TM 5-226

WAR DEPARTMENT

U. S. Dept. of Army

TECHNICAL MANUAL

CARPENTRY

May 6, 1943

TECHNICAL MANUAL

CARPENTRY

CHANGES
No. 1

WAR DEPARTMENT,
WASHINGTON 25, D. C., 20 May 1944.

TM 5–226, 6 May 1943, is changed as follows:

11. Allowable stresses.—Various kinds of * * * is used. **See FM 5–10 for table of strengths of various woods.**

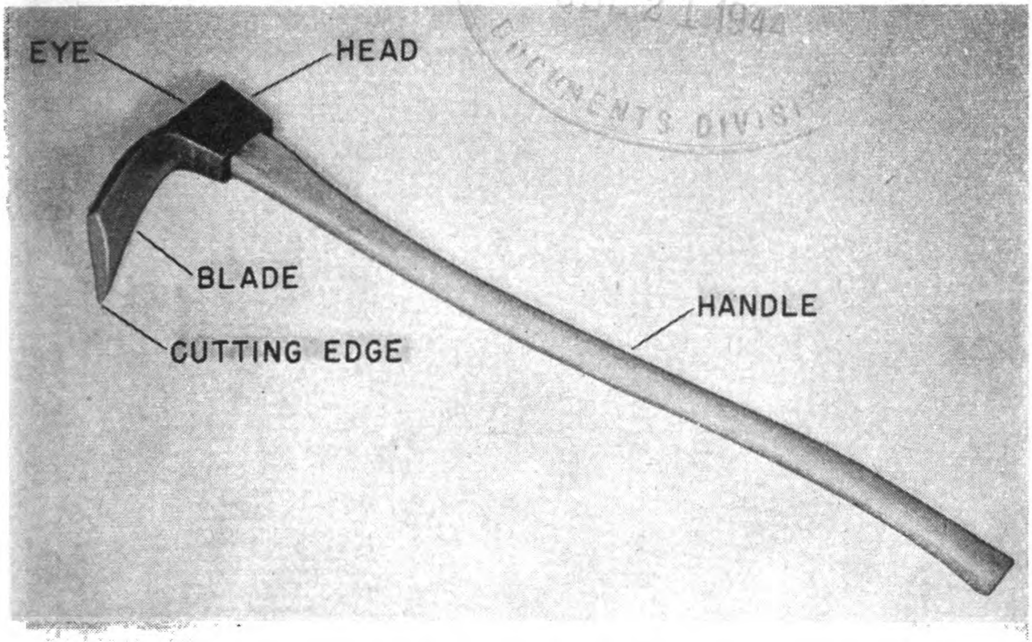

FIGURE 13.—Adze.

29. Hatchet, half.—*a. General.*—The half-hatchet * * * blade (fig. 16). To pull nails, some hatchets have a claw in addition to the hammer head, while other are notched in the **rear** edge of the blade (fig. 17). Hatchets are made * * *. (See fig. 17.)

* * * * * * *

35. Wood rasp.—The wood rasp * * * in handle fitting. Oil **must not be used on a rasp** as it will cause the rasp to become clogged with wood particles.

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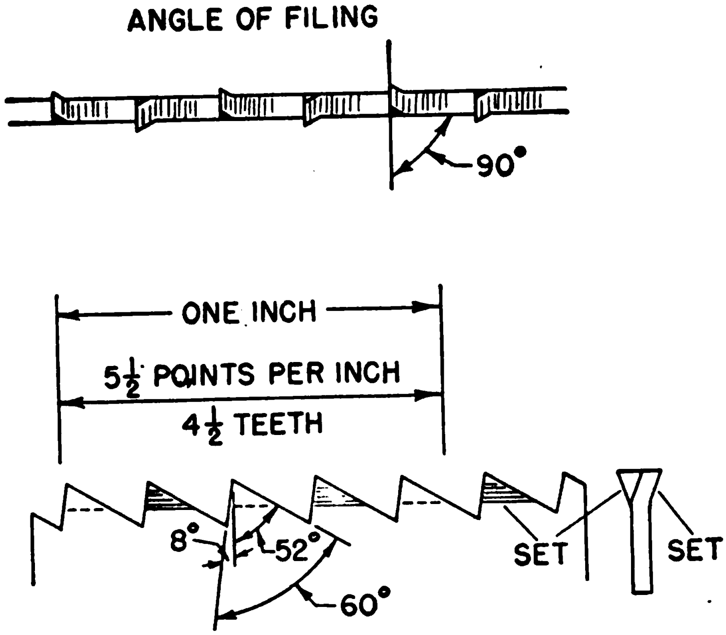
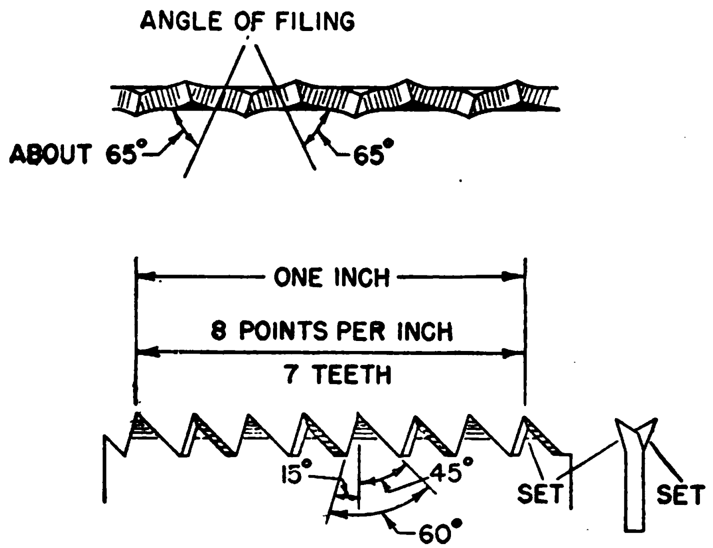


① Rip.



② Cross cut.

FIGURE 38.—Angles of saw teeth.

36. Hand saws.

* * * * * * *

d. Sharpening.—(1) Jointing always is the first step in sharpening. The purpose of jointing is to make all the teeth the same height. To joint a saw, place it in a clamp, lay a flat file lengthwise on the teeth and pass it lightly from heel

to toe until a flat top has been filed on the tip of each tooth. The teeth then * * * or the other. The jointing tool **will hold the file flat when used.**

(2) Shaping **is done only when the teeth are unevenly spaced or shaped. To shape, file the teeth** with a regular hand saw file to the correct uniform size and shape. The gullets must * * * teeth while shaping. **If a whole tooth is missing, joint and shape alternately so as not to lose the correct spacing of the teeth.**

* * * * * * *

(4)

* * * * * * *

(*b*) To file a * * * underneath (fig. 37). The file may be held in the file holder guide as shown in figure **91.** The guide holds * * * tooth is sharpened.

(*c*) Hold the file * * * the desired angle. The correct angle is approximately 65° (fig. 38 ②). Tilt the file * * * with the vertical. (See fig. 38 ②.) Keep the file * * * saw is reached.

* * * * * * *

(*e*) In filing a * * * to the blade. The file should be placed on the gullet so as to file the breast of the tooth at an angle of 8° with the vertical (fig. 38 ①). Stand in positions * * * not cut satisfactorily.

* * * * * * *

37. Crosscut saw.

* * * * * * *

b. When the saw * * * from the vertical. (See fig. 38 ②.)

38. Ripsaw.—*a.* The ripsaw is * * * through the wood. (See fig. 38 ①.)

* * * * * * *

55. Claw hammer.

* * * * * * *

b. Operation.

* * * * * * *

(3) (Added.) *To drive a nail with one hand* (fig. 71.1).—(*a*) Insert the nail between the claws with its head against the hammer head as shown in figure 71.1.

(*b*) Grasp hammer handle as shown in figure 71.1.

(*c*) Swing hammer forward to drive nail into wood.

(*d*) Remove hammer from nail, reverse to bring head into normal driving position.

(*e*) Drive nail.

(4) (Added.) *To drive a nail with one hand* (*alternate method*) (fig. 71.2).—(*a*) With hammer head held in hand as shown in figure 71.2, grasp nail between thumb and forefinger holding nail head against side of hammer head.

(*b*) With a sharp stroke, start the nail in the wood.

(*c*) Release nail and grasp hammer handle in normal manner.

(*d*) Drive nail.

* * * * * * *

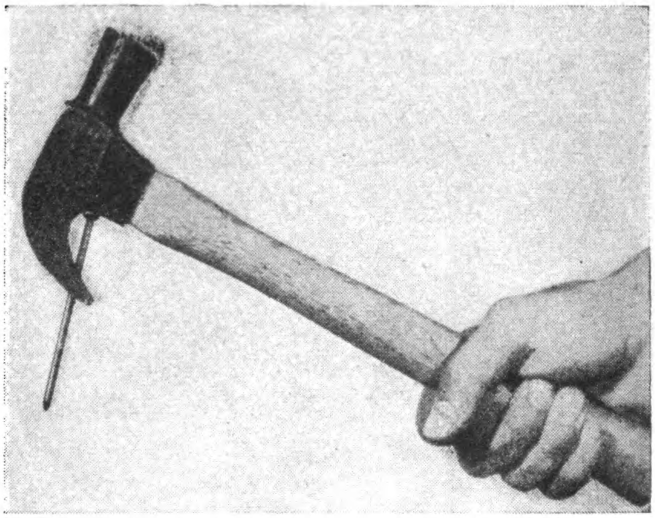


FIGURE 71.1 (Added).—Starting nail with one hand.

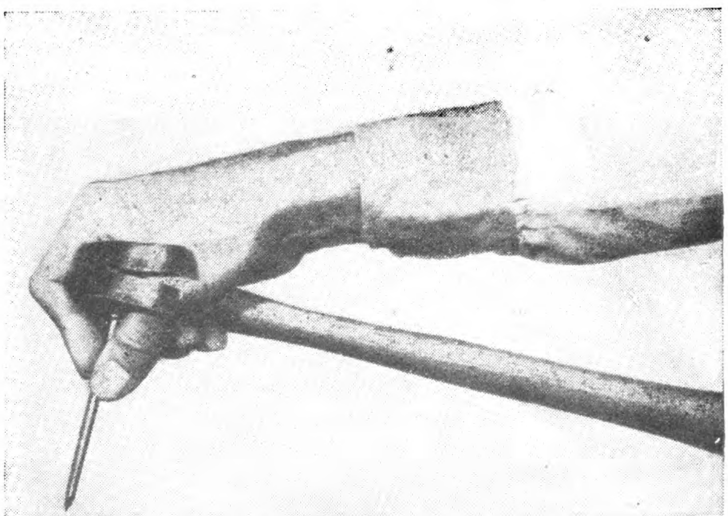


FIGURE 71.2 (Added).—Starting nail with one hand (alternate method).

76. How to read a blueprint.

* * * * * * *

d. When the title * * * type of covering. The rafters, plates, braces, and type of roof **covering also are** shown. The front frame * * * the frame elevation.

* * * * * * *

83. General.

* * * * * * *

b. The connections between * * * they are strong. The Army **carpenter** must learn to make these connections accurately and quickly.

93. Splices for bending.

* * * * * * *

b. The parts are * * * place (fig. 96⑤). Occasionally such a splice must be constructed in a member with tension in the upper part, such as overhanging or cantilever beams (fig. **147**). In such a * * * be turned over.

* * * * * * *

95. Nails.

* * * * * * *

d. Size.—Wire nails come * * * and table VII. **Spikes are similar to nails but made of heavier-gauge wire. Commercial sizes range from 10 d to 60 d and from 7 to 12 inches long.**

98. Driftpins.

* * * * * * *

b. Types.—Driftpins **may be provided with heads or may have plain driving ends. They** vary in diameter from ½ to 1 inch, in length from 18 to 26 inches.

* * * * * * *

116. Corner posts.

* * * * * * *

a. A corner post may consist of a 4 by 6 with a 2 by 4 nailed on the **broad** side, flush with **the** edge. This type of * * * timber is used.

* * * * * * *

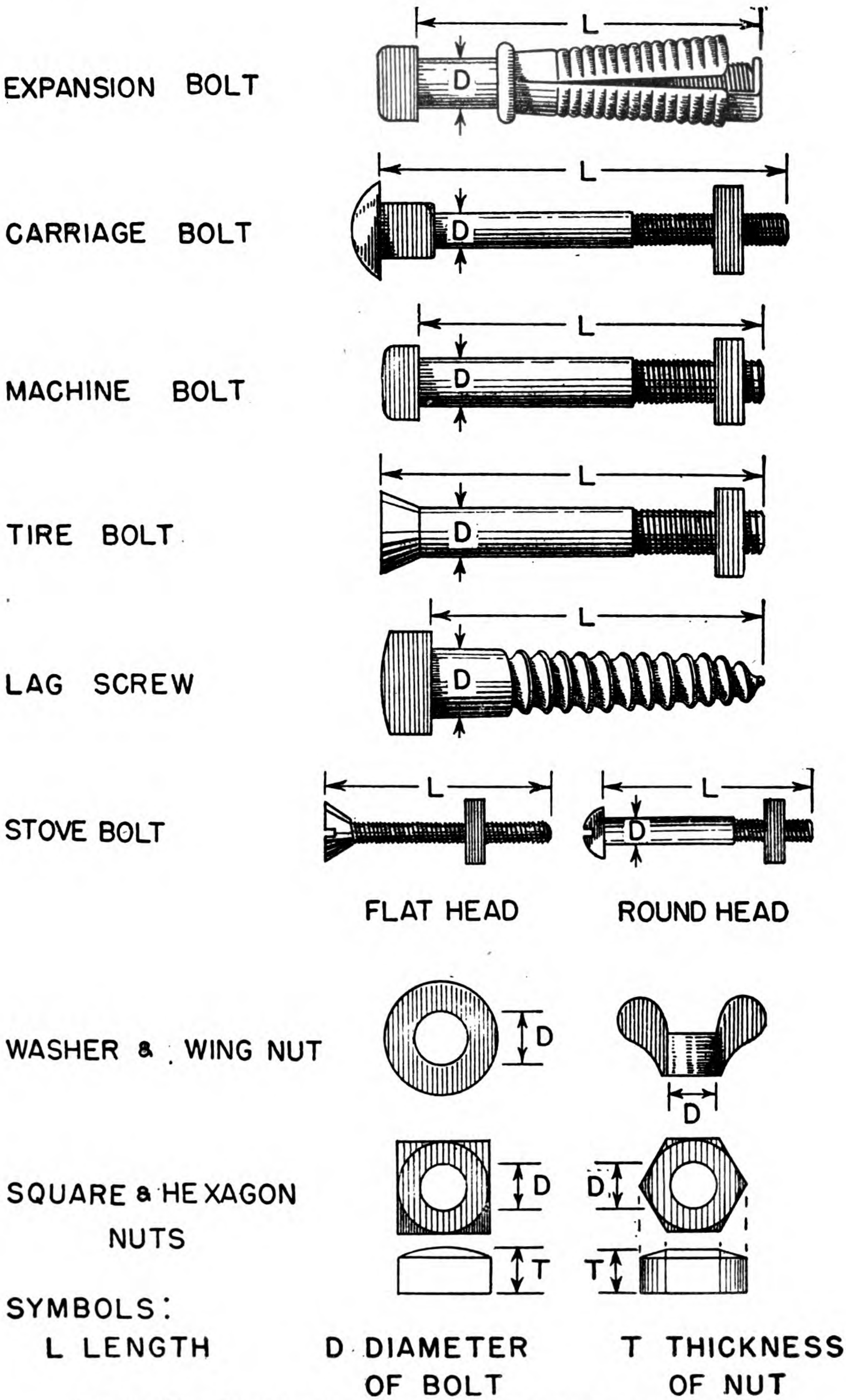


FIGURE 100.—Types of bolts (size designated by dimensions indicated).

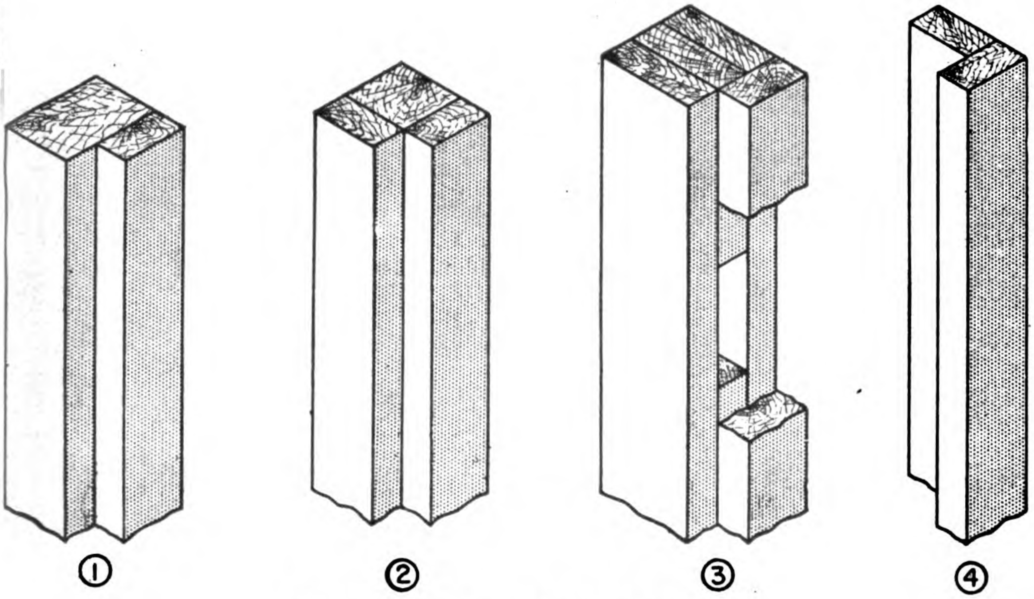


FIGURE 127.—Corner-post construction.

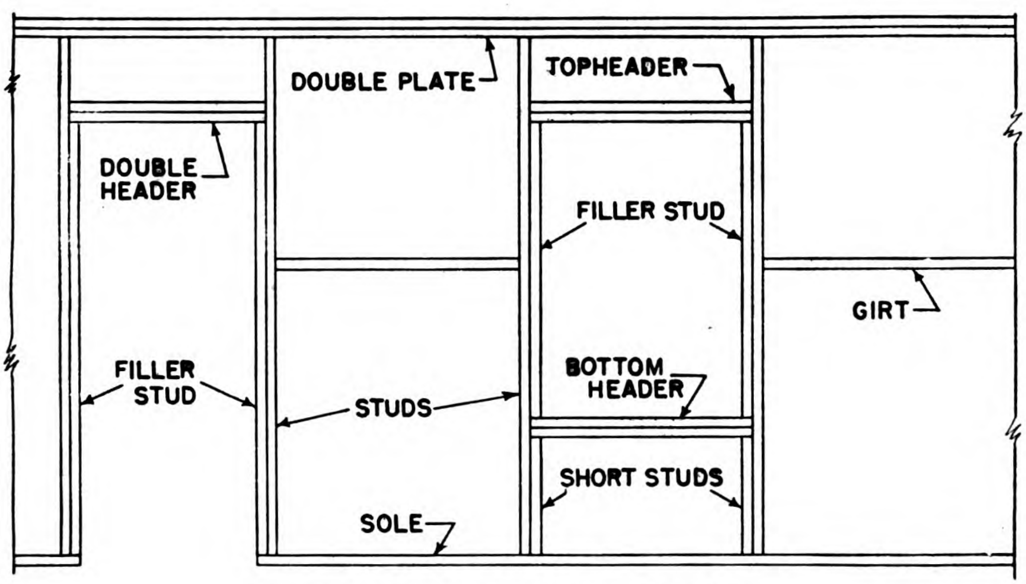


FIGURE 132.—Door and window framing.

130. Methods of laying out rafters.

* * * * * * *

c. Table method, using rafter table on framing square.

* * * * * * *

(3)

* * * * * * *

(*c*) If the run * * * add the two. The **length** for 23 **feet** with a pitch of one-fourth is 25 feet, $8\frac{5}{12}$ inches. For 4 feet, the **length** is 4 feet, $5\frac{2}{3}$ inches. The total **length** for 27 feet is 30 **feet**, $2\frac{1}{12}$ inches. When the run * * * in *a* above.

* * * * * * *

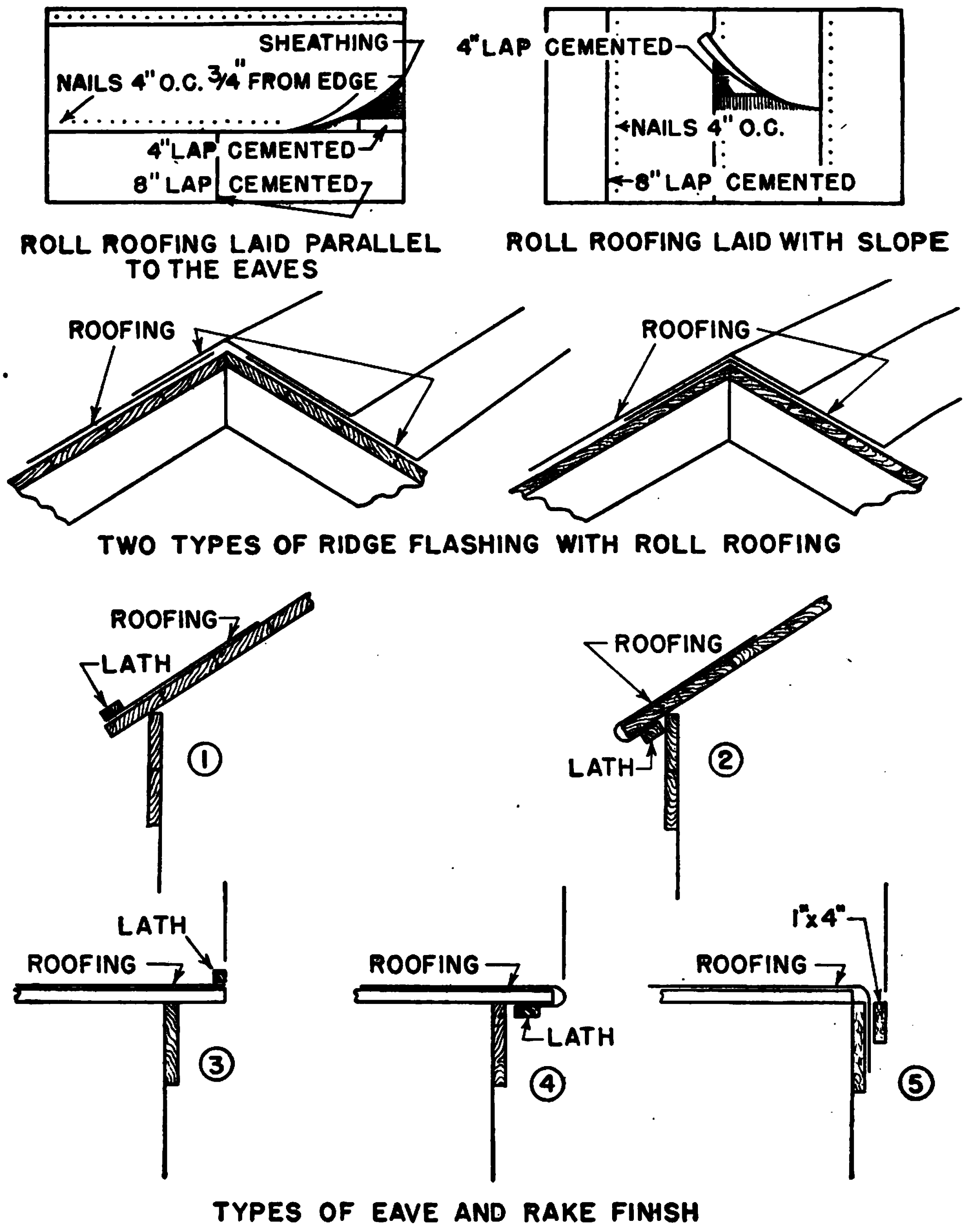


FIGURE 145.—Types of roof finish.

144. Flashing.

a. Stovepipes.—(1) Where stovepipes are carried through the roof, roof jacks are used with flashing attached (figs. 161 and 162). In most cases * * * wall (fig. 163).

* * * * * * *

164. Trestle bent.

* * * * * * *

e. Longitudinal cross-bracing.—Longitudinal cross-bracing * * * move the trestles. The bracing is nailed to the outside post of a trestle with one end of the brace nailed to the bottom of one trestle post and the other end to the top of the other trestle post. Two pieces are * * * at the ends.

* * * * * * *

169. Pile bents and pile piers.—*a. Use.*—Pile bents and * * * for framed trestles. They are used in rivers which are subjected to freshets, deep water, or scouring action due to high velocity of water; in marshy ground; in river bottoms which are too uneven for trestles; or in sea-landing piers.

* * * * * * *

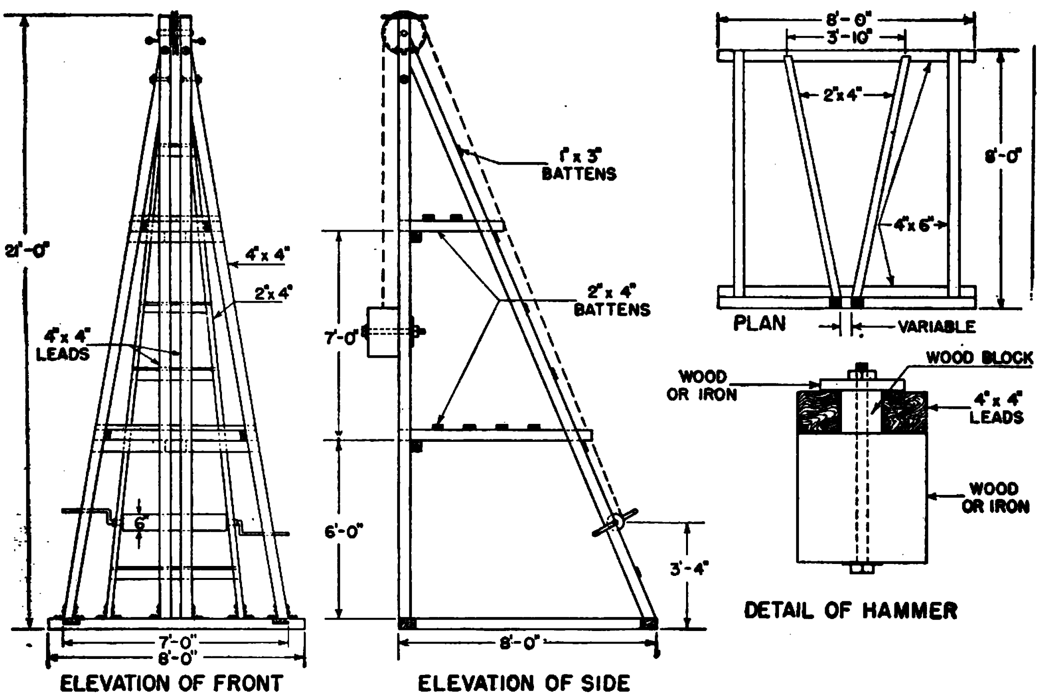


FIGURE 200.—Pile-driving frame.

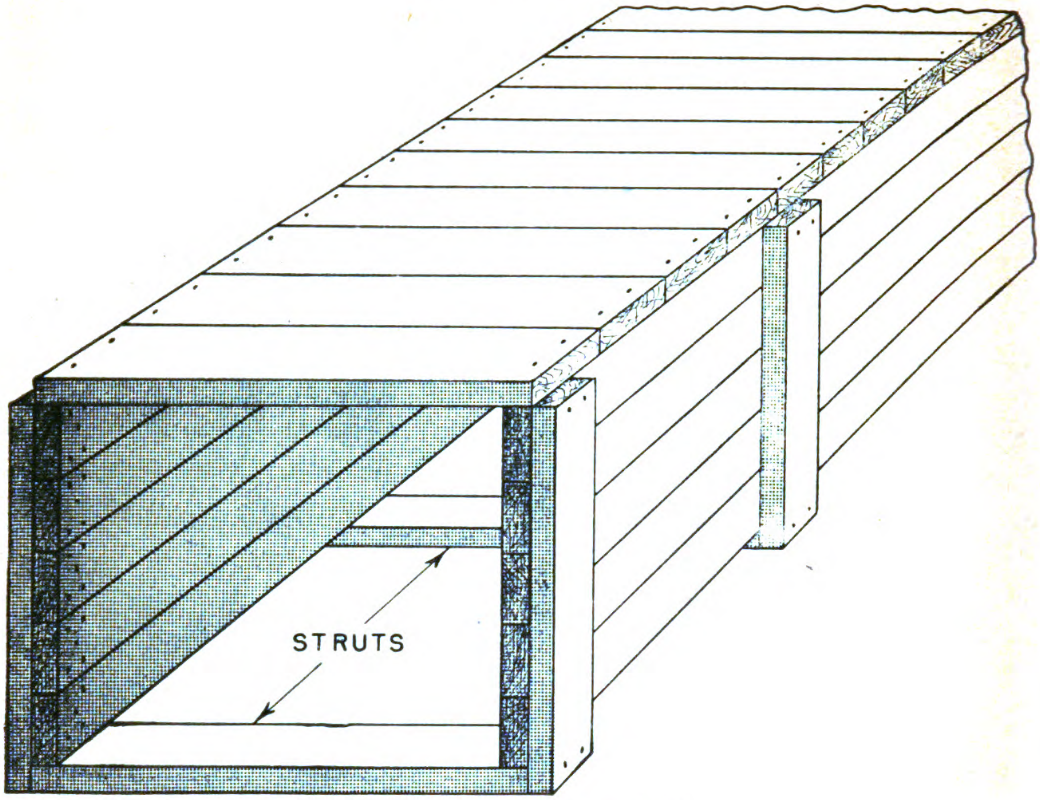


FIGURE 205.—Wood box culvert.

