many.

84. Drawing tools. (**A.**) *The board equipment.* — In making a working drawing, the student should have a *drawing board* (Fig. 112, *a*), a *T square* (*b*), and also a 45° *triangle* (*c*), a 30° and 60° triangle (*d*), and *thumb tacks* (*f*). (See also Figs. 190 and 191.)

Besides the above tools, there should be an architect's *triangular scale, pencils, erasers,* both hard and soft, and a set of *drawing instruments,* which may be as simple or as elaborate as desired. A medium-priced set, containing the compass with pen and pencil points, divider, ruling pen (if ink work is to be done), and one or more of the spring bow instruments, will be found serviceable and convenient, though the latter instruments may be omitted if desired, as they are necessary only upon small details where accuracy is required. It is false economy to purchase the cheapest set possible, as satisfactory results cannot be obtained by their use; on account of the poor material of which they are made, repeated adjustments will quickly strip the screw threads. A ruling pen with either a wood or a metal handle will be found more serviceable than one of bone, as the latter will break easily.

(**B.**) In ordinary architectural drawing, and in the drawing connected with this series, by far the larger part of the work will require only the board equipment; therefore, on account of the space required, special instructions in the use of the instruments will be omitted. The writer has observed that the average student will master the use of the instruments in less time than is required for him to attain a moderate facility in the use of the board equipment.

In using the board tools, the head of the T square should invariably be kept upon the left of the board, as in Fig. 112; it may be moved from top to bottom of the board to allow horizontal, parallel lines to be made at any point upon the paper, as indicated by lines *m m.*

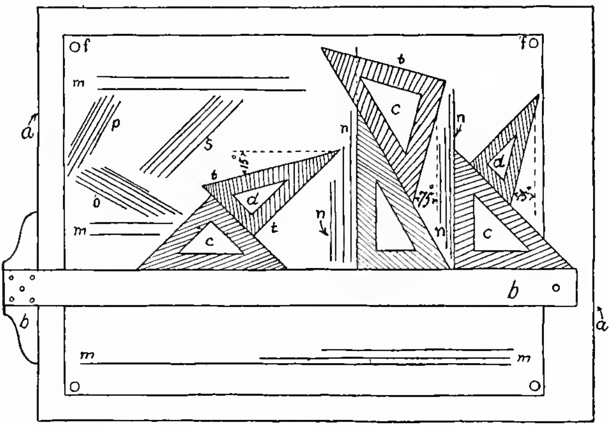

FIG. 112.—DRAWING BOARD, T SQUARE, AND TRIANGLES.

Lines to be made at any angle with the usual position of the T square should be drawn by the triangles; it is allowable to use the T square for a very long line, especially if the work is to be inked. Lines at an angle of 30° or 60° with the T square, as at *o* and *p*, should be made by the 30° and 60° triangle, resting upon the T square as indicated. Lines at an angle of 45° should be made by the 45° triangle, as at *s*. The 15° and 75° lines may be made by placing the triangles as shown at *t*; in fact, any multiple of 15 degrees may be drawn by the manipulation of the triangles from the T square in its horizontal position.

To make parallel lines in any part of the paper, which cannot be made by either of the triangles resting upon the T square in its horizontal position, place the T square at any angle that will allow the triangles to rest upon its edge and coincide with the desired angle.

The paper should be placed square with the left end of the board, as shown. The pencils should always be kept sharp, and in drawing horizontal lines should be used only upon the top edge of the T square and upon the edges of the triangles, *not against the edge of the rule.* The latter should be used only for measuring; if used for guiding the pencil, the graduations will soon become so indistinct that it will be difficult to read them.

In making the drawings necessary in working out the exercises of the following chapters, the principles explained in Topics 77 to 81 should be reviewed and applied.

Suggestive Exercises

77. Why is a knowledge of drawing essential to a workman? What is the difference between a photograph, or a perspective sketch, and a working drawing? What is the object of a working drawing?

78. How many views of an object are generally necessary? State exceptions. Describe the mental process by which a draftsman determines the different views of an object.

79. Read and explain a working drawing. Describe sections, and the methods of indicating them. Describe and explain the purpose of breaks in a drawing.

80. What is the purpose of a center line?

81. How are radical dimensions shown?

82. Should the workman scale a dimension which is indicated by figures? How do draftsmen generally change a drawing if it is neces-

sary? How much attention should be paid to explanatory notes upon a drawing?

83. How should a workman think of measurements when scaling? What are the usual scales? Why are not ½″ and 1″ scales generally used upon woodwork? What is the scale commonly used upon plans and elevations of medium-sized buildings? What scales are used for details? Mention cases in which full-sized details are made. Describe and demonstrate the process of using the scale. Demonstrate the method employed in using an ordinary rule for scaling.

84. Describe the tools used in mechanical drawing. Demonstrate the use of the different instruments to obtain various results. What tools should be used to guide a pencil in drawing a line? Why not use a rule?

CHAPTER VIII

Constructive Exercises

85. Object of exercises. — The tool exercises of this chapter are not intended to be performed one after the other, though a certain amount of this work is valuable in forming correct habits in the use of tools before really important work is undertaken. A sufficient number of these exercises should be worked out to familiarize the student with the constructive details of the supplementary models which form the actual course of work. They are also intended to inform the student of the important forms and uses of the different types of joints which are the basis of all construction in wood.

Many of the exercises are shown in *isometric projection*, and are planned to serve only as a basis from which working, or scaled, drawings may be made by each student, before the actual work is begun.

86. Use of exercises. — Before beginning a piece of work, the student should read the text and the references, and should understand every step necessary to complete the model. It will be noticed that the sequence of exercises has been carefully worked out in connection with some of the models which include unusual or difficult features. Where this has been done, the progression should be followed carefully, as otherwise troublesome conditions may develop as the work progresses.

When a tool is used for the first time, the directions for its use should be carefully studied, and correct methods followed from the first.

87. Wood for exercises. — (**A.**) The following exercises may be made of any soft, easily worked wood. *White pine* is the most desirable in localities where it is not too expensive; *poplar*, or *whitewood*, as it is called in many sections of the country, *bass wood*, and *white walnut*, the latter often known as *butternut*, are also very satisfactory woods for practice.

In general, it is not good practice to cut the pieces to their exact length until after the joint, or one end, has been fitted, as any deviation from absolute accuracy may make it impossible to work to the required dimensions, and the fraction of an inch of wood left for "working," will often save wasting all the material and a great deal of time.

(**B.**) *General directions.* — All exercises may be glued together after the joint is made, if desired; but it is not necessary, as the pieces may be marked so that they can be laid together as they were fitted.

It is of the utmost importance that neither files, rasps, nor sandpaper be used in making the joints included in the exercises of this chapter, as the student should depend entirely upon his cutting tools in fitting of all kinds. A file, or sandpaper, will invariably destroy a joint instead of improving it.

The face sides of models, which are held together by their construction, should not be smoothed or sandpapered separately, but after they are in their places.

In every case where it is possible, all of the marking, or laying out, should be done for the entire model before a cut is made upon any piece.

Exercises

88. Straight edge. Fig. 113.

Material: 1 piece, $24'' \times 1\frac{3}{4}'' \times \frac{1}{4}''$ thick.

A. Lining off: Select a straight-grained, soft $\frac{1}{2}''$ board, and, holding the pencil and rule as shown in Fig. 114, line off the piece about $\frac{1}{4}''$ wider than desired.

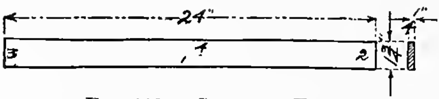

Fig. 113. — Straight Edge.

B. Use of the ripsaw: Saw to above line. See Topic 37 D.

C. Use of the cutting-off saw: Cut the piece off about $\frac{1}{2}''$ longer than desired.

D. Marking the face side: Mark the figures 1, 2, 3, 4, upon the best, or face, side of the piece, as in Fig. 113, the face edge, or best edge, being marked "1."

E. Planing edge straight: Straighten edge 1. Plane straight and square with face side. See Topics 41 and 45. Use the try-square as in Fig. 29; if desired, the piece may be held in the hand instead of in the vise.

Fig. 114. — Lining off for Ripsawing.

F. Testing an edge: Prove that the edge is straight by sighting along it, and then use a straight-edge to see whether or not the eye is true. All edges should be tested in this way until the eye is trained to know when an edge or surface is true. The use of mechanical aids to accuracy ought not to be encouraged, as the eye should be trained to perform this work without depending upon artificial means.

G. Square end 2; cut in the bench hook, as in Fig. 115. Use the backsaw, but be careful when the saw cuts through the wood to have it come in contact with the bench hook, and not with the bench.

FIG. 115.—USE OF THE BENCH HOOK AND THE BACKSAW.

H. Block planing: Block plane end 2. See Topic 44, B, Fig. 58. Make the end square and true, after which it should not be touched again.

I. Cutting to exact length: Cut end 3 to neat, or exact, length. Measure from end 2, and mark with a distinct knife cut by the blade of a try-square; do not use a pencil. With a backsaw, cut the end off carefully, leaving the knife mark upon the piece, and with a block plane, work it down to exactly the required length, in the same way that end 2 was finished.

J. Use of gauge: Gauge to width. See Topic 33, Fig. 35. Working from edge 1, make a line exactly $1\frac{3}{4}''$ from that edge. Before doing this it will be wise to practice upon a waste piece, until the tool is well under control.

K. Planing a parallel edge: With a jack plane, plane edge 4 exactly to the gauge mark, when it should be parallel with edge 1, and square with the face side.

The foregoing is, in general, the method which should be followed in making any piece square.

L. Planing to thickness: Using the gauge as above described, make a line upon the edge of the piece entirely around it, and $\frac{1}{4}''$

from the face side. Plane to this line, and, if working against an iron bench dog, guard against bruising the end of the straightedge by placing a waste piece between it and the dog. Do not hold the piece in the vise, as a piece so thin will be sprung out of shape by the pressure.

M. Working from the face side or edge: It is an almost invariable rule in carpentry to work from one side or edge, generally the best, which is known as the face side or edge, and from which everything is worked, measured, or squared. The student should never lose sight of this, and from the very beginning should acquire the habit of working from this edge. This habit becomes second nature to a good workman.

89. **Exercise in chiseling.** Fig. 116.

Material: Poplar or pine. 1 piece, $12'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

In preparing the material for this and for the following models, the exercises from 88 *A* to *M* should be followed with each piece, although if the models are made of $\frac{7}{8}''$ stock, Exercise *L* may be omitted, because that is a stock thickness, always carried by lumber dealers.

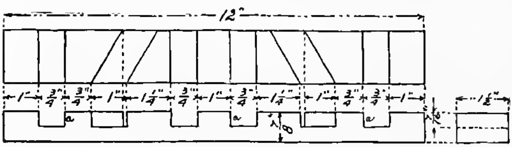

FIG. 116.—EXERCISE IN CHISELING.

If one end is to be fitted against another piece, as in the various forms of construction, Exercise *I* should be omitted until after the joint is fitted. See Topic 87 A.

A. Laying out grooves: 1. Mark the grooves with a knife, try-square, and bevel; make the marks upon the face side at angles similar to those shown in Fig. 116.

2. From each of the lines above described, with a knife and try-square, make distinct marks or cuts upon the edge, a little less than one half of the thickness of the piece, measuring by the eye.

3. Gauge very lightly upon both edges, $\frac{7}{16}''$ from the face side between the knife marks (*a*), thus indicating the sides of the grooves which are to be cut. In using the gauge, be careful not to run over the spaces which will be cut out by the grooves, as the scratches will be a blemish upon the finished work.

B. Cutting grooves: 1. With the backsaw, cut the grooves across the face and by lines *a*, as nearly to the depth gauge marks as possible, without touching them. In doing this, hold the work in the bench hook, as shown in Fig. 115.

2. Cut the grooves by using a sharp paring chisel, somewhat narrower than the width of the groove; remove the wood from between the saw cuts (*a*), as shown in Fig. 116, guarding carefully against cutting

Fig. 117.—Use of the Bench Hook with the Paring Chisel.

below the gauge marks upon the edges, or allowing the chisel to follow the grain deeper than is desired. Make light cuts; do not try to take the wood all out at once by using a mallet to force the chisel, but be sure that the chisel is perfectly sharpened, and work slowly and carefully. The best results may be obtained by using the tool as shown in Fig. 117, the beveled side up. Usually it is best to use the widest chisel possible, for the reason that, the chisel being longer and larger, it can be controlled more easily than a narrower one. Small work should be held against the bench hook firmly, but a piece requiring heavy cuts may be held by handscrews or in a vise.

90. Square butt joint. Fig. 118.

Material: 1 piece, *a*, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.
1 piece, *b*, $4\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

A. Fitting the joint: Preferably holding the work as shown in Fig. 58, saw the joint with the backsaw, and block plane it to a perfect fit. Work carefully to a knife mark, and test the work continuously with a try-square to maintain accuracy with both face side and edge.

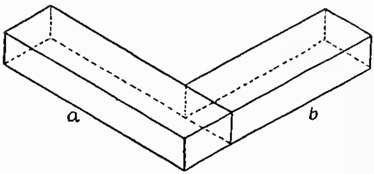

FIG. 118.—SQUARE BUTT JOINT.

B. Marking with a knife: If accurate work is desired, *never work to a pencil mark,* as it is not possible to work as closely to a pencil line as to a *distinct cut made with a sharp knife,* which gives a definite line by which the joint may be made. If the work requires that a chisel should be used, as in cutting a shoulder, the knife cut makes a definite line in which the edge of the chisel may be placed. Upon this particular piece of work, however, the chisel will not be used; but the definite knife mark will make possible more accurate sawing, and then all that is necessary to finish the joint is to block plane to the sharp edge indicated by the knife cut.

C. Cutting to length: After *a* and *b* are fitted at a right angle, cut off the unfinished end of piece *b*, block plane it, and make it square with the faces.

To repeat and emphasize a previous statement, the student should learn as early as possible in his work to look ahead to see which pieces should be cut to a neat length, and which pieces should be left long to allow for working. The following is a good general rule to apply to all work,—*never cut to a neat length if it can be avoided.* Like nearly every other rule, this will demand judgment in its application, or the endeavor to follow it may result in working to a disadvantage. However, it should always be kept in mind when cutting the stock for a piece of work.

The square butt joint is one of the most common forms of construction, as it is the type of joint used where two pieces are butted together at any angle, as outside and inside finish, plain boxes, etc.

91. End butt joint. Fig. 119.

Material: 2 pieces, $4\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

Fitting the joint: Fit these pieces to each other, end to end, the process of fitting being the same as in the preceding problem.

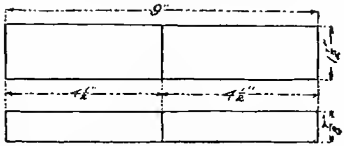

FIG. 119. — END BUTT JOINT.

The work should be done so accurately that, when it is finished, the face edges and the sides of the pieces will form a perfectly straight line with each other. This joint is used where two pieces are butted together, as in lengthening flooring, siding, etc.

92. Edge joint. Fig. 120.

Material: 2 pieces, $12'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

Neither piece should be cut to length nor planed to width until the exercise is completed, when it should be treated as one piece.

A. Fitting the edges: Method 1. One edge of each piece should be made perfectly square, by using the jack plane as shown in Fig. 55, and these edges fitted to each other so that the ends will bear a very little harder than the middle, the difference being so slight that the eye cannot detect it. This does not mean that the pieces should be jointed hollowing, as they should be made as nearly perfectly straight as possible.

In doing this work, the plane should be in first-class condition, and the finest possible shaving taken off in finishing the joint. This slight difference in the center of the joint is to allow a certain amount of shrinkage to take place at the ends before the joint will open, as the ends of a board are more quickly affected by temperature and humidity than is the middle.

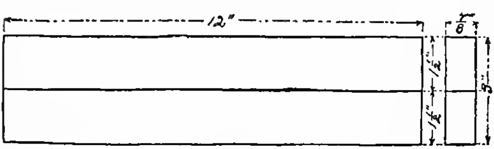

FIG. 120. — EDGE JOINT: METHOD 1.

B. Reënforced edge joints: This joint is used for table tops and for wide boards, and if reënforcement is necessary, the joint should be matched, tongued, and grooved, or doweled, as in Fig. 121, *a b c*. It is also used on square-edged floors; matched flooring and beaded ceiling are elaborations of the same joint, not entirely for the purpose of reënforcement, but mainly to allow of blind nailing, as in Fig. 38, and to minimize the effect of shrinking and warping, as the tongue prevents an open joint between adjoining pieces, and keeps the face sides flush with each other. In beaded ceiling, indicated by the dotted line at *h*, the bead hides the joint if shrinking or warping occurs.

C. Gluing the joint: Be sure that the joint is perfectly fitted before the glue is applied, and *do not depend upon the clamps to bring the joint together.* Any glue joint should be made wood to wood, or the glue is worthless, and if the joint does not fit perfectly, it will always be weak and apt to give way when shrinking or swelling takes place, or from a sudden blow. (See *H* below.)

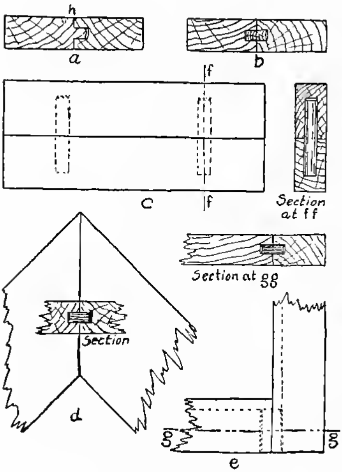

FIG. 121. — JOINTS.

a, Matched joint; *b*, tongued and grooved joint; *c*, doweled joint; *d*, tongued and grooved mitered joint; *e*, tongued and grooved panel work.

A wide miter joint may be tongued and grooved as at *d*, Fig. 121. In a case of this sort, the length of the tongue, or its grain, is at right angles with the face of the joint, so as to give all the strength possible to resist the tendency of the joint to open. The joint may be held in place by handscrews until the glue sets, as described in Topic 108. It is important that the student should realize the difference in application between a tongue prepared in this way, and one in which the grain is parallel with the face of the joint, as at *b*.

A cheap grade of panel work is sometimes made by the use of a tongue as shown at *e*, Fig. 121.

D. Jointing wide boards: In general, the face side of the work should at all times be kept toward the workman, and especially is this true in making a glue joint. The joint should be made so that the faces of adjacent boards will be as nearly as possible in line with each other. This will be difficult if the boards are warped or twisted, though the worst of them may be ripped through the middle, and the inaccuracies of one piece used to compensate those of the boards against which it is fitted. This requires more work, but if a poor grade of stock is being used, a much better job may be done.

E. Fitting the edge joint: Method 2. Some workmen joint the edges of the two members of a joint at the same time, as in Fig. 122. It requires skill to do this well, and it is necessary that the plane iron should be nearly straight on the edge, and carefully sharpened and adjusted. By this method, if the face sides are opposite each other while the joint is being made, as indicated, and if the work is accurately done, the joint will be a perfect fit when the pieces are brought into their proper relation.

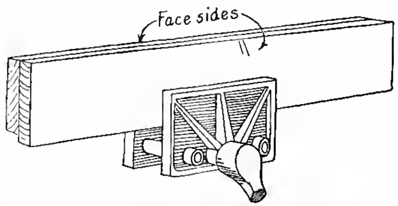

FIG. 122. — JOINTING TWO PIECES AT ONCE: METHOD 2.

F. Fitting the edge joint: Method 3. In making a glue joint less than four feet long, many workmen do not fit the edges by means of a try-square, as it may be done more economically by the "try" method, if the workman has sufficient skill.

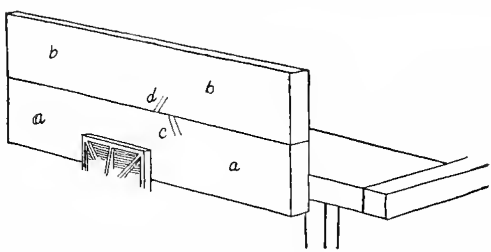

FIG. 123. — THE "TRY" METHOD: METHOD 3.

1. Mark the face corners as at *c*, *d*, of pieces *a*, *b*, Fig. 123, which is the usual face mark, and is so understood by other workmen. (This mark will hereafter be used to designate the face side and edge where necessary.)

2. Joint the edge of piece *a* by simply planing it straight, not using the try-square, but depending upon the "feel" of the wrist to make the

edge approximately square. (The student may use the try-square until he has acquired the "feel.")

3. Remove piece *a* from the vise, turn it "end for end," or reverse the ends, and lay it upon the bench with the face corner, *c*, in position,

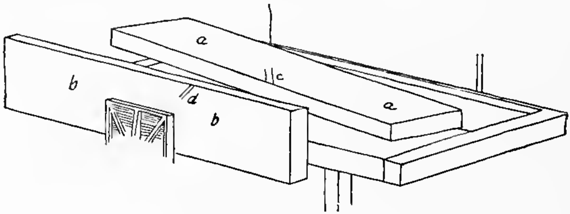

FIG. 124.—POSITION OF THE PIECES OF THE JOINT IN FITTING THE SECOND PIECE.

as shown in Fig. 124. Place piece *b* in the vise, with the face corner, *d*, up, and toward the workman, as indicated.

4. Joint the edge approximately straight, and square by the same method used in jointing piece *a*.

5. Place piece *a* upon *b*, as in Fig. 123, and apply the try-square as in Fig. 125, to see whether or not the faces of the two boards are straight or fair with each other. If they are not, edge *d* of *b* may be jointed to bring both pieces in their desired relation.

6. Unless both pieces are perfectly fair and "out of wind" (*i* as in kind), that is, unless they will lay perfectly flat upon a true surface, it is impossible to make a joint which will stand this test of the try-square; and by this method, if the boards are a little winding or twisted, as they are very apt to be, they may be averaged to make the finished board more nearly true than would be practicable if its accuracy depended upon a try-square.

7. In testing the two members of a joint for accuracy, place their edges together with nothing to hold them, as shown in Fig. 126, and move piece *a* back and forth a little, sideways; if there is a lump upon either edge, *a* will swing upon it as upon a pivot, as at *k*. The same test should be applied from each end, and the defect carefully remedied.

8. To obtain the best results in gluing up a wide board, the center of the joint should be a very little open, as explained in *A* of

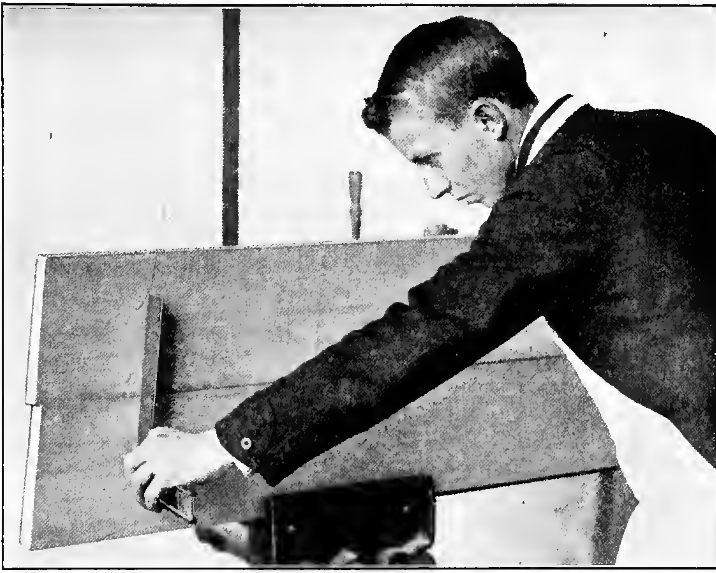

FIG. 125.—TESTING THE FACES OF THE PIECES.

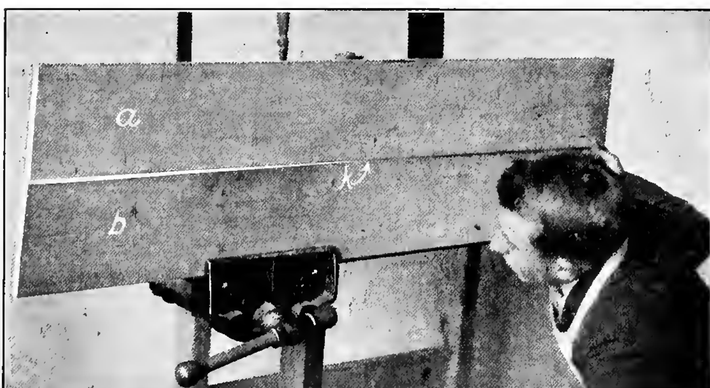

FIG. 126.—TESTING THE JOINT.

this exercise. If this is well done, a short board may be glued up with but one clamp to hold it together, instead of with three or four clamps, which would be necessary if the joint were made perfectly straight.

G. Rub joint: Method 4. This joint, which is sometimes used in gluing up wide boards, is made by fitting two edges together, so that they will bear equally their entire length. The glue is then put on and the pieces rubbed back and forth endways until the glue is well rubbed out of the side of the joint or into the wood. In doing this, care should be taken that the sides of the boards are kept flush; therefore this form of joint can be used only with perfectly straight stock. After the joint is made, the board should be set away until the glue is thoroughly hardened, until which time the board should be handled very carefully, as a sudden jar or blow may break the joint. If well made, this joint is as strong as any unreënforced square-edged joint.

H. Gluing: In all glue joints, except the rub joint, the pieces should be fitted and held wood to wood with clamps, or hand screws, until the glue sets. The glue should all be squeezed out, as there is very little strength in a joint which shows a fine line of glue.

To repeat and emphasize *B*, it is the glue which enters the pores of the wood of each member of the joint that gives the joint its strength, and if the joint is not perfectly fitted, a quick rap or exposure to a sudden change in temperature is liable to break it open.

I. Preparation for smoothing: After the glue is set, which will take at least three hours for hot glue, or twelve hours for cold glue, the superfluous glue upon the surface of the board should be cleaned off, and the board trimmed to the required size when it is ready for smoothing. For smoothing a surface, see Topic 43.

J. Sandpapering: In making ready for the sandpaper, do not depend upon the sandpaper to make the work smooth, as it is easy to scour a hole in the surface. Although this may seem of no importance, when the finish is spread, it may be very prominent, and will always stand as an evidence of unskillful work. The smoothing plane and the scraper are the tools which should do this part of the work. For the use of the latter tool, see Topics 55 and 56.

In using sandpaper, a sheet should usually be torn in halves the short way of the paper; if it is to be used upon a flat surface, one half should be folded back to back, and held, not tacked, around a block about $3'' \times 4'' \times \frac{7}{8}''$ with the hand, as in Fig. 127.

The act of grasping the block with sufficient force to hold it while at work will keep the sandpaper in its place. The use of any device to fasten it there is an unmistakable mark of the novice, as the workman realizes that his time is too valuable to spend upon anything so useless as tacking a piece of sandpaper to a block or using any of the devices

Fig. 127. — Method of Grasping Sandpaper.

that some amateurs consider an advantage. A sandpaper block should always be used upon a flat surface, and the smaller the surface, the more need there is of a block.

If there is much sanding of moldings to be done, it is best to make blocks to fit their curves, as it is hard upon the hands to do this work very long at a time, though nothing has ever been devised which fits irregular forms as well as the fingers. *Never use sandpaper upon a piece of wood until all of the cutting upon it with edge tools has been done,* as the particles of sand will enter the grain, and any edge tools used upon it afterwards will be dulled quickly.

1. In using sandpaper, the workman should guard against rounding square corners or destroying the form of curved or flat surfaces, a raw corner, however, should always be removed with a few light, careful strokes, as otherwise, if it is square, it will be more or less ragged. When this is well done, it is one of the evidences of skillful workmanship.

2. Do not use a piece of sandpaper so large as to prevent any part of it from being under perfect control, for the loose ends will scratch the wood, and it has an awkward and unworkmanlike appearance.

3. Always work parallel with the grain, and be sure that all plane marks and uneven places are well rubbed down. In order to do this, it is often necessary to use considerable muscle. This part of the work requires good judgment, for unless sandpapered thoroughly, there are apt to be places which will show when the finish is spread on the work, though they may have been invisible before. No one can tell as well as the workman himself when he has sandpapered enough, though it may be evident to any one if it has been done injudiciously, and one or two careless strokes may destroy an otherwise good job.

Upon a coarse job it is usually allowable, and sometimes desirable, to sandpaper across the grain, especially if the work is to be painted.

Too much care cannot be taken in the use of sandpaper, especially upon the part of the amateur, for he is more liable to injure his work than to improve it.

93. **Intersection joint.** Fig. 128.

Material: 1 piece, *a*, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.
1 piece, *b*, $6'' \times 2\frac{1}{2}'' \times \frac{7}{8}''$.

1. *Fitting the joint:* Lay the pieces upon each other, as indicated by the dotted lines, at the angle of their intersection, and mark point *c* upon both pieces. Never measure with a rule in a case of this sort, if it is possible to measure with the piece of wood itself.

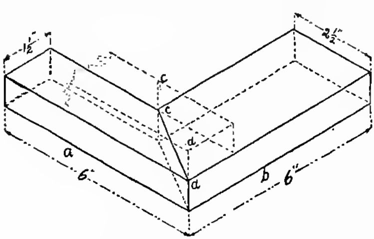

Fig. 128. — Intersection Joint.

2. Connect points *c* and *d* across the face of each piece by a distinct knife mark, which will give the cut. With a try-square and knife, transfer the angle to the other side of each piece.

3. Cut carefully to the mark with the backsaw, leaving the mark upon the piece wanted.

4. Block plane the pieces to form a perfect joint at the angle desired.

5. Cut pieces to the desired length.

6. Fasten the pieces together by a rub joint.

7. Smooth and sandpaper after the glue has set.

This joint is used where it is desired to joint pieces of different widths together without allowing end wood to show. The same method may be used when two pieces of the same or different widths join at any angle.

94. Lap joint. Fig. 129.

Material: 2 pieces $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

1. *Fitting the joint:* Plane the two sides which are to be glued together, and sandpaper them; do the same to the end of each piece which is adjacent to the joint, as at *a a*.

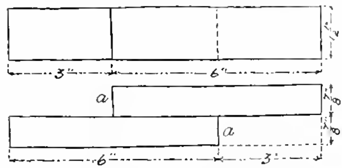

FIG. 129.—LAP JOINT.

2. Fasten the pieces together with glue or brads, or both; if the glue is used, apply *sparingly*, or it will squeeze out at the ends, and make unnecessary work in cleaning it off. Hold the joint closely together with a hand screw until the glue sets; see Fig. 87 and Topic 59 *B*.

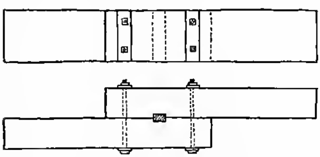

FIG. 130.—LAP JOINT, KEYED AND BOLTED.

3. After the glue is set, work the model to the desired dimensions; smooth and sandpaper.

The form of the joint shown is one of the simplest and most common in use. It may be seen wherever two pieces lap over one another. Upon heavy work, the joint is often keyed with one or more keys and bound round with strap iron, or bolted through plates, as shown in Fig. 130.

95. Fished joint. Fig. 131.

Material: 2 pieces, *a*, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.
2 pieces, *b*, $6'' \times 1\frac{1}{2}'' \times \frac{1}{4}''$.

Prepare the pieces by jointing one edge of each and making pieces *b* of the desired length. Do not work either *a* or *b* to width.

1. *Fitting the joint:* Fit pieces *a* as in Fig. 119.

2. Smooth and sandpaper both sides of pieces *a*, keeping them both of the same thickness.

3. Sandpaper ends of pieces *b*.

4. Fasten together with either glue or brads, or both, keeping planed edges flush, and ends of pieces *b* opposite each other.

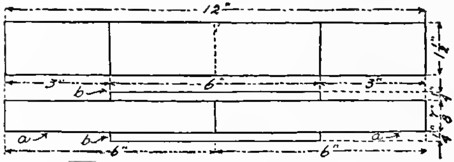

FIG. 131.—FISHED JOINT.

5. Cut pieces *a* to the desired length, measuring from the joint, and plane entire model to the desired width.

6. Smooth and sandpaper the entire model.

This is a strong though unsightly joint. The form shown is used in piecing out studding and in other places which are out of sight. If the work is judiciously done, it will be as strong as the material from which it is made. This type of joint is often used upon heavy construction, in which case it is keyed and strapped in order to secure the greatest strength and rigidity.

96. Mitered joint. Fig. 132.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

A. Uses of the mitered joint: The term *miter* is usually applied to the angle of 45°, by which a right angle is joined together, but any angle may have its miter. It is one of the most common joints, and is used in making picture frames, and in fitting door and window casings, base moldings, etc. It takes the place of the square butt joint upon plain wood in many places where it would be objectionable for the end wood to show. The intersection joint is an adaptation of this joint.

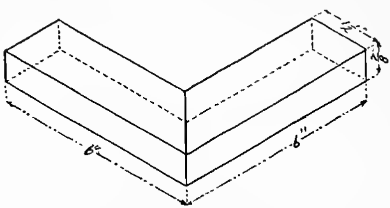

FIG. 132. —MITERED JOINT.

B. The miter box: In cutting a miter, it is customary to use a miter box. The form of miter box shown in Fig. 133 is one of a number of patented, adjustable, iron miter boxes upon the market, one of which is usually owned by every carpenter who works upon the bench or inside finishing. (In purchasing a tool of this sort, the longest saw possible should be selected.)

1. Place the molding in the box, as indicated.

2. After the ends of the pieces which form the joint are sawed, fit them together with a block plane. If the pieces are for outside work,

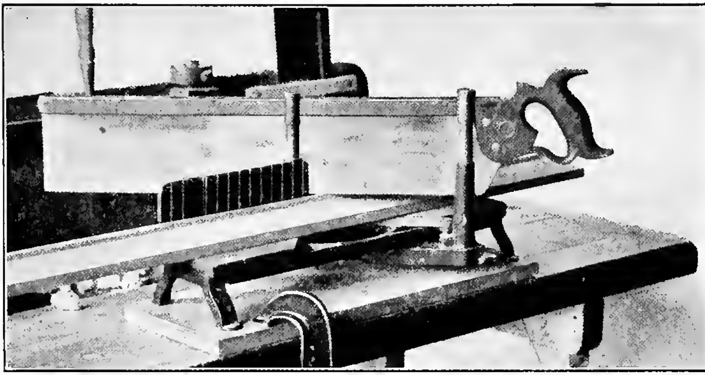

FIG. 133.—IRON MITER BOX WITH PIECE IN PLACE READY FOR SAWING.

an accurate saw cut is generally sufficient, but if the saw has not made the miter a good fit, or if the mitered angle is not exactly true, the block plane must be used.

C. Nailing a mitered joint: In nailing a mitered joint (as in a picture frame), bore holes for the nails in pieces *c*, and place *b* in the

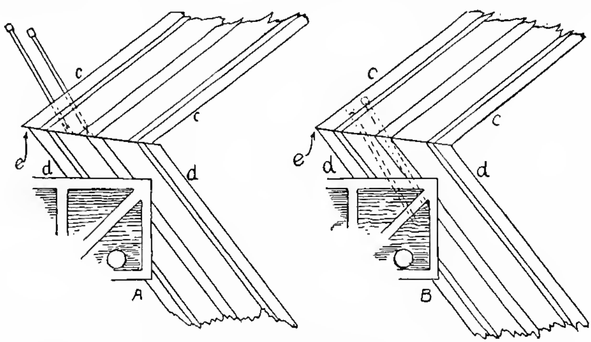

FIG. 134.—*A*. METHOD OF HOLDING MITERED JOINT FOR NAILING. *B*. MITERED JOINT NAILED, MEMBERS INTERSECTING.

vise as indicated. The pieces should be held as shown in Fig. 134, *A*, piece *c* projecting beyond piece *d* about $\frac{1}{8}''$, as at *e*, so that when the nails are driven home they will force the members of the moldings to coincide, as at *e* in Fig. 134 *B*.

Glue should always be used if the best results are desired.

After the nails have been driven as indicated, piece *c* may be placed in the vise, and holes bored and nails driven through *d*, if the greatest strength is desired; this is not advisable upon ordinary work, however, and should be done only upon large moldings, on account of the danger of splitting the wood, and of nailing the joint open unless the nails are driven very skillfully, since they pull against each other.

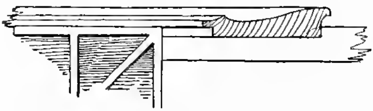

Fig. 135. — Method of Holding Finished Molding in a Vise.

Notice that the nails are pointed a very little outside of square with the edge of piece *e*. A little practice will convince the workman that driving nails at about this angle will give better results than if the nails are driven square, or at a greater angle, as the tendency to slide, or drive open, is thereby lessened.

A wooden miter box is preferred by many workmen in finishing down the outside of a house. (See Topic 109.)

D. Marking a miter with the bevel: If it is desired, the student may, in this exercise, lay out the angle of the miter by using a bevel for the face, and the try-square to mark across the edge; or, in place of the bevel, he may use the miter square, a tool made the same as a try-square, except that the blade is set at an angle of 45° with the beam. If the bevel is used, the angle of 45° may be found by the method indicated in Fig. 33.

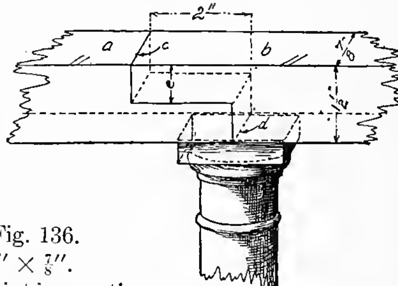

Fig. 136. — Halved Scarfed Joint.

97. Halved scarfed joint. Fig. 136.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

A. Fitting the joint: This joint is sometimes used when it is necessary to join two timbers lengthwise. If used as a girder, there should be a support under the joint at *d*. This form of construction is sometimes fastened together by the same methods as shown in Fig. 130.

1. Lay off the shoulders of the joint, say 2″, by a distinct knife

mark upon the face, or top edge, of piece *a*, at *c*, and upon the back, or bottom side, of piece *b*, at *d*.

2. Square from these marks, with a knife, a little less than half of the thickness of the piece upon each edge.

3. Set the gauge to the distance *e*, which should equal half of the thickness of each piece, and mark plainly from the face side upon the two edges and across the end of each piece.

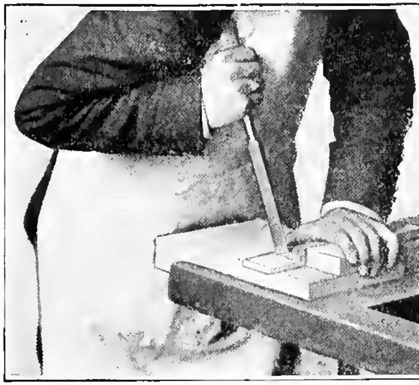

FIG. 137. — CORRECT USE OF THE CHISEL IN FITTING A SHOULDER.

B. Cutting to a knife mark with a saw: With a backsaw, cut to the gauge mark from the face of *a* and the back of *b*. Place the pieces one at a time in the vise, and with the backsaw cut out the recess between *c* and *d*, and their respective ends, which will allow the pieces to come together. If this is done with sufficient accuracy, the faces will fit and be flush (even). *The saw cut should be made with such accuracy, that one half of the knife and gauge marks will be left upon each of the two pieces that are to form the joint,* in which case, all that will be necessary to make a perfect fit will be to trim the joint a very little with a sharp chisel.

FIG. 138. — INCORRECT USE OF THE CHISEL IN FITTING A SHOULDER.

C. Fitting with a chisel: If any fitting of the shoulder is necessary, *do not do it by guesswork,* but make a distinct and accurate knife mark at the exact place required to make a perfect fit. In trimming to this mark, grasp the chisel as shown in Fig. 137, not as in Fig. 138, which is extremely awkward and inefficient. If the chisel is used as in Fig. 137,

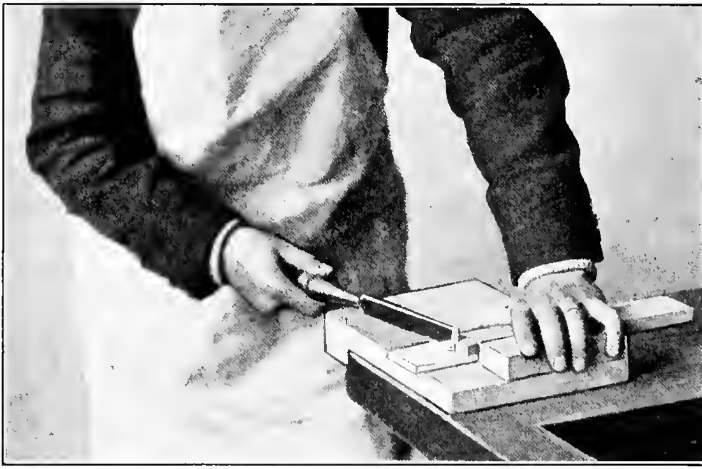

Fig. 139.—Incorrect Use of the Chisel in Following a Line.

very little strength is necessary, as the pressure of the shoulder does the cutting.

In fitting a joint of this sort, it is best to "cut under"; that is, to cut the wood inside of the visible part of the joint a very little back of the line, so that nothing will prevent the joint from coming together.

Never try to follow a line by using the chisel as in Fig. 139, as the chisel is apt to run into the shoulder beyond the line, its bevel giving it a tendency to "lead" back of the knife mark which indicates the shoulder, thus destroying the joint. The visible portion of any joint should be as nearly perfect as possible; therefore in this case, the longitudinal portion should be perfectly straight, or slightly hollowing.

Glue the pieces together, using hand screws to hold them in place each way. Cut the model to desired length, and smooth and sandpaper.

98. **Tapered scarfed joint.** Fig. 140.
Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This form of scarfed joint is used for the same purpose as that described in Topic 97, but it has a greater shearing resistance, or a greater resistance to pressure from above. It is obvious that the pieces must be securely bolted, keyed, or strapped, unless the ends are secured so that there cannot possibly be any slipping endways.

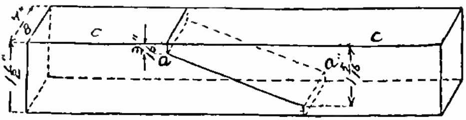

FIG. 140. — TAPERED SCARFED JOINT.

Fitting the joint: In laying out this joint, use a knife and try-square; the distance from the face edge at *a* should be $\frac{3}{16}''$, and that at the other end of the cut should be $1\frac{5}{16}''$. This latter mark should be made only from $1\frac{5}{16}''$ from the face corner, indicated by *c*, to the lower edge of each piece, since, if a knife mark were made across the side, it would remain a blemish upon the finished model, as it is difficult to smooth out a knife mark. These marks, which indicate the lines *a a*, should be made upon both sides of each piece. With a gauge, working from the face edge, which is marked with the face marks, *c*, lay off the distances $\frac{3}{16}''$ and $1\frac{5}{16}''$ by points, not by scratches, as the latter might make a blemish. Join these points with a knife mark; cut and fit as in Topic 97. Fasten together and finish, as in the preceding exercise.

99. **Notched, or locked, joint.** Fig. 141.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

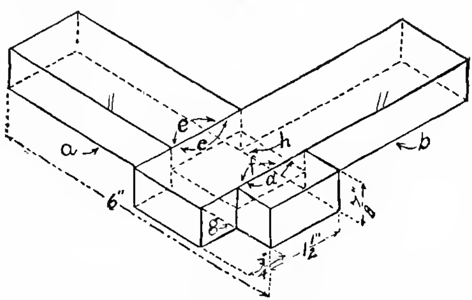

FIG. 141. — NOTCHED, OR LOCKED, JOINT.

A. Laying out the joint: This joint is often used at corners, where a cheap and strong joint is required.

In this and the following exercises, *be sure that every cut is laid out correctly before any cutting begins.*

1. In making this joint, lay off with a distinct knife mark by a try-square, as in Fig. 30, the distance of the lock end, say $\frac{3}{4}''$, upon the face side of piece *a* and upon the back side of piece *b*.

2. It is important that *the size of the cut should not be measured from these cuts by a rule, but by the pieces themselves.*

As the face sides of pieces *a* and *b* should be flush when the model is finished, it is plain that the width of piece *b* on its face side at the joint must be cut out of the face side of piece *a*; likewise, the width of the back side of piece *a* must be cut out of the back side of piece *b*.

3. Hence, turn piece *b* over so that the edge *c* of its face side will rest exactly over the knife mark *d* of piece *a* of Fig. 142.

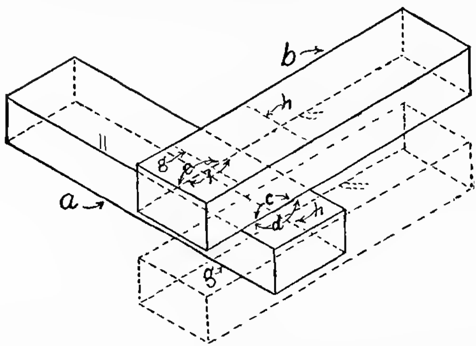

Fig. 142. — Laying Out the Cuts of the Notched, or Locked, Joint.

4. With the point of a sharp knife, make a mark at *e* on piece *a* close to the edge of piece *b*. If made accurately, this will give the exact width of the cut. Using the try-square, make a distinct knife mark a little inside of *e*, not a measurable distance, but enough to insure a close fit.

5. Repeat the process to obtain the exact dimensions of the cut upon the back side of *b*, laying the pieces back to back instead of face to face.

6. From these knife marks, proceed as in 89, *A*, 2.

7. See 89, *A*, 3.

8. If the joint is too close, remedy it by using the chisel as shown in Fig. 137.

Before the joint is glued together, sandpaper the edges of the pieces; be careful not to touch the joint, however, as this may easily be made too small.

B. Smoothing surfaces which join at an angle: After the joint is fitted, the pieces glued together, and the glue set, smooth the face and back sides with a smoothing plane, being careful that the plane is in the best possible condition; also be sure that no cut is made directly across the grain; otherwise, a piece is apt to be chipped off. Plane with the grain if possible, but if it is necessary to plane across the joint, do so at an angle of about 45°, and use care that the plane cuts in the direction of the grain most favorable for smooth work.

If the lock end is left off, we have a halved joint, sometimes erroneously called a lap joint, which is used in the construction of frame buildings in fastening the plates and sills at the corners. The lock joint should be fitted so closely that glue is unnecessary, but it may be glued together if desired.

100. Housed, or tank, joints. Fig. 143.

Material: 3 pieces, $4'' \times 3'' \times \frac{7}{8}''$.

These joints are used in making waterproof tanks and sinks.

Fitting the joint: At *a* is shown the form of joint generally used upon work which will allow sufficient wood beyond the groove, as at *c*, to give strength; it is somewhat cheaper to make than the joint at *b*, which is commonly used for light tanks and sinks, as it may be made more nearly water-tight than the other form.

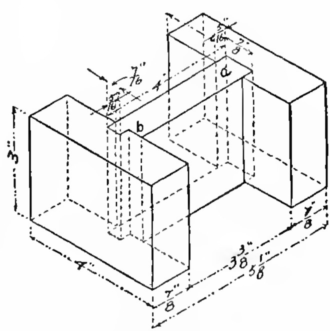

FIG. 143. — HOUSED, OR TANK, JOINT.

1. Smooth the piece which is to connect the two ends.

2. Mark with a try-square and knife the side cuts of the groove of end *a*, by adaptation of the method described in Exercise 99.

3. Mark the end of the tenon of *b* with a gauge, and lay out the shoulder with a knife.

4. Mark the side cuts of the groove to receive the tenon by the same method used in 2 above. Do not change the set of the gauge until it has marked the depth of the cuts *a* and *b* in the end pieces.

5. Saw and make grooves carefully to marks.

6. Smooth and sandpaper all sides of the pieces which will be inside after the model is together.

7. Glue the model together, holding it with hand screws until the glue has set, after which, smooth and sandpaper wherever necessary.

Joint *a* is used in stair building, in fitting the risers and treads into the skirting board, and in the inside corners of the baseboards of the best buildings, as the joint will not be opened by seasoning or settling. If a water-tight job is desired, the joints should be thoroughly doped with white lead.

In building a water-tight tank or sink, the lower edges of the sides and ends should be doped with white lead, and two or three strands of cotton wicking, or soft twine, laid smoothly upon them. The bottom, being thoroughly nailed, will press upon the twine and calk the joint, which, if well made, will be water-tight.