APPENDIX II

* * * * * * *

Joint-butt. (Page 246.)

* * * * * * *

Rub.—A glue joint made by carefully fitting the edges together, spreading glue between them, and rubbing the pieces back and forth until they are well rubbed together.

* * * * * * *

[A. G. 300.7 (4 Apr 44).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:

As prescribed in FM 21-6: except ROTC (O); R 1, 2, 4, 6, 7, 10, 11 (2); Bn 1, 2, 4, 6, 7, 10, 11 (3); 5 (5); C 5 (5).

For explanation of symbols, see FM 21-6.

U. S. GOVERNMENT PRINTING OFFICE: 1944

TECHNICAL MANUAL No. 5-226

WAR DEPARTMENT, WASHINGTON, May 6, 1943.

CARPENTRY

519788°—43——1

CHAPTER 1

GENERAL

1. Object and scope.—The object of this manual is to furnish the officer and enlisted man detailed information and instruction regarding rough carpentry used in theaters of operation. The manual describes carpentry methods and the care, use, and maintenance of carpenter tools. Tools not fully described are covered in TM 5–225 and the various Technical Manuals on individual tools.

2. Definition.—The term "carpentry" as used in this manual means the technique or craft of the carpenter. It includes the functions of the carpenter in maintaining, repairing, and constructing buildings, bridges, and other wooden structures.

CHAPTER 2

TIMBER

SECTION I

USE

3. **General.**—The elemental material of construction in carpentry is lumber. There are numerous kinds of lumber varying greatly in structural characteristics. An essential part of the training of a carpenter is the acquisition of knowledge of wood so that the most suitable material may be chosen for a particular job. This chapter deals with kinds of wood and their physical characteristics.

4. **Function.**—Timber is found in almost every region. It is much lighter than steel and therefore easier to transport. With good timber a carpenter is able to construct nearly every type of bridge or building. Wood is easily adaptable, strong enough for most military construction, and does not require the special tools used in steel work.

5. **Standards for construction in theater of operations.**—In the theater of operations, the general rule is to use what materials are available and to complete the job in the shortest possible time with the least expenditure of labor. The Army carpenter uses any materials at hand as long as they can serve the purpose for the period of time demanded by the military situation. Paragraph 12 and table I give the standard sizes of timber most useful for military purposes.

SECTION II

CLASSIFICATION AND QUALITIES

6. General types.—*a.* Timber is initially classified, according to the nature of growth, into four broad categories:

(1) *Deciduous, or broad-leafed trees.*

(2) *Coniferous, or needle-leafed trees.*

(3) *Bamboo trees.*

(4) *Palm trees.*

b. Each type has characteristic qualities, but within each category timber varies greatly and is further classified. Only deciduous and coniferous timber is used extensively in temperate countries; the properties of these woods are taken up in detail in the following paragraphs.

7. Qualities.—Timber is classified according to the qualities of hardness, toughness, and flexibility, but each quality is dependent upon another.

a. Hardness.—Hardness is measured by the compression which a piece of timber undergoes when a weight is applied to it. Coniferous woods are generally soft woods and are easily worked with tools. Most deciduous woods are hard, and some types are worked with tools only with difficulty.

b. Toughness.—Toughness is the measure of strength and durability of wood. Tough timber will stand much rough treatment before it will break or split.

c. Flexibility.—Flexibility is measured by the amount a piece of timber will bend before breaking. Soft wood is of a brittle type while most hardwood is flexible. The wood in the trunk of a tree is tougher than that of the limbs. Moist timber is more flexible than dry timber. Hickory is one of the most flexible woods found in this country. Hard woods do not split as easily as soft woods and seasoned wood not as easily as green wood.

8. Seasoning.—Seasoning, or controlled drying, of timber improves the strength of the material. Timber has greater strength when dry. The dead weight of buildings and bridges is greatly reduced by using dry timber, and the handling and transportation problem is eased. For most uses, dry timber works better than green in sizing, sawing, making tight joints, etc.

9. Green timber.—Although green timber has a tendency to warp, almost any type of building constructed in the theater of operations may be built using green timber with good results. The only item for which green wood cannot be used with satisfactory results is sheathing. When green sheathing dries out after being covered with roofing it shrinks, and this tears holes in the roof. Nails, spikes, and driftpins do not hold as well in green timber, for, as a rule, it is much softer and not so tough as dry timber.

10. Shrinkage.—All timber shrinks when it dries. Care must be taken to prevent warping. The shrinkage lengthwise is very small, but cross-grain shrinkage is very perceptible. In building large buildings and bridges, seasoned timber should be used where possible; otherwise shrinkage may cause serious defects.

11. Allowable stresses.—Various kinds of wood have been tested to determine the maximum amount of stress which they will bear. In military construction a factor of safety of 3 is used.

12. Sizes.—Lumber is usually sawed into standard sizes of length, width, and thickness. This permits uniformity in planning structures and in ordering materials. Table I lists the common widths and thicknesses of wood in the United States. Common commercial lengths range from 8 to 20 feet. Table II shows the amount of board feet in lumber of typical cross sections and lengths.

13. Grading.—Commercially, all lumber is classified according to its qualities for different uses in construction. The classifications are select, No. 1 common, No. 2 common, No. 3 common.

a. Select timber is the best grade of timber. It is used in two connotations:

(1) In heavy construction, *select* means timber free from large knots, rots, and other weakening defects. This timber has a good bearing stress, flexibility, and toughness.

(2) In finished work, *select* means comparatively soft wood, free from knots, rots, or stains which mar the appearance of the wood.

b. No. 1 common has most of the characteristics of select construction timber, but it is of a slightly lower quality.

c. No. 2 common is used for most ordinary construction. It may have large knots, stains, and rots which do not, however, affect the strength of the timber. It is used for sheathing, forms, framing, and other structural forms where the stress or strain is not excessive.

d. No. 3 common has large knots, bark, rots, thin edges; it may be crooked, warped, or twisted. It is used for such rough work as footing forms, footings, guard rails, and rough flooring.

TABLE I.—*Standard widths and thicknesses of lumber*

Type of lumber	Normal size (inches)		Actual size S4S [1] (inches)	
	Thickness	Width	Thickness	Width
Timbers	2	4	1⅝	3⅝
	2	6	1⅝	5⅝
	2	8	1⅝	7½
	2	10	1⅝	9½
	2	12	1⅝	11½
	2	14	1⅝	13½
	2	16	1⅝	15½
	3	6	2⅝	5⅝
	3	8	2⅝	7½

[1] Surfaced 4 sides.

TABLE 1.—*Standard widths and thicknesses of lumber*—Continued

Type of lumber	Normal size (inches)		Actual size S4S [1] (inches)	
	Thickness	Width	Thickness	Width
	3	10	2⅝	9½
	3	12	2⅝	11½
	3	14	2⅝	13½
	3	16	2⅝	15½
	4	4	3⅝	3⅝
	4	6	3⅝	5⅝
	4	8	3⅝	7½
	4	10	3⅝	9½
	4	12	3⅝	11½
	4	14	3⅝	13½
	4	16	3⅝	15½
	6	6	5½	5½
	6	8	5½	7½
	6	10	5½	9½
	6	12	5½	11½
	6	14	5½	13½
	6	16	5½	15½
	8	8	7½	7½
	8	10	7½	9½
	8	12	7½	11½
	8	14	7½	13½
	8	16	7½	15½
	10	10	9½	9½
	10	12	9½	11½
	10	14	9½	13½
	10	16	9½	15½
	12	12	11½	11½
	12	14	11½	13½
	12	16	11½	15½
	14	14	13½	13½
	14	16	13½	15½
	16	16	15½	15½
Common boards	1	4	25/32	3⅝
	1	6	25/32	5⅝
	1	8	25/32	7½
	1	10	25/32	9½
	1	12	25/32	11½
Shiplap boards	1	4	25/32	3⅛
	1	6	25/32	5⅛
	1	8	25/32	7⅛
	1	10	25/32	9⅛
	1	12	25/32	11⅛
Tongued and grooved boards	1	4	25/32	3¼
	1	6	25/32	5¼
	1	8	25/32	7¼
	1	10	25/32	9¼
	1	12	25/32	11¼

[1] Surfaced 4 sides.

Table II.—*Contents of lumber*

[Number of board feet in various sizes for lengths given]

Size of piece (inches)	Length of piece (feet)								
	8	10	12	14	16	18	20	22	24
2 by 4	5⅓	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
2 by 6	8	10	12	14	16	18	20	22	24
2 by 8	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
2 by 10	13⅓	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
2 by 12	16	20	24	28	32	36	40	44	48
2 by 14	18⅔	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56
2 by 16	21⅓	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
3 by 6	12	15	18	21	24	27	30	33	36
3 by 8	16	20	24	28	32	36	40	44	48
3 by 10	20	25	30	35	40	45	50	55	60
3 by 12	24	30	36	42	48	54	60	66	72
3 by 14	28	35	42	49	56	63	70	77	84
3 by 16	32	40	48	56	64	72	80	88	96
4 by 4	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
4 by 6	16	20	24	28	32	36	40	44	48
4 by 8	21⅓	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
4 by 10	26⅔	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
4 by 12	32	40	48	56	64	72	80	88	96
4 by 14	37⅓	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112
4 by 16	42⅔	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
6 by 6	24	30	36	42	48	54	60	66	72
6 by 8	32	40	48	56	64	72	80	88	96
6 by 10	40	50	60	70	80	90	100	110	120
6 by 12	48	60	72	84	96	108	120	132	144
6 by 14	56	70	84	98	112	126	140	154	168
6 by 16	64	80	96	112	128	144	160	176	192
8 by 8	42⅔	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
8 by 10	53⅓	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160
8 by 12	64	80	96	112	128	144	160	176	192
8 by 14	74⅔	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224
8 by 16	85⅓	106⅔	128	149⅓	170⅔	192	213⅓	234⅔	256
10 by 10	66⅔	83⅓	100	116⅔	133⅓	150	166⅔	183½	200
10 by 12	80	100	120	140	160	180	200	220	240
10 by 14	93⅓	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280
10 by 16	106⅔	133⅓	160	186⅔	213⅓	240	266⅔	296⅓	320
12 by 12	96	120	144	168	192	216	240	264	288
12 by 14	112	140	168	196	224	252	280	308	336
12 by 16	128	160	192	224	256	288	320	352	384
14 by 14	130⅔	163⅓	196	228⅔	261⅓	294	326⅔	359⅓	392
14 by 16	149⅓	186⅔	224	261⅓	298⅔	336	373⅓	410⅔	448
16 by 16	170⅔	213⅓	256	298⅔	341⅓	384	426⅔	469⅓	512

SECTION III

IMPERFECTIONS

14. Defects.—In the growth and life of a tree certain defects occur which weaken timber cut from these trees. The defects are classed as knots, checks, heartshakes, windshakes, and starshakes.

a. Heartshake or heart rot.—Heartshake is a defect of the heartwood found in older trees, especially the hemlock; it is seldom found

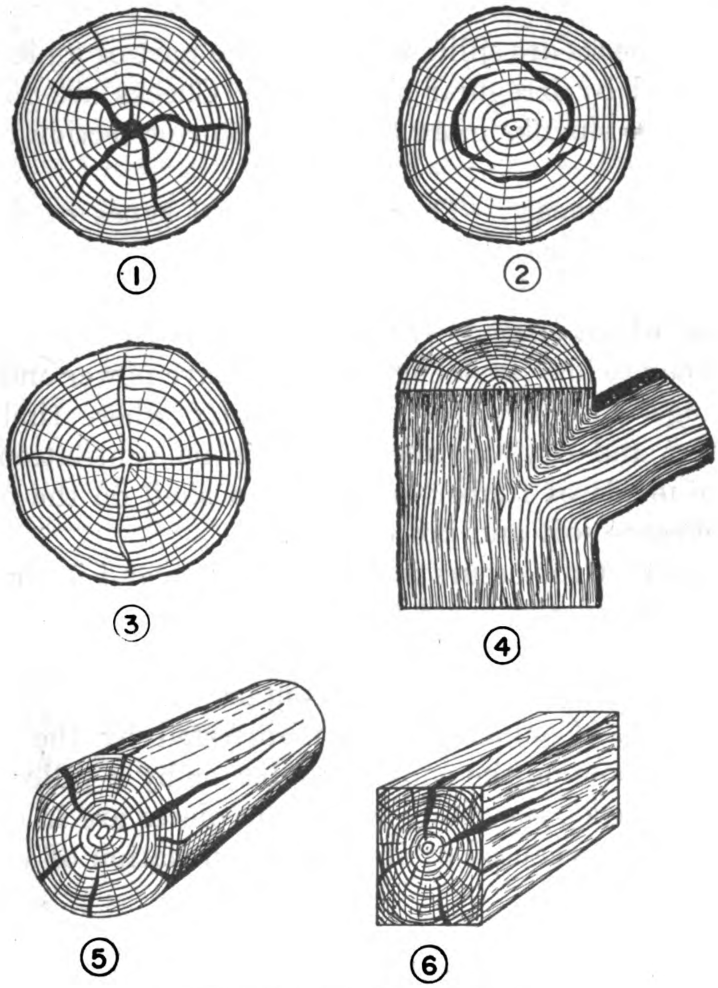


FIGURE 1.—Defects in timber.

in saplings. The heartshake is evidenced by a small round cavity at the center of the tree or timber. This cavity is caused by decay and results in cracks which extend outward to the bark (fig. 1①).

b. Windshake.—Windshake is the separation of the annual rings (fig. 1②). This defect is most common in pine timber. Windshake sometimes extend several feet up the trunk of a tree.

c. Starshake.—A starshake is much like a heartshake in its effect. The difference between the two is that the starshake has no decay at the center. The cracks extend over the cross section of the log, are wide in the center, and narrow to nothing near the bark. The wood along these cracks is solid (fig. 1③).

d. Knots.—Knots are irregular growths in the body of a tree which interrupt the smooth curve of the grain. The fibers of the tree are turned from their normal course and grow around the knot at that point of a tree where a limb is being formed. If the knot is large, cross grains are formed which cause the lumber to break easily (fig. 1④).

e. Checks.—Checks are splits in the outside part of a piece of timber which are caused by irregular shrinkage. Checks are formed when the circumference shrinks more than the interior section of the wood (fig. 1⑤ and ⑥).

15. Causes of decay.—There are several types of decay which render lumber unserviceable: dry rot, wet rot, and common rot.

a. Dry rot.—Dry rot is the most common and the most dangerous. It is a disease which spreads from one part of the wood to another, causing the wood to lose its strength and cohesive power and eventually to decay altogether. Dry rot occurs mostly where timber is kept alternately wet and dry, or where there is no ventilation. The rot occurs on the inside of timber and leaves a shell on the outside; the inner part becomes soft and powderlike.

b. Wet rot.—Wet rot occurs in growing trees and is similar to dry rot. It occurs when the wood becomes saturated with water which it absorbs from a swamp or bog. It may be readily communicated from one piece of wood to another by contact.

c. Common rot.—Common rot is manifested by the presence of external yellow spots on the ends of timber or by a yellowish dust in the checks and cracks, especially where the pieces are in contact with one another. This is caused by improper ventilation of wood-storage sheds and lumber piles.

16. Destruction by insects.—Although decay is the principal cause of deterioration, a great deal of damage can be done by certain insects. The most common land varieties of destructive insects are the powder post, the pole borer, and the termite. The most common water type is the marine borer.

a. Powder post.—The powder post develops very rapidly. It bores into the wood and transforms it into a fine powder. Since the powder post lodges initially under the bark, all bark should be removed from air-dried lumber before it is used in buildings.

b. Pole borer.—The pole borer attacks timber that is somewhat damp and transforms it into reddish-brown dust. It will not attack water-soaked timber, but it will attack dry timber, either sound or decayed.

c. Termites.—Termites are not true ants, although they look much like them and live like them, in large colonies. The winged male and female may be seen "swarming" in the spring or fall on their way to start new colonies. Otherwise they are very seldom seen, as they stay in the earth or in wood. They damage rafters, joists, beams, or other timber of buildings; the inside may be entirely eaten out before the damage is noticed as they leave an outer shell of wood.

d. Marine borer.—(1) Timber placed in water is subject to attack by two classes of marine borers, the mollusk and the crustacean type.

(2) The destructive mollusk is a worm, sometimes called the navalis, teredo, or ship worm. It has a head equipped with a shell-like substance shaped like an auger by means of which it bores its way into timber, usually parallel to the grain. It has been known to grow to sizes of 1/4 to 1/2 inch in diameter and from 1 1/2 to 3 feet in length. It may ruin timber in less than a year. This marine borer prefers clear salty water. It operates against timber set between the mean tide and low water mark and about a foot above the mud line.

(3) The wood louse is a member of the crustacean family. It grows to the size of a grain of rice and bores into wood by means of sharp jaws. It is active only in clear still water and confines itself to a belt or line around the low water line. Wood lice can destroy piling within a year's time in heavily infested areas.

17. Preventive treatment.—The preventive measures for the preservation of timber are shown in the following table:

TABLE III

Cause of damage	Type of damage	Where found	Preventive measures
Wet rot	Decay of the fibers.	In the heart and limbs of standing timber.	No measures.
Dry rot	Decay of the fibers.	Where timber is subjected to moisture or no ventilation.	Keep ventilated and dry; creosote.
Common rot	Decay of the fibers.	Timber stored in poorly ventilated sheds, lumber stacks, etc.	Keep ventilated and dry; creosote.
Termites	Fibers eaten away.	Dark, damp places	Creosote timber; raise timber off ground with flared sheet metal collars around supports.
Marine borer	Fibers eaten away.	Piers, docks, wharves	Creosote timber.

Chapter 3

TOOLS

Section I

WOOD-CUTTING

18. Reference.—For tools not discussed in this chapter see TM 5–225.

19. Brace and bit.—The brace and bit is one of the carpenter's most useful tools. It is used to bore holes, ream holes, and to drive and remove screws, nuts, and bolts. There are several types of brace and bit that are standard Army issue; the principles of operation of all are the same.

20. Description of brace.—The brace is a tool for holding the various kinds of bits used in boring, reaming, and screwing. (See fig. 2.)

a. Head.—The head of the brace is a circular wooden knob, fastened to the crank by means of a bearing which allows the crank to rotate.

b. Crank.—The crank is a steel shaft and provides the leverage which gives the tool its mechanical advantage. The head is fastened to one end of the crank, the chuck and ratchet box to the other. A wooden handle fits loosely around the center of the bow and allows the crank to rotate while the handle is held firmly in the hand.

c. Ratchet box.—The ratchet box is the fixture which controls the direction in which the bit and chuck turn. The bit can be made to respond directly to the direction of turn of the crank, or the ratchet

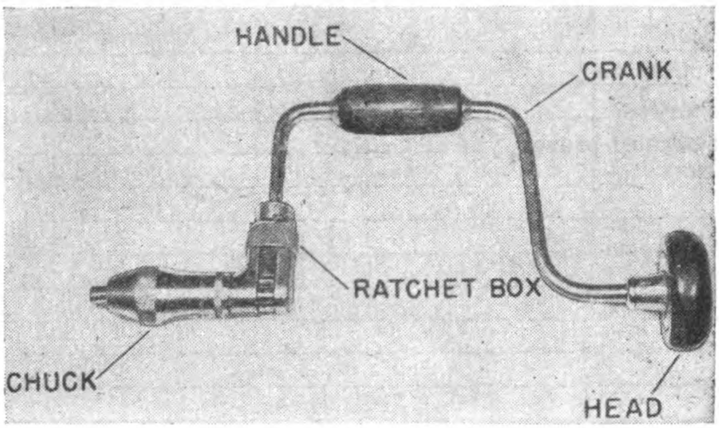


FIGURE 2.—Brace.

can be set so that the brace may be turned in one direction while the bit remains stationary.

d. Chuck or grip.—The chuck, or grip, is that part of the tool which receives the bit and holds it firmly in the brace. The chuck is composed of the number of jaws (long V-grooved fingers) which hold the tang of the bit, and a round, threaded, metal shell, which screws on the base of the chuck to open or close the jaws (fig. 3).

21. Operation and care of brace.—*a. Operation.*—To open the jaws and insert a bit, hold the chuck or grip upward in the left hand and turn the crank clockwise. This opens the jaws of the chuck. Insert the tang of the bit into the jaws of the chuck, placing the edges of the tang into the slots of the jaws. Allow the tang to drop in as far as possible, and turn the crank counterclockwise until the bit is held tightly in the brace (fig. 3). The brace is now ready for operation. To operate the brace, place the end of the bit at the desired point, keeping the brace perpendicular to the wood; hold the head in the left hand and press down, turning the crank clockwise with the right hand. In boring holes in wood, after a few turns, the bit feeds into the wood without pressure. To drive screws, or to ream, the pressure must be maintained. To work in corners or other close places where a full turn of the crank is impossible, shift the ratchet so as to allow the brace to turn counterclockwise without turning the bit. To withdraw the bit set the ratchet so that the bit turns in the opposite direction.

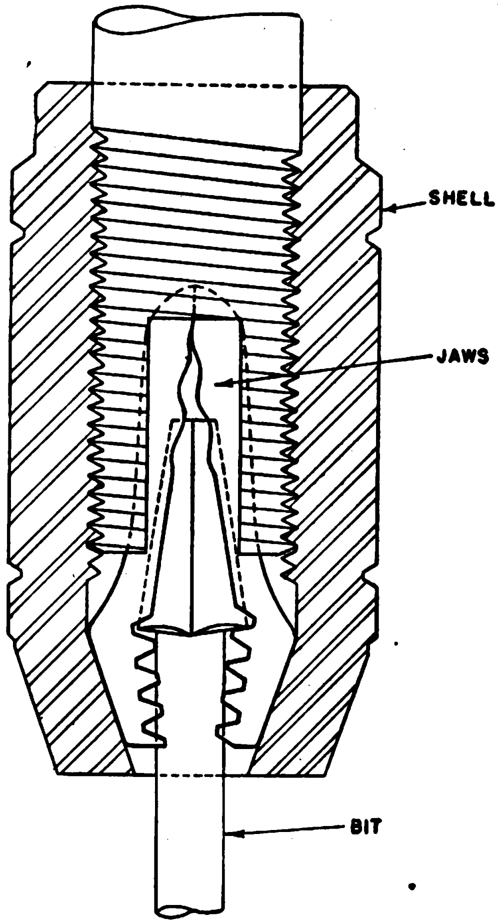


FIGURE 3.—Chuck with bit inserted.

b. *Care.*—After it is used, the brace should always be replaced in the tool box to keep it from being damaged. It should be kept cleaned and well oiled to prevent rust.

22. Auger bit.—*a. General.*—The auger bit is used for all ordinary boring in wood. It has a steel shaft about 8 inches long and is composed of six characteristic parts: the spur, nibs, lips, twist or flutes, tang, and shank (fig. 4).

(1) The *spur* is a screw at the end of the bit which feeds the bit into the wood.

(2) The *nibs* are vertical cutters which cut the side of the hole.

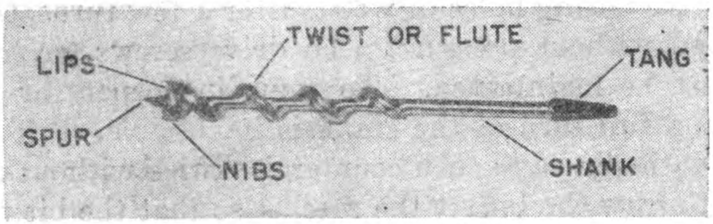


FIGURE 4.—Auger bit.

(3) The *lips* are horizontal cutters which chip out the wood in the hole. Bits are sized in sixteenths of an inch. A No. 11 bit will bore a hole $^{11}/_{16}$ inch in diameter. The size is indicated on the shank or tang. The size of holes bored ranges from $\frac{1}{4}$ to 2 inches in diameter.

b. Operation.—In boring holes, if the bit is forced all the way through the wood, splitting will occur on the opposite side (fig. 5①).

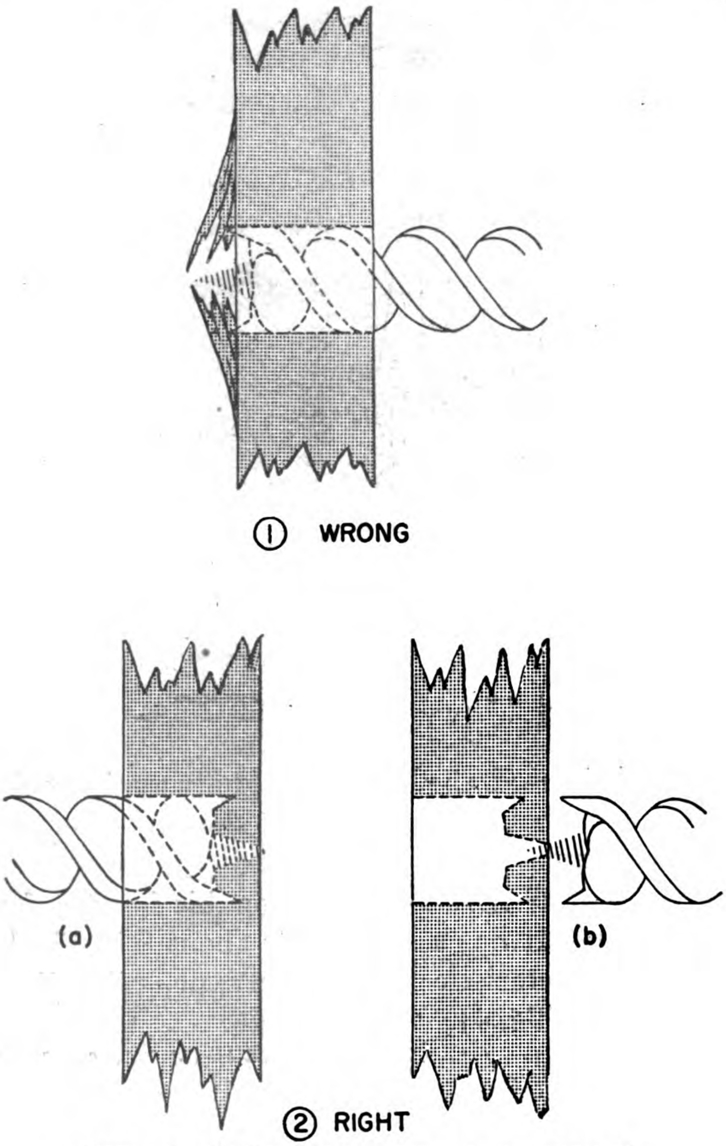


FIGURE 5.—Right and wrong way to use auger bit.

To prevent this, release the pressure on the brace, reverse the direction of crank, and pull the bit out as the spur comes through. Insert the spur from the opposite side and complete the hole. This forms a smooth hole on both sides (fig. 5②).

c. Care and sharpening.—(1) Before a hole is bored, the timber must be free from nails, spikes, metal, and dirt. These materials, no matter how small they may be, damage the auger bit. Once the nibs are broken or the lips rolled, the bit is of no value. Bits should be cleaned, covered with a thin coat of oil, and placed in tool box when not in use.

(2) To sharpen auger bits, a bit file is preferable, although a flat file or tapered hand-saw file may be used.

(*a*) To sharpen the nibs, place the bit, spur end up, against the edge of a bench. Sharpen the nibs from the inside to prevent altering the size of the bits. Both nibs should be of the same length.

(*b*) To sharpen the lips, place the bit, spur end down, on the bench, and sharpen the top side of the lips. This maintains the proper clearance on the under side of the lips.

23. Expansive bit.—*a. General.*—The expansive bit is a drill with an adjustable cutting section. One expansive bit takes the

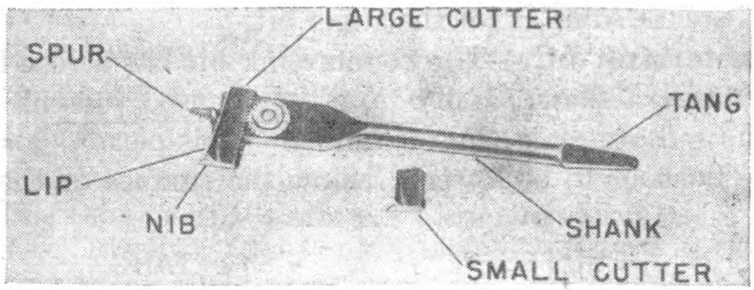


FIGURE 6.—Expansive bit.

place of several large bits. The expansive bit is issued with two interchangeable cutting blades, one of which cuts holes with diameters of from 7/8 to 1½ inches, the other, holes 1½ to 3 inches in diameter (fig. 6). The expansive bit has no twist; the remaining parts are similar to the auger bit.

b. Operation.—To set the expansive bit with a screw driver, loosen the setscrew and slide the cutter to the desired setting, reading the diameter of the hole from the scale on the blade, then tighten the screw. By moving the cutter 1/32 inch, the diameter of the hole is changed 1/16 inch. It is a good rule to test the setting by boring a hole in a piece of waste wood. To prevent splitting on the reverse side, clamp a piece of waste wood on the back of the working piece (fig. 7).