This exercise should be so closely fitted that it will not require glue to hold it together, though it may be used if necessary, or the joints may be fastened with $1\frac{1}{2}''$ brads.

101. Half-dovetailed joint. Fig. 144.

Material: 2 pieces, $6'' \times 1\frac{3}{8}'' \times 1\frac{3}{8}''$.

This is a very strong joint when it is in place with a vertical load upon it, as the dovetail resists all horizontal strains, and has a constant tendency to force itself together. It is sometimes used in fastening sills together at the corners as a substitute for the mortise joint.

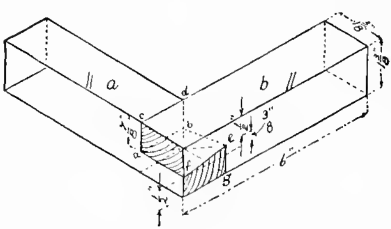

FIG. 144. — HALF-DOVETAILED JOINT.

The exercise should be held together by a screw, as the construction of the joint can be seen only when the two pieces are separate.

102. Checked joint. Fig. 145.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This joint is used in fitting floor timbers to sills, girders, and plates, and is a very common one in building construction. Floor timbers are sometimes mortised into the sills and girts, but this is not generally done upon ordinary work.

The size of the joint is regulated by the width of the timber, as it is measured from the upper edge, the distance from a to b being the same upon all timbers of the same floor, so that the top edges of the floor timbers will be in line, and the floor will be straight. In practice, the vertical height of the shoulder c is not considered, but the distance between the shoulders of each end is sometimes important, as it may be used to govern the distance between the walls.

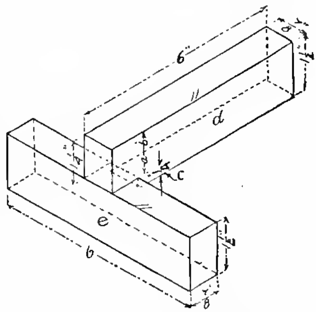

Fig. 145. — Checked Joint.

1. Gauge the distance a b from the top edge.

2. Measure from the end of piece d, the thickness of piece e for the shoulder c; mark with the knife, and cut out with the backsaw. Upon ordinary work this joint is marked with a pencil.

The piece d, representing the floor joint in this exercise, may be fastened to piece e, or the sill, by a brad; or it may be glued, if preferred. Smooth and sandpaper each piece separately.

103. Mortised joint. Fig. 146.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This is a common form of joint, and may be made at any angle. It is used in framing girts into corner posts and the ends of braces, in the manufacture of doors, panel-work, and in nearly every place where two pieces are to be fastened together at any angle, and the greatest strength is desired.

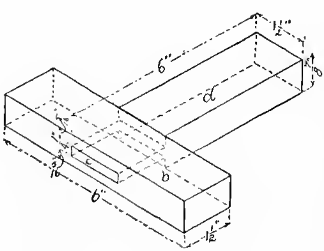

Fig. 146. — Mortised Joint.

A. Laying out the joint: 1. Lay out with a knife the length of the tenon upon d, which should equal the width of the mortise member, b.

2. Lay out the length of the mortise upon each edge of the mortise member, *b*, in the middle of the piece, lengthways; to insure a close fit, this mortise should be a little less than the width of the tenon in length. If made too small, a light cut will remedy it. These two marks should be made with a sharp pencil, since in transferring the lines with a knife across the face of piece *b*, a knife will make a scratch that will be difficult to remove.

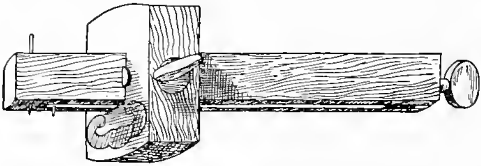

Fig. 147.—Mortise Gauge.

3. *Use of the mortise gauge:* Gauge for the mortise in piece *b*, and the tenon on the end of *d*. Set the mortise gauge, Fig. 147, and mark both pieces at once without changing its set. It is economy to use this tool where two lines are to be made at once, as it saves handling each piece over twice, and the marks may be made more accurately than if the ordinary gauge is used. This tool is used the same as a single-point gauge, the head being set in the right relation to the outside point (in this case, $\frac{9}{16}''$), the screw at the other end of the stick being manipulated to bring the inside point to its correct distance between the outer point and the head (in this case, $\frac{1}{4}''$ from the former, which is the important measurement). Tighten the thumbscrew in the head to hold it in the desired position.

Fig. 148. — Method of Grasping a Chisel for Mortising Small Work.

Always working from the face side, mark around the two edges and the end of the tenon and the mortise, on both edges, using care not to make a scratch beyond the mortise or the tenon, as it will not work out.

B. Cutting the joint: Bore a $\frac{1}{4}''$ hole in the middle of the mortise from each side, halfway through. If bored from one side, it would probably not come through accurately. In a large mortise, or in hard wood, the mortise may be bored nearly out by boring several holes. In cutting out a small mortise with a narrow chisel, work from the hole in the center to each end of the mortise, holding the chisel at right angles with the grain of the wood, as shown in Fig. 148. In this way it may be guided more accurately at the beginning of the cut than if held as in Fig. 149, which is the usual method of grasping a chisel for heavy work. After starting a chisel accurately in a small mortise, the hand will naturally slip up toward the handle. The back of the chisel, *c*, should be kept toward the end of the mortise toward which the student is working. Under no conditions should chisel cuts be made parallel with the grain until after the wood in the center of the mortise has all been cut out, as the wood at the side may be split. The tenon should be made by cutting out the wood on each side of it with a back-saw, and, if necessary, trimming with a chisel, as described in Topics 97 *B* and *C*.

Fig. 149. — Method of Grasping the Chisel for Mortising Large Work.

C. Drawboring: Figure 150 *A* shows a mortised and tenon joint, drawbored; the tenon shoulder, *a*, is less distant from the hole, *c*,

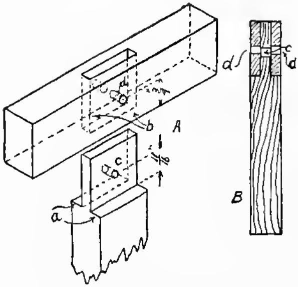

FIG. 150. — MORTISED JOINT, DRAWBORED.

in the tenon than the mortised shoulder, *b*, is from the hole, *d*, which pierces the wood on each side of the mortise. When the tenon is pushed into the mortise, and a pin driven through the hole, it is obvious that the joint will be drawn to a perfect fit, if the work has been well done. This joint is frequently used in the construction of buildings, for additional strength, and where it is necessary to hold the joint together while other parts of the work are being fitted. It is also used in the manufacture of sash and machinery frames, and in furniture to some extent. A section of this joint is shown at *B*.

104. Mortised joint and relish. Fig. 151.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This joint is used in joining the stiles and bottom rails of doors, panelwork, etc. If the mortise extended to the bottom of the stile, to allow the tenon to be the full width of the rail, it is plain that it would be a weak joint, therefore the relish is cut out of the rail. This joint is made by the same methods as those above described. Hold together by pin, if necessary, but do not use glue.

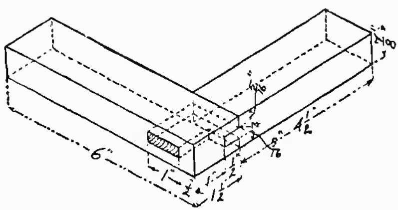

FIG. 151. — MORTISED JOINT WITH RELISH.

105. Dovetailed brace, or halved, joint. Fig. 152.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This joint is sometimes used to fasten braces into corner posts, girts, and sills, where they will be subjected to both tensile and compressive strains. A very strong joint may be made in this way, though piece *b* is weakened 50 per cent on account of the wood being cut away for the dovetail, and piece *a* still more.

1. *Fitting the joint:* Set the bevel to the required angle for the shoulder, *c*, which is the angle of intersection, and cut the end of piece *a* at the same angle.

2. On the back of *a*, at a distance equal to the width of *b*, measure the distance *d*, or the width of piece *b*, square with the end; make a distinct knife mark by the bevel, which indicates the shoulder *c*.

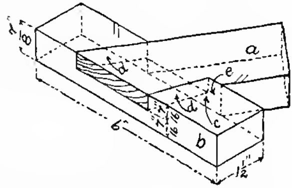

Fig. 152. — Dovetailed Brace, or Halved, Joint.

3. Without changing the angle of the bevel, make a pencil mark across the face of *b*, at the place at which pieces *a* and *b* intersect.

4. With a gauge set one half of the thickness of the pieces, mark the thickness of the dovetail on piece *a*, and of the slot which is to receive it, in piece *b*, working from the face side of each piece.

5. Saw to gauge marks of piece *a* and cut to shoulder *c*.

6. Lay out with a knife, and cut shoulder *e*, $\frac{3}{8}''$ from the edge of *a*, and cut the dovetail on one edge only. The edges of this dovetail should be made a very little less than square, or they should be "cut under" so as to make the surface of the underside of the tail a trifle narrower than the upper, or face, side. The difference on the edges should be almost imperceptible when tested by the try-square. (If this is well done, it will insure a good joint on the face, but if it is cut under too much, the model may be ruined in trying to remedy it.)

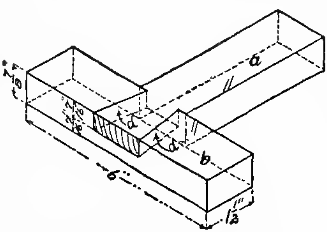

Fig. 153. — Dovetailed Locked, or Halved, Joint.

7. Trim shoulders *c* and *e* with the chisel, if necessary; see Fig. 137.

8. Lay the dovetail of *a* in its exact position on *b*, and with a sharp knife make a distinct mark beside each edge of the dovetail, and square on the edges of *b* to the gauge marks.

9. Cut out the slot to the gauge and knife marks, and trim them carefully with a sharp chisel.

10. If the work has been accurately done at every stage, the dovetail will have to be forced a little to bring it to its place.

11. Smooth and sandpaper. Do not glue the model together.

Figure 153 shows the same joint made at an angle of 90°.

106. Mitered halved joint. Fig. 154.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This joint may be used in making a strong corner at any angle where it is necessary to show a miter upon one side, in order to allow moldings to intersect, as in a heavy picture or a mirror frame. It is, as its name implies, a combination of the halved and miter joint, the miter occupying one half of the thickness; or, if a molding is being fitted together, the miter should be thick enough to insure that all the members of the molding will be upon one side of the half cut.

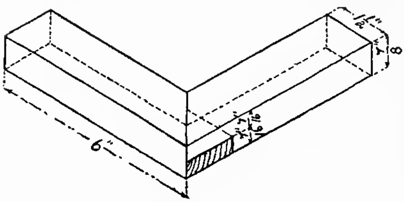

Fig. 154. — Mitered Halved Joint.

Smooth and sandpaper separately; do not fasten together.

107. Doweled joint. Fig. 155.

Material: 1 piece, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.
1 piece, $4\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

If this joint is well made and not exposed to the weather, it is the most efficient substitute for the mortised joint, and may in general be used in any place where a mortised joint would be suitable; under certain conditions it is a stronger joint than that for which it is a substitute. For $\frac{7}{8}''$ material, a $\frac{3}{8}''$ dowel should be used; but for anything thicker, a $\frac{1}{2}''$ dowel is generally necessary to give the desired strength. In doweling thick material, the dowels should be placed as shown in Fig. 156.

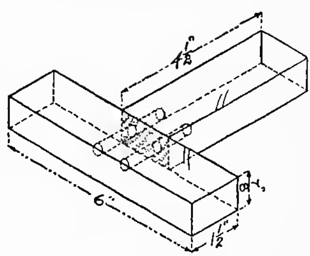

Fig. 155. — Doweled Joint.

A. Marking for dowels: Method 1. *The utmost accuracy is necessary in marking the centers of the holes and boring them,* if satisfactory results are desired. The principal application of this method is in doweling the joints of a wide board.

1. Place the two pieces in the exact relative positions that they are to occupy permanently, as at *A*, Fig. 157.

2. Make a pencil mark across the joint upon the faces of both pieces at once, as at *aa*.

3. With either a pencil or knife, square across both edges of the joint from the marks, as at *bb* of B.

4. With a sharp gauge, make mark *c*, which crosses *bb*. The intersection of these two lines gives the center of the hole, or the point at which the point of the worm of the bit should be placed.

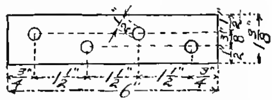

Fig. 156.—Dowels in Thick Material, Placed "Staggering."

5. A scratch awl should be used to make a small hole at the above described point, so that the bit will enter accurately, as otherwise it is apt to enter a little to one side of the intersection, or to follow the grain. The reason for this will be apparent if the point of the worm is examined, since it is the point of a spiral; hence, the point will have a tendency to push to one side when the worm enters the wood. Bore $\frac{3}{8}''$ holes 1″ deep, and fit the dowels so that they may be pushed in with the fingers.

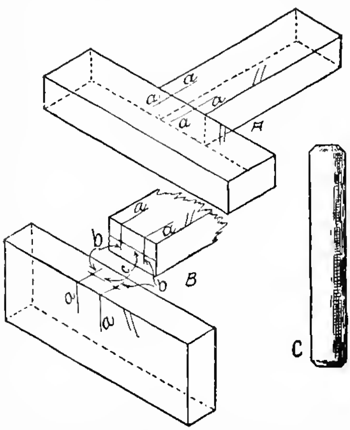

Fig. 157.—*A*, *B*, Marking for Dowels: Method 1. *C*, Pointed Dowel.

Smooth and sandpaper both pieces at once after the joint is made. Do not glue together.

Doweling an edge joint: In laying out dowel holes in preparation for gluing up a wide board, many workmen prefer an application of Method 1, and for medium-sized work it is quite as practicable, and often faster. Place the two pieces, as shown in Fig. 122, with the face sides out, and square across the edges of both pieces at once. With a gauge, working from face sides, mark the distance from the face of the board to the center of the dowel holes, and proceed as in the previous problems.

Length of dowels: It is not wise to use a dowel longer than is necessary; one extending from $\frac{3}{4}''$ to $1\frac{1}{4}''$ each side of the joint will hold as well as one reaching farther into the edge of the side wood, for the reason that the wood between the joint and the end of the dowel will shrink, and the longer the dowel, the greater the width of wood there is to be affected. A longer dowel may sometimes be necessary in the wide stile of a door, to give sufficient strength to resist the slamming which a door receives. A dowel should be at least $\frac{1}{8}''$ shorter than the aggregate depth of the holes which are to receive it, and should be made loose enough to be pushed in with the fingers, but not loose enough to fall out or to be rattled around. The ends of the dowel should be pointed, as at *C*, Fig. 157. This allows some of the glue to be forced up between the dowel and the sides of the hole, and not all pushed before the end of the dowel, which would be the result if the dowel were square-ended; unless the dowel were too loose, in which case it would not have its full strength, as the joint would not be wood to wood.

Uniformity: In boring holes for dowels, it is the custom of many workmen to use one of the many forms of bit stops upon the market, in order to insure a uniform depth to all of the holes; others count the turns of the bit, from twenty to twenty-five giving the desired depth. This uniformity is necessary, otherwise the dowels will have to be cut to different lengths, which will require care and time to locate in their proper holes while the joint is being glued up, just when every second of time is precious.

Comparison of the mortised and the doweled joint: As compared with a mortised joint, when used upon common doors, the dowel is not so satisfactory as the mortise, because the tenon reaches through the stile, and the glue, collecting at the joint as the pieces are brought together, makes a stronger connection there than at the end of the tenon at the outside of the stile; therefore, when the stile shrinks, it usually holds at the joint, and its outside edge draws toward the joint, allowing the end of the tenon to project beyond the stile the amount of the shrinkage. In a doweled door, the joint would probably open.

The material used in making the ordinary grade of commercial doors is apt to be less thoroughly seasoned than it should be, and, as a rule, there are not enough dowels used to give the joint its maximum strength. Moreover, the dowels are generally placed in a straight line, instead of "staggered," as shown in Fig. 156.

If a door which is exposed to the weather is properly doweled, it will stand better than a mortised door in which the tenon passes through the stile, since in the latter case the moisture will quickly find its way into the end of the tenon, and the door will be rapidly destroyed. The mortises of an outside door should be of the type known as "blind," or "fox wedging," Fig. 168, as in this way the end of the tenon is protected from the weather.

When used upon furniture and other work which is set up in a warm shop, and when made of thoroughly kiln-dried lumber, a properly made doweled joint is perfectly satisfactory.

B. Gluing the dowels: The glue should be put in the hole, and not on the dowel; otherwise it will be scraped off as the dowel is pushed into its place, unless the latter is fitted very loosely, in which case the glue will soak into the end wood of the pieces being glued together, not leaving enough to hold the dowel firmly. The joint should be well fitted before the glue is applied; it should be forced together, and held in place by clamps until the glue has set. In preparing for gluing up wide boards, which are to be doweled, apply Method 1 of marking for dowels.

C. Marking for dowels: Method 2.

This method of marking for dowels is sometimes used when it is not practicable to use Method 1, as in doweling irregular forms. See Fig. 158.

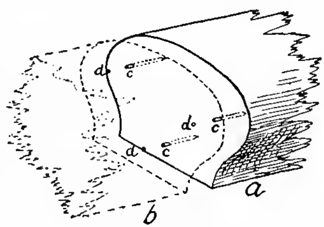

Fig. 158. — Marking for Dowels: Method 2.

1. Drive small brads, *c*, straight into the end of piece *a*.
2. Cut off the heads of the brads at about $\frac{1}{8}''$ from the wood.
3. Move piece *b* against *a*, being careful that the outsides are in just the right relation to each other, and apply enough pressure to make the brads leave imprints, *d*, in the end of piece *b*. These are the centers of the dowel holes.
4. Pull the brads out of piece *a*; the holes thus made are the centers of the dowel holes in that piece.

D. Marking for dowels: Method 3.

If it is desired to dowel irregular forms, or to make a number of joints just alike, this method will not only give good results and save a great deal of time, but the pieces just alike will be interchangeable.

1. *Use of the templet:* Make a templet of pasteboard; or, if it is to be used indefinitely, of tin or zinc, as shown in Fig. 159, and through it prick small holes in the position which will denote the exact centers of the desired dowels, as at *a*.

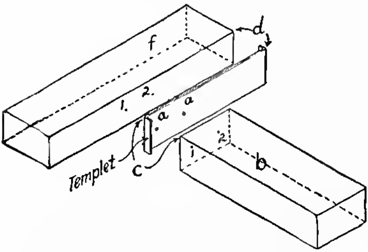

Fig. 159. — Marking for Dowels: Method 3.

2. Place the templet upon the end of piece *b*, with the corner *c* of the templet at *c* of piece *b*, and flush with the face side; with a pricker, mark through the holes of the templet the centers of the dowels, 1, 2.

3. Place *d* of the templet on the edge of *f*, and flush with the face side, so as to coincide exactly with *d* of piece *f*. Through the holes *a a* of the templet, mark 1, 2 upon the edge of piece *f*. This method is much used upon large or irregularly shaped work of all kinds, as it permits of accurate work, and needs no tools but the templet and the pricker. The ends of the templet need not be turned over, as indicated, except for the purpose of making more rapid work possible.

108. Mitered doweled joint. Fig. 160.

Material: 2 pieces, $6'' \times 2\frac{1}{2}'' \times \frac{7}{8}''$.

Fit the joint; then fit the dowels by Method 1, Fig. 157.

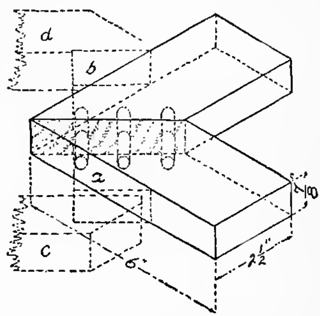

Fig. 160. — Mitered Doweled Joint: Method 1 of Gluing Angles.

A. Gluing a mitered joint: Method 1. It is plain that a joint of this shape will be hard to clamp rigidly, but pieces *a* and *b* indicate a common method of holding joints of this nature. The same principle may be applied to any irregular forms. These pieces are glued on by a rub joint, after the miter joint is fitted; when they have set perfectly, they are ready for use. It will be seen that they furnish a grip for the hand screws or clamps; therefore it is necessary that the faces which receive the clamps should be approximately parallel. The joint may now be treated as a doweled edge joint.

After the glue is set, remove the pieces *a, b* carefully; otherwise, they may take some of the wood of the model with them. Smooth and sandpaper the model.

B. Gluing a mitered joint: Method 2. Fig. 161 shows another method of holding a mitered joint, which is an application of the same

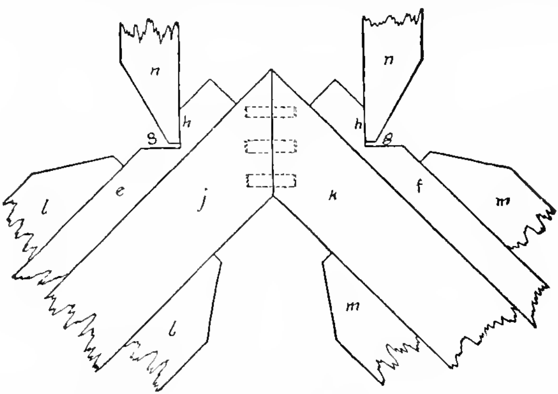

Fig. 161.—Mitered Doweled Joint: Method 2 of Gluing Angles.

principle, its advantage being that it may be used without waiting for the glue to set. After the joint is fitted, the clamp strips *e* and *f* should be prepared of any convenient material, and notches cut in them as at *g g*, faces *h h* being parallel. These clamp strips should be held rigidly to pieces *j, k* by hand screws, *l, m*. After the glue is applied, hand screw *n* will hold the joint rigidly in place until the glue has set. Smooth and sandpaper the model. Either of the above methods may be applied in gluing pieces of any angle or of any irregular shape.

109. **Miter box.** Fig. 162.

Material: 2 pieces, $16'' \times 3\frac{7}{8}'' \times \frac{7}{8}''$.
1 piece, $16'' \times 2\frac{1}{2}'' \times \frac{7}{8}''$.

This is an important adjunct to a kit of carpenter's tools, for if it is made accurately, a perfect miter may be fashioned by its use. A box of this sort is of course inferior to an iron miter box, but it may be made at any time, while the iron box is unhandy to carry around. A wooden box is accurate only when first made, but it may receive as many new cuts as the size of the box will permit.

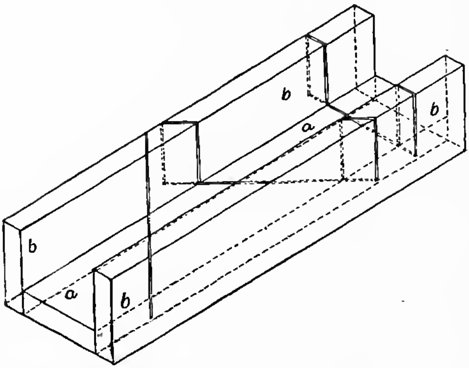

Fig. 162. —Wooden Miter Box.

Making the box: Joint the edges of the bottom perfectly square, and glue the sides upon them, holding the sides in place, until the glue sets, by means of hand screws. Be sure that when the sides are in their places, their inside angles with the bottom are all perfect right angles. This form of wooden miter box is the most satisfactory, as there is no danger of sawing upon nails.

If it is not practicable to use glue, the sides may be nailed upon the bottom, though the saw will in time cut down to the nails, unless care is used that the cuts are made and the nails driven so that they will clear each other.

Making the cuts: The miter cut for a square miter may be found by the steel square (see Fig. 33), the inside top corner of the back of the box being the line upon which the steel square is placed in marking for the cuts. Any equal figures upon the outside of both the blade and the tongue held to coincide exactly with the top of the inside of the box, as described above, will give the angle. Lines should then be squared with a sharp knife to the bottom of the box upon both the inside and the outside, and cuts made to these lines with a keen, sharp saw, preferably with the one which is to be used in it. The life of a miter box is lengthened if but one saw is used, and that one with a very little set. Trim the ends of the box after it has been made.

110. Joggled and wedged splice. Fig. 163.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This form of scarfed joint is used to lengthen timbers with the least possible sacrifice of shearing strength, the method used in making it being similar to that described in Topic 98. Like other forms of construction of this type, it is not used as much as formerly, on account of the development of steel construction. It is, however, valuable as an exercise in accuracy.