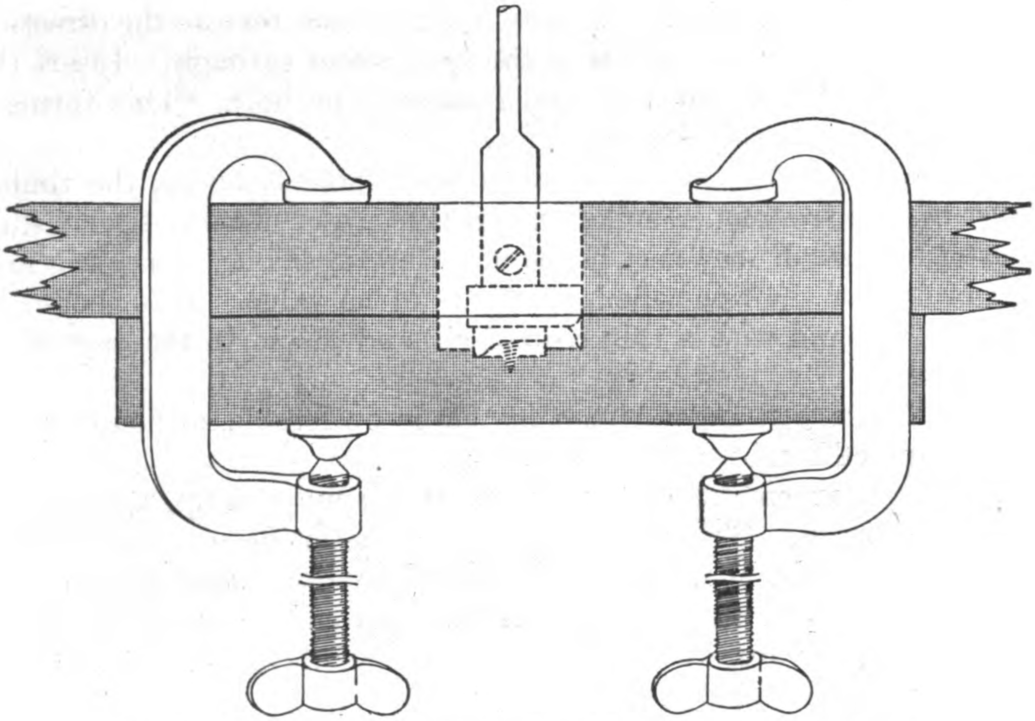


FIGURE 7.—How to use expansive bit without causing rough edge.

c. Care and sharpening.—The care and the sharpening of the expansive bit are the same as for the auger bit.

24. Countersink bit.—The countersink bit has a rose-head point of conical flutes, a shank, and a tang. It is used for enlarging and tapering the end of a hole (figs. 8 and 9). This permits a screw head to be made flush or to be lowered below the surface of the material.

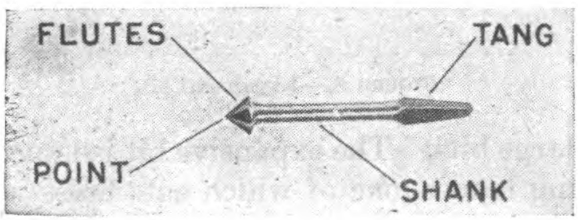


FIGURE 8.—Countersink bit.

Contact with nails and other metals should be avoided. The countersink is used with the brace in the same manner as the auger bit.

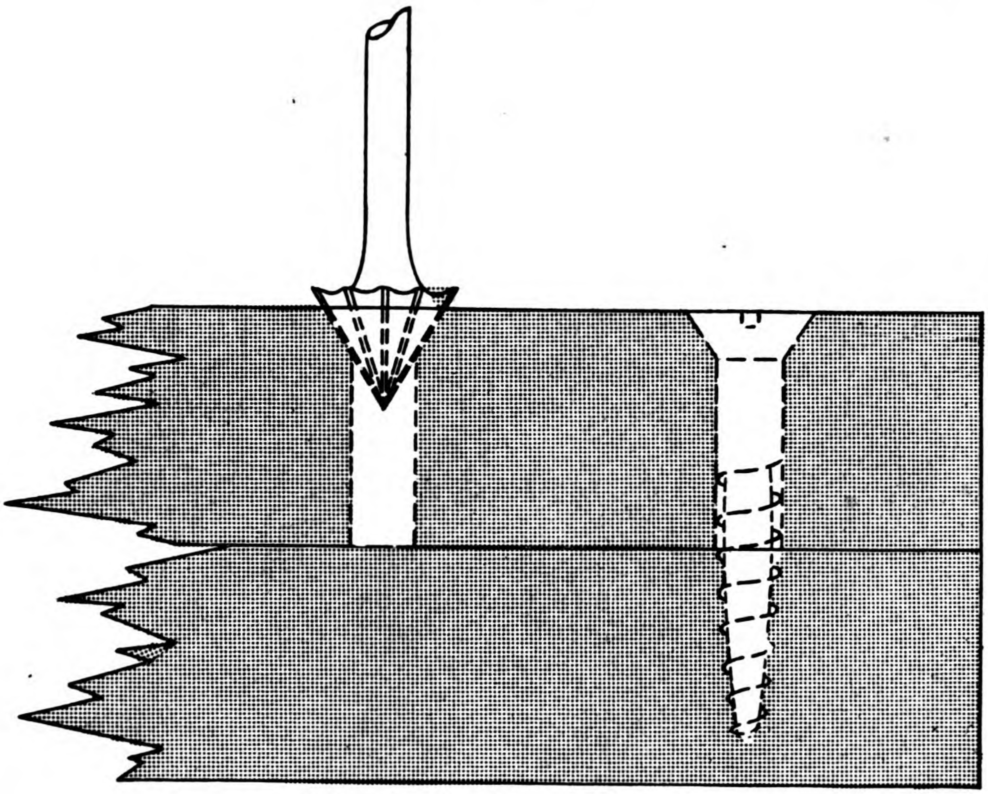


FIGURE 9.—Use of countersink bit.

25. Screw driver bit.—The screw driver bit is composed of four parts: the tip, blade, shank, and tang (fig. 10). It is used in the brace in the same manner as the auger bit. It speeds up and also reduces the work of sinking screws in wood or metal. The correct bit size is determined by the size of the screw. Care must be exercised in selecting the bit size; a bit of improper size may be damaged by, or may damage, the screw (fig. 11).

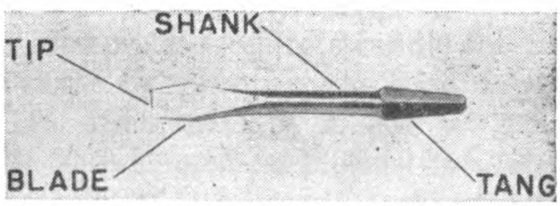


FIGURE 10.—Screw driver bit.

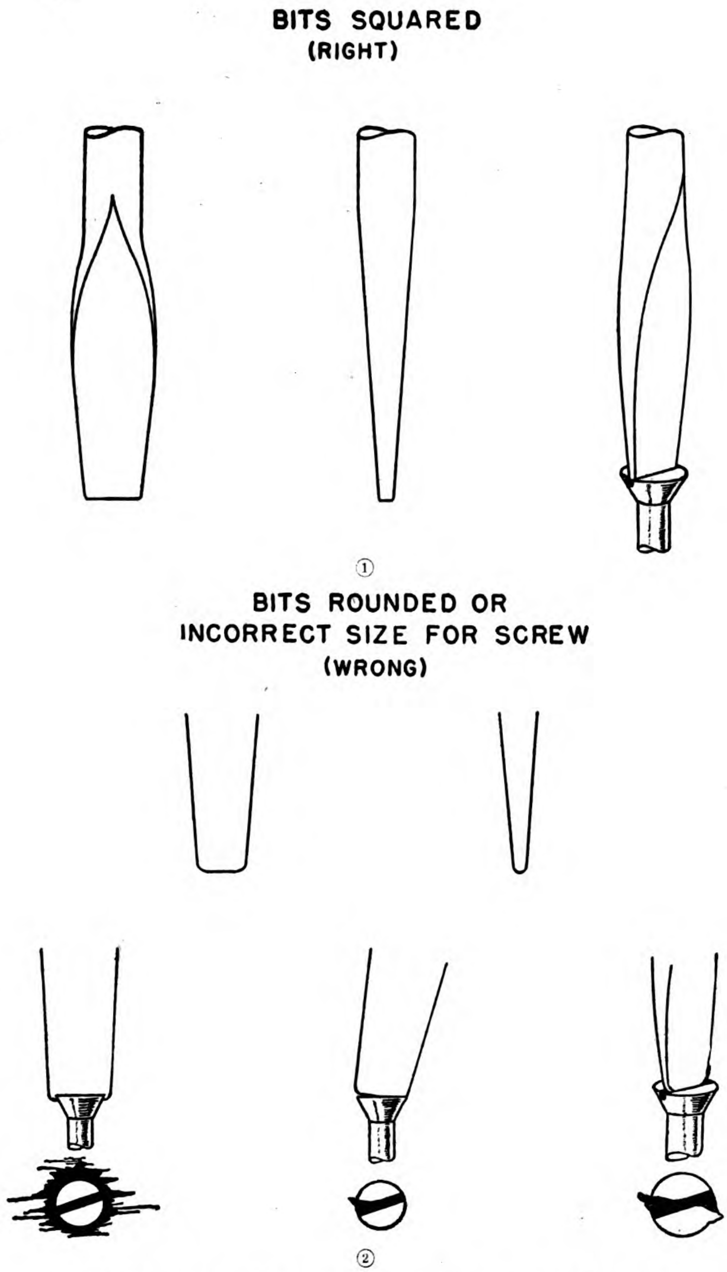


FIGURE 11.—Correct and incorrect screw driver bits.

26. Twist drill.—The twist drill is used for boring small holes for nails, screws, and bolts. The drill is composed of the following sections: the point, lips, twist or flutes, shank, and tang (fig. 12).

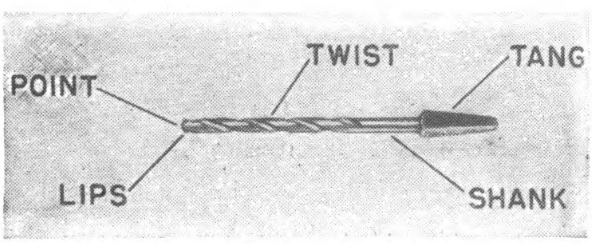


FIGURE 12.—Woodcutting twist drill.

This type of drill is for wood and soft metal and will not stand heavy duty. Drill sizes are graduated into thirty-seconds of an inch, starting at 1/8 of an inch. For care and sharpening, see TM 5–225.

27. Adze.—*a. General.*—The adze, commonly known as the foot-adze, is a hewing and smoothing tool used on lumber or logs where a great deal of wood is to be removed. It is composed of two main parts: a hardened steel square head with a square eye and a finely tempered blade; and a wooden handle, curved to give balance to the adze and to provide the proper angle for cutting (fig. 13). The blade is curved and its cutting edge is beveled and sharpened on one side.

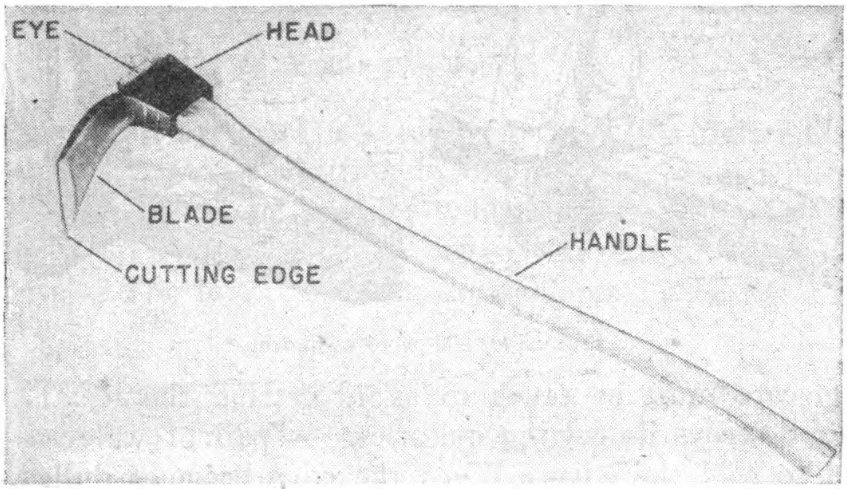


FIGURE 13.—Adze.

b. Operation.—In using the tool, the handle should be gripped with both hands, about 12 to 15 inches apart, and held in front of the body. The legs are spread so as to straddle the timber to be hewed, and strokes are made by swinging the adze downward and toward the hewer (fig. 14). Short choppy strokes are better than long ones. The timber to be hewed must be blocked securely against slipping, sliding, or rolling. The blade should be kept clear of chips as they may cause the adze to vary from its course and cause serious injuries by cutting the leg or foot.

c. Care and sharpening.—(1) The adz should never be used as a driving or prying tool, nor should it be used to cut into foreign material. When not in use it should be given a thin coat of oil and should be placed in a tool box. The cutting edge should be protected from coming into contact with other metals.

(2) The adze is sharpened by means of a tool grinder and an oilstone. When the adze becomes dull and needs refacing, or has been nicked, it should be resurfaced with a tool grinder with a fine abra-

sive wheel. An oilstone should be used to obtain a keen cutting edge. Only one side of an adze is sharpened. The bevel should be from 25° to 30°, depending upon the type of wood to be worked. In


① ②

FIGURE 14.—How to use adze.

grinding, care must be taken to avoid getting the metal too hot, since this destroys its cutting qualities. A pail of water should be provided to cool the edge. When the edge becomes dulled, a new edge is put on by means of the oilstone; grinding is unnecessary.

28. Ax.—The ax is a chopping tool used to fell and prune trees, cut them into convenient lengths, hew logs, cut brush, and split and cut wood. There are several kinds of axes. The ax issued by the Army is a single-bit (or single-bladed) ax, weighing 4 pounds. The head of the ax is made of soft steel, with several inches of the blade

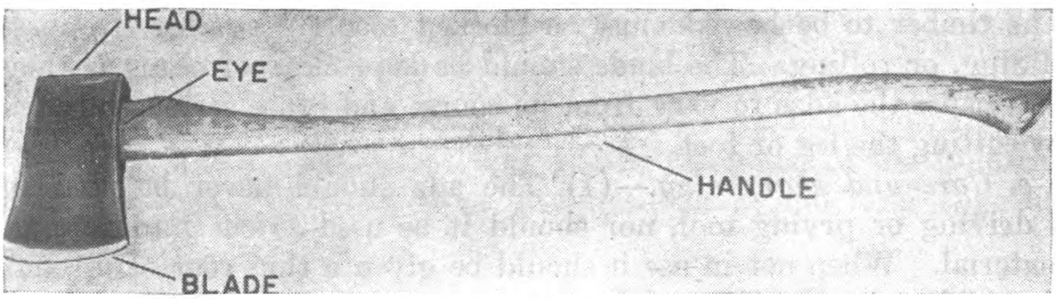


FIGURE 15.—AX.

hand-tempered to a highly polished and honed cutting edge. The head has an oval-shaped eye into which is fitted a hickory, slightly curved handle (fig. 15). See TM 5–225 for use and care of the ax.

29. Hatchet, half.—*a. General.*—The half-hatchet (commonly called hatchet), is a chopping and driving tool similar in some respects to a hammer. It is used for light cutting, trimming, hewing, and (because it is heavier than a hammer) for driving large nails or spikes. It has a wooden handle and a steel head composed of a

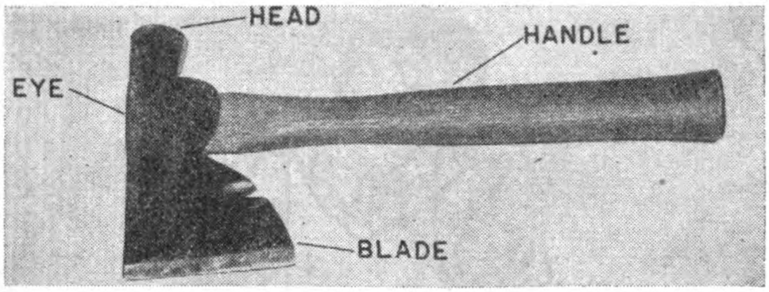


FIGURE 16.—Hatchet.

hammer head, an eye, and a blade (fig. 16). To pull nails, some hatchets have a claw in addition to the hammer head, while others are notched in the lower edge of a blade (fig. 17). Hatchets are made with two types of cutting edge, the single bevel and the double bevel. The latter is the more common. (See fig. 17.)

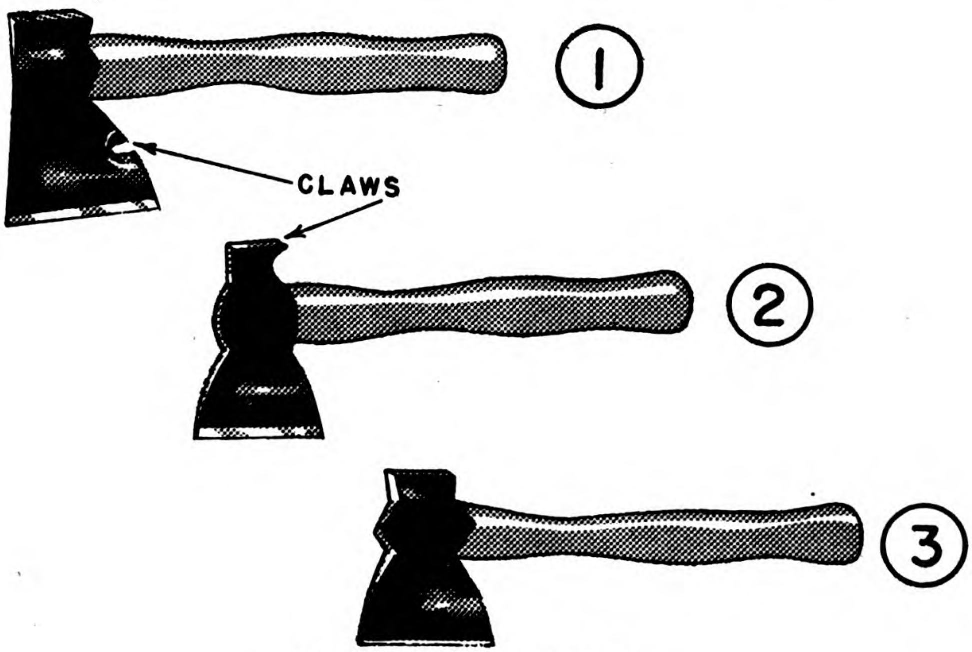


FIGURE 17.—Types of hatchets.

b. Operation.—(1) To make heavy strokes with the hatchet, grasp the handle with one hand near its end; for light strokes, hold the handle close to the head.

(2) The hatchet is used mostly to hew to a line *with* the grain. Set

the piece of wood on its edge and make a series of small, closely spaced cuts at an angle of about 45° across the grain and near the line (fig. 18). Cut away the notched compartments by striking with the grain along the line. In making the scoring cuts, when the grain is irregular, change the direction of the blow to cut across the grain with every stroke.

FIGURE 18.—How to use hatchet.

c. Care and sharpening.—The hatchet is cared for and sharpened in the same manner as an adze or ax, according to the type.

30. Drawknife.—*a. General.*—The drawknife is a smoothing tool used to supplement the hatchet or the adze. It is used to remove a small amount of wood and is employed especially on round timber.

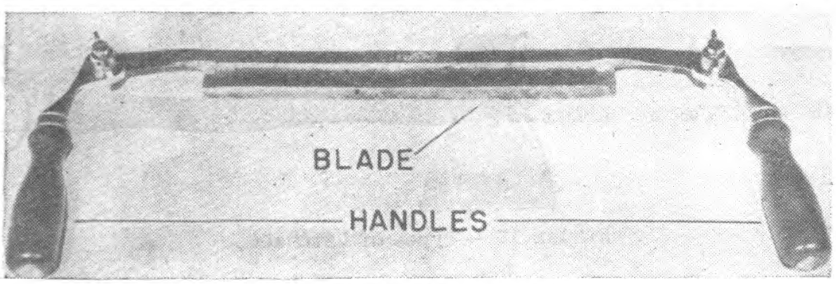


FIGURE 19.—Drawknife.

It consists of a single-bevel, knife-edged, steel blade, approximately $1\frac{1}{2}$ inches wide and 12 inches long. At each end of the blade are wooden handles at right angles to the blade. (See fig. 19.)

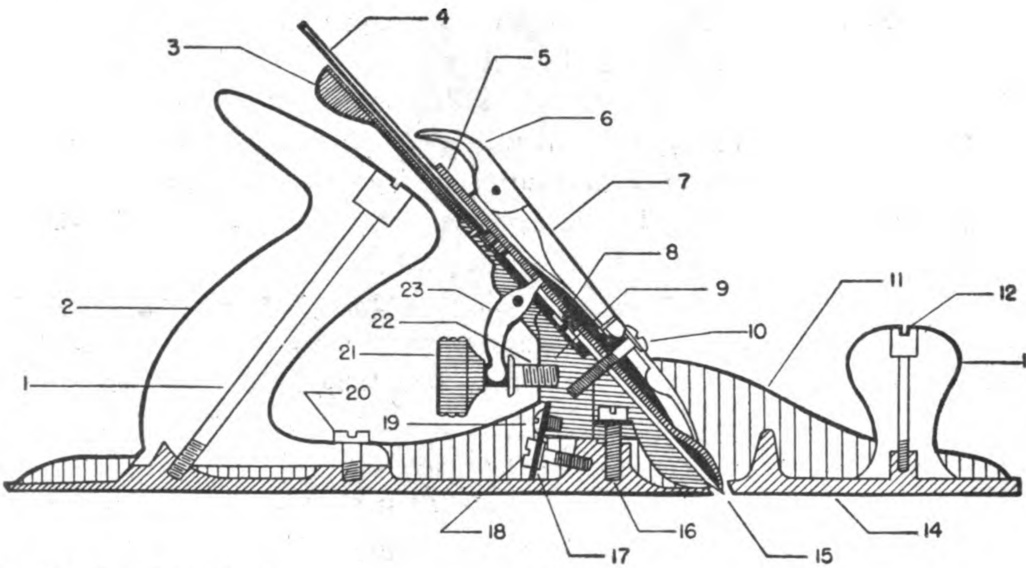
b. Operation.—For small pieces of wood, place the piece in a vise, grasp both handles of the knife, hold the blade at a slight angle to the piece of wood, and pull the blade toward the body (fig. 20). Always work with the grain. If the grain is irregular, change the direction of the stroke or the position of the wood accordingly.

FIGURE 20.—How to use drawknife.

c. Care and sharpening.—The drawknife is a fine-edged blade and care must be taken that it is not allowed to cut into grit or metal. It is sharpened much as the adze is sharpened except that the angle of bevel is approximately 20°.

31. Planes.—The plane is a smoothing tool used to true the edge or surface of lumber where close-fitting joints are required. There are several kinds of planes, each with a special use, but the general construction and method of operation of all planes are the same. Each plane has a straight face, an adjustable cutting blade, and a handle. The carpenter should know the particular characteristics of each kind of plane so that the proper tool may be used for a particular job. In general, there are two broad classifications of planes: the bench plane and the block plane.

32. Bench planes.—Bench planes receive their name from the fact that they are *used on the bench*, that is, at a stage in the working of a piece of wood where smooth, careful workmanship is required. Bench planes are used primarily for shaving and smoothing *with* the grain. There are three types of bench planes: the fore plane (sometimes called the jointer), jack plane, and the smoothing plane. Each of these types has either a smooth, or a longitudinally corrugated bottom surface. For parts of the bench plane see figure 21.



1. Handle bolt and nut.
2. Handle.
3. Lateral adjusting lever.
4. Blade.
5. Cap-iron or blade.
6. Cam lever.
7. Cap.
8. Cap-iron screw.
9. Frog.
10. Cap screw.
11. Plane bottom.
12. Knob bolt and nut.
13. Knob.
14. Face.
15. Throat.
16. Frog screw.
17. Frog clip.
18. Frog adjusting screw.
19. Frog clip screw.
20. Handle toe bolt.
21. Adjusting nut.
22. Cutter adjusting screw.
23. Y-adjustment lever.

FIGURE 21.—Bench plane.

a. Fore plane.—(1) *General.*—The fore plane is used to true a surface or edge of lumber. It varies in length from 18 to 24 inches, with blades $2\frac{3}{8}$ to $2\frac{5}{8}$ inches wide.

(2) *Assembly.*—Ordinarily the plane is disassembled only to the extent of removing the cap iron, blade, and lever cap. To assemble these parts:

(*a*) Lay the cap iron crosswise on the flat side of the blade and insert the cap-iron screw into the enlarged end of the blade slot. Slide the cap (still crosswise) along the slot until the cap can be turned parallel to the blade without the cap spring dragging across the cutting edge. Set the cap $1/16$ of an inch from the cutting edge for ordinary planing; set it at $1/32$ of an inch for cross-grained or irregularly grained (*curly*) wood. Tighten the screw.

(*b*) Place the assembled cap and blade, cap iron up, into the plane over the frog so that the cap-iron screw fits into the round slot in the frog. The cap and iron should now be correctly seated.

(*c*) Place the lever cap, with the cam in the disengaged position, over the cap iron so that the lever-cap screw fits into the hole in the lever cap. Slide the lever cap forward as far as it will go and engage the cam. The lever-cap screw should be tight enough to prevent vibration of the blade when the plane is in use.

(3) *Adjustment.*—(*a*) To adjust the plane, hold it bottom side up in the left hand and sight down along the smooth, bottom surface. Turn the adjusting nut until the cutting edge just projects. If the blade does not project evenly, straighten it by moving the adjusting lever to the right or to the left. (See fig. 22.)

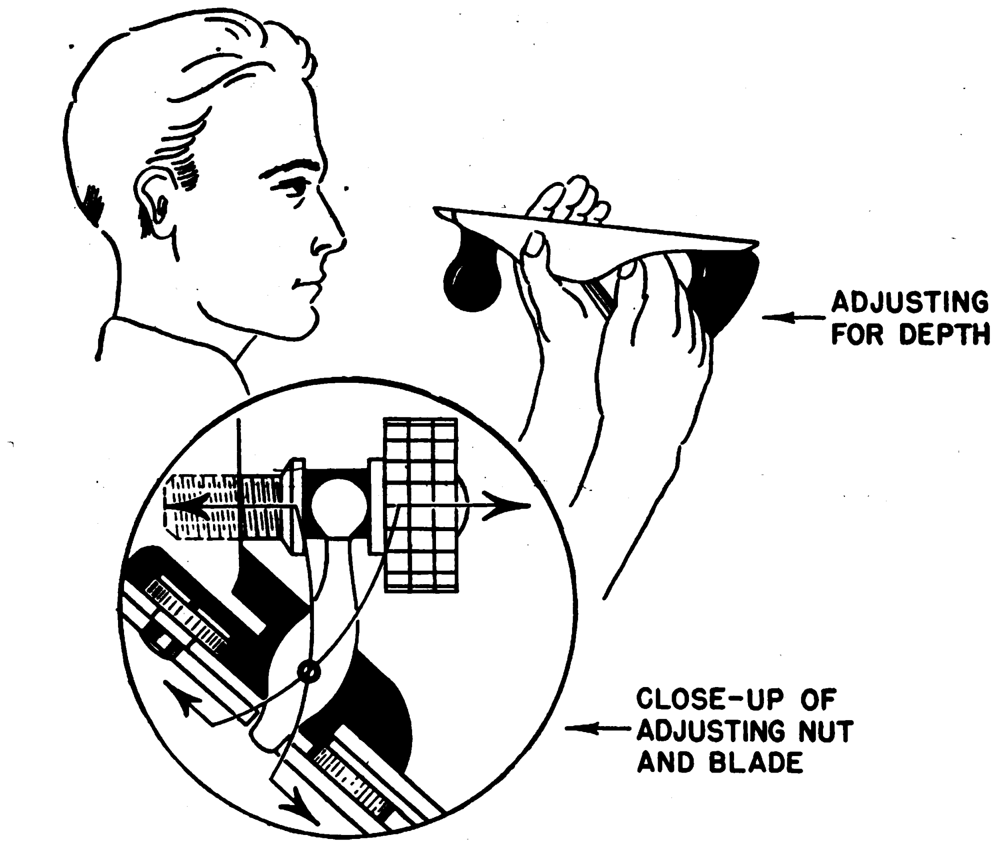
(*b*) For certain kinds of work (such as making heavy cuts), it may be necessary to adjust the frog. In this case, loosen the frog screws and turn the frog adjusting screw until the frog is moved backward far enough, then tighten the frog screws. This procedure opens the mouth of the plane and permits larger chips to be cut.

(4) *Operation.*—(*a*) Hold the plane firmly with the right hand on the handle and the left hand on the knob (fig. 23). Place the plane on the edge or surface of the wood at a slight lateral angle, push forward and down with both hands, taking long, even strokes. On the return stroke, either tilt the plane to the side so that the blade clears the wood or raise the plane completely.