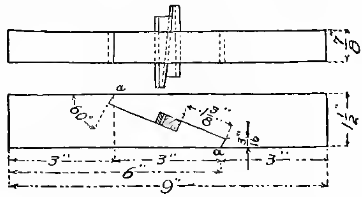

FIG. 163.—JOGGLED AND WEDGED SPLICE.

The cut at *a* is made at an angle of about 60° with the edges of the pieces, and should be about 3″ long. The angle of the joint should be ascertained by marking with a knife from the bottom of the cut of one edge to the face of *a* on the other. Transfer these lines to the other side of each piece.

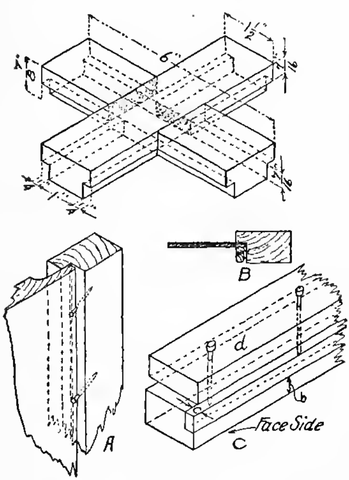

FIG. 164.—HALVED AND RABBETED JOINT.

The key should consist of two wedges, made to fit the key way snugly; do not cut the keys to a neat, or close, length, but leave them long enough to run through, and allow for driving them to bring the joint to a perfect fit. Afterwards they may be cut off, say $\frac{1}{4}''$ from each side of the model.

111. Halved and rabbeted joint. Fig. 164.

Material: 2 pieces, $6'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

Panelwork is sometimes built by this form of construction, the panels being put in and fastened from the back with brads, as shown at *A*. Glass doors are often made with a rabbet in the back, the joints being held in place by a bead, as shown at *B*, or by putty, though the rabbet is to be preferred.

Rabbeting by hand: At *C* is shown the method of rabbeting by hand. Note that, as the piece is shown, it is lying face side down, as the rabbet is to be upon the back side.

1. Gauge from the face the distance, *b*; in this case, $\frac{7}{16}''$.

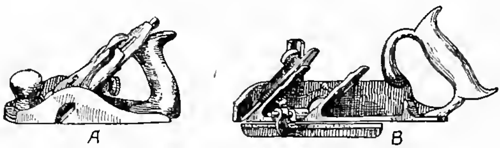

FIG. 165. — *A*, RABBET PLANE. *B*, FILLETSTER.

2. Gauge from the edge to obtain the other dimension of the rabbet, *c*; in this case, $\frac{1}{4}''$.

3. Place the fence piece, *d*, directly upon the piece to be rabbeted and hold the fence piece with small brads. Its purpose is to guide the rabbet plane (*A*, Fig. 165) in making the first cuts. The plane should be stopped directly at the gauge mark, *b*.

This joint is simply an elaboration of the halved joint, the same methods of cutting and fitting being used as in Topic 99.

A plane known as a "filletster" (*B*, Fig. 165) is constructed upon the same general principle as the rabbet plane, but it has, in addition, an adjustable depth and width gauge, which are a great convenience upon this kind of work, as their use makes the fence, *d*, and the gauge marks, *b* and *c*, superfluous.

Do not fasten this joint together with glue.

112. Table leg joint. Fig. 166.

Material:

1 piece, $4\frac{1}{2}'' \times 2\frac{1}{2}'' \times 2\frac{1}{2}''$.
2 pieces, $6'' \times 3'' \times \frac{7}{8}''$.

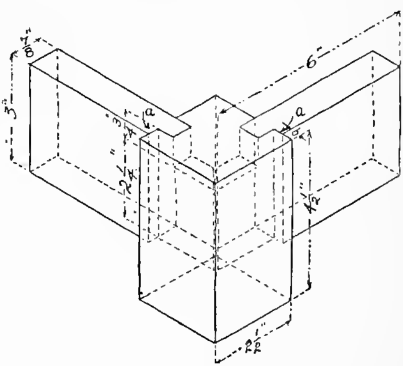

FIG. 166. — TABLE LEG JOINT.

As its name implies, this joint is used to fasten the rails and legs of a table together. It is an application of the mortised and the relish joint, Topic 104, but it has a shoulder upon the face side only, as at *a*. This saves making two cuts upon each end of each rail, and gives a thicker and stronger tenon. The dowel joint is frequently used as a substitute.

The mortise gauge should be used in marking the leg for the mortise; a sinkage of from $\frac{5}{16}''$ to $\frac{1}{2}''$ should be allowed at *b*. In cutting the tenons on the ends of the rails, we have an illustration of a case in which it is best to work from the *back* side, instead of from the face, as the thickness of the tenon must be marked from that side. The joint is sometimes drawbored from the back side, which adds much to the strength of the table.

Smooth and sandpaper separately, and do not glue together.

113. Double mortised joint. Fig. 167.

Material: 1 piece, $12'' \times 2'' \times \frac{7}{8}''$.
1 piece, $7'' \times 5'' \times \frac{7}{8}''$.

A. Comparison of a wide and double mortised joint: Where wide rails are used, such as the middle and bottom rails of a large panel

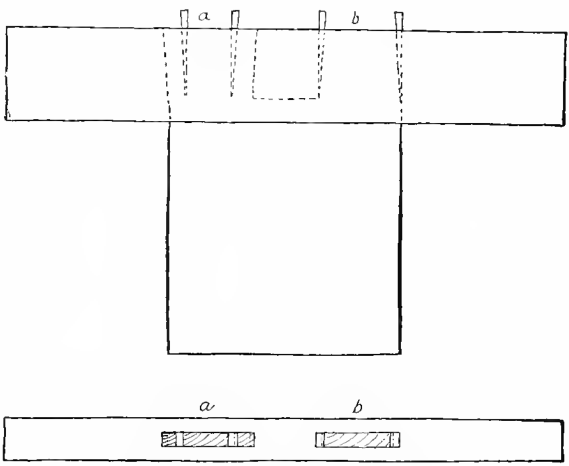

FIG. 167. — DOUBLE MORTISED JOINT.

door, a single mortise would cut away too much wood, and make a tenon of too great width. The middle of the length of a mortise long enough to receive a very wide tenon, would have little strength, as the wood would all have been cut away, and that on each side of the mortise would not be stiff enough to give the joint the strength and rigidity it should have. By making two tenons instead of one, the shrinkage of a wide tenon is distributed, and the liability of breaking the glue connection is much decreased. In driving the wedges, they should be driven as at *a*; not beside the tenon, as at *b*, though this is the method usually followed upon common work.

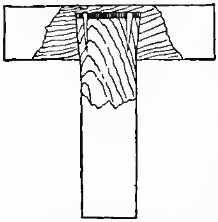

FIG. 168. — BLIND, OR FOX-WEDGED, MORTISED JOINT.

B. Blind, or fox, wedging: Upon the best grades of work, the wedges are frequently entered as shown in Fig. 168, which is called "blind," or "fox," wedging. In this, the mortise is cut longer at the bottom than at the joint, and when the tenons are forced into their places by the clamps, the wedges are pushed into the cuts made to receive them, thereby spreading the tenon and forming a dovetail, which makes a very strong joint. This joint is often used upon the best grades of outside doors, as the end of the tenon is not exposed to the weather. Good judgment and careful work are necessary to make this joint well.

114. Coped joint. Fig. 169 (sash joint).

Material: 1 piece, $6'' \times 2\frac{1}{2}'' \times 1\frac{3}{8}''$. Molded on one edge.
1 piece, $4'' \times 1'' \times 1\frac{3}{8}''$. Molded on two edges.

This material may be secured at a sash factory or a planing mill, though the student may make his own molding, as a straight bevel will answer all the purposes of this problem.

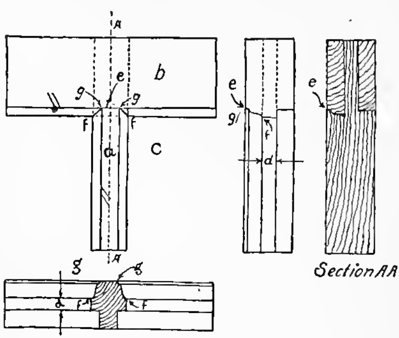

FIG. 169. — COPED JOINT.

"Coped joint" is the term applied to that form of butt joint in which the end piece, *a*, is fitted to the molded edge of piece *b*, the end of piece *a* being cut to fit the contour of piece *b*. The fact that the connection may be strengthened by a mortise, as it is in Fig. 169, or by a tongue and groove, as it is in *C* and *E* of

Fig. 170, does not alter the fact that the coped joint itself is an elaboration of the square butt joint.

Uses of the coped joint: A coped joint shows a miter on its face, as in the face view at *C*, Fig. 169; it is used in many places where moldings intersect, and it is desirable to show a miter, as in cutting in base moldings, as at *A*, Fig. 170, or room moldings, as at *B*. It is chiefly employed upon moldings of small dimensions. In practice, if an inside joint is mitered, the joint will be nailed open when the nails are driven; but if it is coped, the full length piece, *b*, of *A* and *B*, Fig. 170, is nailed firmly into its permanent place, and the coped pieces, *a*, are cut long enough to allow them to be sprung and forced into making a perfect fit.

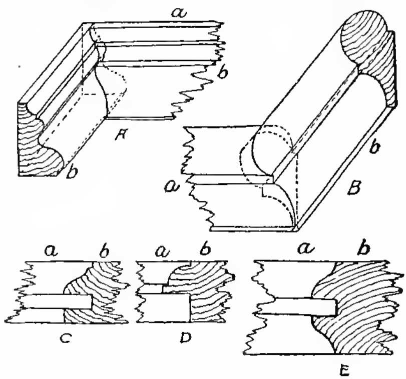

FIG. 170. — USES OF THE COPED JOINT.

Fitting a coped joint: In describing this exercise, the joint of a sash has been taken as a model. After the pieces are prepared, proceed as follows:

1. Mark tenon on *a*, and mortise on *b* of Fig. 169, so that they will each come in the flat inside edge, *d*; cut them, working only to the shoulder, *e*.

2. Place *a* in a miter box and cut the miters *f*, *g*, mitering the molding only. As a coped joint shows a miter, this will give the edge, or line, to which the end must be cut.

3. With convenient sizes of chisels and gouges, cut away the wood, leaving the mitered edges *f*, *g*, of piece *a*, as shown in section *AA*; cut back far enough so there will be no wood to prevent piece *a* from fitting perfectly against the edge of *b*, but be careful not to cut back of the edges, *f*, *g*, on the surface of the molding, or back of the shoulder, *e*, on the face of piece *a*. Cut the pieces to the desired length, smooth and sandpaper them.

Forms of this joint are used in making ordinary grades of panelwork and stock doors; see *C*, *D*, *E*, Fig. 170.

115. Wedged and halved scarfed joint. Fig. 171.

Material: 2 pieces, $6\frac{3}{8}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$.

This joint is used in heavy wooden construction in places where it is necessary to have the greatest tensile strength, though it is obviously a weaker joint in regard to resistance to a shearing stress, if concentrated at the joint, than is that described in Exercise 110.

After the pieces *a* and *b* have been accurately squared and made parallel, proceed as follows:

1. *Fitting the joint:* Lay the pieces side by side in their relative positions, and with a sharp knife mark distinctly, by the edge of a

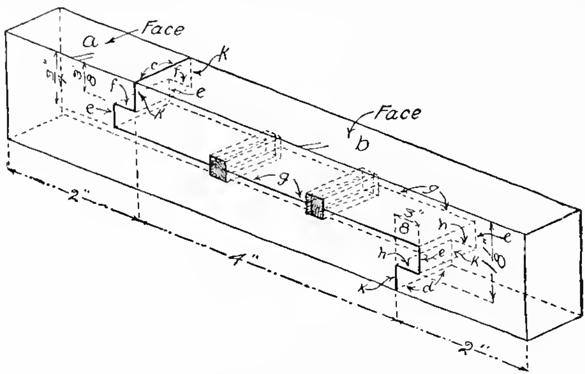

Fig. 171.—Halved and Wedged Scarfed Joint.

square, the lines *c, d* upon both edges of each piece. Notice that the lines are 2″ from one end of each, and $\frac{3}{8}''$ from the other end.

2. With a fine, hard pencil, mark lines square with the edges lightly upon both sides.

3. With a sharp gauge, lay out upon both sides of each piece in the order given, the lines *f, g, h*; be careful not to continue the lines beyond the point where they will cut away, or they will cause a blemish upon the finished model. Work from the face side and edge at all times.

4. Go over *c, d, e, k* with the knife, carefully.

5. In cutting to the marks, leave half of the knife or gauge marks upon the piece wanted. Saw in the following order: *c, k* to *C*, and *d, k* to *g, f, h*. With a sharp chisel, cut *e*, cutting back of the lines in

the thickness of each piece. To insure a tight fit at *g*, the joint should be perfectly straight: if there is any deviation, it should be a little rounding in its length. If this should be done very carefully, and if all the work is executed with accuracy, all members of the joint will fit perfectly.

6. After all the fitting is done, clamp the pieces in their permanent position, and with a knife mark the key ways and fit the wedge keys, which may be allowed to project $\frac{1}{4}''$ upon each side, if desired.

7. Smooth and sandpaper.

116. Plain dovetailed joint. Fig. 172.

Material: 2 pieces, $4\frac{1}{2}'' \times 3'' \times \frac{7}{8}''$.

This joint is rarely used upon anything but the most expensive work, as it requires a high degree of skill to make it economically. It forms the strongest possible unreënforced joint for the corners of boxes, chests, etc.

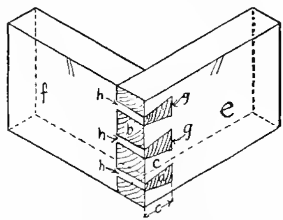

FIG. 172.—PLAIN DOVETAILED JOINT.

A. Laying out and cutting the dovetails: In making a dovetailed joint, some workmen lay out and cut the pin, *a*, first, which necessitates that the tails, *b*, should be marked and cut one at a time. Good results may be obtained by this method, but it is slow, and is rarely used upon practical work. The common method used by workmen is to saw the tails, *b*, first, and mark the pins by the tails. If two or more joints are to be dovetailed alike, the sides may be made into a bunch, and all sawed at once, as shown in Fig. 173.

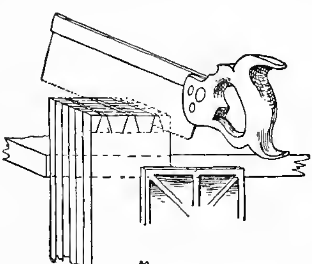
FIG. 173.—SAWING DOVETAILS.

The pieces for this exercise should be prepared about 2″ longer than actually needed, as it is possible that the first attempt will be a failure.

1. Make the ends to be dovetailed perfectly square and true.

2. Gauge upon each side from these ends, the distance, *c*, or the thickness of the piece to be dovetailed.

3. Place *e*, or the tailpiece, in the vise, end up, and face side toward the

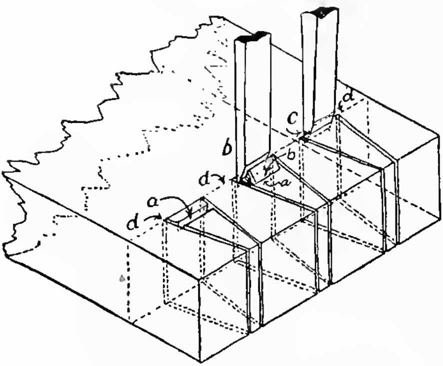

Fig. 174. — Cutting Dovetails.

workman. Beginning at an equal distance from each edge, say $\frac{5}{8}''$, mark the distance, *h*, of the two outside tails. These should be rather small, not more than $\frac{3}{16}''$. Lay out an equal distance halfway between these two for another tail.

4. Mark the bevel of the pin; this may vary, but the bottom, *g*, of the tail, should not be more than $\frac{9}{16}''$ for $\frac{7}{8}''$ stock. If the angle of the tail is too sharp, it is apt to be broken off when the pieces are driven together.

5. Saw with a backsaw, in every case leaving the line of the piece which is wanted.

6. Lay the pieces face down upon the bench, and with a chisel narrower than the bottom of the cut, make one cut, as at *a*, Fig. 174. This will minimize the tendency of the chisel to push back, so that when the next cut is made upon the line *d*, the wood will break into cut *a*, as at *b*, instead of pushing the chisel back of line *d*, as at *c*, which will probably happen if cut *a* is omitted.

7. The gauge mark, *d*, at the bottom of the pin cut upon both sides should be kept perfectly straight, and the cut be made exactly to this line, as a straight piece of wood is to fit against it. The section of the cut should be similar to *d*, Fig. 175, and half of it cut from each side, holding the chisel, as shown by the try-square at *a*, so as to cut under, which will allow the edges *b*, *c* to fit closely against the pin. The novice is more than likely to make a cut that will be full in the middle

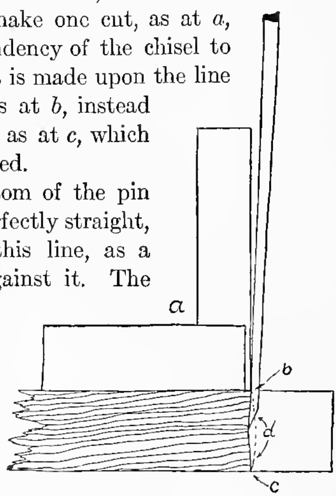

Fig. 175. — Section of Dovetail.

of the thickness of the board, shown by the dotted line at d, which will prevent the pin from making a good joint at b and c. Grasp the chisel as shown in Fig. 148.

8. Turn the piece over, face up, and make the cut from that side; clean out the chips, or core.

B. Marking and cutting the pins.

1. Place f, of Fig. 176, in the vise in a vertical position.

2. Place piece e upon the end of piece f, as indicated. It is important that the mark d, which is the same as d of Fig. 174, should exactly coincide with the corner, or the back side, of piece f. The relation of the ends of the tails of e, with the face of f, at h, is of no importance, providing they are long enough to come flush, or project by the face of f. If piece e cannot be held firmly enough to allow of accurate marking, it may be held by small brads driven through the tails, as at k. *Avoid doing this if possible, as the holes will show in the finished model.*

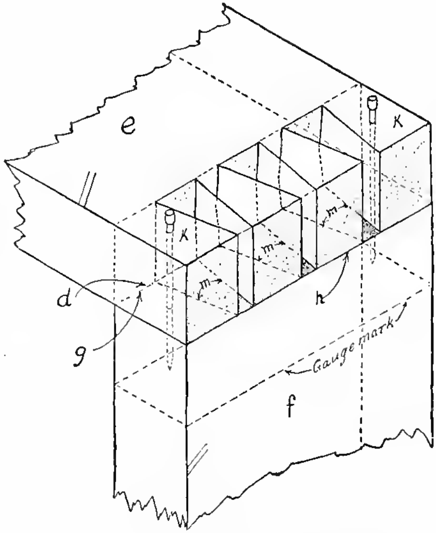

Fig. 176. — Dovetailing; Marking Pins.

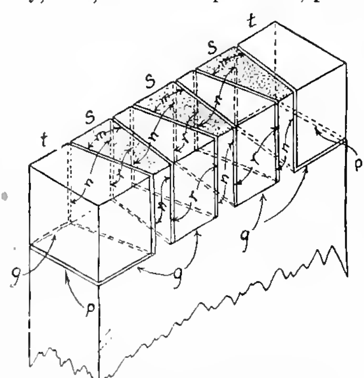

Fig. 177. — Dovetailing; Sawing Pins.

3. Remove piece e, and with try-square and sharp pencil, or knife, mark lines, n, upon the face and back side of f, as in Fig. 177.

4. With backsaw, cut down to lines g, as shown by double lines, being careful that in every

case the cut is made outside of *m* and *n*, or that these lines are left on the pin.

5. Turn the piece over in the vise so that the cuts *p*, *g* may be made in each edge. These should be made exactly to the line upon each surface of the cut, with a backsaw. This will cut out the corner, *t*. If the work has been accurately done, these corners should not be touched again.

6. Clean out the spaces, *r*, with a chisel by the same method used in cutting the tails. See *A* 6, of this topic.

7. If this work has been done with sufficient accuracy, there will be no need of trimming either the pin or the tail to allow the two pieces to come together and make a perfect joint. To attain this accuracy should be the ambition of each student, as the skillful workman must be able to make dovetails rapidly, surely, and without trimming. In cutting the pins, the amateur is quite as likely to cut inside as outside of the lines, thus making the pins too small; this tendency should be guarded against, and the pins, *s*, *s*, *s*, left the exact size desired. In every case, the saw cut should be made with such care that chiseling or fitting will be unnecessary, as it is quite as likely to injure as to improve the joint.

8. The inside of both pieces should be smoothed and sandpapered before being put together permanently; and care should be taken not to plane any off of the back side of the pins, or they may be too small. If the pins fit too closely, with a hammer bruise the corners of their ends a little, where they enter the space between the tails; this makes them a little smaller, but when they are glued together, the moisture of the glue will swell the pins to their normal size. Glue the pieces together, being sure that the angle of the joint is square; apply the glue sparingly.

If the work has been done accurately, the joint should be so tight that when it is set away for the glue to harden, it will hold itself together without the aid of hand screws; though if necessary, these may be used judiciously.

9. Smooth and sandpaper.

117. Half-blind dovetailed joint. Fig. 178.

Material: 1 front, $4\frac{1}{2}'' \times 3'' \times \frac{7}{8}''$.
1 side, $4\frac{1}{2}'' \times 3'' \times \frac{1}{2}''$.

This is the joint which is used in the construction of drawers upon the best grades of work. (In laying out the dovetails of a drawer side, care should be used that the groove for the drawer bottom comes in one of the tails, for if it comes in a pin, it will show upon the end of the drawer front.) As this is the form of dovetailing used the most, there have been several machines invented for the purpose of dovetailing drawers, and the work of the best of these is equal in strength to the work done by hand, though no machine has yet been devised which will exactly reproduce hand-made dovetails.

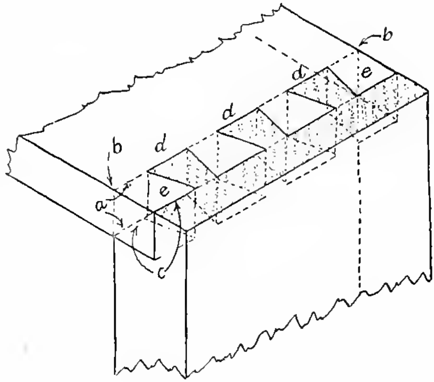

FIG. 178. — HALF-BLIND DOVETAILED JOINT.

In making the half-blind dovetailed joint, we have another instance in which it is necessary to work from the back, instead of from the face of the front, as we will designate the $\frac{7}{8}''$ piece.

After the pieces have been prepared as described in the last paragraph of Topic 116 *A*, proceed as follows:

1. *Marking and cutting the joint:* Set the gauge to the thickness of the side, and gauge upon both sides of the end of the side which is to be dovetailed, as at *a a*. Without changing the set of the gauge, working from the back corner, or corner *b*, of the back of the front, make gauge marks, *c*, which indicate the length and depth of the space that must be cut out from between the pins, *d, d, d*, and the corners, *c, c*.

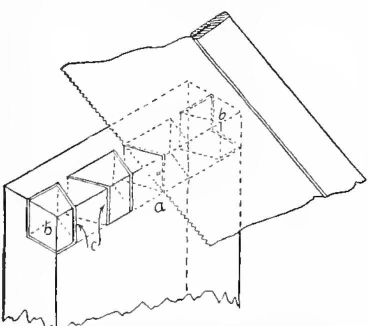

FIG. 179. — HALF-BLIND DOVETAIL; SAWING THE PINS.

2. Lay out, saw, and cut the dovetails upon the end of the side. Mark the pins upon the end of the front, being careful that the lines *a* of the side, and *b*

of the front, coincide perfectly, and proceed by the same method as in the preceding problem. The experienced workman learns to make the cut without the guide lines *c*, of Fig. 179, with sufficient accuracy to insure a good fit, but the amateur should be cautious in attempting methods of work which are beyond his skill.

3. Saw the pins as indicated in Fig. 179 at *a*, and with a chisel cut out the rest of the space which is to receive the dovetails of the side. Workmen who have much of this to do generally have a short, stout chisel, which may be handled more easily than one of the ordinary size. Cut out corners, *e*, with a backsaw, as far as possible, placing the piece in the vise so that a nearly vertical cut may be made on all sides, as it is difficult to make an accurate cut in any other position.

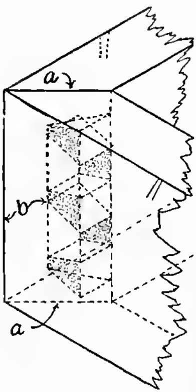

Fig. 180. — Blind Dovetailed Joint.

4. Smooth and sandpaper the inside of the model.

5. Glue together, smooth and sandpaper as in the plain dovetail.

118. Blind dovetailed joint. Fig. 180.

Material: 2 pieces, $4\frac{1}{2}'' \times 3'' \times \frac{7}{8}''$.

On account of the time and skill necessary to make this joint, and from the fact that after all the work has been done, it appears no different from an ordinary miter joint, it is used only upon the finest work. It is, however, an excellent exercise in accuracy.

In making this joint, proceed as follows, observing the utmost care and accuracy at each step: —

1. *Marking and cutting the joint:* Lay out the miter upon the four surfaces of each piece, making a distinct knife mark.

2. Lay out the square *a a*, indicated by dotted lines in Fig. 181, which is to receive the dovetails.

3. Cut the square *a a* to exact size, being careful not to cut beyond the miter lines, using a backsaw and finishing with chisels.

4. With a backsaw cut the miters, trimming with a chisel exactly to surface lines and to lines *b*, if the saw cut is not sufficiently accurate.

5. Mark the tails in the square of piece *B* and cut them by the same method used in cutting the spaces between the tails in the previous

problem. To assist in accurate marking, make a templet of a piece of thin cardboard or zinc, similar to that shown in Fig. 159, on which the bevels of all the teeth are carefully laid out, and cut and use this to mark the bevels on both pieces. This may be done by measuring, if desired, but a templet makes more accurate work possible.

6. Lay out and cut the pins, using the templet. If a large piece of this form of construction is being made, the marking may be done by the same method as in Topic 116.

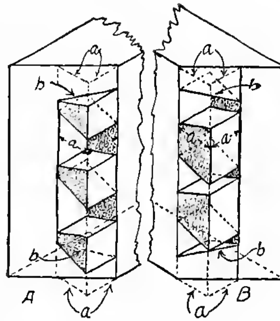

FIG. 181.—BLIND DOVETAIL: METHOD OF FITTING THE JOINT.

7. This joint should not be glued together, as the construction cannot then be seen. Smooth and sandpaper as in the preceding problem.

SUGGESTIVE EXERCISES

87. What nature of wood is best adapted for use in the work of this chapter? What kinds of wood? Why should not files, rasps, or sandpaper be used in making joints? Should pieces be cut to their exact length before fitting the joint? Why?

88. Demonstrate the process of "lining off." How should saw cuts be made in relation to guiding lines and the pieces wanted? What are the probable results of forcing a saw? Describe and give reasons for the progression in squaring up a board. How should a straight edge be tested? Why should a block plane not cut from edge to edge across the end of a board? How prevent the bench dog from bruising the end of a board? Describe the face edge. Why is it important?

89. Why is Exercise 88 *L* omitted in most of the work of this chapter? What should be guarded against while cutting grooves with a backsaw and chisel? Demonstrate method of holding work and using tools in cutting grooves.

90. Why use knife in making marks demanding accuracy? Describe uses of the square butt joint. Give a good general rule which applies to cutting and fitting stock.

91. Describe the uses of an end butt joint.

92. Are best results obtained if an edge or glue joint is in perfect contact the entire length? Why? For what is an edge joint used? What is apt to happen if the joint is forced by clamps too much? Describe method of joining both edges of a board at once. Describe method of joining boards less than 4 ft. long. What is meant by the "face mark"? What is meant by "end for end"? What is meant by "out of wind"? How should a well-made joint appear to a trained eye? If a joint is well made, how many clamps are necessary in gluing it up? Describe a rub joint, and process of making it. Should a joint be made "wood to wood," or should there be a perceptible line of glue? Describe conditions under which glue should be used. Describe the glue room of a factory. Describe preparations for gluing. Describe process of gluing. What tools are used in preparing for sandpaper? How should sandpaper be held around the block? How should curved surfaces be sandpapered? At what stage of the work should sandpapering be done? What is the result if edge tools are used after sandpapering? What should the workman guard against in sandpapering around curves or square corners? How should a sharp corner be treated? How should sandpaper be used in relation to the grain? What exceptions to this rule? What is the danger in the use of sandpaper by an amateur?

93. Describe an intersection joint and its uses.

94. Describe a lap joint and its uses.

95. Describe a fished joint and its uses. How is it strengthened for heavy work?

96. Describe a mitered joint and its uses. Demonstrate method of placing different forms of moldings in the miter box. Describe method of mitering by a bevel. How should a molding with a finished face be held in a vise?

97. Describe a halved scarfed joint: its uses; method of making. Demonstrate method of trimming a joint with a chisel. How should a halved joint be supported when used as a girder?

98. Describe a tapered scarfed joint and its uses. Compare it with the halved joint. Describe method of making.

99. Describe the lock joint; its uses, and process of making.

100. Describe the housed or tank joint and its uses. How should it be made thoroughly water-tight? How may the bottom of a sink be made water-tight?

101. Describe a beveled or halved joint and its uses.

102. Describe a checked joint and its uses.

103. Describe a mortised joint. Name its two parts. What kind of gauge should be used in making this joint? Describe method of marking and cutting both members of the joint. Describe method of grasping chisel for accurate work. Describe drawboring and its uses.

104. Describe a mortised joint and relish and its uses.

105. Describe a dovetailed brace joint; its uses, and process of making.

106. Describe a mitered halved joint and its uses.

107. Describe a doweled joint and its uses. Compare it with a mortised joint. What size dowel should be used for $\frac{7}{8}''$ materials? for material an inch or over in thickness? How should dowels be placed in thick material? Demonstrate the process of marking for dowels and of making a joint. Compare long and short dowels. How should a dowel be glued? How long should a joint remain in the clamps if made with cold glue? If made with hot glue? Describe process of marking dowel holes with brads; with a templet.

108. Describe a mitered doweled joint and its uses. Describe two methods of gluing.

109. Describe a miter box and its use. Compare iron and wood boxes. How should a wooden box be made? Demonstrate method of laying out a miter.

110. Describe a joggled and wedged splice. Describe its uses.

111. Describe a halved and rabbeted joint and its uses. Describe the rabbet plane and its use.

112. Describe a table leg joint. What joint is often substituted?

113. Describe a double mortised joint and its uses. Demonstrate different methods of wedging.

114. Describe a coped joint and its uses. Describe process of making it. Compare it with a mitered joint.

115. Describe a wedged and halved scarfed joint. Describe its uses. Demonstrate method of making joint.

116. Describe a plain dovetailed joint: its uses, and method of making. Demonstrate the method of holding a chisel. What should be guarded against in smoothing the inside of the pin member?

117. Compare the plain dovetail with the half-blind dovetail. What should be considered in laying out the dovetails of a drawer side?

118. Describe a blind dovetailed joint. Why is it not used commonly?

CHAPTER IX

SUPPLEMENTARY MODELS

THE construction of the following supplementary exercises is based upon the problems discussed in the previous chapter. It is assumed that the student has, by the preceding exercises, gained a knowledge of tools and processes sufficient to enable him to select wisely those which he should use to accomplish certain results; therefore these models are intended to be only suggestive, and it is not necessary to follow the course as outlined. Any model may be selected which is of approximately the same degree of difficulty as those described. Specified exercises will not generally be mentioned, but at each step the previous work should be reviewed, and its application to the work in hand carefully considered. Complete dimensions of models are sometimes purposely omitted, as the student should use his judgment in developing a working drawing from the sketch of each model that he makes. The stock lists are made out for a few of the models simply to indicate the method to be followed in making out the lists for others, and not for the purpose of making the work easy. Unless noted otherwise, the following models may be made of any soft wood. In making them, the student should in each case first make a working drawing, being guided by Chapter VII. A stock list should be prepared by the method indicated in those following. The exact dimensions should be placed upon the stock list in the order given, — length, width, and thickness, though in some localities the order is thickness, width, and length. Allowance for working should be made when the stock is cut.

119. **Bench hook.** Fig. 182. (*See* Handbook: Fig. 14.)

A. Stock list: 1 cutting board, $12'' \times 6'' \times \frac{7}{8}''$.
1 hook, $2\frac{1}{2}'' \times 6'' \times \frac{7}{8}''$.
1 rest, $2\frac{1}{2}'' \times 4'' \times \frac{7}{8}''$.

B. Length and width of wood: In the above dimensions, which are given in the order of length, width, and thickness, it will be noticed that the last two items are wider than they are long. It is the invariable custom that the length of a board shall be parallel with the

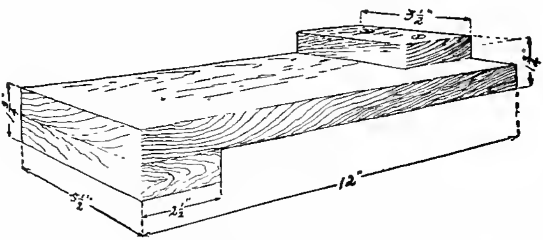

FIG. 182. — BENCH HOOK.

grain, and the width at right angles to it. This model is useful upon the work bench for the purpose of holding work while it is being cut (see Figs. 115 and 117), and of providing a place upon which all cutting should be done, as a cut should never be made directly upon the bench with any sort of cutting tool.

C. Sequence of work: 1. Prepare one piece $\frac{1}{4}''$ wider and $2\frac{1}{2}''$ longer than necessary to include all the pieces in one length.

2. Plane one edge, and block plane each end straight and square, regardless of the length of the piece.

3. Cut one piece 3″ long from each end, and make one piece of the required width for the rest, or narrow piece.

4. Plane the cutting board smooth, but do not sandpaper it.

5. The vertical distance between the inside faces of the hook and

the rest should, of course, be 7″, which should be laid off in the middle of the length of the cutting board. Indicate the location of the hook by two knife points (not a mark) the entire width of the board. Locate the rest upon the opposite side of the board by the same method, as shown in the sketch. In placing both pieces, the squared end should form the vertical faces. *Do not mark with a pencil, as the black mark will disfigure the finished model.*

6. Bore screw holes in the hook and in the rest, using a German bit, and countersink the holes; by this is meant the boring of a hole which tapers from the surface of the board to the center of the hole, and which allows the screw head to be driven flush, or below the surface of the wood. Hold both pieces in their exact places, and with a hammer tap the screws lightly, but sufficiently to mark the holes in the cutting board; remove the pieces preparatory to gluing, and bore small holes in the cutting board to receive the screws.

7. Be sure that both the small pieces fit the cutting board; spread the glue *sparingly* upon the side of the hook which is to form the joint, and force it into its place by screws. Do the same with the rest, and whether the joint is as good as it should be or not, apply hand screws to force the pieces of wood closely together, and hold them while the glue hardens. If the pieces are not held firmly, the moisture of the glue will cause the pieces to swell upon the sides which have received it, thus causing the joint to open at the edges.

8. After the glue has hardened, treat the pieces as one, cut to length, blockplane the ends, plane to width, and make the model square and true. If the work is planned and executed accurately, each of the three pieces will finish the size called for in the stock list.

120. Coat hanger. Fig. 183. (*See* Handbook: Fig. 18.)

Material: 1 piece, $15\frac{1}{2}'' \times 2\frac{1}{2}'' \times \frac{7}{8}''$. (*See* Note, page 231.)

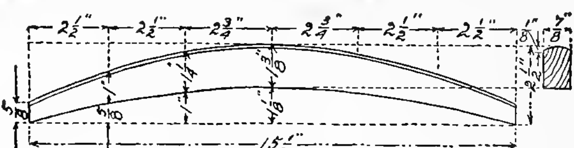

FIG. 183. — COAT HANGER.

A. Drawing curves through given points: Make the piece square and parallel, and mark the intersections of the curves upon it from the dimensions given; these marks should be made upon the face side, as shown in the sketch, and curves should be carefully drawn through the intersections, as indicated. They should be drawn free hand; by resting the elbow upon the bench, and using it as the center of an arc, an almost perfect curve may be made. In working down to these marks

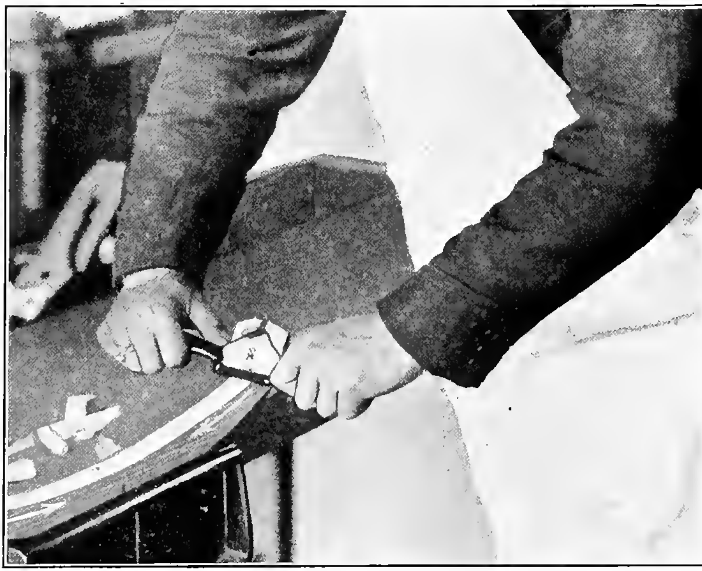

FIG. 184. — USE OF THE SPOKESHAVE — TAKING ADVANTAGE OF THE GRAIN.

with a compass saw, or with a frame or turning saw, care should be used that the marks are not cut off. (A *frame saw* is simply a small bucksaw; it is preferred by many workmen for nearly all purposes for which a compass saw would ordinarily be used, as it does not bend nor break so easily, and the arc of a smaller circle may be cut.)

B. Sawing "under": It seems that every novice has an irresistible tendency to "cut under" in a case of this sort; that is, to make the back side of a piece of work smaller than its face: the result of this is, that the piece must be cut below size, or the edge finished out of square, neither of which is permissible. To prevent this, the edge of the blade should be carried as nearly as possible at right angles with the face of the board, and about $\frac{1}{8}''$ outside of the mark.

C. The grain: Study the direction in which the grain runs, and as the spokeshave is to be used, the student should be careful to work in the direction in which the tool cuts without tearing the grain. The method of grasping the spokeshave is shown in Fig. 184, and the direction indicated by the arrows should be the direction of the cut of the spokeshave upon the inside of the model. Upon the outside of the coat hanger, the stroke should be made from the middle to the end. Ordinarily the spokeshave should leave soft wood and straight-grained hard wood smooth enough for sandpapering.

D. Use of the wood file: On this model the *wood file* may be used. This tool may be used on soft wood only when a curly or cross-grained place makes it necessary; its principal use is in working into curves and corners of both hard and soft woods which cannot be reached easily with the spokeshave.

E. Machine planing: Boards which have been run through the planing machine are not ready for the sandpaper; they should always be smoothed with a smoothing plane, as it is almost impossible to remove with sandpaper the minute ridges which are left by the planer at right angles with the grain of the wood.

F. Smoothing and sandpapering: The term "smoothing" applies only to planing; if sandpapering is meant, it will be noted separately.

This model should receive a shellac finish, well rubbed down; one coat of shellac will be enough, if it is not too thin, and provided it is finished with wax finish and well rubbed.

121. Foot rest. Fig. 185. (*See* Handbook: Fig. 37.)

Material: Any wood of medium hardness.

1 top, $13'' \times 8\frac{1}{2}'' \times \frac{7}{8}''$.
4 legs, $6\frac{1}{2}'' \times 1'' \times \frac{7}{8}''$.
2 side rails, $12\frac{1}{2}'' \times 1\frac{3}{4}'' \times \frac{5}{8}''$.
2 end rails, $8'' \times 1\frac{3}{4}'' \times \frac{5}{8}''$.

Make allowances for working beyond listed dimensions.

In this model the joints are locked, $\frac{3}{16}''$ being cut out of each leg and intersecting rail, allowing the latter to project $\frac{1}{4}''$ beyond the legs.

A. Fitting locked joints: Care should be used in cutting the joints, as the sides of the cut must be square with both the face sides and the edges. It is safer to make the cuts very close, since it is better to have to trim a little, than to have an open joint. As the student gains skill, the correct cut will be made the first time. See Topic 99.

B. Cutting "standing": Contrary to the tendency of the amateur in the previous model, his tendency in work of this sort is to cut "standing"; that is, to make the sides of the cut wedge-shaped toward each other, thus preventing the piece, which is supposed to fit, from coming to a joint. In theory, a joint of this sort should always be cut perfectly square with the face; but in practice, either it should be cut slightly under, or the bottom of the cut should be made a very little larger than at the face of the joint, in order to insure a perfect fit upon the face.

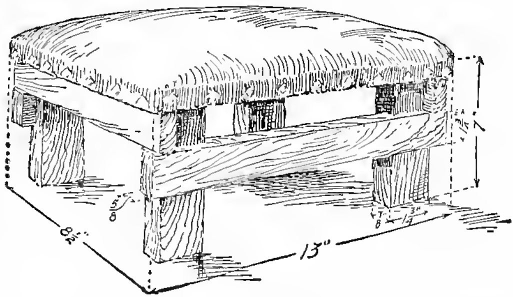

FIG. 185.—FOOT REST.

C. Smoothing and scraping: These pieces should be smoothed, scraped, and sandpapered before being glued together. The top should be put on by dowels, by Method 2, Topic 107.

Finishing: This model may be finished in the natural wood by a filler and shellac, or by a stain with either a shellac or a wax finish.

Upholstering: If desired, the top may be made of any ordinary wood, and upholstered by covering it loosely with cotton cloth fastened on three edges, and filled from the fourth with curled hair, moss, or tow. It should then be covered with the desired material, which should be fastened to the edge with common tacks, and the latter covered with gimp and ornamental upholsterer's tacks.

122. Tool box. Fig. 186.

Material: Pine or poplar.

1 bottom, *a*, $20'' \times 12'' \times \frac{1}{2}''$.
1 partition, *b*, $18\frac{1}{2}'' \times 7'' \times \frac{5}{8}''$.
2 sides, *c*, $19'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$.
2 ends, *d*, $10\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$.
1 handle, *e*, $7\frac{1}{2}'' \times 1\frac{1}{4}'' \times 1\frac{1}{4}''$.

A. The bottom and sides: The bottom of this box should not be cut to the exact size until the ends and sides are nailed together, on account of the possibility of variation, as the bottom is to fit the rim, and not the rim the bottom. The student will notice that the partition

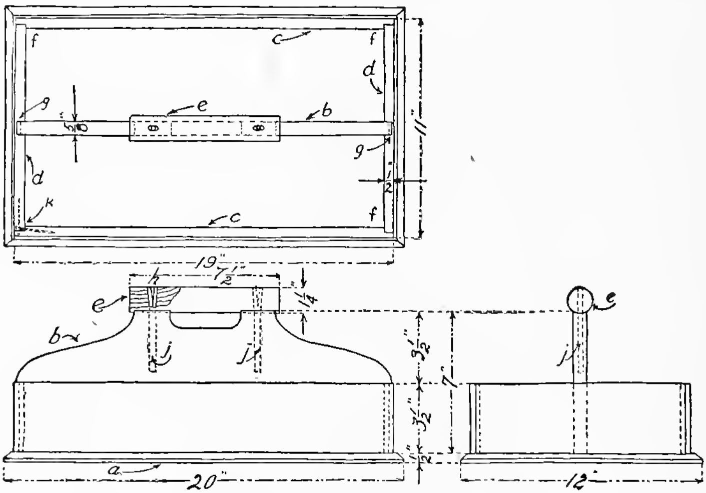

FIG. 186. — TOOL BOX.

is halved, or housed, into each end, as at *g*, and the ends into the sides, as at *f*, each joint being cut halfway through the thickness of the stock. The curves of the partition should be carefully studied, and accurately worked out.

B. The rim: The sides and ends of the rim should be smoothed upon both sides, and sandpapered upon the inner sides before being put together; the outer sides of these pieces may be sandpapered better after they are nailed together. The grooves in the ends for the partition should be cut before the pieces are sandpapered on the inner side.

Glue should be used *sparingly* on the joints of the rim, so as not to be squeezed into the inside of the box, thereby causing unnecessary work in cleaning it off. The bottom should be made square, and of a size to project beyond the rim $\frac{1}{2}''$ upon all sides, after which the corner should be chamfered as indicated, or rounded to a true quarter round. If the latter form is adopted, care should be used that the curve does not extend upon the top of the bottom far enough to prevent the rim of the box from fitting.

C. Fitting the rim to the bottom: In order to insure that the joint between the bottom of the rim and the bottom of the box is as nearly perfect as possible, the inside of the bottom of the rim should be planed under a little. This may be accomplished by resting the plane upon two sides of the box rim, and making the stroke as shown in Fig. 187, the iron cutting between its center and the outside of the face of the plane. This will allow the middle of the iron to cut upon the inside of the box more than upon the outside, thus "cutting under," and making the outside of the box fit the bottom closely where it is the most conspicuous.

Fig. 187. — Planing the Edge of a Box to Fit the Bottom.

D. The partition and handle. The partition, *b*, Fig. 186, should be smoothed and sandpapered and put in its place and nailed; and the round handle, *e*, prepared and fastened by $\frac{1}{4}''$ dowels, which should be thoroughly glued and wedged, as at *h*, to prevent the handle from being pulled off. Be sure that the wedges are driven at right angles with the grain, or they may split the handle. Extreme care should be exercised not to bore the holes which are to receive the dowels through the sides of the partition at *j*. Long, slender, round-headed screws may be used instead of the $\frac{1}{4}''$ dowels, if desired.

E. Nailing: In nailing the box together, $1\frac{1}{4}''$ brads should be used, which should be driven both ways of the joint, as shown at *k*, Fig. 186. Do not use common nails, as they should be used only upon the roughest work, and where the greatest strength is necessary.

F. Nails: The nails used by carpenters, illustrated in Fig. 188, are of four different kinds, as follows: —

Common nails, *A*, which range in size from 3*d* (3 penny) to 60*d* box nails, other nails for common use being generally of this type.

Finish nails, *B*, which range in size from 6*d* to 10*d*, and are used for moldings, picture frames, and other places where it is required that the nails should be as nearly invisible as possible. This shape of head may be set beneath the surface with the least danger of splitting the wood. The smaller sizes of this type of nail are called brads, or sprigs, and range in sizes from $\frac{3}{8}''$ to $1\frac{1}{2}''$ and are of different sizes of wire.

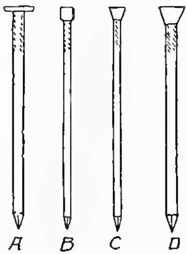

FIG. 188.

A, Common nail.
B, Finish nail, or brad.
C, Casing nail.
D, Flooring nail.

Casing nails, *C*, used for fastening casings, or inside finish, though the finish nails are often used for this purpose. The heads of these nails are supposed to enter the wood without tearing it, making only a clean round hole.

Flooring nails, *D*, the most essential difference between this type of nail and the finish or casing nail being the size of wire from which it is made, which will, in most cases, allow the nail to be driven into moderately hard wood without the necessity of boring a hole for each nail.

123. Bookshelf. Fig. 189.

Material: 2 ends, $18\frac{3}{4}'' \times 6'' \times \frac{5}{8}''$.
2 shelves, $23\frac{1}{4}'' \times 5\frac{3}{8}'' \times \frac{5}{8}''$.
1 back, $23\frac{1}{2}'' \times 6'' \times \frac{1}{2}''$.
1 back, $23\frac{1}{4}'' \times 4'' \times \frac{1}{2}''$.