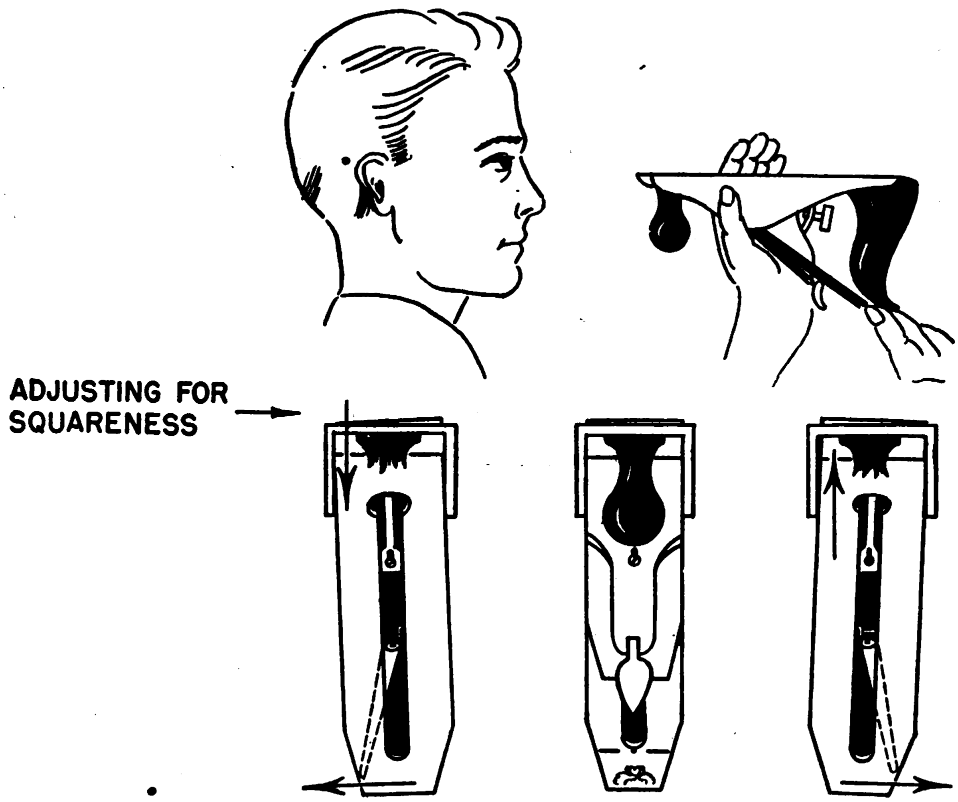
(*b*) The length of the projecting cutting edge depends upon the kind of wood being cut and upon the amount of wood to be removed. Always have the grain of the wood slope upward in the direction of the planing stroke.

(5) *Care and sharpening.*—(*a*) Never lay the plane face down. It should always be laid on its edge, otherwise the blade may be nicked or dulled by contact with hard surfaces. Make certain that wood to be planed is entirely free of nails, dirt, or other foreign matter. When the plane is not being used, it should be covered with a thin coat of oil. When the plane is put into the tool box, the blade should be withdrawn slightly so that it does not project beyond the face.

(*b*) The blade is sharpened with an oilstone or with a tool grinder with a fine abrasive wheel. The angle of the bevel should be between



① To adjust for depth (length of the cutting edge) hold the plane in the left hand, bottom side up, and sight down along the smooth bottom surface. With the right hand, turn the adjusting nut until the cutting edge just projects. Turning the adjusting nut to the left shortens the cutting edge; turning it to the right lengthens it.



② If the blade does not project evenly, hold it in the same position and straighten it by moving the adjusting lever to the right or left.

FIGURE 22.—Adjustment of a plane.

20° and 30°. Care should be taken to keep the cutting edge straight and exactly perpendicular to the length of the blade.

b. Jack plane.—The jack plane, except for its length, is similar to the fore plane and is used for the same type of work. It varies in length from 11½ to 15 inches; its blades are 1¾ to 2⅜ inches wide. Since it is shorter than the fore plane, it will not perform work as precisely but it is frequently used as a substitute for the fore and smoothing planes.

c. Smoothing plane.—The smoothing plane, except for its length, is similar to the fore and jack planes. It varies in length between 5½ and 10 inches and has blades 1¼ to 2⅜ inches wide. It is used for

FIGURE 23.—How to use a plane.

smoothing rough surfaces where straight edges and sides are not required.

33. Block plane.—*a. General.*—The block plane is much smaller than the bench planes. It is used, in making close joints, to cut across the grain or edges of small lumber. It varies in length from 4 to 8 inches, and has blades 1 to 1⅝ inches wide. It is composed of several parts, the finger rest, mouth, plane iron or blade, bottom or face, lever-cap screw, lever cap, and adjusting screw (see fig. 24). The bevel of its cutting edge is turned up, the reverse of the procedure in bench planes.

b. Operation.—The block plane is constructed to make light cuts. It is used with one hand. Strokes are short and are always made toward the center of the edge or surface, never permitting the plane to run over the edge of the piece of wood.

c. Care and sharpening.—The care and sharpening of the block plane is the same as for bench planes.

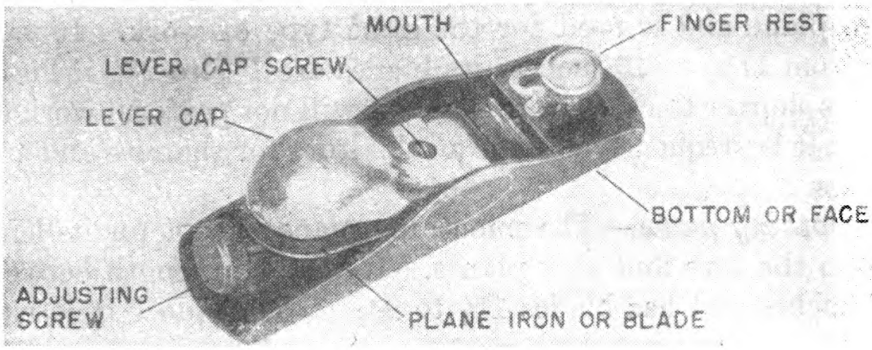


FIGURE 24.—Block plane.

34. Wood chisels.—*a. General.*—Wood chisels are used for operations which necessitate the removal of chips or sections of wood. A chisel consists of a steel blade with a single-bevel cutting edge; a wooden handle is fitted into the tang of the blade. (See fig. 25.) Sizes are measured by the width of the cutting edge.

b. Operation.—For light cuts in soft wood, the chisel may be operated by hand pressure. For hard wood, however, a wooden mallet is used to force the chisel into the wood. The chisel is held in one hand, bevel edge down, against the wood and the end of the handle is struck lightly with the mallet which is held in the other hand. (See fig. 26.) When finished work is required, the chisel is used with the beveled edge of the blade turned away from the finished surface.

c. Care and sharpening.—(1) The chisel should not be used to cut

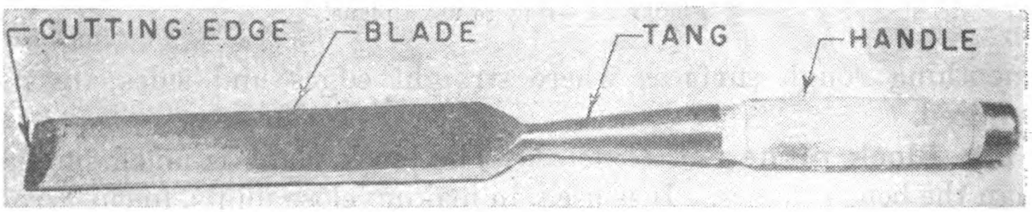


FIGURE 25.—Wood chisel.

metal. Care should be taken that no foreign substance damages the blade. Steel-headed hammers should not be used in place of the wooden mallet. The chisel should be oiled to prevent rust.

(2) The chisel is sharpened by means of an oilstone or a fine-grained tool grinder. The bevel of the cutting edge varies between 25° and 35°; the angle is determined by the type of wood to be cut, small-angled bevel for soft wood, large-angled bevel for hard wood.

d. Types.—The two types of chisels with which the Army carpenter is concerned are the firming chisel and the framing chisel.

(1) The firming chisel has cutting edges which vary from ⅛ inch to 2 inches in width.

(2) The framing chisel has cutting edges which vary in width from 1 inch to 2 inches. The framing chisel is of heavier construction and

FIGURE 26.—How to use chisel.

is larger than the firming chisel. It is used in heavy chisel work, such as for framing and bridge building. The handle usually is fitted with a band of iron or leather to prevent splitting when it is struck by the mallet.

35. Wood rasp.—The wood rasp is a coarse file made for cutting wood. It has one flat side and one arched side, both of which are

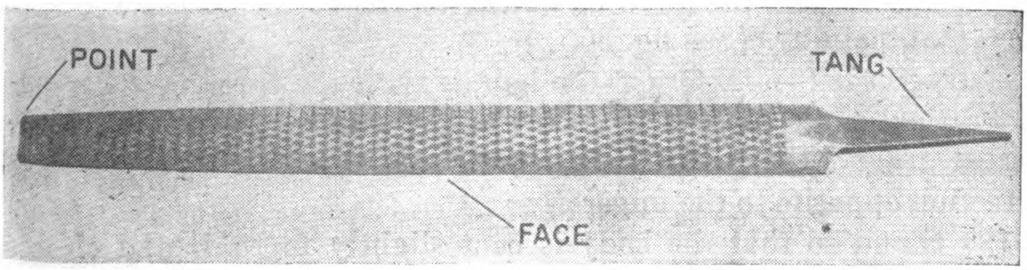


FIGURE 27.—Wood rasp.

closely toothed; one end is a tang which fits into a wooden handle. (See fig. 27.) The rasp is used for cutting and dressing joints where the plane cannot be used, and to dress handles in handle fitting. Oil on a rasp must not be used as it will cause the rasp to become clogged with wood particles.

36. Hand saws.—*a. General.*—The hand saw is one of the most commonly used tools in the carpenter set (fig. 28). There are several types of hand saws; each is used for a different purpose, but in general they are operated and cared for in the same manner.

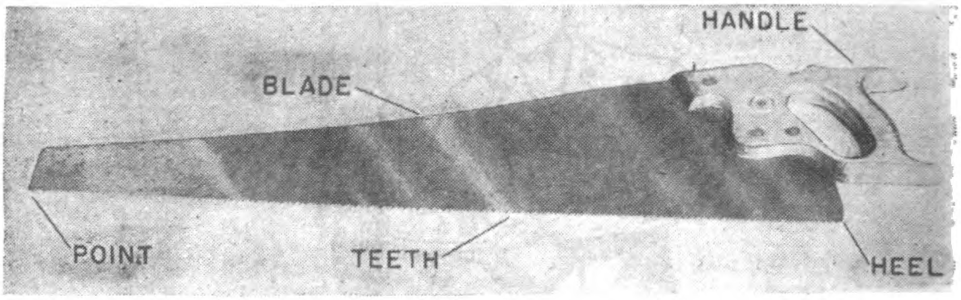


FIGURE 28.—Hand saw.

(1) The hand saw consists of a steel blade with a wooden handle attached at one end. The blade is made narrow at one end, known as the point or toe; the other end is known as the handle, or heel end. The cutting edge is a line of cutting teeth. These teeth act like two rows of cutting instruments running close together in parallel grooves. Both ends of the short chips of wood are cut at the same time and the smaller chips (sawdust) are rolled or pushed out by the bevel part of the teeth.

(2) To prevent the saw from binding, the teeth are bent (set), one to the right and one to the left, alternately, in order to cut a groove wider than the thickness of the saw. (See figs. 29 and 30.) The amount of set, or bend, of teeth is determined largely by the type of timber to be sawed. Wet, green, or soft timber requires more set than hard, or dry timber.

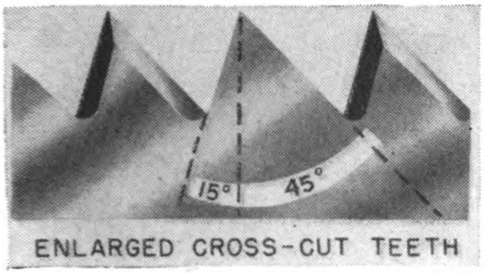
(3) The number of the saw is determined by the number of teeth points per inch. It should be noted that there is one less tooth per inch than points. (See fig. 30①.)

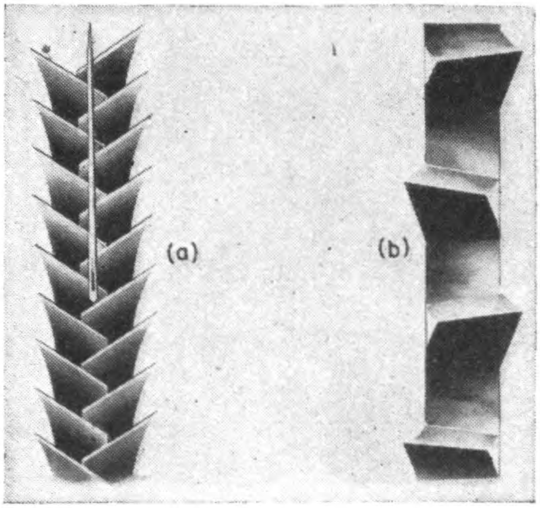
b. Operation.—(1) Grasp the handle with the forefinger extended along the handle toward the point of the saw, the remaining fingers curled around the grip of the handle and the thumb curled in the direction opposite to the fingers.

(2) Stand so that the body is bent slightly forward and clear of the arm swing. The arm should swing parallel to the body, at the side. When cutting across the grain, the saw should be held at a

vertical angle of 45° to the timber. When cutting with the grain, the angle should be at 60°. (See fig. 31.)

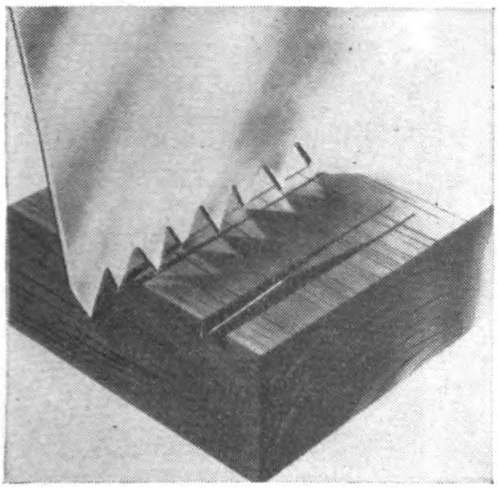
(3) Place the saw on the piece of wood so that the heel rests with its inside edge just touching the line. Use the thumb of the opposite

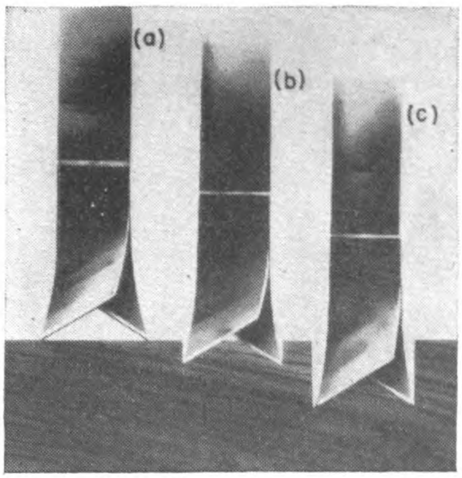




① Selecting a saw for crosscutting. See that the angle of the teeth and the bevel on the face and back is as shown above; that the upper half of the tooth is evenly set right or left for clearance; and finally, that all the teeth have sharp points.

② Top view of teeth (enlarged).
(a) Sight along the top of the teeth. Note the V-groove down which a needle will slide.
(b) Look down on the teeth. Teeth for crosscutting are filed at a 65° angle. See that the teeth are set evenly about half the thickness of the blade.



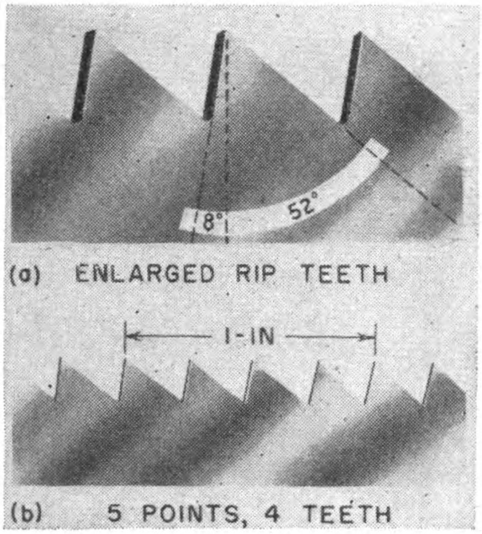


③ How a crosscut saw cuts. Crosscut teeth first score like points of two parallel knife blades, as saw is drawn across the grain. The edges of the teeth then begin paring the groove.

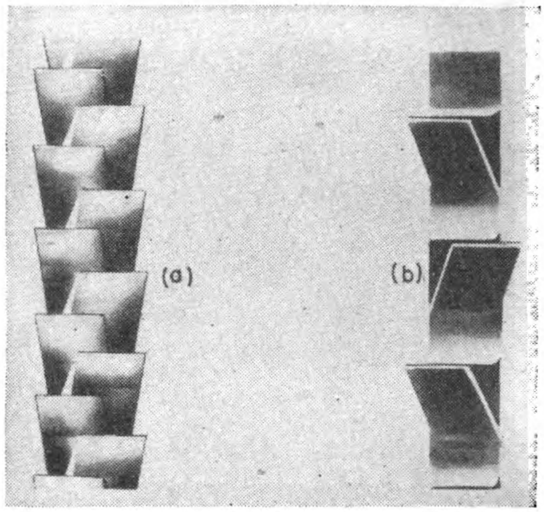
④ End view of saw (enlarged). Looking lengthwise of blade as the saw cuts into work, note (a) the knife action; (b) the paring action; and (c) the full cut. Notice how the set of teeth gives clearance of blade.

FIGURE 29.—Set of saw for crosscutting.

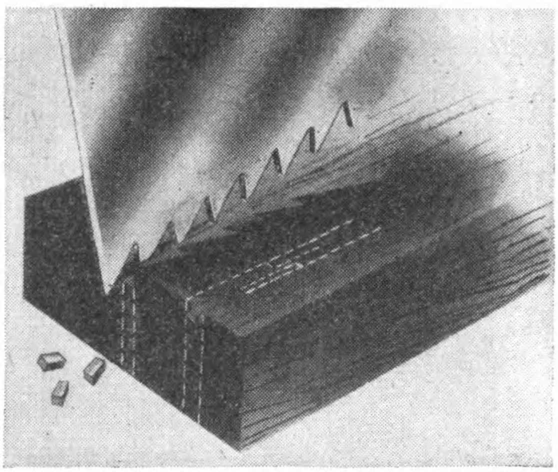
hand to guide the saw; use the fingers and palm to hold the timber and to steady the thumb. Pull the saw backward, exerting no pressure but allowing the weight of the saw to rest on the timber; a slight groove is thus made for the saw to run in. (See fig. 31.)



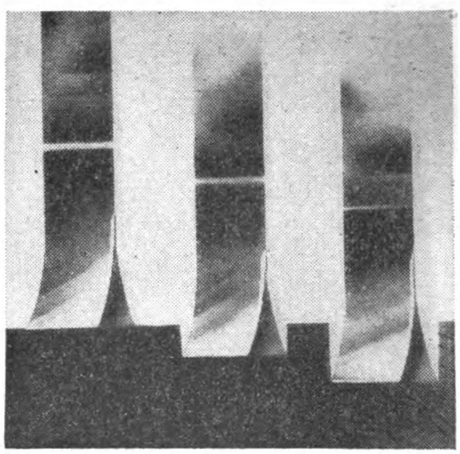
① Selecting a ripsaw. Pick out a saw with the front face of the teeth as shown in (a). The upper half of the teeth are set alternately right and left to give clearance. Note method of counting points per inch (b).



② Top view of teeth (enlarged).
(a) Look along the line of teeth. The edge of a ripsaw is similar to rows of chisel edges, set right and left.
(b) Look down on the teeth. Rip teeth are filed straight across the face. Note that teeth are set evenly about half the thickness of the blade.

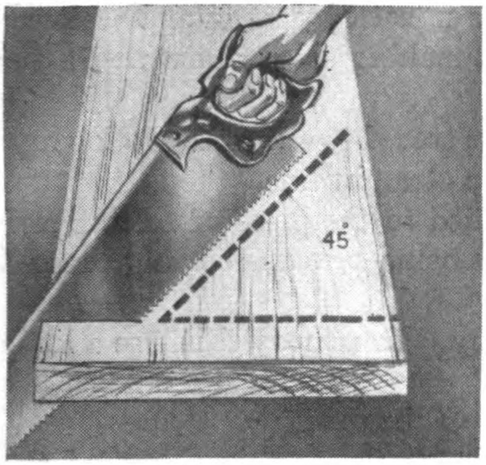


③ How a ripsaw cuts. Rip teeth cut like vertical chisels. First, on one side of the set a small piece of wood is cut loose across the grain and pushed out. On the other side, the tooth following plows out a similar particle. The cut is called the kerf.

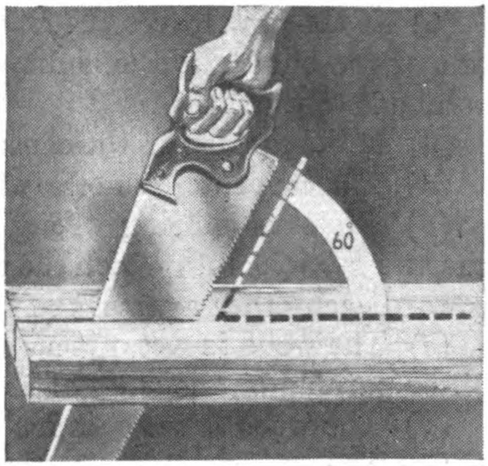


④ End view of saw (enlarged). Looking lengthwise of the blade, as the ripsaw cuts into the board, observe the width of the kerf and that the set of the teeth gives clearance for the blade.

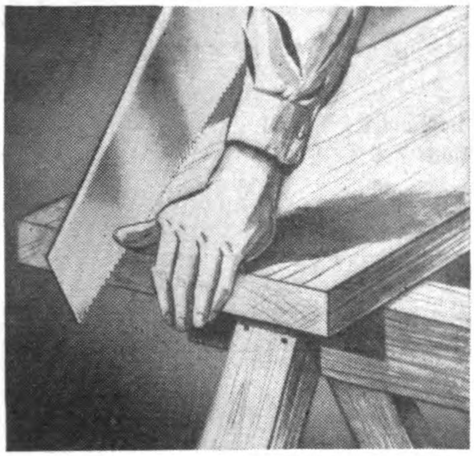
FIGURE 30.—Set of saw for ripping.



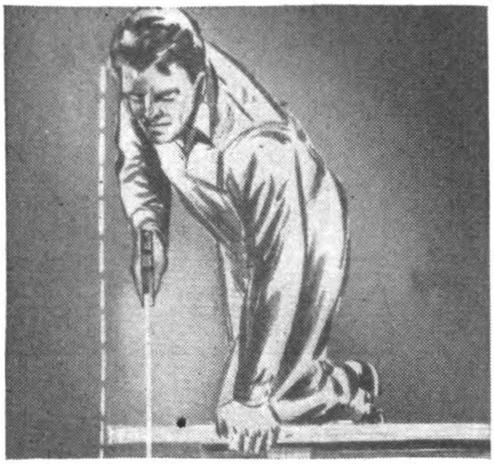
① Proper angle of saw for crosscutting. An angle of 45° is recommended between the edge of saw and face of the board. Don't twist or force the saw in the cut. Some operators prefer to allow forefinger to lie alongside, instead of through the handle.



② Ripping on sawhorse. With the cut started, get the body into position to permit long, easy strokes. Note the recommended angle of saw with the face of work. Do not twist or force the saw in the cut.



③ Starting the cut. Rest blade on edge of the work, on the waste side of the line and support the side of the blade by left thumb. Draw the saw toward you a few inches and repeat until a slight groove is formed. For ripping some workmen prefer short forward thrusts to start the cut.



④ Proper position for crosscutting. Rest blade on edge of the work, on the waste side of the line. Note proper sawing position. An imaginary line through the saw, arm, and shoulder would be slightly to the left of the operator's eye, permitting view of the line.

FIGURE 31.—How to hold saw for crosscutting and ripping.

(4) Now push the saw forward, with just enough pressure to make it cut, guiding it with the forefinger of the moving hand and with the thumb of the other. Do not force the saw as this may cause it to bend or to jump out of the groove and scar the face of the timber. Continue the backward and forward motion, exerting pressure only on the forward strokes until the saw has cut through the timber.

(5) If the saw leaves the line, force it back by twisting the lower side of the handle to the right or left, making short strokes with the point end of the saw.

(6) If the saw binds, the cause can be traced to one of the following:

(*a*) The carpenter is not sawing in a straight line.

(*b*) Pressure is being wrongly applied to the piece of lumber and the two sections into which the piece is being sawed are being pressed toward each other against the saw.

(*c*) The wood is wet, green, or pitchy. To remedy this, use a little oil or paraffin on the sides of the saw.

(*d*) The wood is too soft for the set of the saw.

(7) The guiding line should remain on the working part of the timber. Saw away from the line, just enough to leave the line. (See fig. 32.) In cutting mortises, or similar notches, care must be taken

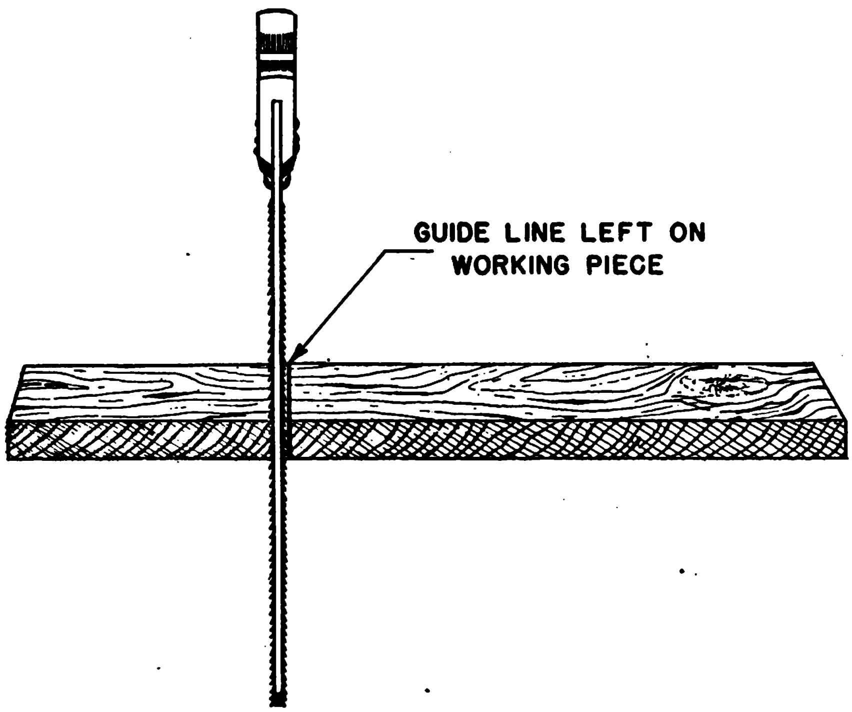
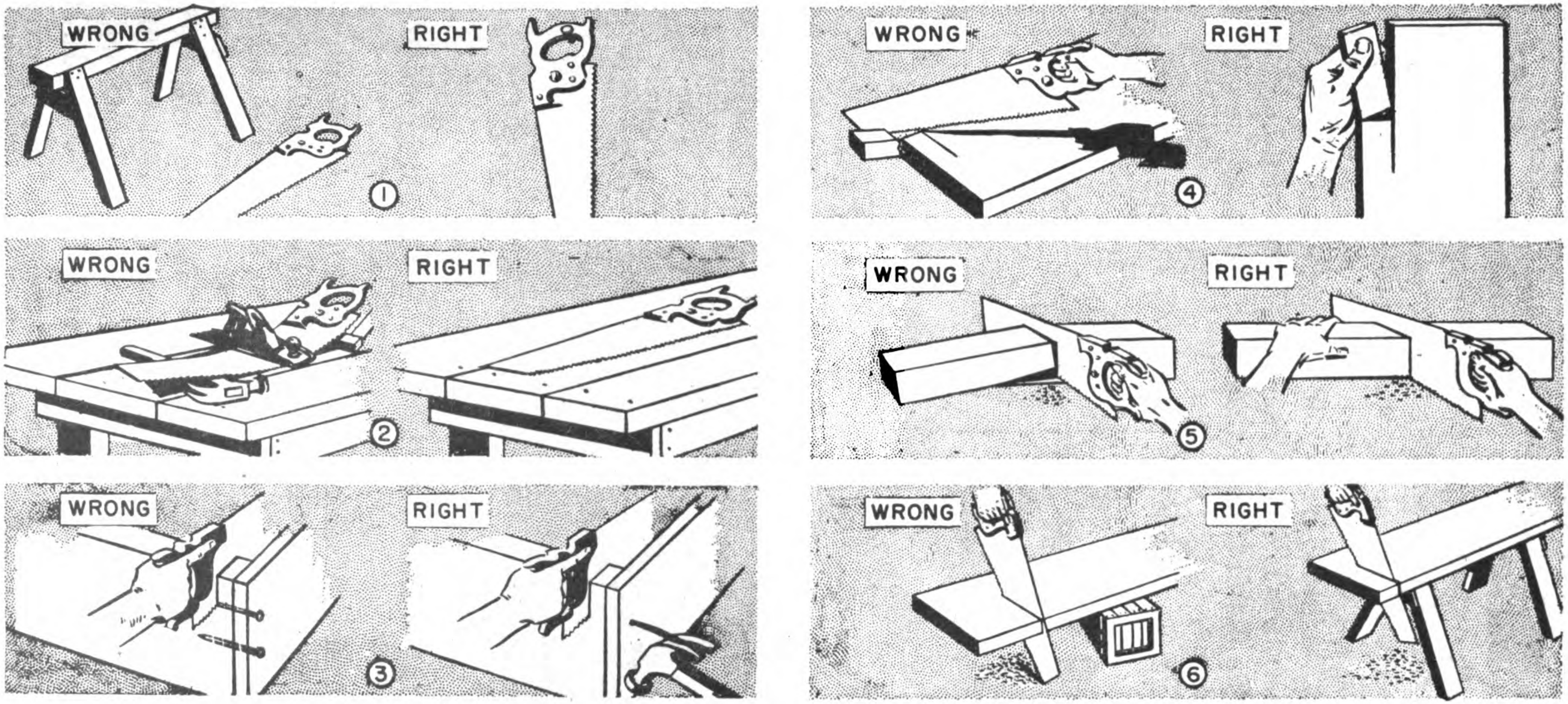


FIGURE 32.—Leaving guiding line on timber.

not to make the opening too large. Where close-fitting joints are required, or where the work is with soft lumber, a fine-toothed saw is used.

c. Care.—Care must be taken that the saw is not kinked. A saw with a kink in it is useless. The carpenter must make certain that nails, spikes, and other foreign objects are removed from the timber before it is sawed. When not in use, the saw should be oiled and kept in the tool box. Saws rust easily if they are not cared for properly; a rusty saw binds and is difficult to use. (See fig. 33.)