Construction of model: The ends of the bookcase should be grooved or housed, as at *f*, to receive the shelves, the length of which should be $\frac{3}{4}''$ less than the outside length of the case, to allow for the depth of the groove. These grooves should be laid out by knife marks, and to insure their fitting the shelves closely, should be made a little less in width than the thickness of the shelves which enter them, just as the cuts in a halved joint are made smaller than the pieces that go into them. Attention is called to the horizontal section *a a*, which shows that the groove is stopped $\frac{1}{2}''$ from the face edge of the end, and that the shelf is notched $\frac{7}{16}''$, as at *g*, so as to prevent the groove from showing on the front edge of the end, as it would if it were cut through. The shoulder cuts, or the cuts across the face edges of the shelves, should be made upon all the shelves at once, clamping the pieces together for that purpose. The distance between them should be carefully calculated so as to *make each shoulder about $\frac{1}{16}''$ less than the extreme length of the shelves;* this will allow the ends of the shelves, beyond the shoulders, which fit into the grooves of the ends of the case, to be a little less than the depth of the grooves, as at *h*, thus insuring a good joint at *c* and *g*,

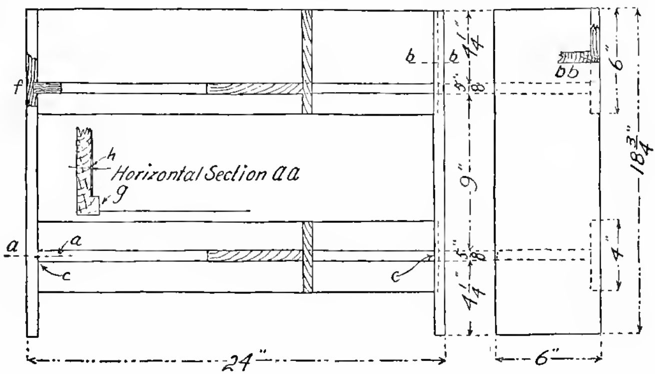

FIG. 189.—BOOKSHELF.

at each end of the shelf. The depth of the shoulder should be about $\frac{7}{16}''$. This is the most important joint of the case, and the fitting should be done carefully, as a poor joint at *c* will be in the most conspicuous place.

The face edges of the shelves should set back from the face edges of the ends about $\frac{1}{8}''$, as it is an almost invariable custom that two pieces should not be finished flush in work of this sort. This, to some extent, hides an imperfect joint, if one is made, or any opening after the work is finished.

The backs should be fitted into a rabbet made in the back of the ends, as shown by the section *b b*. Any suggestion of the shape of the ends is purposely omitted, as the student should make his own design, being governed by the advice of the teacher.

This model may be finished in the natural wood with shellac, well rubbed down, or may receive a dark stain and a wax finish.

124. Drawing board. Fig. 190. (*See* Handbook: Fig. 39.)

Material: 6 pieces, $25'' \times 3\frac{1}{4}''$ (about) $\times \frac{5}{8}''$.
2 cleats, $19'' \times \frac{5}{8}''$.
18 F.H.B. screws, 1″ No. 9.

A. Gluing a wide board: This is an exercise in gluing up a board so that the effect of the tendency to warp will be minimized, which may be accomplished by so placing narrow pieces that the concave and convex sides of the annual rings will alternate in forming the surface of the

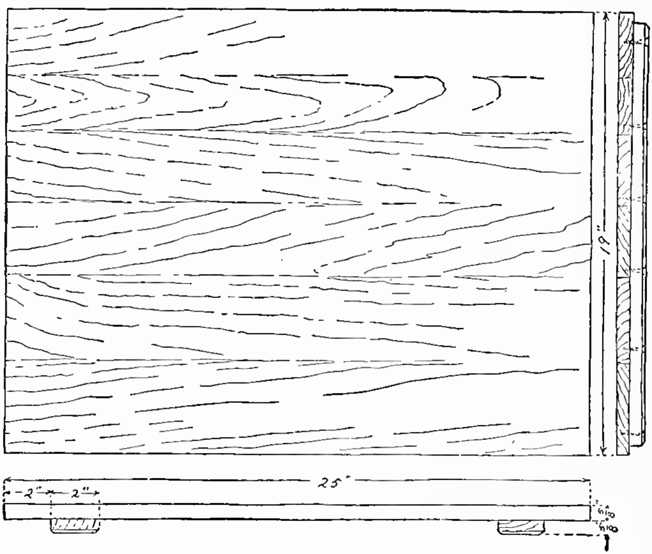

FIG. 190.—DRAWING BOARD.

board. These sides may be determined by examining the annual rings of the boards, which may be seen at either end. As the tendency of a board is to warp with its concave side toward the outside of the tree, the warp of each narrow piece will offset that of those which join it. (See Fig. 23.) The joints should be carefully fitted and doweled; see Topic 107, Method 1.

B. Cleating across the grain: The cleats should be screwed upon the back as shown; the holes for the screws being slotted by boring two holes beside each other, parallel with the grain, which will allow the screws to move a little back and forth as the board shrinks and swells.

A cleat should never be glued across the grain, as when the board begins to shrink, the glue will not allow it to do so, and the result will be that the joints will open, or the board will warp and twist badly. The cleat may be glued in the center for two or three inches, if desired, though this is not at all necessary; but it allows the board to shrink from the edges to the middle, and the screw holes being slotted, will permit this movement to take place without its surface or shape being affected.

C. Squaring the board: The ends of the board should be jointed perfectly straight, and square with the face and sides of the board, so that the T square will move accurately upon either end, or edge.

D. The surface of a drawing board: After the board is carefully straightened and smoothed, it should be sandpapered diagonally from each corner, and finished parallel with the grain. It needs no finish aside from the sandpapering.

125. **T Square.** Fig. 191. (*See* Handbook: Fig 40.)

Material:	1 tongue,	$28'' \times 1\frac{3}{4}'' \times \frac{1}{8}''$.
	1 head,	$10'' \times 2\frac{1}{4}'' \times \frac{3}{8}''$.
	5 brass screws,	$\frac{3}{8}''$ No. 3.

Maple, cherry, or any close-grained, well-seasoned wood, may be used in making this model. The pieces may be glued up of any dark wood

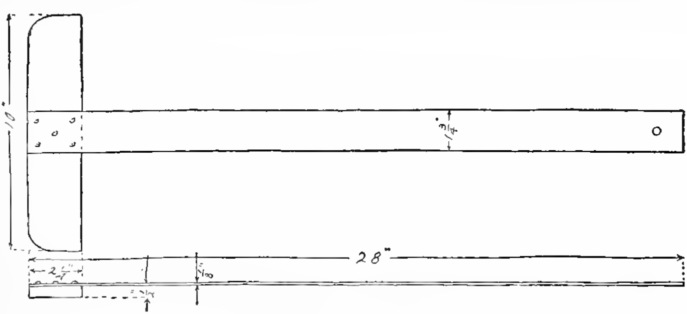

FIG. 191. — T SQUARE.

edged with maple or white holly, but it is not necessary except that it makes a better looking job. If the gluing is well done, however, a piece of glued-up work will hold its shape better than if made of one piece,

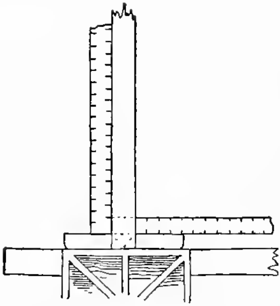

FIG. 192. — FASTENING THE TONGUE AND THE HEAD.

A. Accuracy of the model: This model requires that the utmost care should be exercised at each step. The working edges of the head and tongue, which are being tested in Fig. 192, should be accurately straightened; the accuracy of the other edge of the tongue and the shape of the head are unimportant.

The tongue should be fastened to the head of the square by means of small screws and glue. Use glue sparingly, and place both pieces in a vise, as shown in Fig. 192, applying a gentle pressure at first. Set the tongue in its exact relation with the head, placing a steel square, as indicated, to insure accuracy. Set up the vise to furnish sufficient pressure to hold the pieces firmly while putting in the first two or three screws, after which a handscrew may be put over the screws already in place, and the square removed from the vise, while the rest of the screws are being driven. Lay the square away for the glue to set, with handscrews so placed as to impart an equal pressure on all parts of the joint.

For finishing the model, two thin coats of shellac should be applied and well rubbed down.

126. Threefold screen frame. Oak. Fig. 193.

A. Omission of stock list: The stock list for this and succeeding models will be omitted, mention being made simply of the pieces necessary, the student estimating their dimensions.

Sequence of work: Get out all the pieces except the panels *b*, and the beads *h*, which hold the panels in place to their exact dimensions. The stiles should be planed square upon their inside edge; that is, the

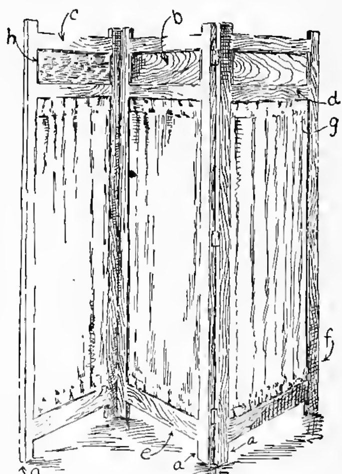

FIG. 193. — THREEFOLD SCREEN.

edge against which the shoulders of the tenons fit. Work from the face side, and leave the stiles the full width to which the piece has been roughly cut (without planing the other edge) and an inch or more longer than desired, as this extra wood may be needed before the screens are finished.

Cut off the top rails, *c*, the middle rails, *d*, and the bottom rails, *e*, 2″ longer than the desired distance between the stiles, because the tenons on each end will enter the mortise in the stiles, 1″. Mark all the shoulders on these rails at once, allowing exactly the same distance between, that it is desired that the stiles shall be apart; mark each separately, and square carefully around all sides with a distinct knife mark, working always from the face side and edge.

B. Laying out mortises and tenons: The stiles should now be placed side by side, inside edges up, as in Fig. 194. Across the inside edges of all the stiles draw pencil lines square with the sides, as at *b*, indicating the exact location and length of the mortises. With a mortise gauge set to make the marks for a $\frac{1}{4}$″ mortise, mark all the mortises in the stiles, and the tenons on the ends of all the rails, without changing the set of the gauge, working from the face side in every case. This is important.

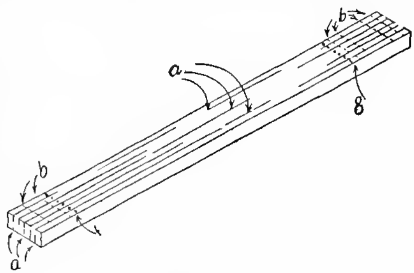

Fig. 194. — Threefold Screen — Marking for Mortises.

With a $\frac{1}{4}$″ bit, bore one hole in the middle of the length of each mortise, and with a $\frac{1}{4}$″ chisel, cut out the mortise, cutting across the grain in every case, never parallel with it; be careful that neither the $\frac{1}{4}$″ hole nor the mortise goes through to the other edge of the stile.

C. Drapery rods: Bore a $\frac{3}{8}$″ hole, 1″ deep, 1″ to its center above the bottom rail, as at *f*, and the same distance below the middle rail, as at *g*, to receive the dowels or brass rods which support the drapery panels. Smooth and sandpaper the edges of the rails and stiles, except the outsides of the latter, but not the sides of any of the pieces.

D. Gluing: Glue the frames together, holding them in place by clamps, as in Fig. 195, which are used for the same purpose as handscrews upon work which is too large for the latter to reach. These should be placed exactly opposite each rail, so as to hold the frame square. If the frame is not perfectly square, move one clamp to a

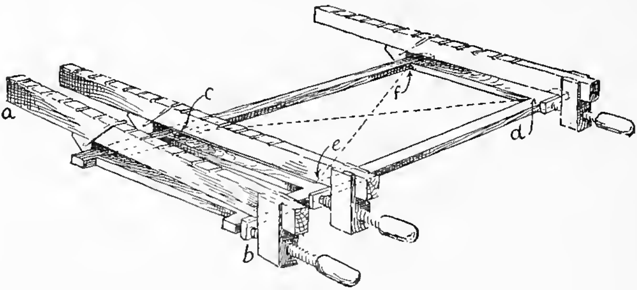

FIG. 195.—THREEFOLD SCREEN—GLUING AND SQUARING BY DIAGONALS.

slight angle, as at *ab*; this angle and its direction must be such that the pressure applied by the clamp will pull the frame square and hold it so until the glue sets.

E. Squaring the frames: Do not use a square to test the frame, because the clamp may spring the stile out of a perfectly straight line, in which case a square would be useless. Use a stick of suitable length, sharpened to a chisel point, to measure the diagonals *cd*, and *ef*. Place the point of the stick in the angle at *d*, and make a pencil mark at *c*; change the stick to *ef* and compare *cd* and *ef*. By swinging the clamp as described above, make the diagonals the same length, if the first measurements do not coincide.

After the glue has set, joint the edges of the stiles square and to the desired width. Smooth and scrape both sides of the frame. If strap hinges, as shown in Fig. 197, are to be used, round the edges as shown at *e*, Fig. 196, and sandpaper thoroughly.

F. Beads and panels: Prepare, miter, and fasten in place upon one side of the frame the small beads shown at *f*, Fig. 196. These should be made flush with one face of the frame, leaving those of the other side loose. They may be made with a bead plane, which makes a molding shaped like those indicated, or the pieces may be rounded by hand, though any small

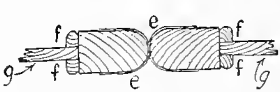

FIG. 196.—THREEFOLD SCREEN—SECTION OF STILES FOR FLY HINGE.

molding may be used which does not project beyond the face of the frame, in which case the screen cannot be folded together. Cut the panels, *g*, to the correct size; smooth, scrape, and sandpaper them; then remove the loose beads, put the panels in place, and fasten the other beads, which will hold the panel securely.

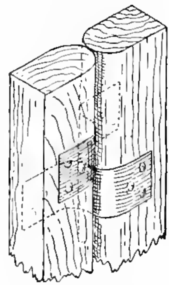

FIG. 197. — THREE-FOLD SCREEN — THE FLY HINGE.

G. Finish and hinges: Stain, fill, and finish the screen to suit taste. Double swing screen hinges may be purchased at almost any well-stocked hardware store, though double swing strap hinges, as shown in Fig. 197, are preferred by some. Prepare twelve strips of thin sheet brass or rawhide, say $3'' \times 1''$, for hinges, and put them on as shown in the figure, using brass tacks with a very flat round head, so that they will not mar the face of the screen which is folded against them. This makes a satisfactory screen hinge, as it allows the screen to be opened either way; two of the strips make one hinge, and three hinges are necessary for each joint.

H. Drapery panel: Six $\frac{3}{8}''$ dowels, or brass curtain rods, should be made the right length to enter the holes which were bored to receive them; these are to hold the drapery which forms the large panel of the screens. The drapery should then be adjusted on the rods and the latter sprung into position.

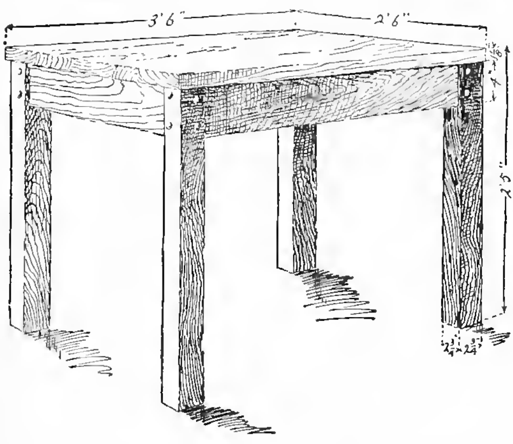

FIG. 198. — LIBRARY TABLE.

127. Library table. Fig. 198. (The construction of this table is fully explained in Figs. 45 and 46 of the Handbook of this series.)

Get out the stock list. From the dimensions upon it, cut the tapered legs and the rails. Make the table leg joint, smooth and sandpaper the members, and glue them together. In cutting the material for the top, the appearance of thickness may be secured without the expense or the weight of using thick stock, as follows: Cut the top from $\frac{7}{8}''$ stock, and glue it up in the ordinary way, making a doweled glue joint. Cut the top to its required size roughly, and straighten the under side across the ends by traverse planing. Glue pieces about 5″ wide and as long as the top on the under side of the top, flush with the edges. Cut pieces 5″ long, and wide enough to fill in be-

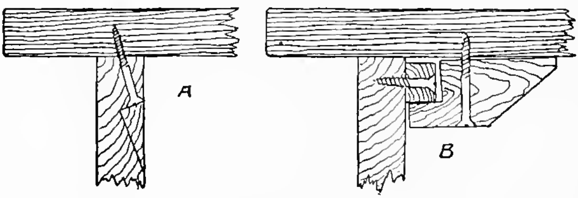

Fig. 199. — Method of Fastening the Top of Table to Rails.

tween these edge pieces, and glue them flush with the end of the top. The whole may now be treated as though the entire top were made of thick material. Fasten the top on by one of the methods indicated at *A* or *B*, Fig. 199. If it is desired to make a more elaborate table, the construction need not be essentially different. Upon a table of this size, the top should not project more than $1\frac{1}{2}''$ beyond the legs.

128. Mission piano bench. Fig. 200.

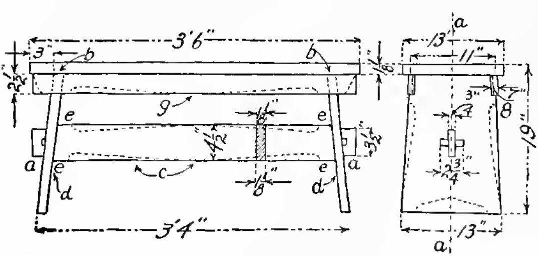

Fig. 200. — Piano Bench.

Material: Oak.

1. *Sequence of work:* Prepare the rectangular pieces with which the standards, *d*, and the stretcher, *c*, are to be cut. Locate the tenons upon the ends of

the stretcher, and the mortises in the standards, before the pieces are cut to their desired shape, as it is much more convenient to work from the face edge of a rectangular piece than from the center line, *a a*, which would be necessary if the standards were made as designed.

2. Cut and fit the shoulders and tenons of the stretcher, and the mortises of the standards, to each other, using care that the shoulders, *e*, of the stretcher, and the tops and bottoms of the mortises are made at the correct angle. To guard against the tendency to cut the mortises so large that the tenons will not fill them, the student should make a very close fit, in anticipation of trimming, if necessary, when the pieces are fitted together. The mortises should be bored out as much as possible to avoid the liability of splitting the standard while using the chisel and mallet. The mortises should be cut under on all sides, as indicated at *g*, Fig. 201, in order to insure a perfect fit upon the surface.

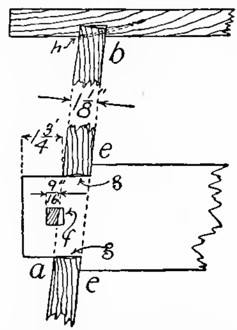

FIG. 201. — PIANO BENCH — SECTION SHOWING CONSTRUCTION AT *a b*, FIG. 200.

3. Design the contour of the standards, stretcher, and side rails, and work out their forms carefully, using a wood rasp or file, taking care not to chip off pieces from the back side. If this should happen, save the pieces and glue them back in their places.

4. The top and the bottom of the wedge must be parallel, and when it is in place, the outside should be plumb, and the inside planed to fit the angle of the standard, and wedged, or tapered, about $\frac{1}{16}''$ for each inch in its length. The wedges should be made considerably longer than necessary, so that they may be driven as they are fitted, and not cut to length until the foot rest is ready to be set up permanently.

5. Smooth, scrape, and sandpaper the standards and stretcher.

6. Fit the side rails in their places, halving them into the tops of the standards by the same method used in fitting the top rails of the foot rest of Topic 121. Their top edges should not be less than $\frac{1}{4}''$ from the tops of the standards, so that the latter may enter the groove cut for them in the under side of the top.

7. At *b*, Fig. 201, is shown the method of fitting the top to the

standards; at *a* is shown the method by which the stretcher is fitted. The space at *f* is for the purpose of allowing the stretcher to be pulled to a joint by the wedge.

8. Prepare the top, cutting the grooves in it for the ends of the standards. Smooth, scrape, and sandpaper it and fasten it on with glue, and with nails driven as shown at *h*.

9. Stain and finish to suit taste.

129. Medicine cabinet. Fig. 202.

Material: Poplar (Whitewood).

In making this model, the top, bottom, and two sides should be made first; and the rabbet, shown at *a*, should be cut before the pieces are nailed together, stopping the rabbet in the top and bottom at nearly the place where it will intersect with the rabbet *d* of the sides, so that when the case is nailed together, the back, *b*, will fit into both rabbets. The location and use of the various pieces will be seen by a careful study of the sections.

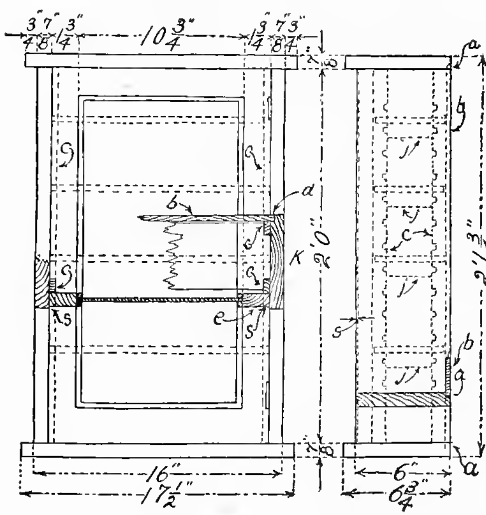

Fig. 202. Medicine Closet.

A. Movable shelves: In preparing the ratchets, *c*, which allow the shelves to be placed where wanted, cut a $\frac{7}{8}''$ piece the same length as the sides of the case, and wide enough to allow all of them to be cut from it, say $2\frac{1}{4}''$. With a sharp knife, lay out the cuts, *d*, across the piece, as shown at *A*, Fig. 203, marking their depth with a gauge. Make the cuts with a backsaw, and remove the wood between them with a narrow chisel. With a sharp ripsaw, cut the pieces as indicated by dotted lines, *e*, and plane them down to $\frac{3}{8}''$ or $\frac{5}{16}''$ uniform thickness. Allow wood enough to insure that there will be little danger of planing them too thin. The ratchets, *c*, Fig. 202, are placed against the back, *b*; and the door stile, *e*, as indicated at the section of the side, at *K*. The cleats, *j*, are cut between the ratchets, *c*. Cut these from a piece about 4″ wide, as indicated at *F*, Fig. 203, the seven dotted lines showing where the pieces should be ripped, after the ends, *t*, *t*, have been cut. They should then be planed to the same thickness as the ratchets, *c*.

B. *The door:* The pieces for the door should be about $\frac{1}{8}''$ wider than needed, to allow the door to be planed to a fit after it has been

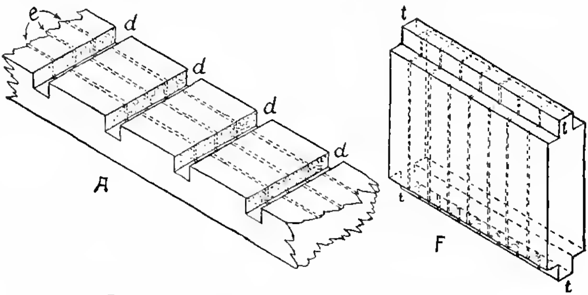

FIG. 203. — MEDICINE CLOSET DETAILS.
A, Method of cutting ratchets. *F*, Method of cutting cleats.

made. The stiles, especially, should be longer than needed, so that they may be sawed off after the door is glued up. The door may be either doweled or mortised together, and the glass or wood panel held in by the same method as in the screen. See Fig. 196.

C. *Accuracy of case and door:* Care must be used, in setting up the case and the door, to have them both square and out of wind; the latter may be proved by sighting across them. If the faces of the two stiles of the door coincide, and the front edges of the sides of the case appear the same, they will be all right.

D. *Fitting the door:* The door should be carefully fitted so that it will fall back of the front edge of the sides, or have a sinkage of about $\frac{1}{16}''$, as shown at *s*, Fig. 202, as nothing of this sort should be finished flush.

E. *The hinges:* In cutting in hinges, the gauge is an indispensable tool, as a high degree of accuracy is necessary if even fairly satisfactory results are desired. They may be cut half into the door and half into the side of the case, though upon ordinary work of this nature, they are usually cut entirely into the door. Whichever method is used, the hinges should be fitted carefully against the wood. In this instance, there is an advantage in cutting them by the latter method, as more wood is obtained for the screw in the side, thus permitting a longer screw to be used.