① When work is completed, hang up the saw.
② Do not pile tools on top of the bench so as to distort blade.
③ Look carefully over repair or alteration work; see that all nails are removed to avoid cutting into metal.
④ Strips of waste should not be twisted off with blade, but broken off with hand or mallet.
⑤ Supporting the waste side of the work will prevent splitting off.
⑥ Raise the work to a height sufficient to keep the blade from striking the floor. If the work cannot be raised, limit the stroke.

FIGURE 33.—Care of saws.

d. Sharpening.—There are five steps in the sharpening of a saw: jointing, shaping, setting, filing, and dressing.

(1) Jointing is done only when the teeth are uneven or incorrectly shaped, or when the tooth edges are not straight. If the teeth are irregular in size and shape jointing must precede setting and filing. To joint a saw, place it in a clamp with handle to the right. Lay a flat file lengthwise on the teeth and pass it lightly back and forth the length of the blade and on top of the teeth until the file touches the top of every tooth. The teeth then will be of equal height. (See fig. 34.) Hold the file flat; do not allow it to tip to one side or the other. The jointing tool or hand saw jointer will aid in holding the file flat.

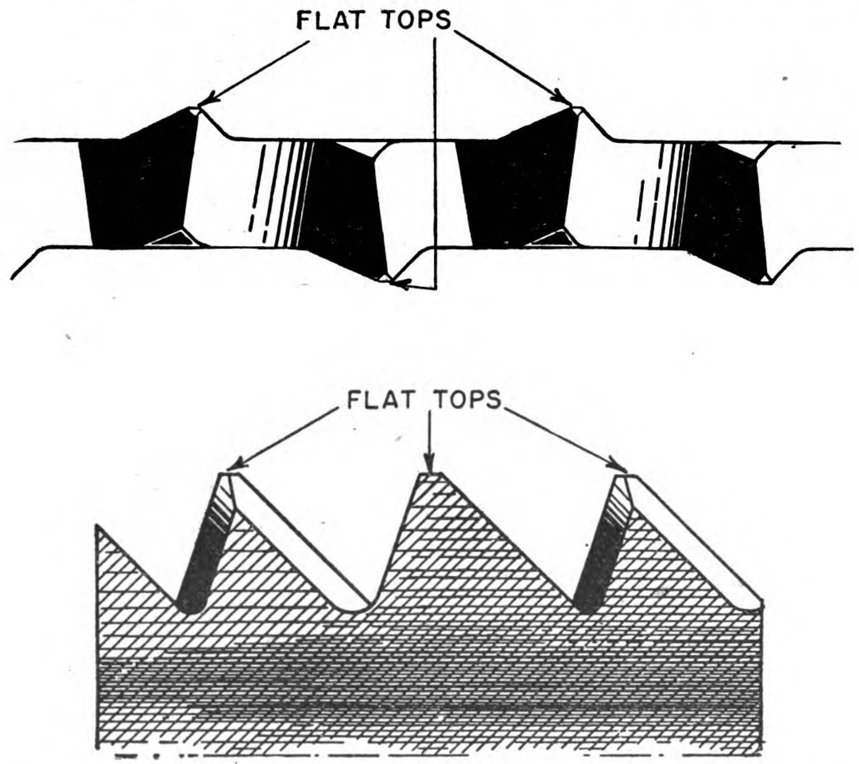


FIGURE 34.—Flat tops of jointed teeth.

(2) Shaping consists of making the teeth of uniform width. This is done after the saw has been jointed. The teeth are filed with a regular hand saw file to the correct uniform size and shape. The gullets must be of equal depth. For the crosscut saw, the front of the tooth should be filed with an angle of 15° from the vertical, while the back slope should be 45° from the vertical (fig. 29). In filing a ripsaw the front of the teeth are filed with an angle of 8° with the vertical and the back slope 52° with the vertical (fig. 30). In shaping teeth, disregard the bevel of the teeth and file straight across at right angles to the blade with the file well down in the gullet. If

the teeth are of unequal size, press the file against the teeth with the largest flat tops until the center of the flat tops made by joining is reached. Then move the file to the next gullet and file until the rest of the flat top disappears and the tooth has been brought to a point. Do not bevel the teeth while shaping. The teeth, now shaped and of even height, are ready to be set.

(3) Setting a saw is the process by which the points of the teeth are bent outward by pressing with a tool called a saw set. Setting is done only when the set is not sufficient for the saw to clear itself in the kerf. It is always necessary to set the saw after the teeth have been jointed and shaped. The teeth of a hand saw should be set before the final filing to avoid injury to the cutting edges. Whether

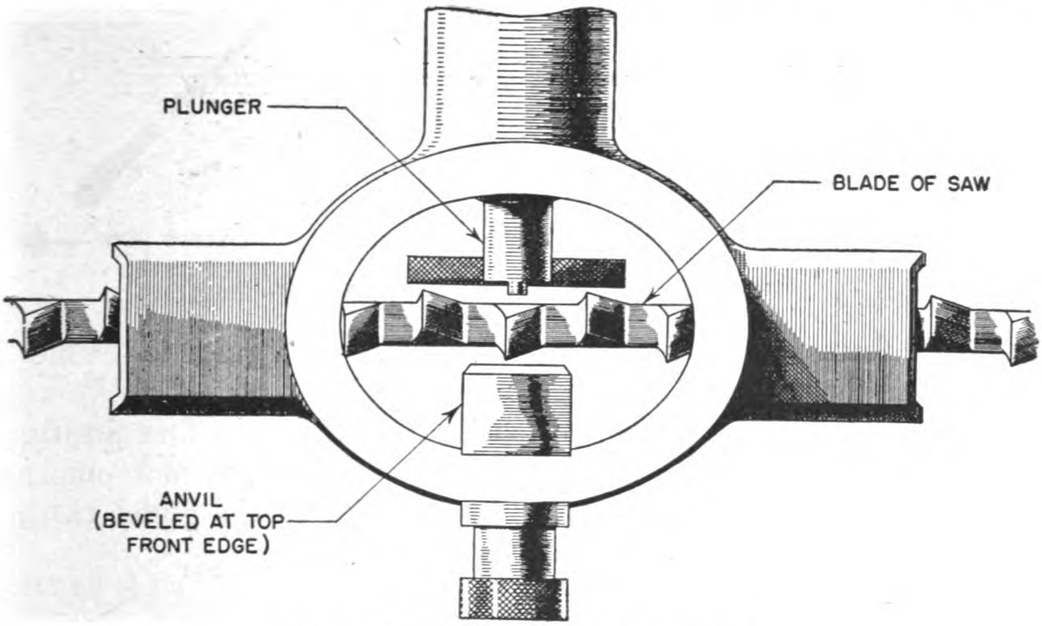


FIGURE 35.—Position of saw set on saw.

the saw is fine or coarse, the depth of the set should not be more than half that of the tooth. If the set is made deeper than this, it is likely to spring, crimp, crack the blade, or break out the teeth. In setting teeth, particular care must be taken to see that the set is regular. It must be the same width the entire length of the blade and the same width on both sides of the blade. The saw set should be placed on the saw so that the guides are over the teeth with the anvil behind the tooth to be set (fig. 35). The anvil should be correctly set in the frame, the handles pressed together. This causes the plunger to press the tooth against the anvil and bends it to the angle of the bevel of the anvil. Each tooth is set in the manner described.

(4) (*a*) Filing a saw consists of sharpening the cutting edges. Place the saw in a filing clamp with a *handle at the right.* The bottom

of the gullets should not be more than 1/4 inch above the jaws of the clamp. If more of the blade projects, the file will chatter or screech. This dulls the file quickly. If the teeth of the saw have been shaped, it will aid the saw filer to pass a file over the teeth as described in

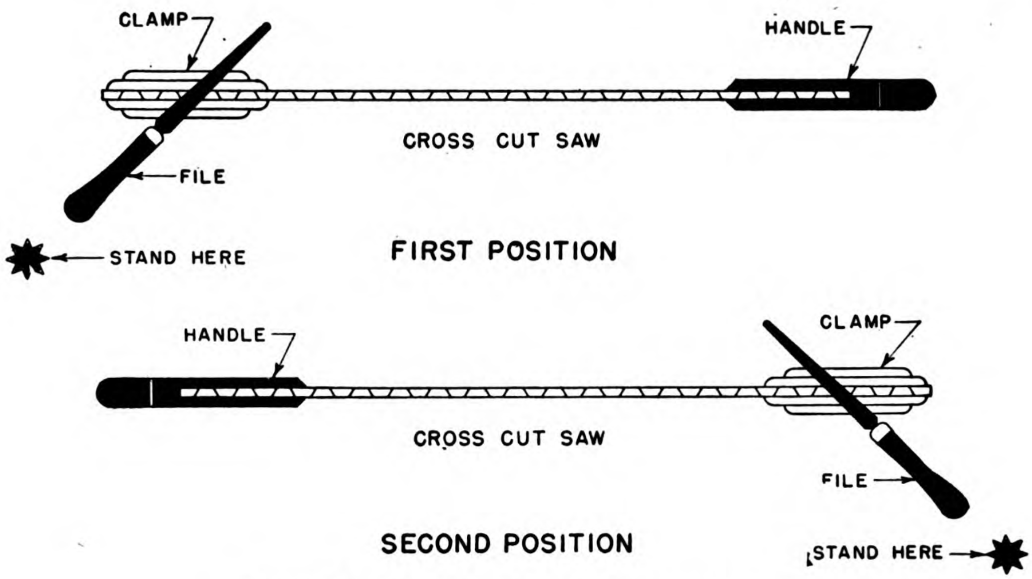


FIGURE 36.—Positions for filing crosscut saw.

jointing to form a very small flat top. This acts as a guide to the filer; it also evens the teeth.

(*b*) To file a hand saw for crosscutting, stand at the first position as shown in figure 36. Begin at the point of the saw, pick out the first tooth that is set toward you, place the file in the gullet to the

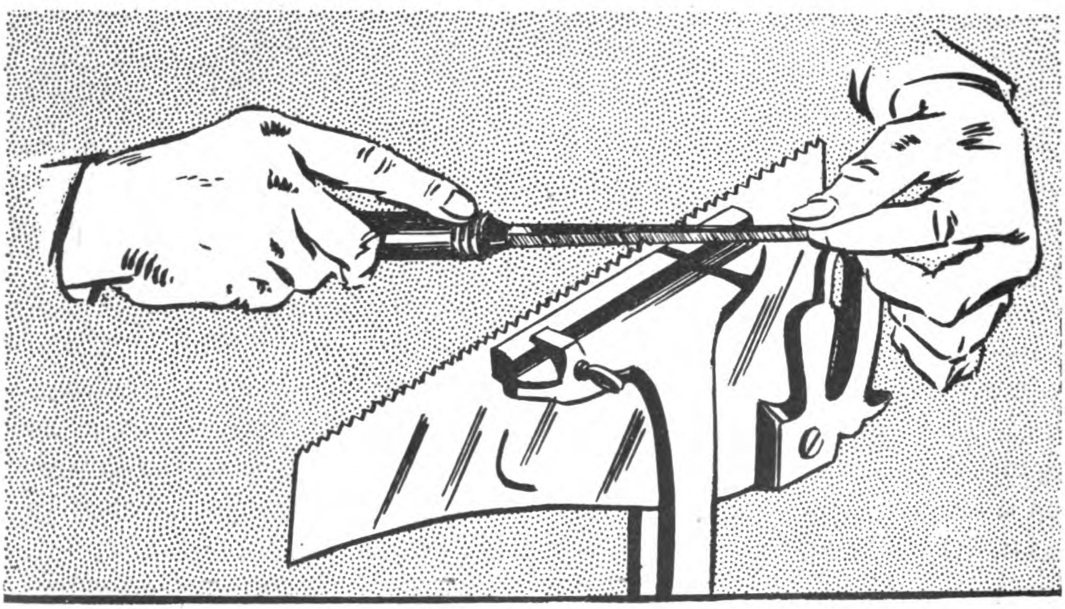
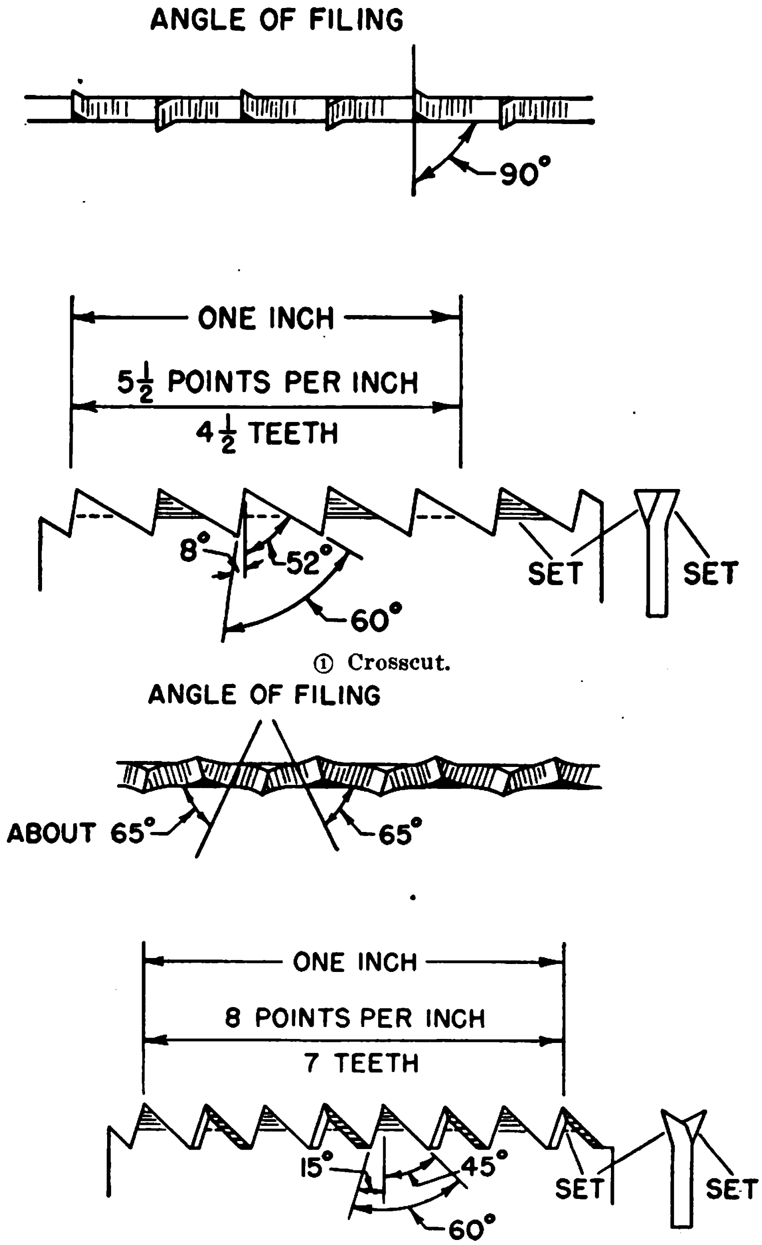


FIGURE 37.—How to hold a file.

left of this tooth, and hold the handle in the right hand with the thumb and three fingers on the handle, the forefinger on top of the file or handle; hold the other end with the left hand, the thumb on top, and the forefinger underneath (fig. 37). The file may be held in the file



① Crosscut.

② Ripsaw.

FIGURE 38.—Angles of saw teeth.

holder guide as shown in figure 93. The guide holds the file at a fixed angle throughout while each tooth is sharpened.

(*c*) Hold the file directly across the blade then swing the file to the left to the desired angle. The correct angle is approximately 65° (fig. 38). Tilt the file so that the breast (the front side of the tooth) side of the tooth may be filed at an angle of approximately 15° with the vertical. (See fig. 38.) Keep the file level and at this angle, do not allow it to tip upward or downward. The file should cut on the push stroke, and be raised out of the gullet on the reverse stroke. On the forward stroke, it cuts the teeth on the right and left. File the teeth until half of the flat top is removed, then lift the file, skip the next gullet to the right, and place the file in the second gullet toward the handle. If the flat top on one tooth is larger than the other, press the file against the larger so as to cut that tooth faster. Repeat the filing operation on the two teeth which the file now touches, always

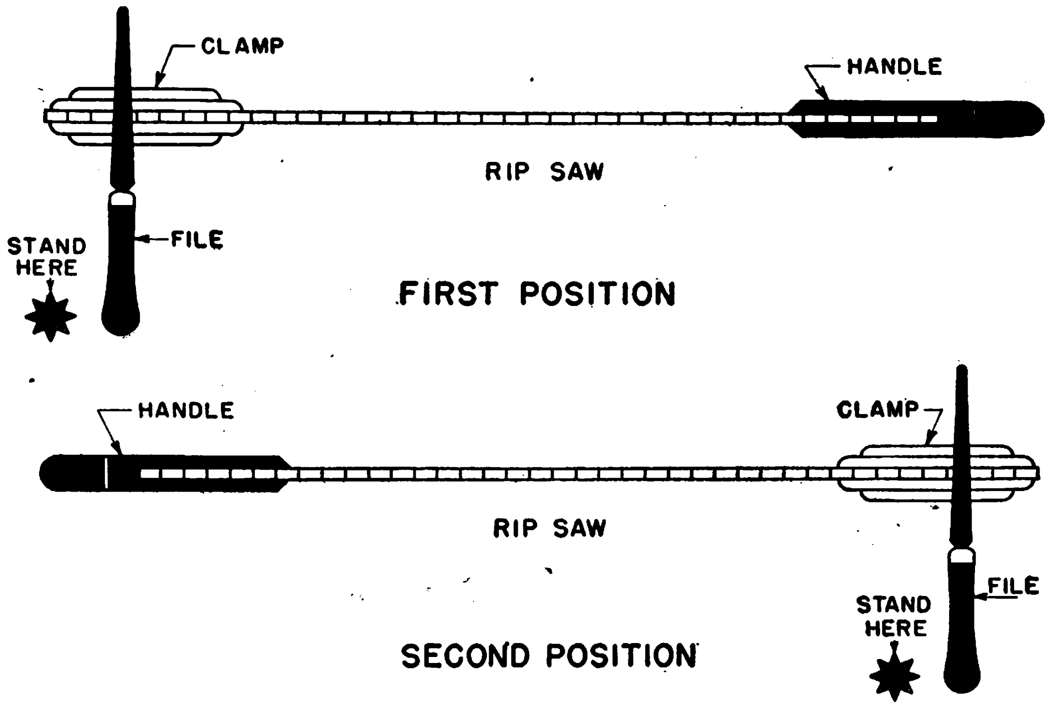


FIGURE 39.—Position for filing a ripsaw.

being careful to keep the file at the same angle. Continue in this manner, placing the file in every second gullet until the handle end of the saw is reached.

(*d*) Turn the saw around in the clamp, *handle to the left.* Stand in the second position and place the file to the right of the first tooth set toward you (fig. 36). This is the first gullet which was skipped when filing from the other side. Turn the file handle to the right until the proper angle is obtained, and file away the remaining half of the flat top on the tooth. The teeth that the file touches are now sharp. Continue the operation until the handle end of saw is reached.

(*e*) In filing a ripsaw, one change is made in the above operation: the teeth are filed straight across the saw at right angles to the blade. The file should be placed on the gullet so as to file the breast of the tooth at an angle of 8° with the vertical (fig. 38). Stand in positions as shown in figure 39. When sharpening a ripsaw, file every other tooth from one side, then turn the saw around and sharpen the remaining teeth as described in (*d*) above. In filing teeth, care must be taken that in the final sharpening process all teeth are filed to the same size and height, otherwise the saw will not cut satisfactorily.

(5) Dressing of a saw is necessary only when there are burs on the side of the teeth. These burs cause the saw to work in a ragged fashion. They are removed by laying the saw on a flat surface and running an oilstone or flat file very lightly on the side of the teeth.

(6) Try the saw to see if it cuts a straight line or cuts a curve as shown in figure 40. This shows the result when one row of teeth is shorter than the other.

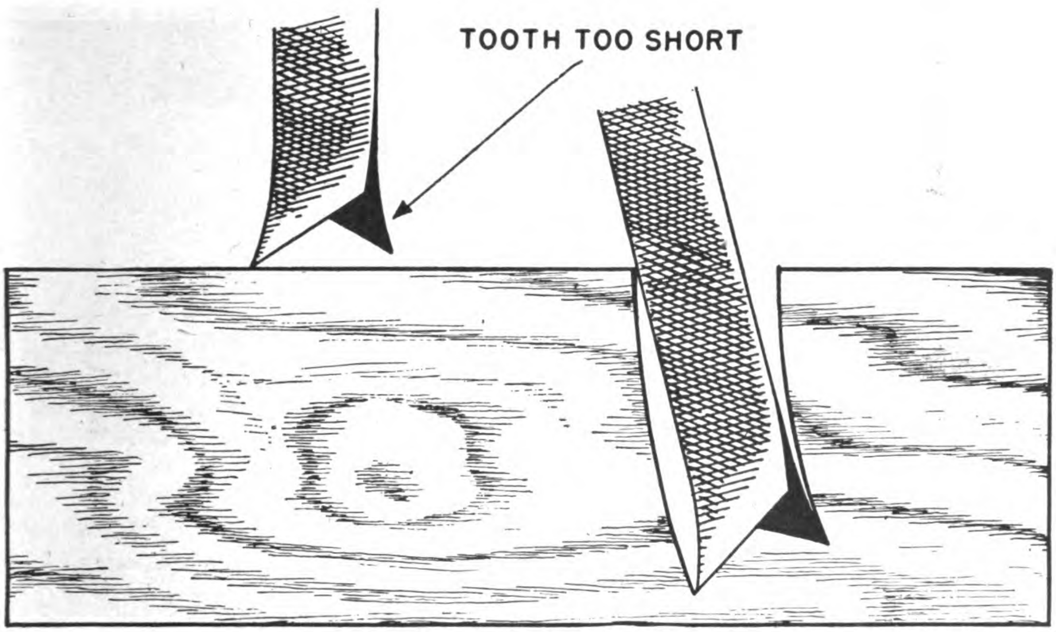


FIGURE 40.—Results of incorrect sharpening.

37. Crosscut saw.—*a.* The crosscut saw is used to cut across the grain, and to cut wet or soft wood. Its teeth are sharpened in such a manner that they act like small knife edges which cut the wood fibers.

b. When the saw is sharpened, each tooth should be filed so as to conform as nearly as possible to the following specifications: the cutting edge beveled 65° from the line of teeth, the fore slope about 15° from the vertical, and the back slope about 45° from the vertical. (See fig. 38①.)

38. Ripsaw.—*a.* The ripsaw is used to cut wood along the grain. It is similar in construction to the crosscut, but it is slightly heavier. It differs from the crosscut mainly in the rake of the teeth. The teeth are sharpened in such a manner that they act like numerous small chisels, each of which removes a small chip as the saw moves through the wood. (See fig. 38②.)

b. The teeth are filed straight across the front, with a fore slope of about 8° from the vertical and a back slope of about 52° from the vertical.

39. Compass saw and keyhole saw.—The compass saw and the keyhole saw, similar in construction and purpose, are used to cut along

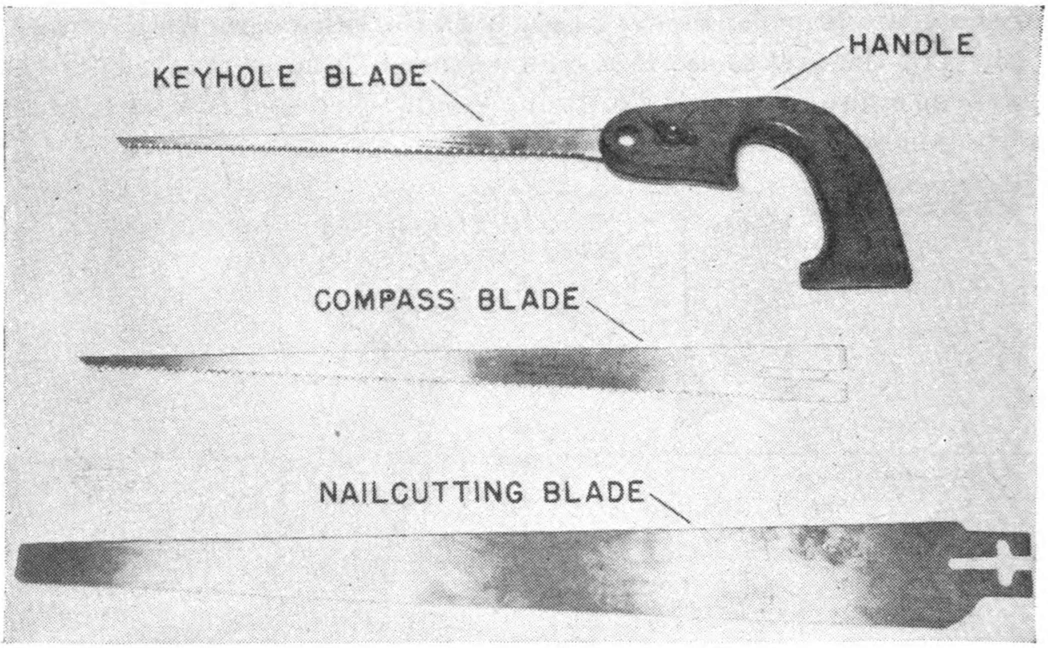


FIGURE 41.—Compass and keyhole saw.

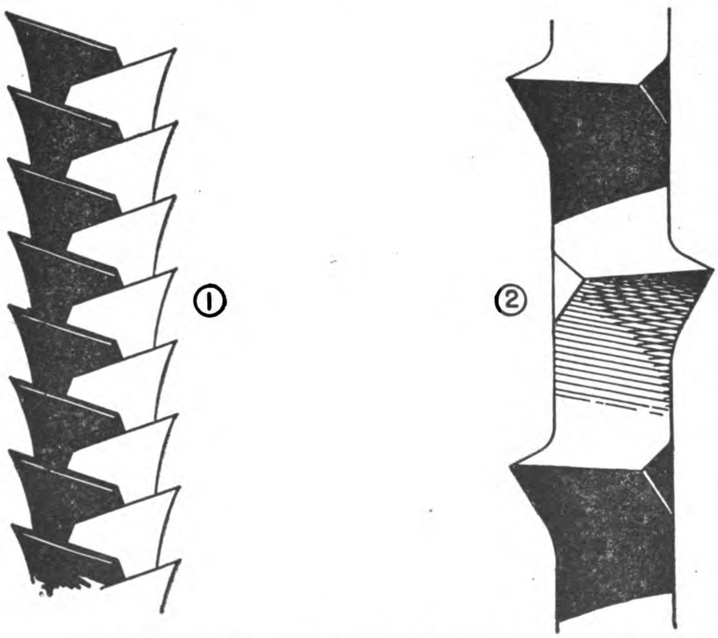


FIGURE 42.—Set and shape of compass saw teeth.

curved lines and to start cuts for larger saws. These saws have blades of thin, high-grade steel, shaped like an elongated **V** (fig. 41). The Army issues a handle with three interchangeable blades: one to cut sharp curves; one to cut moderate curves; and one to cut nails, screws, and other thin pieces of metal which may obstruct the passage of the wood saws through a piece of lumber. The teeth of the wood cutting blades are shaped and sharpened to combine the qualities of the crosscut saw and ripsaw (fig. 42). The groove cut is wider than that of the crosscut saw and ripsaw in order to allow more freedom for the blade to turn when cutting curves. The handle is a modified pistol-grip type, and should be used cautiously to avoid breaking.

40. Crosscut saw, two-man, handled.—*a. General.*—The two-man, double-handled, crosscut saw is used for heavy-duty work, such as felling trees, cutting large trees into logs of usable lengths, and sawing heavy bridge timbers. It is made of high-grade steel, with arched, taper-ground blades varying in length from 5 to 6½ feet and

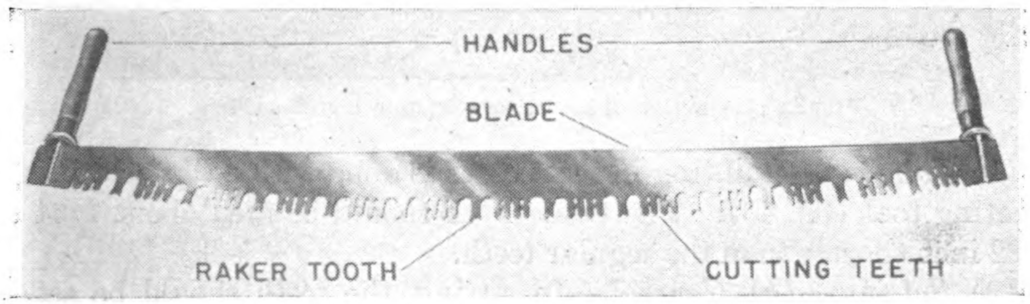


FIGURE 43.—Two-man crosscut saw.

in width from 3¼ to 8 inches (fig. 43). The cutting teeth are grouped in sections, usually four teeth to a section. Between sections are raker teeth which chisel out and remove the chips (fig. 44).

b. Operation.—Two men, one for each handle, are required to operate the saw. The saw is moved across the wood by pulling action only. Each man pulls the saw toward him as far as it will go, then ceases to exert any except a guiding pressure, while the other operator pulls back the saw. No downward pressure is needed as the weight of the saw is sufficient. In sawing horizontally, only slight pressure is required. Oil or paraffin rubbed on the blade lubricates the sawing action.

c. Care.—Like all saws, the two-man saw must be well taken care of. When the saw is not in use, in addition to the usual precautions, protect the teeth in some manner so that they will not become damaged.

d. Sharpening.—The two-man crosscut saw is sharpened somewhat differently from other saws.