The top of the top hinge should be placed opposite the bottom of the top rail, and the bottom of the bottom hinge should be placed at the top of the bottom rail, and both set so that about two thirds of the round of the hinge will project beyond the face of the door. A pair of $1\frac{1}{2}''$ butts will be suitable; they should be fastened on with $\frac{3}{4}''$ screws, which should be of a size to allow their heads to be driven flush with the inside of the hinge.

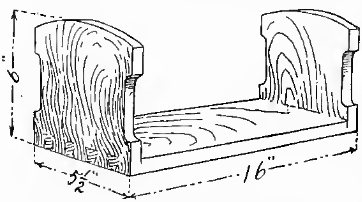

Fig. 204. — Dovetailed Bookrack.

Finish in the natural wood with shellac, or stain and wax to suit taste.

130. Dovetailed bookrack. Fig. 204. (*See* Handbook: Fig. 41.)

Material: Oak or Poplar.

Dovetail the pieces together as shown in the sketch; if the design shown is used, be sure that the curves are symmetrical. It is better, however, that the student make an original design for the end. When the model has been glued, and set away to harden, be sure that the ends stand square with the bottom. See Topic 116, *A*.

This model may be given a shellac finish, or stained and finished in wax.

131. Magazine stand. Fig. 205.

Material: Oak.

The ends: Lay out and cut the curves of each end. Prepare the top and bottom shelves. Mark the tenons, or tusks, upon them, and the corresponding mortises in the ends, following the same methods as in Topic 128, except that the work should be from a center line, instead of from a straight edge.

The shelves: The mortises and the grooves, or housings, for the top and bottom shelves should be cut in the ends, and the shelves fitted before the grooves are made for the middle shelves. All the shelves should be cut with the shoulders as at *g*, Fig. 189, except that the face of the shoulders should be at the same angle as the flare of the sides, as at *a*, Fig. 205. The student should be careful that the shoulder bevel is in the right direction at each corner of the shelves. The shelves should each be about $\frac{1}{8}''$ narrower than the width of the end of the case at the groove, so that they will not finish flush.

In fitting the middle shelves, the ends and the top and bottom shelves should be set up temporarily, and the wedges fitted as upon the piano bench, care being taken not to cut the wedges off until the case is ready to set up permanently. While the case is in this stage, locate the middle shelves and ascertain their length, taking the measurements at exactly the places they are to occupy.

Setting up the case: In setting up the case, both sides should have the same pitch inward, though if the mortises of the top and bottom shelves have been made accurately, this will take care of itself. The joints of the shelves should be held in place by clamps while the glue is setting; $1\frac{1}{2}''$ brads should be driven through all the shelves into the ends, as shown at *b*, Fig. 205.

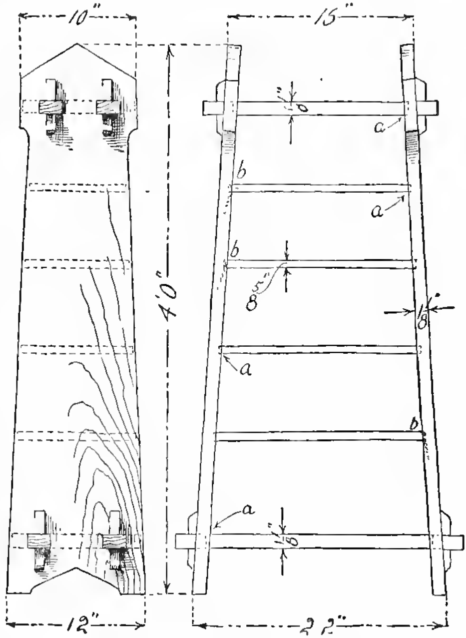

Fig. 205. — Magazine Stand.

Suggestive Exercises

119. How should a student review his previous work to assist in new work? What is the relation between the length and width of a board and its grain? Review processes of making a bench hook, and discuss other ways of obtaining the desired results.

120. Demonstrate the method of drawing a curve through points. How may the elbow be used to assist in drawing curves of certain dimensions? What should be guarded against in sawing a curve?

How should the spokeshave be used with reference to the grain?

In what cases should a wood file, or rasp, be used?

121. How should cuts be made to insure a perfect joint? What should be the relation of the bottom of a joint to its face?

Describe the method of doweling the top on the foot rest.

122. Should the bottom of a box be cut to its exact size before the rim is made? Why? How should the bottom of the rim of a box be planed to allow a perfect fit? Describe the different kinds of nails used by the carpenter.

123. How should grooves be laid out to insure a perfect fit? Should two pieces be finished flush? Why?

124. How may a wide board be glued up to minimize the tendency to warp? Should a cleat be glued the entire distance across the end of a board? Why?

125. Which holds its shape better, a solid piece, or a well glued-up piece?

126. How may pieces be worked in pairs? How may a piece of gluing be squared by manipulating the clamps? How should a piece of work similar to a screen frame be squared?

127. How may a table top be fastened on without nails or screws showing in its surface?

128. Describe method of laying out a mortise at an angle. What should be done with chips which break off?

129. How should ratchets be cut? Should a door be made exactly the desired size? In gluing up a door, what should be guarded against to insure that it will fit well? Should a door be hung flush with its frame?

130. Review dovetailing.

131. How should the lengths of the shelves of a magazine stand be ascertained?

NOTE: In preparing for this model there is an opportunity for drill in the process of planing and squaring a piece of wood. As this exercise comes early in the courses outlined in the Handbook, it should be made the most of. In other words, preparing the piece may be made a separate exercise. If desired, one edge only need be planed, the two ends being cut to the neat length and block-planed; the other edge may be left rough as it will be destroyed in cutting the top curve of the coat-hanger. In practical work for making more than one of these, a pattern would be laid upon a board and several marked out, fitting into one another, thus saving much material. (See p. 210.)

CHAPTER X

Arithmetic Questions

1. Measure the distance from corner to corner between the windows of a given side of the shop, and give total distance in feet and inches.

2. Measure the bench top to the nearest inch (avoiding fractions), and give number of square feet and inches it contains.

3. How many square feet are there in a given blackboard?

4. How much should a gauge be set to make a mark in the middle of the edge of a $\frac{7}{8}''$ board?

5. If a gate $38\frac{1}{2}''$ wide is made of slats $2\frac{1}{2}''$ wide, and set $2''$ apart, what is the total width of the slats?

6. A man builds a barn $27'\ 9'' \times 35'\ 6''$ in the middle of the short dimension of a lot which is $62' \times 135'$, and $20'$ from the N. end of the lot. If the short dimension of the barn is set the short way of the lot, how much land will there be on the E., S., and W. sides of the building?

7. How many square feet of land are left in the lot after the barn has been built?

8. Measure the width of the window openings in a given side of the shop, and give total amount in feet and inches.

9. Give total length of a given side of the shop.

10. Measure to the fraction of an inch the distance between two given benches.

11. If the entire top of a given bench were of uniform thickness, how many feet, board measure, would there be in it?

12. How many square inches of lighting surface are there in a given side of the shop?

13. If a tenon $\frac{1}{2}''$ thick is to go in the exact center of a piece of $1\frac{3}{4}''$ lumber, how much wood will be left on each side of it?

14. How many pieces $2\frac{3}{8}''$ wide will be necessary to fill closely a space $40\frac{3}{8}''$ wide?

15. Measure the distance from corner to corner, and between windows, of a given side of the shop, and give total length in feet and inches.

16. Measure the window openings of a given side of the shop, and give total area in feet and inches.

17. If a box is $8\frac{1}{4}'' \times 7'' \times 4''$ high, how many cubic inches of water will it contain?

18. What is the capacity of the above box in liquid measure?

19. If a board is 14′ long and 13″ wide at one end and 11″ at the other, how many feet B. M. are there in it?

NOTE. — In practice, the terms sq. ft. and sq. in. are rarely used, as "sq." is omitted, but in measuring lumber it is always understood.

20. How many feet of $3\frac{1}{2}''$ flooring should be ordered to lay a floor $12' \times 16'\ 8''$, allowing $\frac{1}{4}$ of area for waste?

NOTE. — Hereafter, the words "of area" will be omitted, as they are never used in practice, it being always understood that any quantity denoting waste indicates the proportion of the actual area to be covered which must be allowed.

21. How many inches are there in a floor $17\frac{2}{3}' \times 19\frac{3}{4}'$?

22. How many feet are there in a floor $17\frac{2}{3}' \times 19\frac{3}{4}'$?

23. If a 2″ floor is laid in the above room, how many feet of flooring will have to be ordered, allowing $\frac{1}{4}$ waste?

24. A four-light window is $33'' \times 62''$. Allowing .233 of its entire area for the sash, what is the size of the glass?

25. If a mitered frame is to be made of molding $2\frac{1}{2}''$ wide, how much more than the given sight dimensions must be allowed to each piece, in order to estimate the exact length of molding required?

26. If the light area of a $14'' \times 28''$ glass is $\frac{3}{8}''$ less than the actual size of the glass, what is the total light area of a four-light window?

27. Measure a given end of the shop, and calculate the entire space, exclusive of openings.

28. What is the total of the door openings of a given end of the shop?

29. What is the sectional area of one of the posts in the shop, measuring to the nearest inch?

30. What is the area of the shop floor?

31. A lumber pile of 1″ lumber has 62 layers, averaging 4′ in width, and 12′ in length. How many feet B. M. are there in the pile?

32. How many inches of lighting surface are there in a given side of the shop?

33. If one of the posts supporting the floor above is 12′ long, how many feet B. M. are there in it?

34. How many cubic inches are contained in a box $16'' \times 11\frac{3}{16}'' \times 12''$ deep?

35. To what dry measure is the above box practically equivalent?

36. If a certain roof requires twenty $2'' \times 6''$ rafters 13′ long, how many feet B. M. would have to be purchased?

Note. — Lumber carried in stock by lumber dealers is rarely of any other lengths than multiples of two, as the logs are cut in the woods to those lengths. Thus, if a piece is needed which cannot be cut from a 12′ piece, a 14′ piece will have to be purchased.

37. A floor is $15' \times 18'$. A carpet showing an 18″ border all around it is to be purchased. How many square yards will be necessary?

38. How many feet of flooriug will have to be bought to lay the above floor, allowing $\frac{1}{4}$ waste?

39. If a house $28' \times 40'$ is to have for the cellar an excavation $\frac{1}{3}$ the size of the house and 4′ deep, how many cubic yards of earth will have to be removed?

40. At $12\frac{1}{2}$ ¢ per cubic yard, how much will it cost to excavate the above cellar?

41. If a man sets and cases 4 door frames a day, at $2.25 per day, how much will it cost to have him do this work upon a house having 31 door frames?

42. How many feet of flooring will it take to lay the floor of the shop in which the class meets, allowing $\frac{1}{4}$ waste?

43. If the lumber in a given wooden blackboard cost 4 ¢ per foot, what was the total cost if $\frac{1}{4}$ waste was allowed?

44. What is the light area of a $14'' \times 28''$ four-light window, if the glass is covered $\frac{1}{4}''$ all the way around by the sash?

45. How many feet are there in a pile containing twenty-four $\frac{1}{2}''$ boards, 14′ long and 11″ wide?

Note. — Any thickness of lumber under 1″ is measured as 1″ thick. Lumber over 1″ in thickness is measured as 1″ plus the fractional parts of an inch. Thus, a $1\frac{1}{2}''$ plank is measured as $1\frac{1}{2}'$ of lumber per square foot of surface.

46. A glazed sash weighs 16 lb. What size of weights are necessary to hang it properly?

47. A cellar $20' \times 36'$ is to be dug; the excavation will be 2′ deep

at one end and 4′ deep at the other. At $12\frac{1}{2}$ ¢ per cubic yard, what will the excavation cost?

48. A and B receive 10 ¢ and 8 ¢ per hour, respectively. They take a contract for $18.75, the material for which costs $6.35. What will be the share of each?

49. If the material used in painting a given blackboard cost $1\frac{1}{3}$ ¢ per square foot, what was the total cost?

50. The labor upon a certain job cost $4, which was furnished by A and B @ 8 ¢ per hour. C and D do the same job in 15 hr., @ $12\frac{1}{2}$ ¢ per hour. Which is the cheaper help? How much cheaper?

51. A table top is 10′ long × 3′ wide, and $1\frac{3}{8}''$ thick. How many feet B. M. are there in it?

Note. — Lumber is sawed to stock thicknesses at the mill, and dressed lumber should always be estimated as being dressed from one of the stock thicknesses, generally the one $\frac{1}{8}''$ or $\frac{1}{4}''$ thicker than the dressed plank which is being figured. The thicknesses usually sawed are $\frac{3}{4}''$, $1''$, $1\frac{1}{4}''$, $1\frac{1}{2}''$, $2''$, $2\frac{1}{2}''$, $3''$, etc. Thus, a $\frac{7}{8}''$ board is sawed from $1''$ stock, and $1\frac{3}{8}''$ is taken from $1\frac{1}{2}''$ plank.

52. A roof of $22\frac{1}{2}$ squares is to be shingled with shingles costing $2.21 per square. If 4 lb. of nails @ 4¢ per pound are used per square, and labor costs 60¢ per square, what will the job cost?

Note. — A square is equivalent to a space 10′ × 10′, or 100 sq. ft.

53. A timber 5″ × 9″ × 18′ long contains how many feet B. M.?

54. How many nails should be purchased to lay the floor of this shop, if 4 lb. per square are used?

55. If the labor to lay the floor costs 75 ¢ per square, what will be the total labor cost?

56. Figuring to the nearest inch, how much space does a certain bench occupy upon the floor?

57. What is the total length of a given side of the shop?

58. A and B do a job in 12 hr., for which they receive $2.40. How much did each receive per hour?

59. C and D receive 8 ¢ per hour to do the same job. How long ought it to take them to complete it?

60. Twelve bottles, 5″ in diameter and 11″ high, are to be packed for shipment. If they are packed in four rows of three each, and $\frac{3}{4}''$ is allowed all around for packing, how much lumber will be needed to make the box, allowing nothing for waste?

61. Make a stock list for the above box, denoting the use of each piece and giving the exact size.

NOTE. — The length of a piece of wood is always with the grain, regardless of the dimension the other way. Thus, it will be possible for a board to be much wider than it is long.

62. How many feet of flooring should be ordered to lay the floor in a hall $8' \times 22'$, with a stair opening $4' \times 14'$, allowing $\frac{1}{4}$ net area for waste?

63. After deducting the space occupied by benches, stock, and model cases, what is the aggregate area of the aisles of the shop?

64. A does a job @ 10¢ per hour, and receives \$1; B does the same job @ 8¢ per hour, and receives \$1.10. How much should A's pay be raised to equalize the cost of their work?

65. To what should B's pay be cut down to equalize the cost of their work?

66. How many feet B. M. should be ordered for a $5\frac{1}{2}'' \times 1\frac{3}{4}''$ door frame for a $2'\ 8'' \times 6'\ 8''$ door, allowing $1\frac{2}{3}'$ waste? Give answer to nearest even feet. (This frame would be cut from $2'' \times 6''$ stock.)

67. What is the weight upon the supports of a floor $20' \times 20'$, if the floor and joists weigh 18 lb. per square foot, and merchandise weighing $47\frac{9}{25}$ lb. per square foot is piled upon it?

68. How many feet of timber would have to be cut for a post $8'' \times 8''$ and $13'\ 6''$ long?

69. A and B contracted to build a blackboard containing 80 sq. ft. for \$10. Allowing $\frac{1}{4}$ waste, and estimating lumber @ 4¢ per foot, painting @ $1\frac{1}{3}$¢ per foot, labor at \$.06875 per foot, and the cost of other material at 75¢, did they make or lose, and how much?

70. A contracts to build a bookcase for \$3.25. The lumber costs him 65¢, other material 36¢, and he works 16 hr. on it. How much does he make an hour?

71. A board is 12' long and 7" wide. How many feet B. M. does it contain?

72. A picket fence is to be built, 100' of which is on level ground; the rest goes over a mound which is 100' through from side to side at its base, and 30' high. Which part requires more pickets?

73. How many cubic feet are there in a room which is $12' \times 14' \times 9'$?

74. What will be the actual area of the section of a door jamb $5\frac{1}{2}'' \times 1\frac{3}{4}''$, with a $1\frac{1}{2}'' \times \frac{1}{2}''$ rebate taken out?

75. From a pile containing 2976′ of lumber, 536′ was taken and used for ceiling; the remainder was stuck into flooring and sold for $40 per M. What did the flooring bring?

76. The above 536′ was made into ceiling and sold @ $35 per M. Allowing $\frac{1}{4}$ waste, how much surface would it cover, and what would it bring?

77. The above entire pile was bought for $22 per M. It cost $1 per M for stacking; $4.50 per M for handling and kiln-drying; $6 per M for sticking into ceiling and flooring. Did the dealer make or lose, and how much?

78. A journeyman mechanic, receiving 25¢ per hour, cuts up 100′ of lumber in one hour; an apprentice, @ 8¢ per hour, cuts up the same amount in the same time, but wastes 8′. With lumber @ 4¢ per foot, which would be the more profitable man for the employer, and how much would he save upon the hour's work?

79. A box is 6′ long, 2′ wide, and 12″ high, inside dimensions, is to be built of 1″ boards, with the solid top and bottom put on with the grain running crossways. Make a stock list, showing the use and dimension of each piece.

80. Tell exactly how many feet of lumber there are in the above box, making no allowance for waste.

81. A board is 14′ long, 9″ wide. How many feet B. M. are there in it?

82. A board is 16′ long, 19″ wide. How many feet B. M. are there in it?

83. A bottom sash is 31″ high. The top of each pulley is 54″ from the stool. The cord extends from the top down upon the sash 14″. Allowing 6″ for knots at the ends, and 6″ for weight to hang from the top of the pulley, how long will the cord be?

84. The sash weight of the above window is 20″ long. If the sash slides upward 30″, how far will the bottom of the weight be from the stool?

85. If the above sash weighs 14 lb., how many and what weights are necessary to hang the window?

NOTE. — A window as described above consists of two sashes.

86. How much siding will be necessary to side a house 32′ × 40′ × 18′ high, if there are 24 window openings 3′ × 7′ and 4 door openings 3′ 6″ × 8′, allowing $\frac{1}{4}$ of the net area for waste?

87. A board is 10′ long and 16″ wide. How many feet are there in it?

88. A board is 18′ long and 7″ wide. How many feet are there in it?

89. A plank is 16′ long, 14″ wide, and 2″ thick. How many feet B. M. are there in it?

90. A took a contract to build a desk for $17.50. He hired B and C to help him, paying them 10¢ and 8¢ per hour, respectively. A worked 24 hr., and B and C 20 hr. each. The material cost $6.75. What was A's share?

91. What did B and C each receive?

92. A pitch roof is 24′ long, with rafters set 2′ to centers. How many rafters are there in the roof?

93. If the above rafters are $2'' \times 6'' \times 15'$ long, how many feet will have to be ordered to furnish them?

Note. — In ordering framing material of the above nature, it is customary to order the number of pieces needed; thus the waste will be the difference between the neat length and the length purchased.

94. A table top is 6′ $4\frac{1}{2}$″ long, 3′ 2″ wide, and $1\frac{1}{4}$″ thick. How much surface has it? ($1\frac{1}{2}$″ stock is necessary to finish $1\frac{1}{4}$″).

95. Allowing $\frac{1}{4}$ waste, how much lumber was cut in getting the stock out for the above table top? Give measurement to the nearest foot.

96. Students A and B receive the same pay, and are given a job together, with A as foreman, who does $\frac{2}{3}$ of the work, as B shirks his share. A, as foreman, gets credit for doing only $\frac{1}{2}$ of the work. What is his duty as foreman? What is his duty to himself, and his financial loss?

97. A board is 14′ long and 21″ wide. How many feet are there in it?

Note. — Anything less than 1″ in thickness is usually called a board; anything over 1″, a plank. Where no thickness is given, 1″ is assumed.

98. A plank is 12′ long, 9″ wide, and $1\frac{1}{4}$″ thick. How many feet are there in it?

99. A plank is 14′ long, 19″ wide, and $1\frac{1}{2}$″ thick. How many feet are there in it?

100. A board is 12′ long, 15″ wide, and $\frac{3}{4}$″ thick. How many feet are there in it?

101. How many shingles laid $4\frac{1}{2}$″ to the weather will be needed to cover a pitch roof which is 50′ long, with rafters 14′ in length?

NOTE.—Shingles are generally put up in bundles of 200, 250, or 500; 1000 shingles means the equivalent of 1000 shingles 4″ wide, though the shingles may be of any width; if the bales are full, they will measure 4000″ in width per M. As about 25 per cent are thrown out, or wasted at the hips and valleys, it is customary to figure that 1000 shingles will cover a square if laid 4½″ to the weather. As this is an average exposure, these quantities are usually figured as suiting nearly all pitches and exposures.

102. If 1000 shingles were all perfect and all laid 4½″ to the weather, with no waste, how much surface would they cover?

103. A, B, and C divide equally the money they receive for doing a job which requires 12 hours' work from each. Their usual pay is 9 ¢ per hour, but in this case it was increased ¼. How much did each receive?

104. If an irregularly shaped room is 50′ upon one side, 20′ upon another, and 15′ upon each of the others, how many feet B. M. will be necessary to cover the floor, allowing ¼ waste?

105. If a person, standing, occupies a space 20″ × 20″, how many people can stand in a hall which is 60′ × 90′?

106. A scantling is 2″ × 6″ × 14′. How many feet B. M. has it?

107. A scantling is 2″ × 4″ × 16′. How many feet B. M. has it?

108. A joist is 2″ × 8″ × 16′. How many feet B. M. has it?

109. Measure the sight of glass of the windows of a given side of the shop, and give total width of the sight of each window.

110. If a man lays 4 squares of floor a day, how long will it take him to lay a floor 75′ × 160′?

111. The rafters of a pitch roof are 14′ long, and the roof is 28′ long. How many shingles will it take to cover it?

112. Allowing 4 lb. of nails per M, how many nails will it take to lay the above roof?

113. How much will it cost to lay the above roof, if the shingles cost $2 per M and the nails 3½¢ per pound, and if the work is done by a man who lays 2000 shingles a day and receives $2 per day for his labor?

114. If a door is 2′ 8″ × 6′ 8″, and a rebate of ½″ is allowed for the top and two sides, how many square feet are there in the opening?

115. Give total widths of the glass of the windows of a given side of the shop.

116. Give total width of the windows of a given side of the shop between stop beads.

117. How much wider is the sash than the total width of the glass?

118. If A receives 8¢ per hour, and B 7¢, how much does each make on a job for which they receive the total sum of $13.50? The stock costs $4.50, and they each work the same number of hours.

119. How many square feet of siding will it take to cover one side of a barn 40′ long × 18′ high, allowing $\frac{1}{4}$ waste?

120. It takes a student 36 hr. to do a piece of work. If he spends $1\frac{1}{2}$ hr. a day, how many days will it take him to finish it?

121. A board fence 8′ high is to surround a piece of land 60′ × 100′. How many feet of lumber will it take, if two 2″ × 6″ rails are used? Give itemized answer.

122. Allowing a space of 8 sq. ft. to each person for aisles, etc., how many people can be seated upon a floor 60′ × 90′?

123. Allowing 20 lb. per square foot for a dead load, and 150 lb. for each person present, as in question 122, what weight do the walls of the building have to carry?

124. Measure a piece of furniture for a packing box, allowing $\frac{3}{4}$″ in length, width, and height for packing.

125. Make out a stock list for the above box, and estimate the cost of material.

126. If A receives 8¢ an hour, and B 6¢, the work done by B costs $\frac{1}{8}$ less than the work done by A. What change should be made in B's pay to equalize the cost of their work?

127. A cleated ceiling barn door 12′ × 12′ is to be made. Allowing $\frac{1}{4}$″ waste, how much will the material, exclusive of cleats, cost @ $40 per M?

128. If 18 laths cover 1 sq. yd., how many laths will it take to lath a room 18′ × 32′ × 9′ 6″ high, allowing for 6 windows 3′ × 7′, 3 doors 8′ × 3′ 6″, and a light shaft 4′ × 14′ 6″ in the ceiling?

129. Make out a stock list for a $1\frac{1}{8}$″ doweled screen door, 2′ 8″ × 6′ 8″, outside, stiles and top rails to be 4″ wide, middle rail 5″ wide, and bottom rail 7″ wide.

130. Allowing $\frac{1}{4}$ waste, how many feet B. M. will there be in the above door?

131. An excavation is to be made for a cellar 20′ square, and 6′ deep. How many cubic yards of earth will have to be removed?

132. At $12\frac{1}{2}$¢ per cubic yard, how much will the above excavation cost?

133. How many laths will it take to cover a house which has 6 rooms, averaging $12' \times 12' \times 8'$, making no allowance for openings?

134. If it costs $1.75 to make and set an ordinary window frame, how much will it cost to make and set the frames in a given house?

135. The market price of window frames is $1.50. Student A receives $12\frac{1}{2}$¢ an hour, and makes a frame upon which the labor and material cost $1.50, beside 6′ for waste at 3¢ per foot. Student B receives 10¢ per hour, and makes a frame which costs $1.40, but wastes $12\frac{1}{2}'$. Which is the more profitable man?

136. Estimating lumber @ 4¢ per foot, how much cheaper is A's labor than B's upon this job?

137. A plank is $2'' \times 12''$ and 18′ long. How many feet B. M. does it contain?

138. A board which is 18″ wide when wet, shrinks, in drying, $\frac{11}{16}''$. How wide is it when it is dried?

139. A cellar $22' \times 35'$ is to be excavated 6′ deep at one end and 4′ at the other. How many cubic yards of earth will have to be removed?

140. A pitch roof house 40′ long is to be built. The rafters are to be $2'' \times 6''$ 14′ long, and placed 20″ to centers. Make stock list for the rafters.

141. At the rate of 60¢ per square for labor, how much will the labor cost to lay a floor $65' \times 98'$?

142. A board weighs 57 lb. green; in drying, its weight decreases $\frac{1}{3}$. How much does it weigh when dried?

143. If 6 boxes cost $3.50 to make, how much will 40 cost, if a price $\frac{1}{20}$ less is agreed upon on account of the larger number?

144. If the work would allow it, how many students, @ 8¢ each per hour, would be needed to do the same work as 20 students, who receive 10¢ each per hour?

145. How many times may a board 12″ wide be ripped, if the strips are to be 1″ wide, and the saw cut $\frac{1}{8}''$ wide? How wide a strip will be left?

146. If a board $14' \times 9''$ has a knot which destroys $\frac{1}{8}$ of it, how much good lumber is there left?

147. A receives 10¢ per hour for his work, and B, 8¢. They are given a job together. How much of the work ought each to do?

148. How many square feet of flooring should be ordered to cover a floor 20′ long, and 14′ wide at one end, and 20′ at the other, allowing $\frac{1}{4}$ waste?

149. A four-light window is $29'' \times 54''$ high; allowing 5″ in width and 6″ in height, what is the size of the glass?

150. If the above window weighs 24 lb., what size weight will be necessary? How many weights?

151. How many wooden tiles $5'' \times 5''$ will it take to lay a floor $15' \times 17'\ 6''$?

152. How many pounds of weights will be necessary to hang the windows of a given house properly?

153. How many feet of window cord will be needed to hang the above windows?

154. A partition 14′ long and 8′ high is to be put up. The material for the job costs $40 per M, and the nails 20¢. The work is to be done by two students, receiving respectively 10¢ and 8¢ per hour, working 8 hr. each. Allowing $\frac{1}{4}$ waste, how much will the job cost?

155. How much will each student receive?

156. Nine pieces, each containing 1 sq. ft., are cut from a board containing 13′. How much of the board is wasted, if, by injudicious stock cutting, the rest of the board is worthless? No allowance is made for the saw cut.

157. A certain field is inclosed by a rail fence 4′ 6″ high, $1\frac{1}{3}$ ft. of rails to the foot in length. The fence contains 1760′ of fence rails. How long is the fence?

158. If the field is square, how many square feet are there in it?

159. If 18 laths are used to cover 1 sq. yd., how many 3d nails will it take to cover 786 sq. yd., using 7 lb. to 1000 laths?

160. If ten panels are each $17\frac{3}{4}''$ long, entering the groove $\frac{1}{2}''$, how long a piece of panelwork would they make if the rails were 3″ wide?

161. If sixteen $\frac{1}{4}''$ boards, each containing 9 sq. ft., are used upon a certain job, how many feet B. M. will be used?

162. A board is 14′ long and 6″ wide; how many square feet are there in it?

163. How many feet of lumber 1″ thick will be used in laying a rough floor in a carriage house, which is $28' \times 24'$, allowing $\frac{1}{4}$ waste?

164. A floor is to be laid in a horse stable $20' \times 75'$ and 4″ thick. Allowing $\frac{1}{4}$ waste, how many feet B. M. will be used?

165. If the top rail of a door is 5″ wide, with a $\frac{1}{2}$″ groove upon one edge, and a $3\frac{1}{2}$″ tenon is to be cut, leaving the rest for a relish, how wide will the relish be?

166. A halved and rabbeted joint is to be made of material which is 3″ wide. If the rebate is $\frac{9}{16}$″ deep, how wide will the space between the rebates on the back be?

167. In making a table, the $\frac{7}{8}$″ rail is to be set back from the face of the leg $\frac{3}{8}$″, and the tenon is to be $\frac{3}{8}$″ thick and in the center of the rail. How far from the face of the leg should the outside edge of the mortise be placed?

168. In making a mortised joint of $1\frac{1}{8}$″ material, the back and face members will each be $\frac{3}{8}$″. How thick will the tenon be?

169. A and B receive jobs of the same character. A cuts up $2 worth of material; B, $2.40. A receives 10¢ per hour, and B, 9¢. A's time amounts to $2; B's, to $1.80. B thinks his pay should be raised to 10¢ per hour. Should it? Why?

170. A board fence 1250′ long is to be built around an athletic field. It is 8′ high and the boards cost 2¢ per foot. How much will the lumber, exclusive of the rails, cost?

171. Twelve boxes cost 72¢ each. How much will 30 boxes cost, if their price is reduced $\frac{1}{12}$ on account of the larger quantity?

172. A room $12' \times 15'$ and 8′ high is to be ceiled. Allowing $\frac{1}{4}$ waste, and no openings, how much ceiling will it need?

173. If there are 18 rooms, averaging the same area as the above room, and the contract is given to furnish the labor of putting the ceiling on the walls for $2.50 per M, what will the entire job cost?

174. If it takes 3 lb. of nails per M to lay the ceiling, how many nails will it take for the entire eighteen rooms?

175. The bottom rail of a door is 9″, with a $\frac{1}{2}$″ groove in one edge and a $1\frac{1}{4}$″ relish on the other, and has two tenons, each $2\frac{5}{8}$″, with a gain between them. How wide is the gain?

176. How many laths will it take to cover 549 sq. yd., allowing 60 sq. ft. for openings?

177. Allowing $4\frac{1}{2}$″ in width, and casings $4\frac{1}{2}$″ wide, how wide will the frame be, from outside to outside, for a $14'' \times 28''$ four-light window?

NOTE.—It is the usual custom to allow 5″ in width and 6″ in height for a four-light window.

178. A board is 10′ long and $12\frac{3}{8}''$ wide. How many feet B. M. has it?

179. B does $\frac{1}{5}$ less work than A, and receives 10¢ per hour. How much ought A to receive?

180. Although A does no better work than B, he is more careful in stock cutting and wastes $\frac{1}{10}$ less lumber. Should not B expect his pay cut down until he can cut stock more economically?

181. A timber $9'' \times 13''$ and 21′ long contains how many feet B. M.?

182. In repairing furniture, A and B work together; A is careful, but B destroys a hand screw worth 25¢. A receives 10¢ per hour, and B, 8¢, though neither does more work than the other. How long will B have to work before the difference in his pay equals the price of the hand screw?

183. What should be the distance between the sill and the head stud of a $14'' \times 28''$ four-light window? Allow 6″ beyond the glass for the height of the sash, 2″ for the thickness of the sill of the window frame, and $2\frac{1}{4}''$ between the top of the upper sash and the head stud.

184. How many square feet in the wall and ceiling of a room $12' \times 16' \times 8'$ high, making no allowance for openings?

185. If the above room has a light area equal to $\frac{1}{4}$ of its wall surface, and glass 14″ wide is used, what size of four-light windows should be ordered, and how many, allowing full size of glass for light area exclusive of the woodwork of the sash? Give total light area in square inches, and the number and size of windows of nearest stock size.

186. How many cubic yards of earth will be removed from an excavation $40' \times 60'$, and 3′ deep at one end, and 5′ deep at the other?

187. At $12\frac{1}{2}$¢ per cubic yard, how much must be paid for the work above described?

188. A plank is $2'' \times 14'' \times 18'$ long. How many feet B. M. are there in it?

189. A plank is $14' \times 9''$. How many feet B. M. are there in it?

190. If poplar is worth $40 per M, how much is 963′ worth?

191. Five workmen contract to build a barn; they use 6000′ of lumber @ $20 per M, 12,000 shingles @ $1.75, and hardware, etc., at a cost of $15. They each work 60 hr. The contract price was $180. How much does each receive for his labor per hour?

192. How much would they have received if the lumber had cost only $15 per M?

193. How many feet B.M. are there in a timber $9'' \times 12''$ and $16'$ long?

194. Twenty-four tables cost \$1.50 each; an order was to be placed for a second lot, if they could be figured down to $\frac{1}{10}$ less. The estimate was for $\frac{1}{15}$ less. What was the estimated price of the second lot?

195. Nine window frames were made at a profit of $\frac{1}{5}$, and each cost \$1.30. What was the entire cost of the job, including the profit?

196. If a window frame costs \$1.50, what will be the cost of the window frames in a house with 19 window openings?

197. Students A and B begin a job to get out a lot of small pieces. A picks up all the small pieces he can find around the shop, but B goes to the lumber shed and takes good whole boards. They both receive 8¢ per hour. The next month one of them has his pay increased $\frac{1}{4}$. Which one is it, and what is his new pay?

198. A $14'$ lumber pile had $2632'$ in it. It was built up of layers, averaging $4'$ wide. How many layers had it?

199. How many and what size of window weights will be required to hang 24 windows, each weighing, complete, 24 lb.?

200. What will be the cost of 42 drawing boards $2' \times 2'\ 6''$, allowing $\frac{1}{4}$ waste @ 4¢ per foot, and 5 hours' labor on each @ 8¢ per hour?

201. If A and B do a piece of work which cost \$3.20 for the labor, and C and D do the same work in 18 hr., at 10¢ and 8¢ per hour, respectively, which piece of work cost the more, and how much?

202. A does a piece of work which costs \$6.40 for the labor. If he works 10 da. of 8 hr. each, how much does he receive per hour?

203. If a man receives 80¢ for doing a certain job, and does it in 6 hr., how much will he make an hour?

204. If he does the work in an unsatisfactory manner, and to correct it, works 3 hr. more how much is his pay per hour for the job?

205. If it takes a boy 12 hr. to make a table, and he receives \$1.20 for labor, how much will he earn per hour?

206. What is the cost of the labor upon a house, if the material cost \$556, and the total cost was \$896?

207. A man has two lots of land which cost \$1000 each. He builds a house on one, and sells the house and lot for just enough to give him the other lot clear. The profit was $\frac{1}{10}$ of the cost of the house. For how much did he sell the property?

208. If the bottom of a tank is $5' \times 4'$, how high will the tank have to be to hold 521 gal. of water, estimating $7\frac{1}{2}$ gal. of water to a cubic foot, and allowing the sides to extend $2''$ above the height necessary to contain the water?

209. How many cubic feet are there in the above tank?

210. If another tank were to be made of the same height, to hold $\frac{4}{5}$ more water, how large would it be on the bottom, if it were perfectly square?

211. Three students take a job for \$3.90, with the understanding that A shall receive $\frac{12}{32}$, B, $\frac{11}{32}$, and C, the balance of the amount. How much does each receive?

212. A piece of property cost \$1350. It is rented for $\frac{1}{15}$ of its cost per year. What rent is paid per month?

213. This property is improved at an expense of \$300, and $\frac{1}{10}$ of this amount is added to the tenant's annual rentals. What is his rent per month?

214. If a student does $\frac{9}{16}$ of a job in 8 hr., how long will it take him to complete it?

215. A student is hired for 10¢ per hour, but for carelessness in stock cutting, his pay is cut down $\frac{1}{5}$. How much is he then paid?

216. If $\frac{1}{8}$ of 1000 ft. of lumber cost \$3.20, how much will 1000 ft. cost?

217. A builds a bookcase in 10 hr., but B needs 12 hr. to do the same job. If A receives 10¢ per hour, how much ought B to receive?

218. If $\frac{3}{4}$ of A's pay equal $\frac{1}{2}$ of B's, and C receives $\frac{1}{2}$ as much as both, or 10¢ per hour, how much do A and B receive?

219. How many feet B. M. should be purchased to board in a flat-roofed barn, $20' \times 30' \times 14'$ high, allowing nothing for waste or for openings?

220. A man bought 2000′ of lumber @ \$40 per M, and upon resurveying it, found only 1968′. What was his money loss?

221. A man did $\frac{1}{3}$ of a piece of work one day, $\frac{2}{6}$ the next day, and $\frac{2}{12}$ the day following. How much of the work will have to be done at some other time?

222. How many feet B. M. are there in a board which is $14'$ long $\times\ 8'$ wide?

223. If a student saves \$40 during the summer vacation, and spends $\frac{1}{2}$ of it for school fees and board, $\frac{1}{8}$ for clothes, and helps his

sister with $\frac{1}{3}$ of it, how much must he earn to pay his way the first term, if his total term expenses are \$27?

224. A and B take a contract to make 20 bookcases for \$20 each. If A does $\frac{2}{3}$ of the work, how much should each receive?

225. A, B, C, and D take a job together. A does $\frac{1}{4}$ of it, B, $\frac{5}{24}$, C, $\frac{8}{24}$, and D, $\frac{5}{12}$. What should each receive if the job cost \$20?

226. If B receives 7¢ per hour, and it takes him twice as long to do a certain piece of work as it takes A, who is paid $12\frac{1}{2}$¢ per hour, how much cheaper is 10 hr. of A's time?

227. If a table costs \$1.62 to make, what will be the price of 22 tables, if the price is reduced $\frac{1}{10}$?

228. Estimate the value of a given pile of dimension lumber.

229. If 12 panels are side by side with a 2″ muntin between them and a 3″ stile on each end, and if each panel is 9″ wide, and enters the groove $\frac{1}{2}$″ upon each side, how long will the entire panelwork be?

230. Students A and B receive 8¢ per hour, respectively, and are given a job together. A does $\frac{2}{3}$ of the work. To what should A's pay be raised to make the cost of their work equal?

231. A student has been receiving 10¢ per hour, but as he spends time in nonsense, his pay is reduced $\frac{1}{5}$. What does he receive then?

232. How many 8ths of a foot are there in $7\frac{1}{2}$″?

233. How many 12ths of a foot are there in $3\frac{3}{4}$′?

234. What part of 9′ is 4″?

235. What part of 10″ is $\frac{5}{16}$″?

236. What part of 9″ is $3\frac{1}{2}$″?

237. The aggregate of a column of mixed numbers is 94′ 8″, $\frac{679}{8}$″. What is the total when reduced to feet and inches?

238. A student's term dues are \$27. He receives \$15 from home, and earns \$15 more. At the end of the term he is \$3.20 in debt. How much more than the necessary expenses has he spent?

239. A man does $\frac{1}{3}$ of a piece of work in $5\frac{1}{2}$ hr. How long will it take him to complete the entire job?

240. A receives $12\frac{1}{2}$¢, and B, 9¢ per hour. Upon a certain job they work together, and A does $\frac{2}{3}$ of the work. How much is B overpaid?

241. A student enters a boarding school with \$35 to pay his first term's dues, which is \$5 more than he needs. He wastes his money, and at the beginning of the third month he is short \$3 for his month's dues. Allowing \$6 for his last payment, how much has he wasted?

242. A lumber dealer bought 20,000 ft. of lumber @ \$20 per M. After culling and spending \$2 per M for handling it, he sold it @ \$26 per M. What part of the amount was profit?

243. From a pile of lumber containing 2240′ B. M., a lumber dealer sold $\frac{1}{3}$ @ \$22.25 per M, $\frac{1}{4}$ @ \$25.80 per M, and the balance @ \$16.12$\frac{1}{2}$ per M. How much did he receive for the whole pile?

244. A contract of \$80,000 is to be let in five sections of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{6}$, $\frac{13}{48}$, $\frac{3}{16}$. How much is each subcontract worth?

245. Three tables of the following dimensions are to be made 30″ high: tops $3' \times 4' \times \frac{7}{8}''$ thick; legs $2'' \times 3''$; rails, $1'' \times 5''$, mitered at the corners. The top is to project 2″ over the rails on all sides. Make the stock lists for the three tables.

246. How many feet B. M. are there in the above tables? (Allow no waste, and work to the nearest foot in estimating.)

247. Students A, B, and C make the tables. A makes his in 10 hr., and cuts 31′ of stock; B makes his in 12 hr., and cuts 35′ of stock; and C makes his in 15 hr., and cuts 40′ of stock. Working upon a basis of 10¢ per hour for A, how much should the others be paid for their labor?

248. Considering that stock costs 4¢ per foot, how much more do the tables built by B and C cost than that built by A?

249. If the tables are sold for \$2.40 each, how much is made or lost upon each table?

250. A fence post is 9′ long, and $\frac{5}{18}$ of its length is below ground. How much is in sight?

251. What will 6$\frac{1}{2}$ cwt. of nails cost @ 3$\frac{7}{8}$¢ per pound?

252. A man paid \$1450 for $\frac{5}{9}$ of a piece of property. How much was the property worth?

253. The property was sold for \$2800. What was his profit?

254. What will six 1″ boards 16′ long × 7″ wide be worth @ \$27.50 per M?

255. Two students do a certain piece of work for \$3.50, one furnishing $\frac{4}{5}$ of the time, and the other the balance, or 7 hr. How much per hour does each receive?

256. A and B undertake a piece of work; A works $\frac{2}{3}$ of the time, and does $\frac{1}{2}$ of it; and B works the rest of the time, and finishes the job. How much ought A to receive, if B receives 8¢ per hour?

257. How much will 16$\frac{1}{3}$ gross of screws cost at 15$\frac{1}{4}$¢ per gross?

258. If a student can do $\frac{4}{5}$ of a piece of work in 2 hr., how long will it take him to do the whole job?

259. If a student does $\frac{7}{11}$ of a piece of work in 4 hr., how long will it take him to finish the entire work?

260. Make out the stock list for a box 2′ 5″ long, 1′ $3\frac{1}{2}$″ wide, and $7\frac{1}{2}$″ deep. All dimensions are inside, and the box is made of $\frac{7}{8}$″ stock.

261. Estimate the exact number of square feet of lumber used in making the above box.

262. If $\frac{4}{9}$ of a keg of nails cost $1.60, how much will the entire keg cost? Weight of keg is 100 lb.

263. A student pays $18 for his entrance fees, which is $\frac{5}{9}$ of all the money that he has. How much has he?

264. A board is 14′ long, and contains $9\frac{1}{3}$ sq. ft. How wide is it?

265. A student spends $100 for a year's work at school. He earns $\frac{6}{17}$ of it, and pays the balance from money he brought with him. How much was left, if he brought $75 with him?

266. A certain job cost $1.46, of which $\frac{2}{3}$ was for stock, $\frac{1}{10}$ for profit, and the balance for labor @ 8¢ per hour. How much labor was furnished?

267. Measure with a tape a given lot of land, and estimate the number of square feet in its area.

268. Estimate the amount of lumber in a given lumber pile.

Note. — This is done by approximation; estimate the amount of an average layer, and multiply it by the number of layers or courses.

269. A job cost $3.15; $\frac{2}{3}$ of the cost was for material, and $\frac{1}{2}$ of the price of the material equaled the cost of the labor. What did the labor cost?

270. Measure a certain piece of furniture for a packing box, allowing $\frac{3}{8}$″ all around for packing. Make the stock list and estimate the cost.

271. A man paid $35 for repainting a house, which was $\frac{1}{27}$ of the amount he paid for the property. What was it worth?

272. After painting the house, he sold the property for $1025. How much did he make?

273. A student was given 5 lb. of nails for a certain job, but used only $3\frac{3}{4}$ lb. At $4 per hundredweight, what was the value of those returned?

274. D receives $\frac{1}{4}$ more pay than A. A and C each receive twice as much as B. D receives $12\frac{1}{2}$¢ per hour, which is $\frac{1}{2}$ of the total which the others receive. How much do A, B, and C each receive?

275. A lot of land is worth $250. The barn is worth $527, and the value of the house equals the value of the barn plus $7\frac{2}{3}$ times that of the lot. What is the value of the entire property?

276. From the ground, or grade line, to the sills of a house, it is $24\frac{5}{8}''$; from there to the lower window sills, it is $30\frac{1}{4}''$; to the window header, it is $5'\,2\frac{7}{8}''$; to the frieze, it is $3'\,4\frac{5}{8}''$; to the edge of the eaves, it is $12\frac{3}{16}''$. What is the entire height of the eaves from the ground?

277. A certain piece of work requires 79 hr. of labor. A works .4 of it; B, .3; C, .15, and D finishes it. How much time does D work?

278. A receives $.10 per hour; B, .7 as much; C, $\frac{3}{4}$ as much, and D, $\frac{5}{8}$ as much. How much does each receive per hour?

279. If B is worth $\frac{3}{4}$ as much for 6 hours' work as A is for 8 hours' work, how much would he receive for $7\frac{1}{2}$ hours' work?

280. If D is worth $\frac{3}{4}$ as much as B in the above problem, how long would he have to work to earn the same amount as B?

281. If E, being a journeyman, can do $\frac{1}{2}$ as much continuously as can A, B, C, and D, in problem 278, how much ought he to receive per hour?

282. If A can do a piece of work in 12 da. and B in 10 da., how many days ought they to take if they do it together?

283. If A and B can build a barn in 8 da., and A could do it alone in 12 da. how long would it take B to do it without help?

284. A and B contract to build a corncrib. It takes them 10 da., A doing $\frac{2}{3}$ as much as B. What part does each do in a day?

285. If they are to receive $20 for the labor upon the job, what should be the share of each?

286. If a student makes a bookcase in $6\frac{1}{2}$ hr., how long will it take him to make 12 of them, if he saves $\frac{1}{8}$ of his time by making a number?

287. At $2\frac{7}{8}$¢ per pound for nails, how many will $$20\frac{3}{8}$ buy? Answer in decimals.

288. How many feet B. M. are there in a board which is 16′ long and 9″ wide?

289. How many feet B. M. are there in a pile of 2″ × 6″, 14′ long, containing 140 pieces?

290. How many feet B. M. should be purchased to lay a matched floor $20' \times 35'$, allowing $\frac{1}{4}$ waste?

291. Allowing $2\frac{1}{2}$ lb. of nails to the square, how many nails will be necessary to lay the above floor?

292. Paying 75¢ per square for labor, how much will it cost to lay the above floor?

293. Make out the stock list for a piece of panelwork which contains 4 panels, the outside dimensions of which are 4′ long, 18″ high. All rails, stiles, and muntins are to be 3″ wide, and the panels are to fit into grooves $\frac{1}{2}''$ all around.

294. How many days' work will there be in laying 75,650 shingles, at the rate of 2000 per day?

295. If two men can lay 800′ of flooring in a day, how many men will be required to lay 40,000′ in 5 da.?

296. At $.75 per M for laying, how much will the labor cost upon a shingle roof 40′ long, with rafters 14′ long?

297. The cost of the material for a certain piece of work is $\frac{9}{13}$ of its entire cost. $2.50 was paid for the labor. What was the price of the finished work?

298. A plank is $2'' \times 14''$ and 24′ long. How many feet B. M. are there in it?

299. A timber is $10'' \times 16''$ and 32′ long. How many feet B. M. are there in it?

300. Estimate the cost of the material in a certain piece of furniture.

301. What is the area of a floor 40′ long, 16′ wide at one end, and 24′ at the other?

302. What will the labor cost upon the floor of the above room @ $.60 per square?

303. Nine men work 2 hr. each, moving a piece of furniture. Three of them receive $8\frac{1}{3}$¢; three, $7\frac{1}{2}$¢, and the others, $12\frac{1}{2}$¢ per hour. What did the job cost?

304. How much will it cost to paint an area $12' \times 36'$ at a cost of 10¢ per square yard?

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