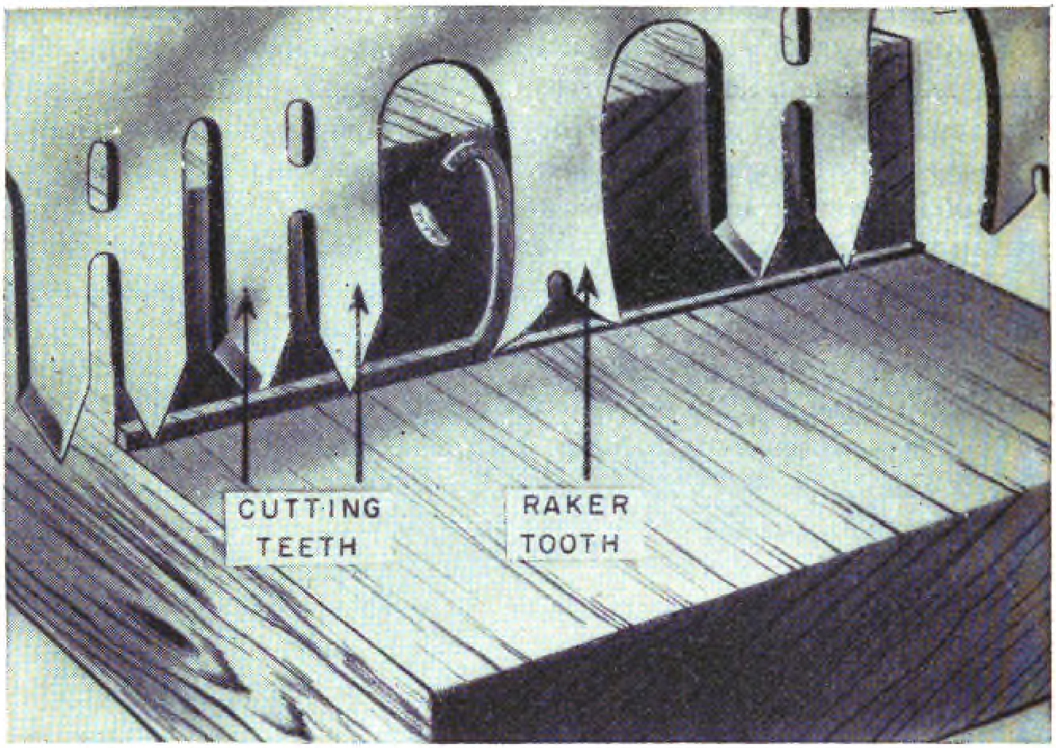


FIGURE 44.—Action of a cutting section of a crosscut saw.

(1) *Jointing.*—Jointing in most cases is done with a file held in the jointing tool (fig. 45). The raker teeth should be filed about 1/64 to 1/32 inch shorter than the regular teeth.

(2) *Setting.*—(*a*) *General.*—In setting, the teeth should be set at an angle that will make a cut wide enough to prevent the saw from

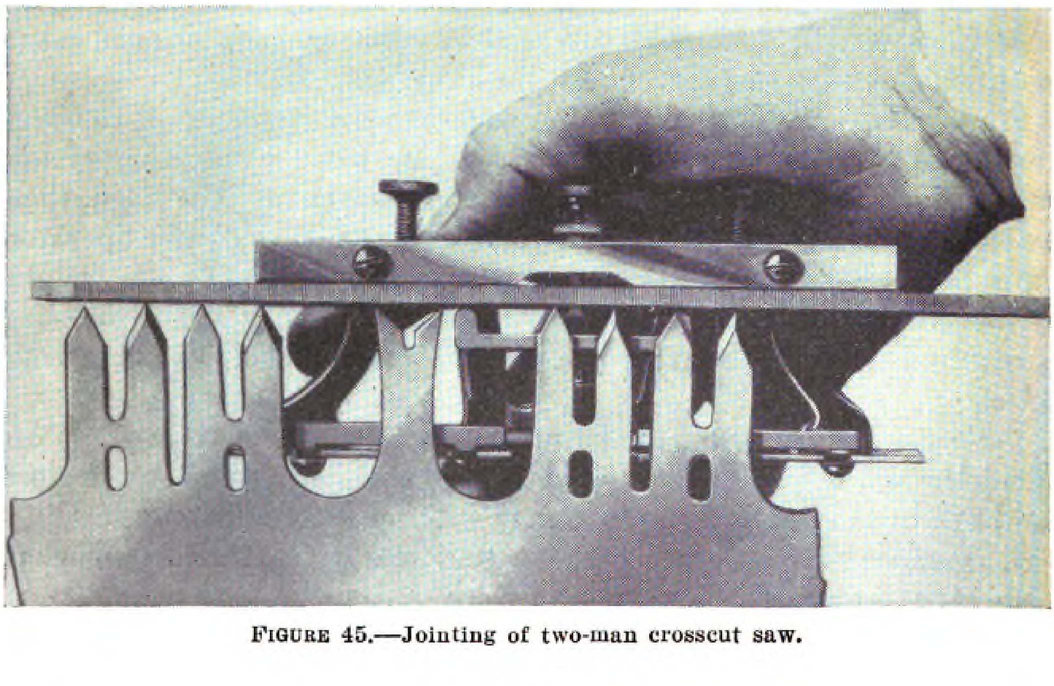


FIGURE 45.—Jointing of two-man crosscut saw.

binding. To do this, use the set called "stumping tool" which was made for this purpose (par. 70*d*). Lay the saw on the saw set with a tooth over the angle surface and strike lightly with a hammer. The tooth will bend to the angle of the set (fig. 46). Caution should be used not to strike too hard with the hammer. No more than half the length of the filed section of the tooth should be set (fig. 47①). Repeat this process for every tooth. The raker teeth are not set.

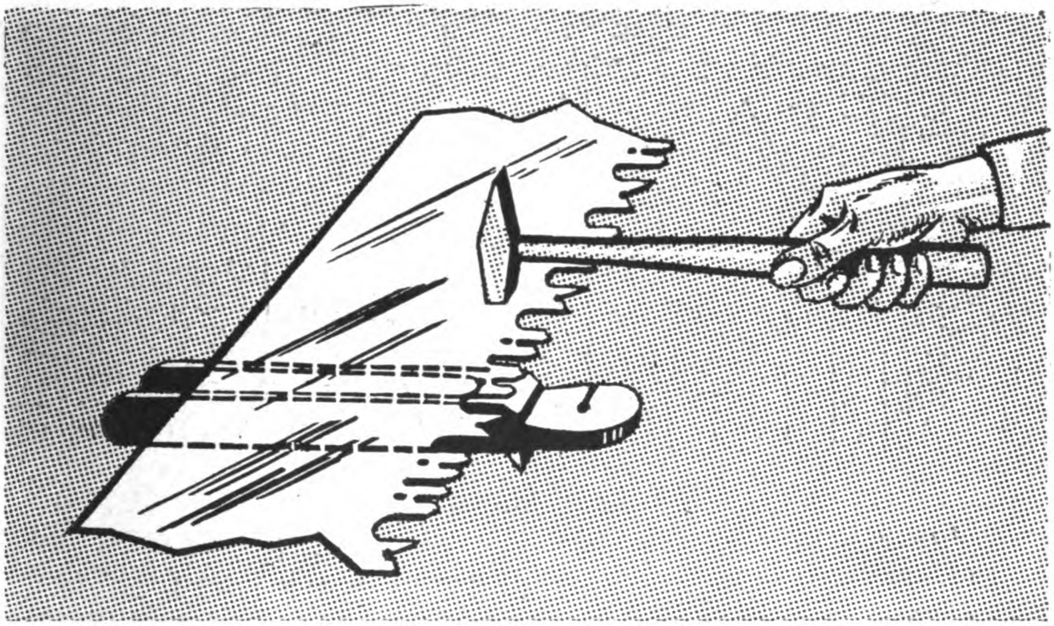


FIGURE 46.—Setting of two-man crosscut saw.

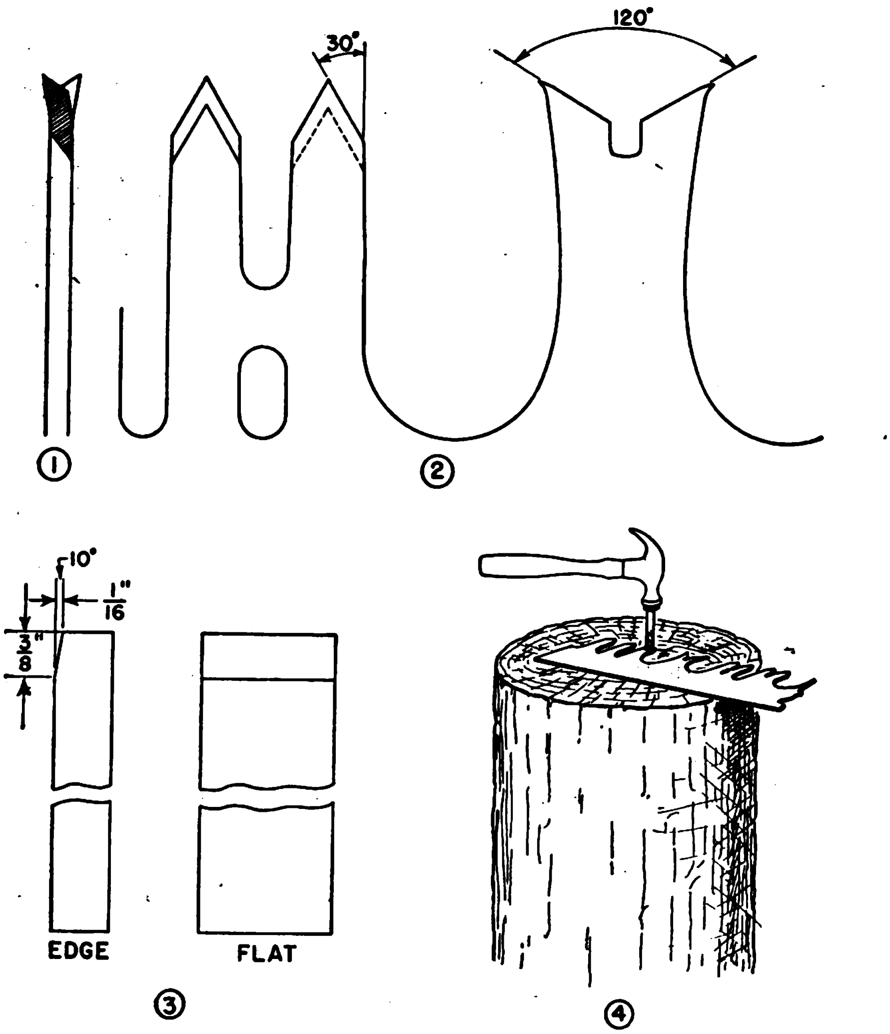
(*b*). *Expedients.*—Since the setting tool may not always be available, it is well to know expedients with which the two-man crosscut saw may be set.

1. Secure a flat piece of metal and grind a bevel at one end with a tool grinder as shown in figure 47③. The bevel should be approximately 3/8 inch long with approximately a 10° slope; this slope may be gained by using a 1/16-inch drop in 3/8 of an inch. This beveled iron may be used as the setting tool was used.

2. A second expedient may be improvised from a smooth, hardwood block used as shown in figure 47④. The saw is held flat on the surface of the wood while a bolt, or any small piece of metal that is flat on each end, is used as a swage. The bolt is placed on the part of the tooth that is to be set and struck with a hammer as shown in figure 47④. Care should be taken not to place a tooth that is to be set over a dent made by a previous setting of a tooth, or over a soft spot in the wood.

(3) *Filing.*—To file the teeth, place the saw in a vise with the points of the teeth about ¾ inch above the vise.

(*a*) To sharpen the cutting teeth, use a flat or mill file. File the teeth with a cutting bevel of about 45° from the line of the saw and with a fore and back slope of about 30° from the vertical (fig. 47②). When half of the tooth is sharpened, change position and sharpen the other side. If the gullets (fig. 47②) are too shallow use a round file to



① Set. ② Angle of teeth. ③ and ④ Expedients.

FIGURE 47.—Setting of crosscut saw.

enlarge them. A thin, abrasive wheel with a round face may be used for this purpose.

(*b*) The raker teeth are sharpened straight across much as the ripsaw teeth are sharpened. The angle of the groove should be approximately 120° (fig. 47②). To give better results, raker teeth may be swaged (fig. 48).

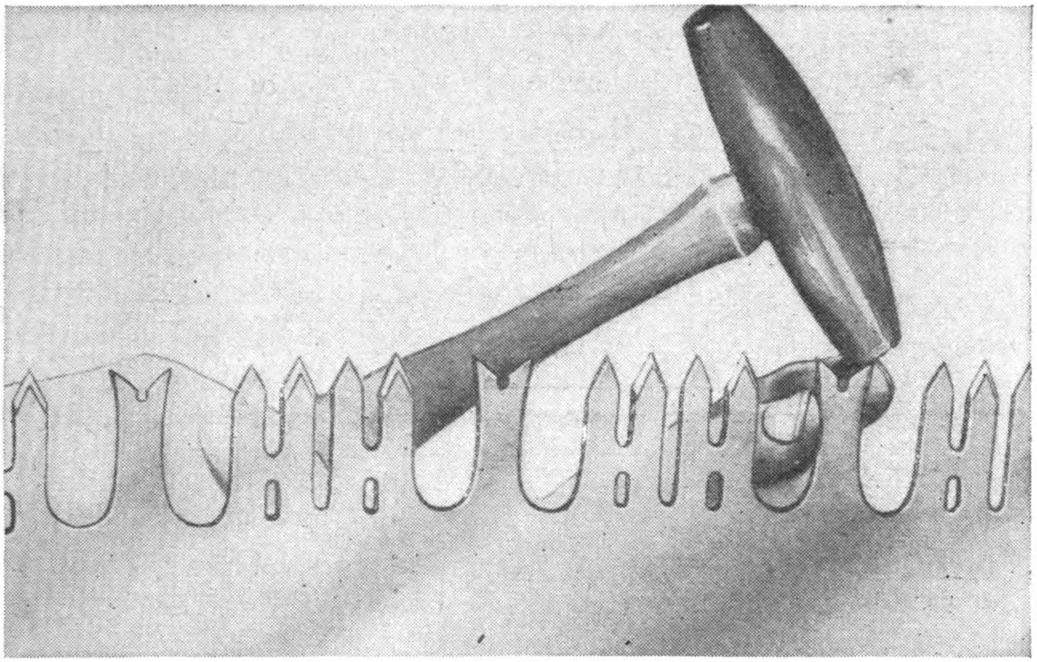


FIGURE 48.—Swaging a raker tooth.

(4) Dressing is accomplished by means of a fine file or an oilstone.

41. Crosscut saw, hand, one-man.—This saw may be operated by one man or two men. It has some of the advantages of both the handsaw and the large two-man saw. It is fitted with two handles, one at each end. One handle is similar to that of the 26-inch handsaw, the other to that of the two-man saw. The blade is of high-grade steel, varying in length from 2½ to 5 feet, and in width from 3¼ to 6 inches. The cutting teeth are like those of the handsaw, but are larger and are grouped in two-tooth sections, with one raker tooth for each section (fig. 49). The saw is taper-ground. The cutting part of the saw is thicker than the noncutting part to prevent binding in the kerf.

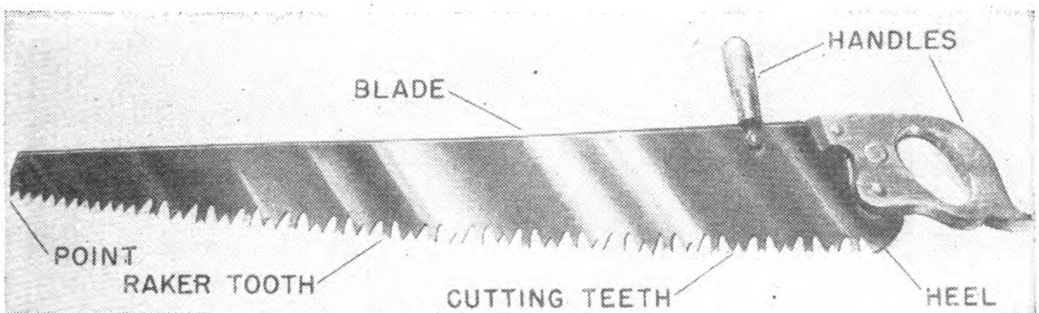


FIGURE 49.—One-man crosscut saw.

Section II

LAY-OUT

42. Square.—The square in its various forms is one of the carpenter's most important precision instruments. With the square the carpenter measures and cuts the numerous angles which, in carpentry, make for well-fitted, tight, and sturdy construction. The three types of square used in carpentry are the framing square, try square, and bevel square.

43. Framing square (steel square).—*a. General.*—(1) The framing square is an all-steel tool consisting of two arms which form a right angle. The larger arm, usually 24 inches long and 2 inches

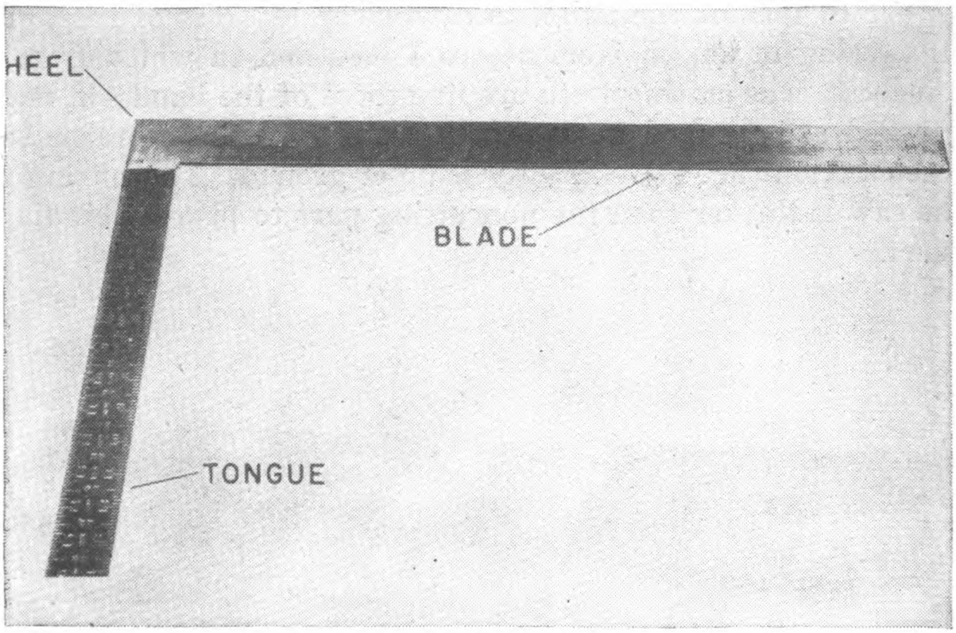


FIGURE 50.—Steel framing square.

wide, is called the blade. The smaller arm, usually 1½ inches wide and from 14 to 18 inches long, is called the tongue. The points of juncture (inside and outside) are called, individually, the heel (fig. 50). The face of the square is that side which carries the manufacturer's name, or, when holding the blade in the left hand, tongue in the right, heel pointed away from the body, the face is the side which is up. The reverse side is called the back.

(2) In using the square, the blade should be held along the edge of the timber with the tongue across the face of the timber (figs. 51 and 52). The face of the timber should be smooth and free from foreign particles. The line is drawn along the tongue. The square should be oiled when not in use and kept in a tool box.

(3) The markings on the square are the scales and tables. The scales are inches and gradations of the inch and are found on all

FIGURE 51.—Use of square for squaring wide timber.

edges of the square. On the back of the tongue, in the corner of the square, there is a hundredth scale for the inch. An octagon scale may be seen along the center of the face of the tongue. There are three tables: the Essex board measure table, brace table, and rafter table.

b. Essex board measure table.—(1) The Essex board measure table appears on the back of the blade. It is used to find quickly the number of board feet in a piece of lumber. It is a simple table to use and once its few essentials are understood it saves the carpenter

FIGURE 52.—Use of square for squaring narrow timber.

much time in estimating lumber requirements for a particular job. (See fig. 53.)

(2) To find the number of board feet in a piece of lumber, its three dimensions must be known—the width, thickness, and length. Two of these dimensions are taken care of simultaneously by the inch markings on the outer edge of the blade. These figures represent the *width* in inches of a board *1 inch thick.* The third dimension of the timber is found in the vertical column of figures under the inch mark *12* (*12* is the base number of the table). The figures under the number 12 represent *lengths* in feet. All other figures in the table represent totals of board feet.

(3) To find the number of board feet in a piece of wood, find its *length* in the column under 12 and guide laterally along this line until the figure under the *width* of the board is reached. This figure is the number of board feet, in feet and inches, of a piece of lumber 1 inch thick. To find the result for lumber of other thicknesses, simply multiply the first result by the thickness of the piece. In the answer table, the figures to the left of the vertical lines represent feet, the figures to the right, inches.

(4) For example: How many board feet of lumber in a piece of wood 8 inches wide, 3 inches thick, and 13 feet long?

(*a*) Find the length, 13 feet, under the inch figure 12.

(*b*) Move along the line to the left until directly under the figure 8, which represents the width of the piece.

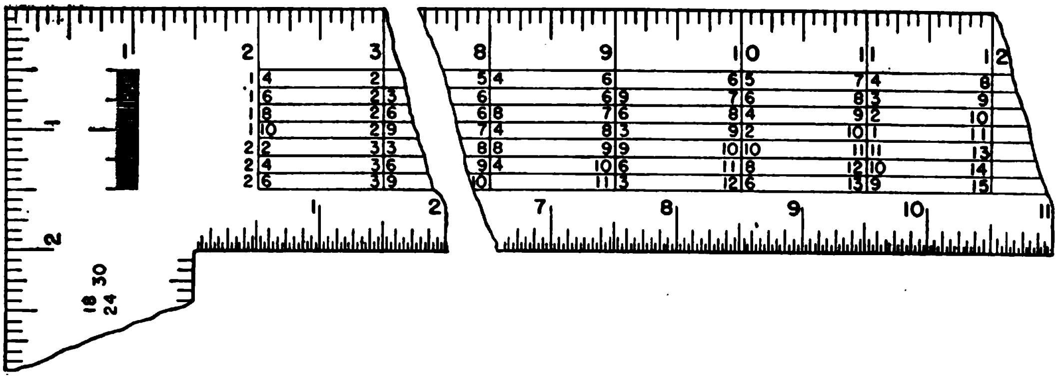


FIGURE 53.—Essex board measure table.

(*c*) Read the figure in the table: 8/8, or $8\frac{8}{12}$ ($8\frac{2}{3}$) feet. This figure is for a board 1 inch thick.

(*d*) Multiply $8\frac{2}{3}$ by the thickness of our board, 3:

$$8\tfrac{2}{3} \times 3 =$$

$$26/3 \times 3 = 26 \text{ board feet.}$$

c. Brace measure table.—(1) The brace measure table is found along the center of the back of the tongue (fig. 54①). It is used to find quickly the length of a brace when the run of the beam (the length of the beam from the end of the brace to the inner side of the post), equals the run of the post (the length of the post from the end of the brace to the inner side of the beam). (See fig. 54②.) It also gives length of brace where the beam run is 18 inches and the post run 24 inches.

(2) The duplicated figures in the brace measure table represent the run and rise of the angle to be braced. The number alongside these figures represents the needed length of brace. For example, to find the length of brace necessary for a post-beam angle in which the brace will be 48 inches from the joint, find the figure 48 in the table. The adjacent figure, 67.90, is the required length of brace.

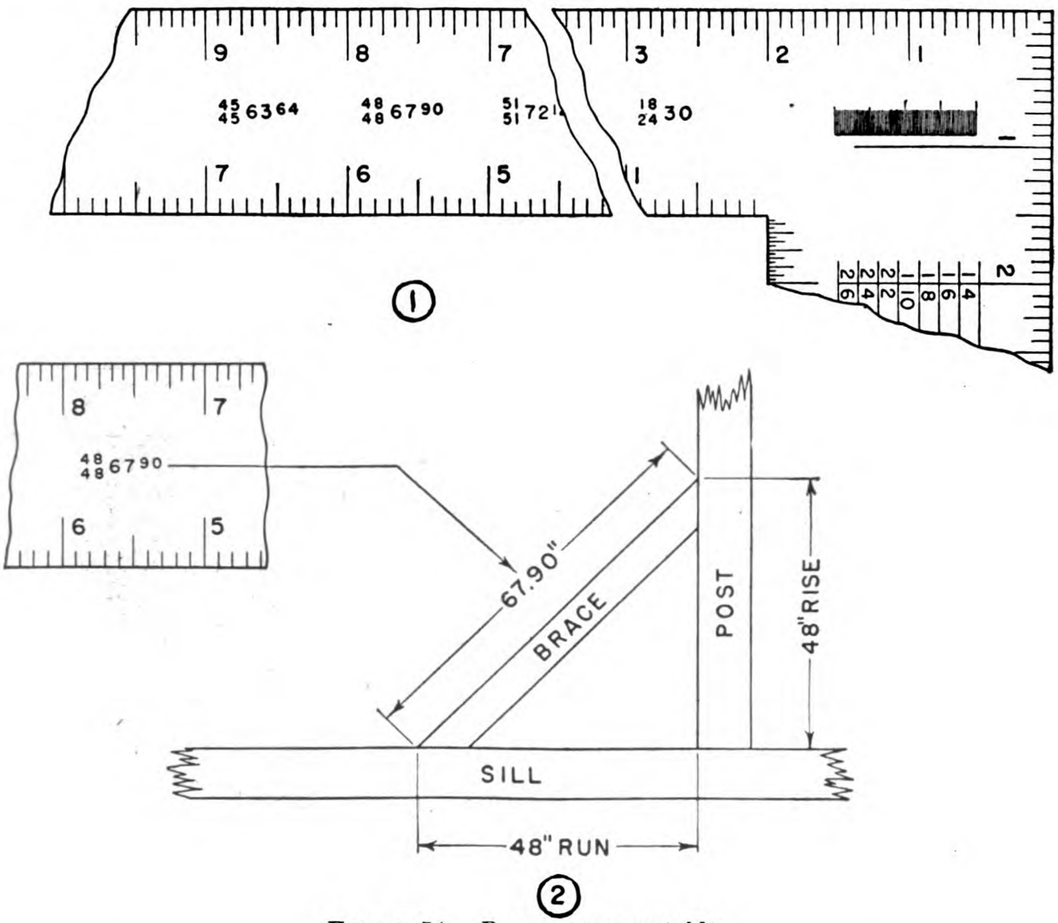


FIGURE 54.—Brace measure table.

(3) When the run and rise cannot be found in this table, treat the brace as a common rafter and use the rafter table (par. 130).

44. Try square.—*a. General.*—The try square is composed of a

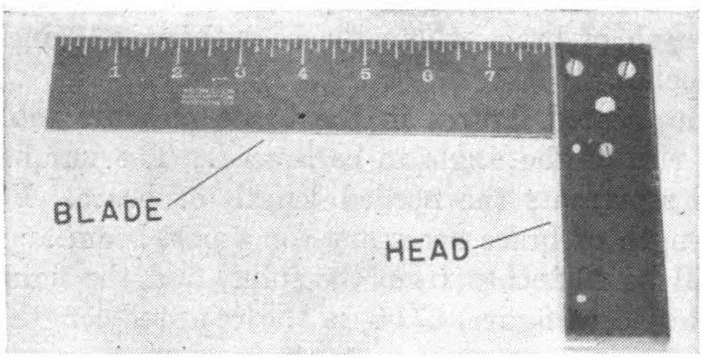


FIGURE 55.—Try square.

steel blade set at right angles into a head (beam) of wood or steel. The blade is graduated into inches and fractions of an inch. See figure 55.

b. Use.—The try square is used as shown in figure 56.

(1) To serve as a guide for the pencil in marking lines at right angles to an edge or surface.

(2) To test an edge or end to determine whether it is square with the adjoining surface or edge.

(3) To test the surface or edge to determine whether it is the same thickness throughout its length.

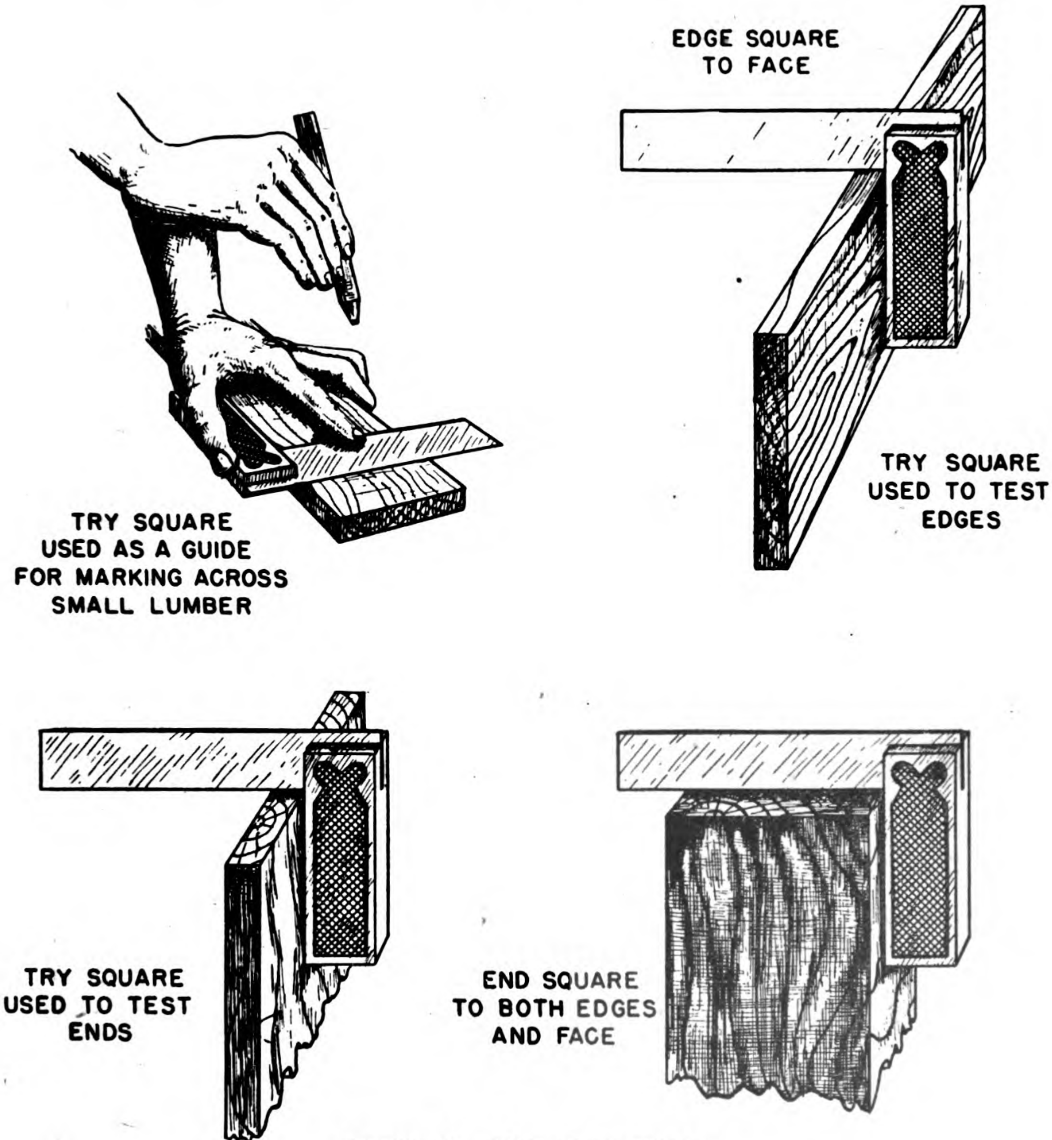


FIGURE 56.—Uses of try square.

c. Combination try square.—The combination try square has removable and adjustable heads, the most common of which is the stock head. Figure 57 illustrates the various uses of the combination square.

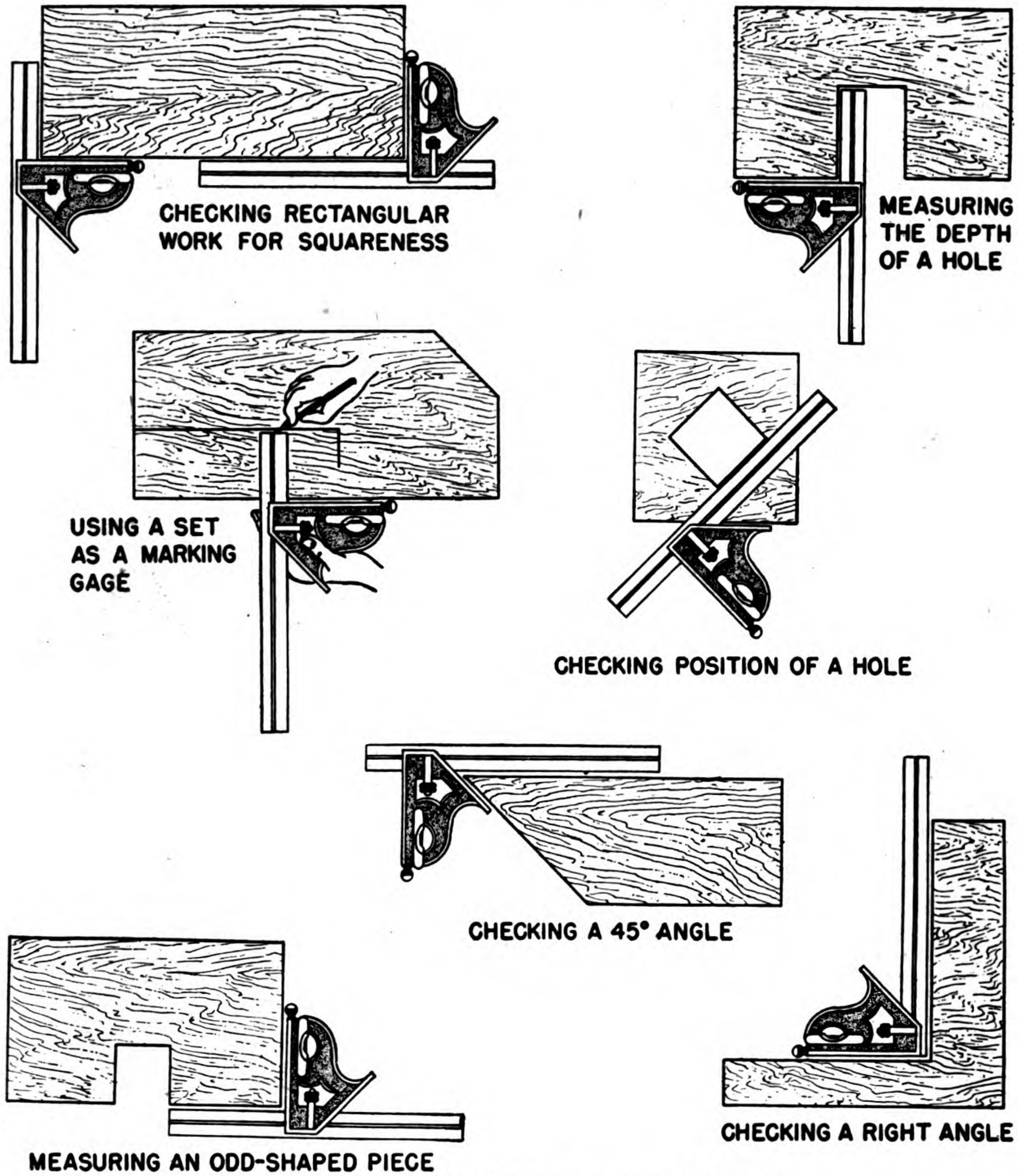


FIGURE 57.—Combination try square and its uses.

45. Bevel square.—The bevel square or T-bevel is composed of a steel blade from 6 to 12 inches long with a 45° bevel point at one

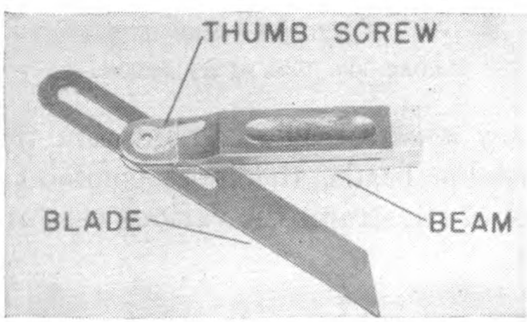


FIGURE 58.—Bevel square.

end. The other end is fitted into a slotted wooden beam and is held in place by means of a thumb screw. The blade has a long slot in the beam end to allow ample working movement and may be set at any desired angle. (See fig. 58.) It can be used for transferring angles from one piece of timber to another, or it can be used in places where other types of squares cannot. It should be well oiled and placed in a tool box when not in use.

46. Carpenter level.—*a. General.*—A carpenter's level consists of a hardwood or metal rectangular block from 12 to 30 inches long, with one or more true surface edges (fig. 59). A bubble tube in the end of the level, perpendicular to the true surface, is used in plumbing. A bubble tube in the center of the level, parallel to the true surface, is used in leveling.

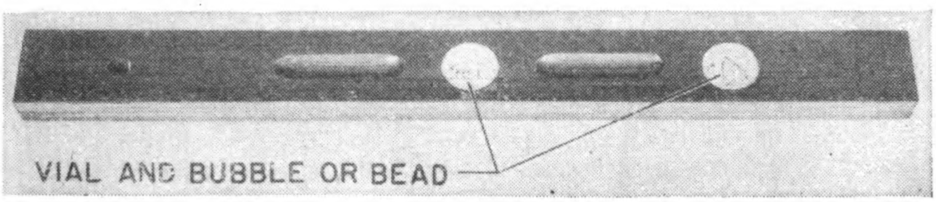


FIGURE 59.—Carpenter's level.

b. Checking the level.—To determine if the level is in adjustment, place it on a fairly level surface. Note the position of the bead in the tube. Reverse the level end for end. The bead should be at the same relative position as in the first instance; if it is not, the level is out of adjustment and should not be used until it has been carefully corrected by means of the adjusting screws which hold the vial in place. The bubble tube in the end of the level used in plumbing should be checked for adjustment in a similar manner on a vertical surface.

c. Operation.—Place the level on the surface to be leveled or plumbed, holding the level still with the hand. If the position of the bead is not in the center of the vial, the surface is not level or plumb. The bead moves toward the higher side. To secure a correct level or plumb, lower the high side until the bead bisects the vial.

d. Care.—The level is a delicate instrument, easily damaged, and care must be taken that it is not abused. It must be kept in a tool box and protected from the danger of being broken by the other tools in the box.

47. Wing dividers.—Wing dividers, or compasses, are composed of two hinged, pointed legs, an angle indicator, and a setscrew (fig. 60). They are used to describe circles, measure angles, distances, and thicknesses. Figure 61 illustrates various ways to use the dividers.

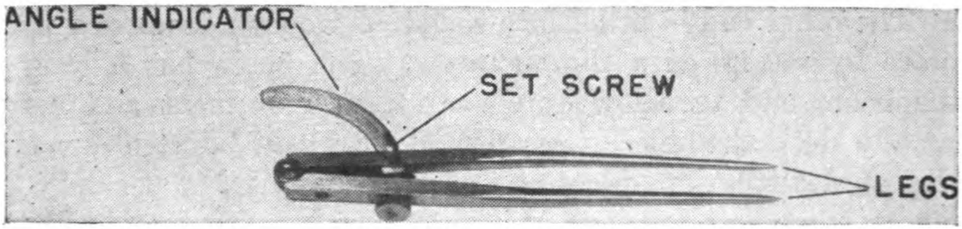


FIGURE 60.—Dividers.

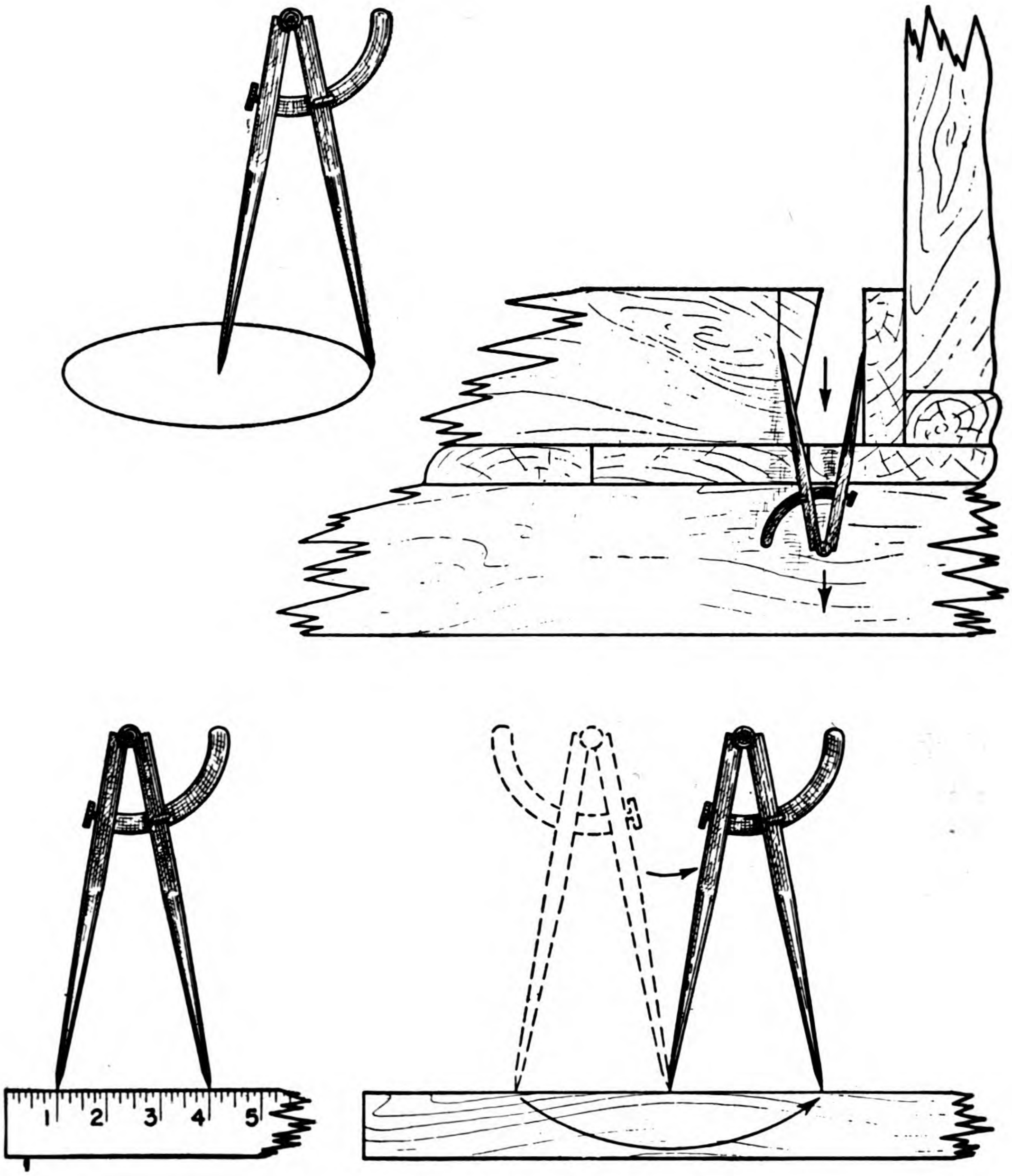


FIGURE 61.—Uses of dividers.

48. Marking gage.—*a. General.*—The marking gage is a wooden instrument used to draw guiding lines parallel to an edge. It consists of a graduated wooden strip (the beam) upon which slides a block of wood (the head). The beam is fitted with a small metal marking point (the spur). (See fig. 62.)

b. Operation.—Set the head at the desired distance from the spur by reading the graduated beam, tighten the setscrew on the head, and

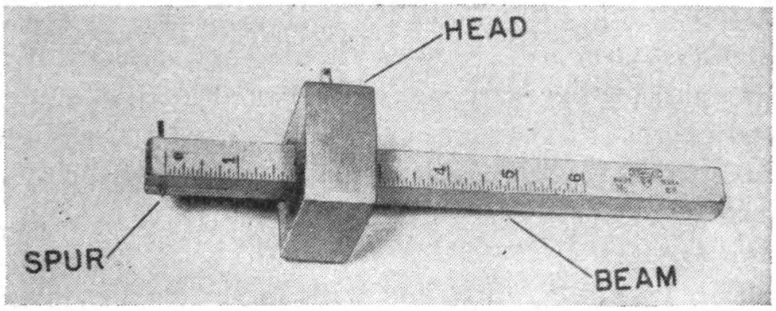


FIGURE 62.—Marking gage.

check the distance with a rule. Lay the gage against the wood to be marked in such a manner that the wood fits into the angle between the head and the beam and so that the spur fits against the wood. Grasp the gage with the fingers over and around the head, the thumb extended along the side of the beam (fig. 63). Engage the spur by

FIGURE 63.—How to use marking gage.

means of a slight rotary pressure of the gage. Holding the gage at a slight angle, with the spur pointing away from the direction in which the gage is to move, make a line by pushing the gage with pressure in two directions as follows: forward to mark the line, and sideward to keep the head tightly against the guiding edge.

c. Care and sharpening.—Care must be taken lest the spur be broken. When the gage is not in use, move the head along the beam until it rests against the spur and fasten it there. Use a file to sharpen the spur. The spur should project about $1/16$ or $3/32$ inch.

49. Tapes.—*a. General.*—Tapes are made of steel, or of cloth reinforced with small copper wire. The former are called steel tapes, the latter metallic tapes. They are commonly used to lay out bridges, fortifications, buildings, and other structures which require a long and accurate measuring device.

b. Metallic tape, 50-foot.—(1) *General.*—The metallic tape is made of a linen strip (usually reinforced with interwoven copper strands),

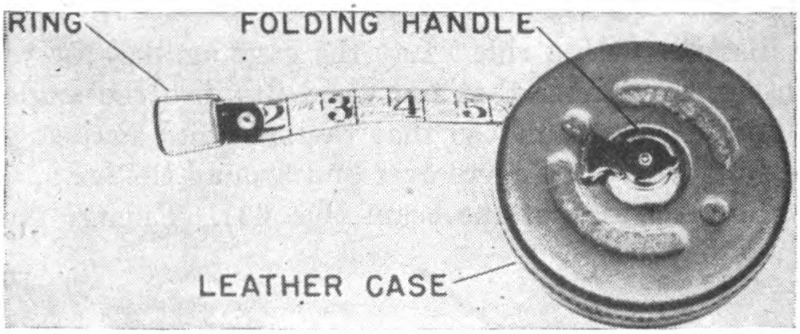


FIGURE 64.—Metallic tape.

$5/8$ inch wide and 50 feet long. It is graduated in feet and inches (sometimes in tenths of a foot) and marked with prominent figures (fig. 64). It is wound on a spool which is manipulated by a folding handle. A small ring is attached to the end of the tape so that it may be easily held or made fast to a stationary object. It is carried in a leather case. The metallic tape cannot be used in precision measuring as it will stretch under tension or when wet.

(2) *Hints on use.*—(*a*) Use a helper to hold the free end of the tape.

(*b*) Make sure that the tape is not kinked.

(*c*) Pull the tape taut, but do not stretch it.

(*d*) Read the measurement, and know definitely whether the graduations are in inches or in tenths of feet.

(*e*) Do not read "6" for "9" or vice versa.

(*f*) Keep the metallic tape dry and free from oil.

(*g*) Be sure to check the zero point of the tape. Some tapes have the zero mark at the end of a ring, others a short distance from the end.

(*h*) Whenever the tape is not in use, keep it wound within its cover.

c. Steel tape, 50-foot.—(1) *General.*—The steel tape is made of high-grade tape steel ⅜ inch wide (fig. 65). Its other features are similar to those of the metallic tape. It is more accurate since it is less subject to stretching.

(2) *Care.*—The steel tape should be cleaned and oiled after it is

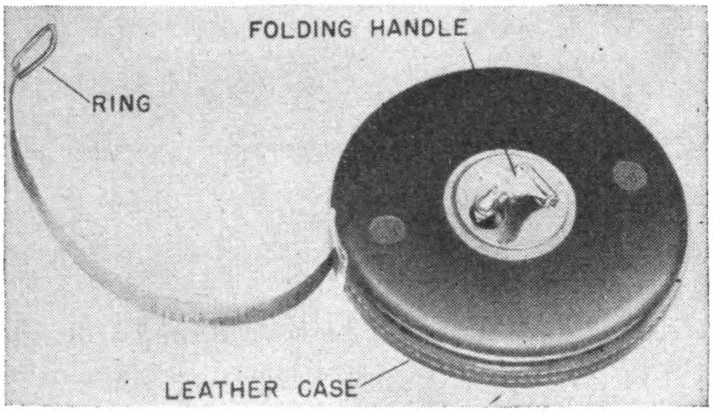


FIGURE 65.—Steel tape.

used. It should not be used to measure around corners. It is easily kinked and must be protected from falling objects. Do not allow a vehicle to run over it.

50. Rules.—*a. Small rule.*—The ordinary carpenter's rule is made of wood or steel and is from 2 to 8 feet long. The wooden rule is the hinged or folding type; the steel rule is either the folding or winding type.

b. Boxwood rule.—(1) The boxwood rule is made of boxwood or maple. It is in four pieces, each 6 inches in length, hinged together

FIGURE 66.—Boxwood rule.

so as to fold into a length slightly more than 6 inches (fig. 66). One edge is graduated to eighths of an inch, the other to sixteenths of an inch. The edges of the rule usually are bound with metal.

(2) The joints must be kept clean and well oiled. The rule should be handled carefully as the hinges are easily broken. When not in use it should be kept in a tool box.

c. Zig-zag rule.—The zig-zag rule is made of hard, well-seasoned wood, or of light metal, in a wide range of sizes and markings. The center of one hinge or lap is 6 inches from the center of the next. Each section is made approximately 8 inches long, to compensate for the overlapping hinges (fig. 67). The length of the rule varies from

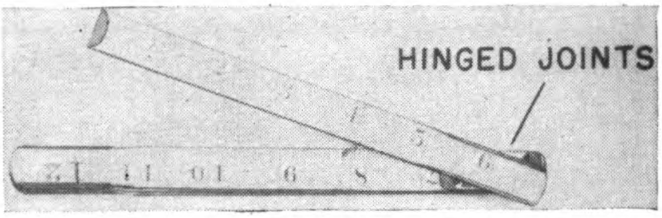


FIGURE 67.—Ziz-zag rule.

4 to 8 feet. The markings are in black letters. It is graduated to sixteenths of an inch.

d. Steel rule, 6-foot.—The 6-foot steel rule is of flexible steel tape and is of the winding type. It is graduated to sixteenths of an inch, but has the first 6 inches of one edge graduated to thirty-seconds of an inch. It is ½ inch wide and is cup-shaped in cross section to prevent bending when the tape is extended. (See fig. 68.) It is carried in a small metal case about 2 inches in diameter.

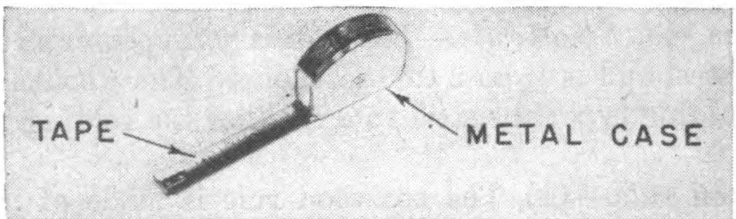


FIGURE 68.—Steel rule.

51. Plumb bob.—The plumb bob is a conelike solid piece of metal (iron, brass, or lead), with one end pointed, the other fitted with a fixture to which a string may be attached so that when the bob is suspended the point falls directly under the center line of the string (fig. 69). For a discussion of its use see paragraph 123*c*.

52. Pencils.—Carpenters use several types of pencils: common lead, hard lead, and the regular carpenter pencil. The one used by the Army is the flat, hard lead pencil, about 8 inches long. For use in rough work, the pencil should be trimmed so that about ¼ to ⅜ inch of lead protrudes from the wood. In finished work the pencil should be trimmed so that ⅜ to ½ inch of lead is exposed and the lead sharpened to a long flat point. When marking, the pencil should be tilted away from the guide so that the lead will mark close along edge of the guide. If the pencil becomes wet, the glue which holds it together may fail.

53. Crayon, chalk, chalkline.—*a. Crayon.*—Crayon is a waxen substance used to mark grades of wood on lumber, to mark points for

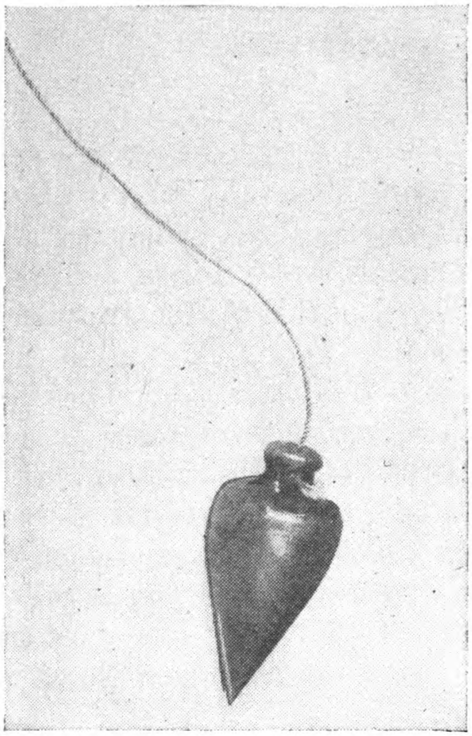


FIGURE 69.—Plumb bob.

easy reference, and to number sections of bridges, buildings, etc. Crayon is easily broken and must be handled carefully.

b. Chalk.—Chalk is a powdered substance, commonly lime, compressed into a cake, in most cases as a hemisphere. It may be obtained in various colors: red, blue, yellow, brown, or white. It is used for marking points and chalking lines. To prepare a line for chalking, hold the chalk in one hand and slide a line over the chalk, rolling the line back and forth over the chalk with the thumb. The line rubs the chalk free from the cake and picks it up in its crevices. To chalk a line, the helper holds one end of it at a designated point, keeping the line clear of the object to be chalked. The other end of the line is placed and the line is tightened. With the line still held taut with one hand, the carpenter, with his other hand, raises the line about 8 or 10 inches from the surface and releases it, depositing a straight chalkline upon the object to be lined. Damp chalk or line should never be used as results are unsatisfactory.

c. Chalkline.—The chalkline is a cord made of cotton. It is used for staking out foundations, chalking lines, laying brick, alining walls, forms, posts, and rafters. Chalklines are made in various sizes.

Section III

DRIVING

54. General.—Driving tools are hand tools used to drive nails, spikes, driftpins, bolts, wedges, etc. They are also used for the purpose of striking cold chisels, wood chisels, drill punches, and nail sets. The driving tools covered in this section are the claw hammer, sledge hammer, mallet, and maul.

55. Claw hammer.—*a. General.*—(1) The claw hammer is a steel-headed, wooden-handled, nail-driving tool. It gets its name from the fact that one part of the hammerhead is formed like a two-pronged, arched claw which is used to pull nails out of wood. The main parts of the steel head are the eye, claws, and face (fig. 70). The face may be flat or slightly convex; the former is called a plain-face hammer, the latter a bell-faced hammer. The most common sizes of claw hammers are No. 1, weighing 20 ounces, No. 2, weighing 16 ounces, and No. 3, weighing 12 ounces.

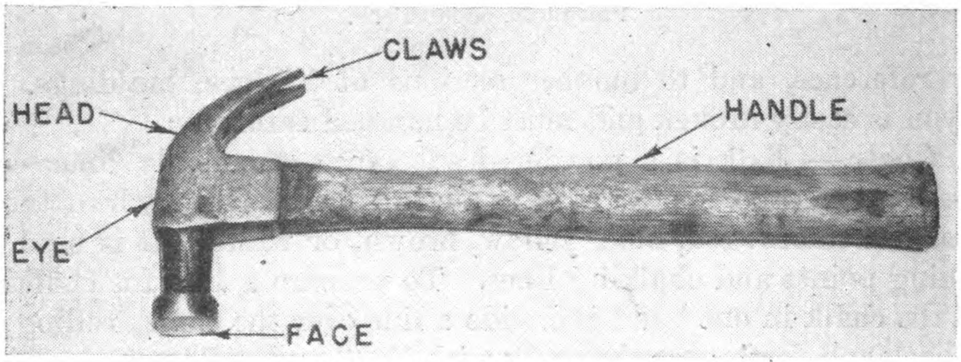


FIGURE 70.—Claw hammer.

(2) The bell-faced hammer is used for rough work. When a flat-faced hammer is used, the face and the nail head must be parallel at the moment of impact. The curved striking surface of the bell-faced hammer allows the hammer to strike when lightly tipped and still offer a uniform driving surface to the nail head.

b. Operation.—(1) *To drive a nail* (fig. 71).—(*a*) Hold the nail in place with the thumb and the first two fingers of one hand.

(*b*) Grasp hammer handle as shown in figure 71.

(*c*) Tap the head of the nail lightly to start it into the wood and remove the guiding hand.

(*d*) Drive the nail.

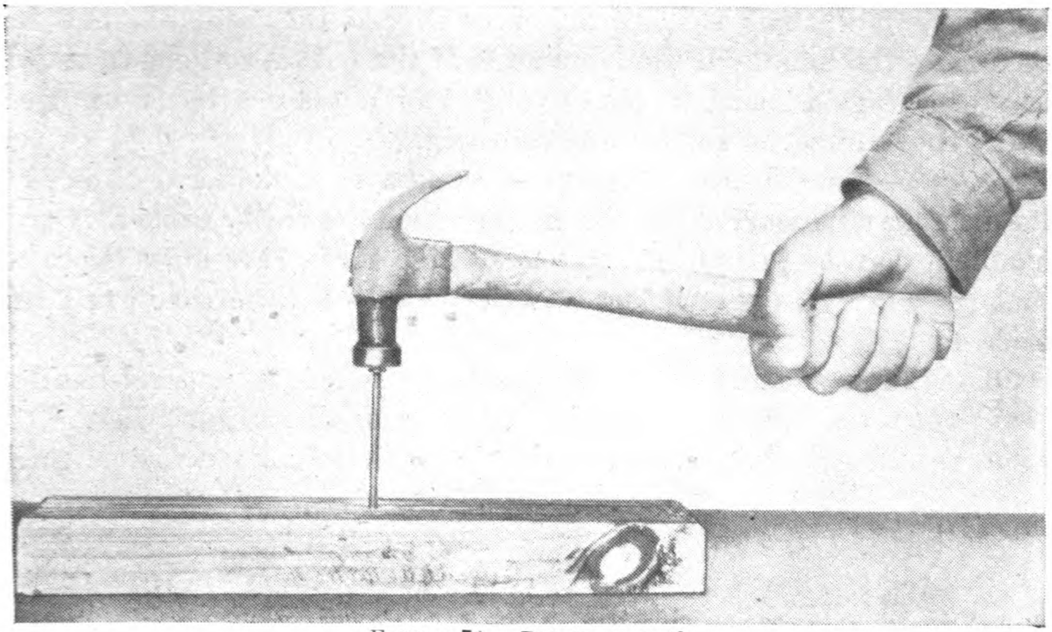


FIGURE 71.—Driving a nail.

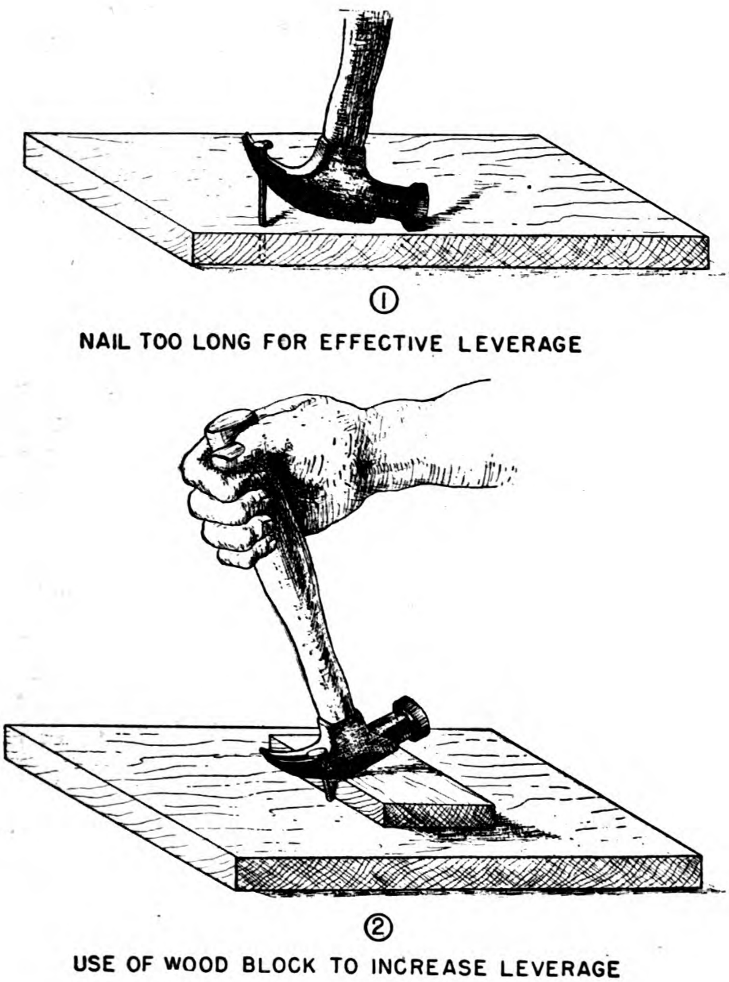


FIGURE 72.—How to pull nails with hammer.

(2) *To pull a nail.*—Place the claws so that they embrace the nail then raise the handle of the hammer. If the nail is so long that adequate leverage is hard to obtain (fig. 72①), place a block of wood under the hammer to act as a fulcrum (fig. 72②).

c. Care.—The hammer should not be used to strike hard objects as the face may be scarred; or the claws, which are easily broken if mishandled, may be jarred off. When pulling nails, care must be taken that proper leverage is secured or the handle will be overtaxed and broken.

56. Sledge hammer.—The sledge hammer is a steel-headed, heavy-duty, driving tool which is used for a number of purposes. The short-handled sledge is used to drive bolts, driftpins, and large nails,

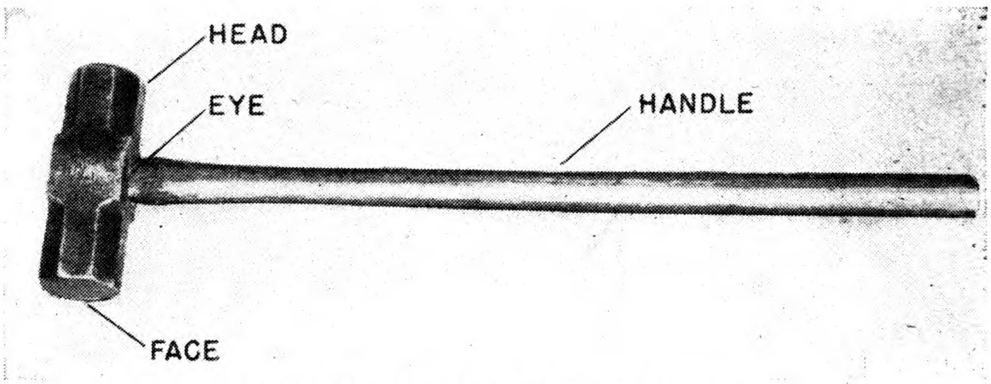


FIGURE 73.—Long-handled sledge hammer.

and to strike cold chisels, and small, hand rock drills. The long-handled sledge is used to break rock and concrete, to drive spikes and bolts, to strike drills and chisels, and to drift heavy timber (fig. 73). (See TM 5–225).

57. Mallet.—The mallet is a wooden-headed, short-handled tool used to drive chisels, gouges, wooden pins, or small stakes. It is re-

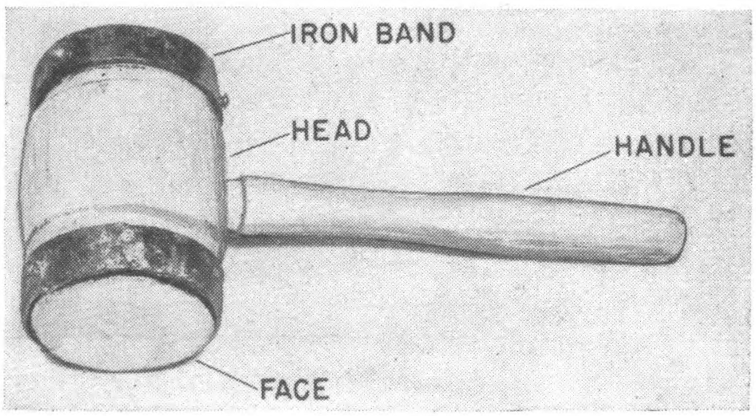


FIGURE 74.—Mallet.

inforced with iron bands at each end. The head is cylindrical and has two driving faces (fig. 74). The mallet is swung as a claw hammer is swung (par. 55). It should not be used to drive nails, screws, or any objects in which metal may come in contact with the face of the mallet. The mallet should not be left in the sun as the heat may cause the head to crack. A light film of oil should be kept on the mallet to maintain the correct moisture content of the wood.

58. Maul.—The maul is a large, wooden-headed, long-handled tool for driving wood (fig. 75). The head varies in weight from 15 to 25

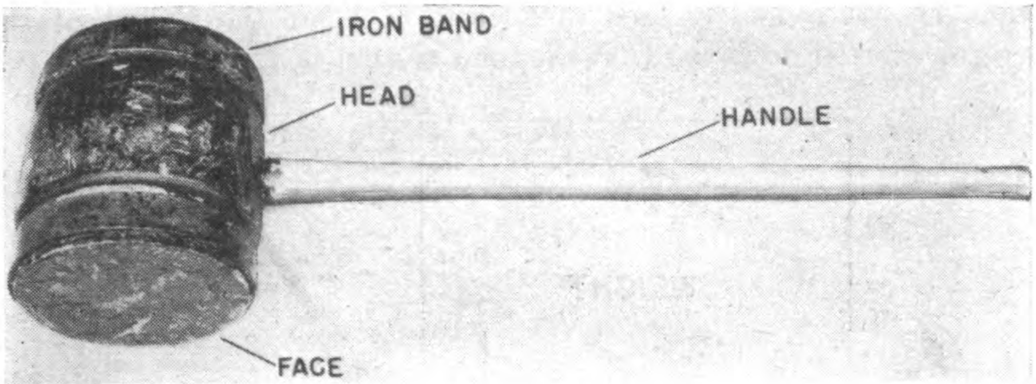


FIGURE 75.—Maul.

pounds. It is 10 inches long and approximately 8 inches in diameter. The handle is from 30 to 36 inches long. The maul is used to drive wooden stakes and posts, and to drift heavy timber. It is not used to drive metal objects.

SECTION IV

MISCELLANEOUS

59. Bars.—Bars are heavy steel tools used to move heavy objects and to pry where leverage is necessary. The most common types of bars are the crowbar, pinch bar, and wrecking bar.

60. Crowbar.—*a. General.*—The crowbar is made of high-grade steel and is about 5 feet long (fig. 76). It is used to move heavy timbers and rocks.

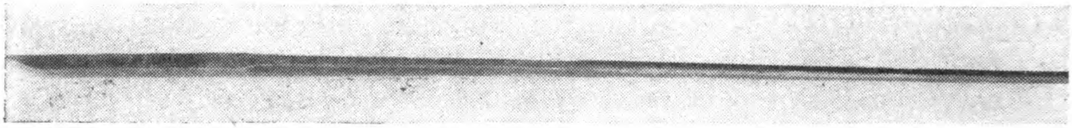


FIGURE 76.—Crowbar.

b. Operation.—To use the crowbar, operate it as a simple lever (fig. 77). It is mostly used in a position where the weight of the body is exerted downward on the long section of the lever.

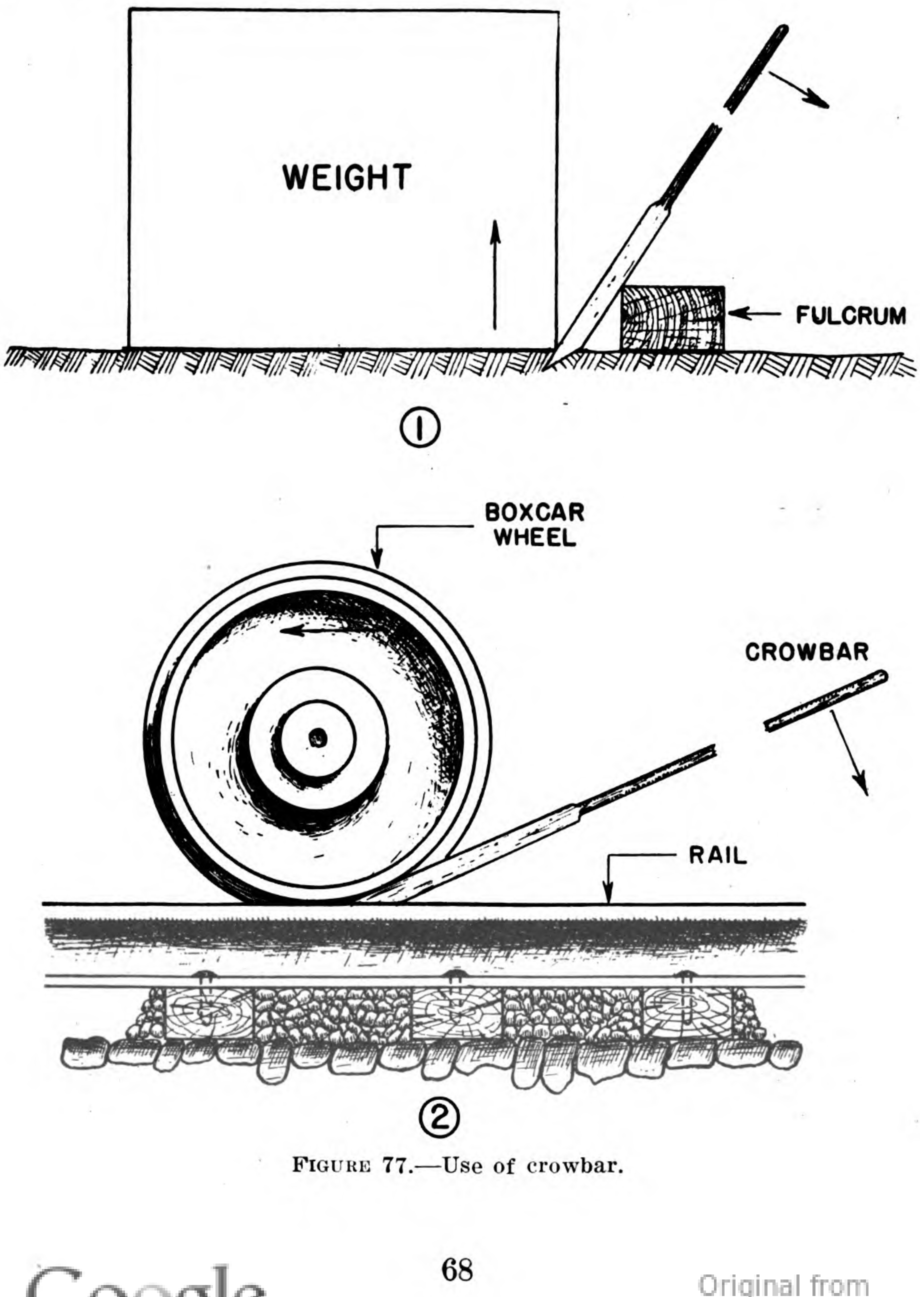
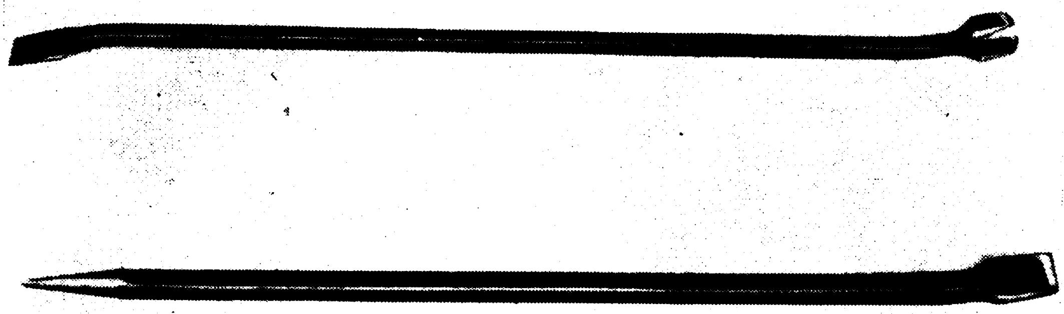
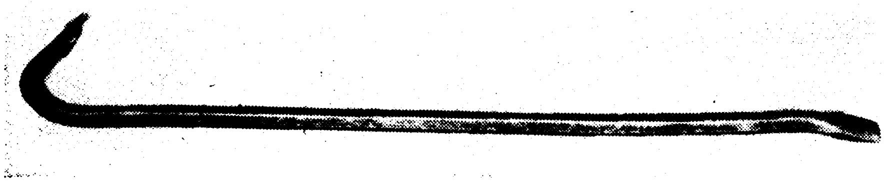


FIGURE 77.—Use of crowbar.

61. Pinch bar.—The pinch bar is octagon-shaped, with either one or both ends bent slightly. It is 18 to 36 inches long. One type of pinch bar is bent at both ends and has a pinch point at one end, a claw at the other. A second type is bent at one end, has a point at the offset end, and a pinch point at the other (fig. 78①). The pinch



① Pinch bars.



② Wrecking bar.

FIGURE 78.—Pinch bars and wrecking bar.

bar is used, in general, as the crowbar is used. It is also employed to pull spikes and to pry apart timber which has been nailed or spiked. If the bar is used to lift great weight it may be bent out of shape.

62. Wrecking bar.—The wrecking bar is octagon-shaped, one end goose-necked with claws, the other offset with a pinch point (fig. 78②). It varies in length from 12 to 60 inches. Its uses are much the same as the crowbar and pinch bar. In addition it may be used for pulling large nails.

63. Nail set.—The nail set is a small tool used to sink nails below the surface of the wood (fig. 79). It is a round steel shaft about $\frac{5}{16}$

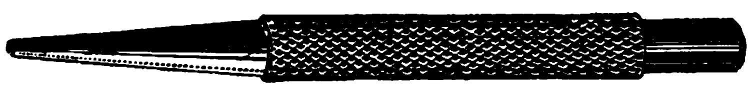


FIGURE 79.—Nail set.

inch in diameter and 4 inches long. Its point is tempered to extra hardness, but its head is untempered and soft to prevent chipping. Points of nail sets vary from $\frac{1}{32}$ to $\frac{1}{8}$ inch in diameter. Care should be taken that small sets are not used on large nails.

64. Vise.—The vise is a tool to hold and keep firm other tools or working materials. It consists of a clamping device to secure the vise to a stable object, such as a work bench, and a clamp to hold the tool or material. The two most common vises are the wooden vise (fig. 80①), for holding wood by means of wooden or metal jaws and a

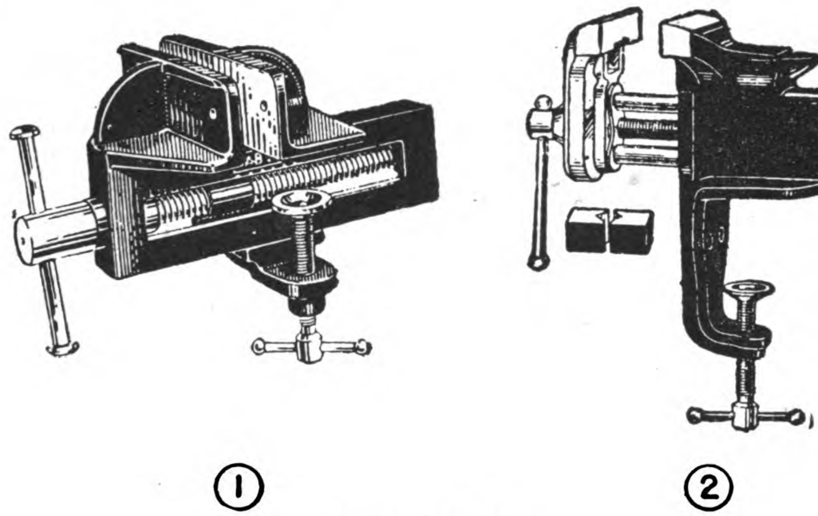


FIGURE 80.—Vise.

metal adjusting screw; and the metal vise (fig. 80②), with metal jaws and metal adjusting screw, for holding metal.

65. Screw driver.—*a. General.*—The screw driver consists of the head, handle, ferrule, blade, and tip. The handle is made of wood, steel, or plastic. The blade is made of high-grade steel with a tempered tip (fig. 81). Screw drivers vary in length and size according to their uses.

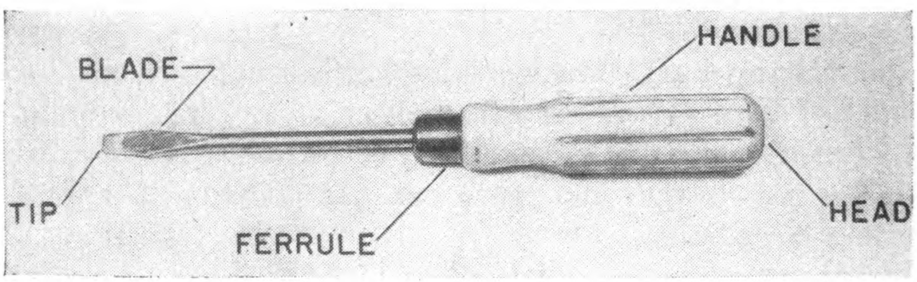


FIGURE 81.—Screw driver.

b. Operation.—To use the screw driver, hold the handle firmly in the palm of the right hand with the thumb and forefinger grasping the handle near the ferrule. With the left hand, steady the tip and keep it pressed into the screw slot; hold the screw driver perpendicular to the screw head; turn the handle, renewing the grip on the handle for each new turn (fig. 82). Use a long screw driver if possible as there is less danger of it slipping out of the slot and scarring the wood or metal.

c. Care and sharpening.—Select a screw driver of the length and size best fitted for the work. The tip should fit the slot in the screw; it should be square, not round or beveled (fig. 11); the sides should be

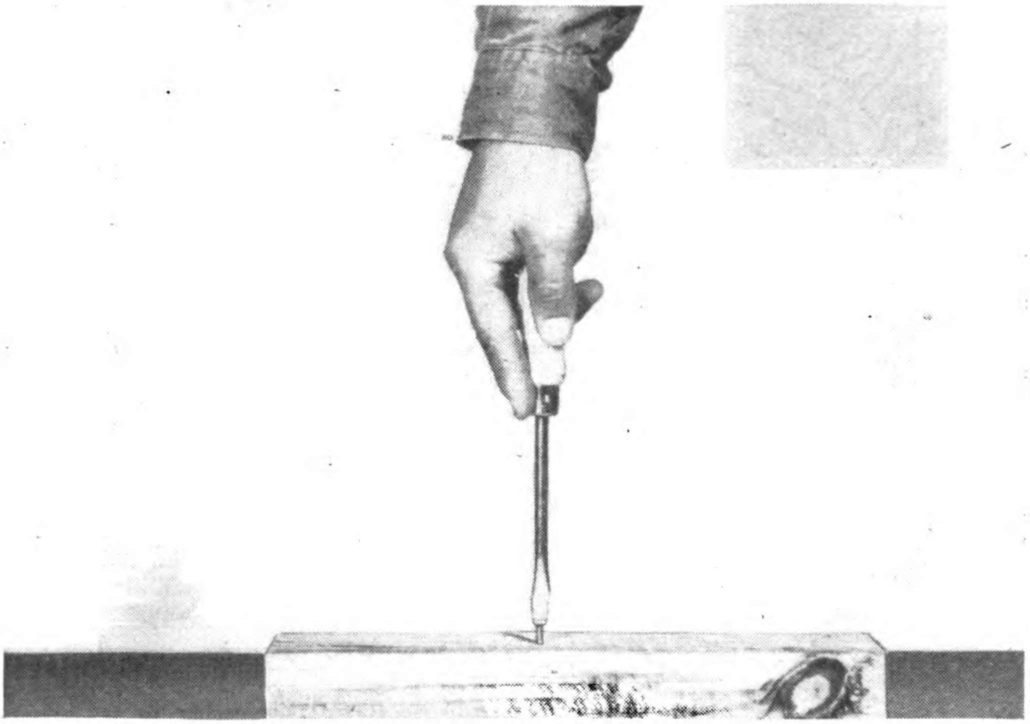


FIGURE 82.—How to use screw driver.

straight and nearly parallel. To sharpen the tip, use the side of the tool-grinder wheel taking care not to overheat the tip.

66. Sandpaper.—Sandpaper is an abrasive made of heavy paper with sand glued to one side. It is used to smooth or finish rough surfaces of lumber. Sandpaper comes in sheets 8¾ by 10½ inches and is sold either in reams or in dozens of sheets. It is manufactured in twelve grades of coarseness and is numbered as follows: 0000, 000, 00, 0, ½, 1, 1½, 2, 2½, 3, 3½, and 4. No. 0000 is very fine and No. 4 very coarse. Figure 83 illustrates methods of using sandpaper. Always work *with* the grain. Sandpaper should be kept free from water or oil.

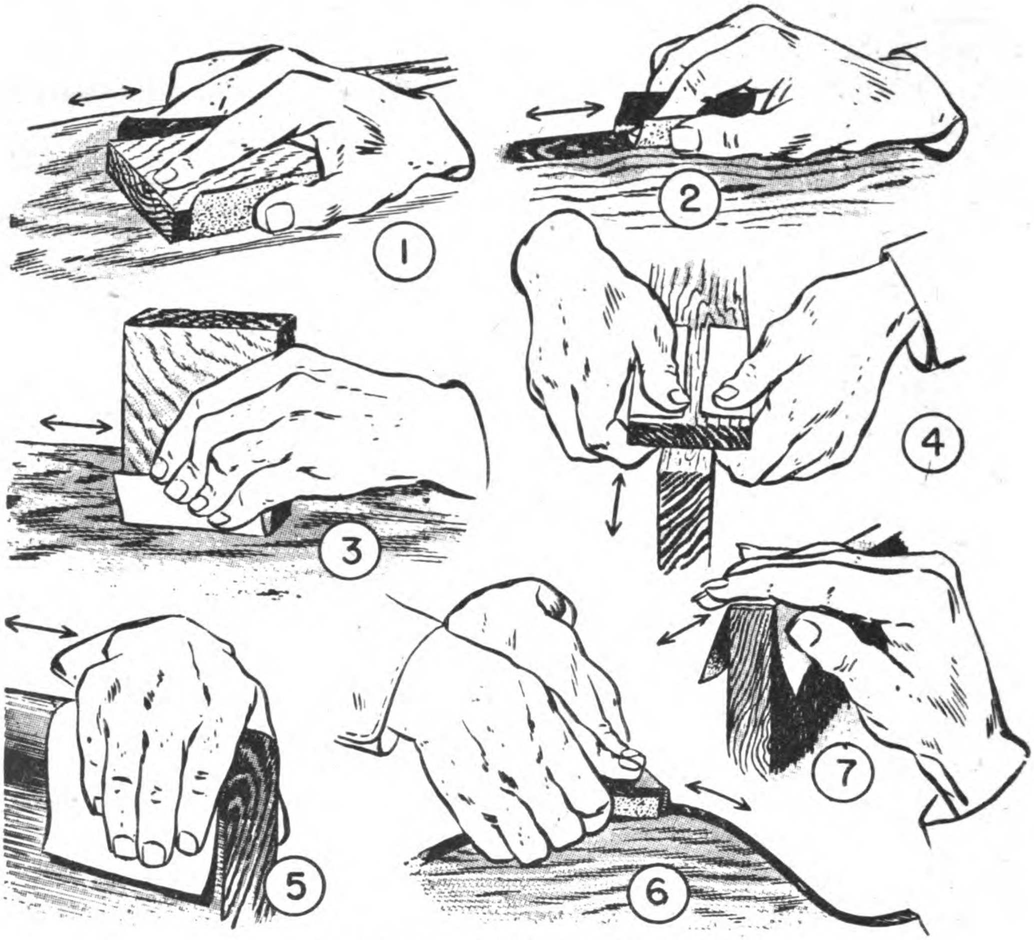


FIGURE 83.—How to use sandpaper.

67. Tool grinder.—The tool grinder or bench grinder is an abrasive tool used in the initial stages of sharpening such tools as chisels, screw drivers, adzes, axes, and plane blades (fig. 84). Two interchangeable wheels of different abrasive qualities are supplied. See TM 5-225 for full discussion of the tool grinder, its operation and care.

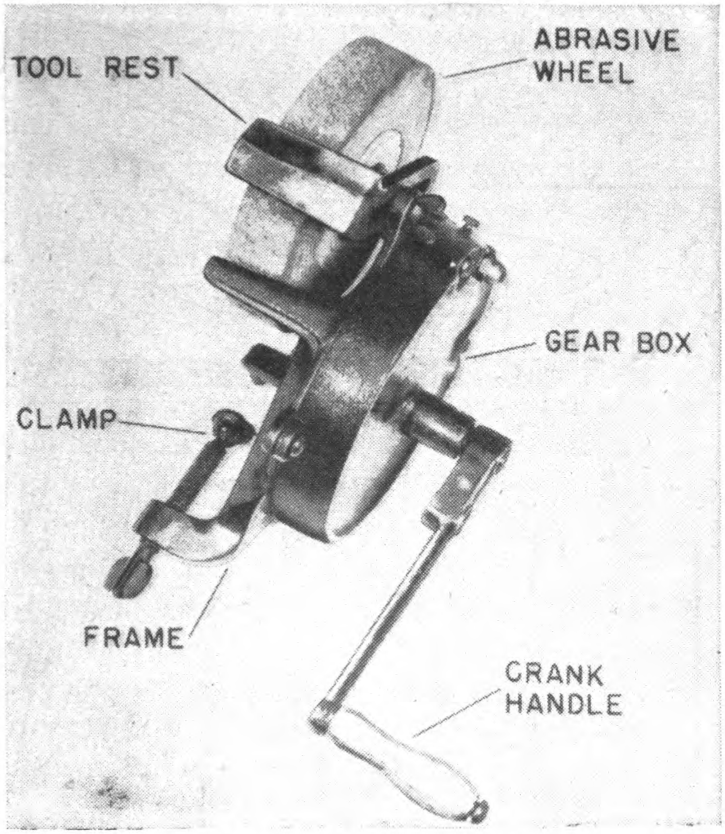


FIGURE 84.—Tool grinder.

68. Oilstones.—*a. General.*—Oilstones are fine-grained abrasive stones used for precise and smooth sharpening of tools. They are of two varieties; the fine-grained natural stone, and the coarse-grained artificial stone. The coarse-grained stone has a rapid-cutting surface,

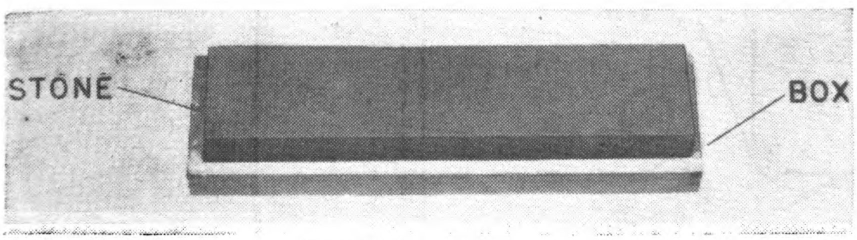


FIGURE 85.—Oilstone.

while the natural stone has a slow-cutting surface. Oilstones vary in size and shape; some are rectangular (fig. 85), others round. The rectangular oilstones are from 1 to 2¼ inches wide and from 3 to 8 inches long. The round stone is about 5 inches in diameter.

b. Operation.—(1) Oilstones should be used with oil. The oil tends to clean the pores of the stone, thereby providing a better cutting surface, and also acts as a lubricating medium. If the stone becomes

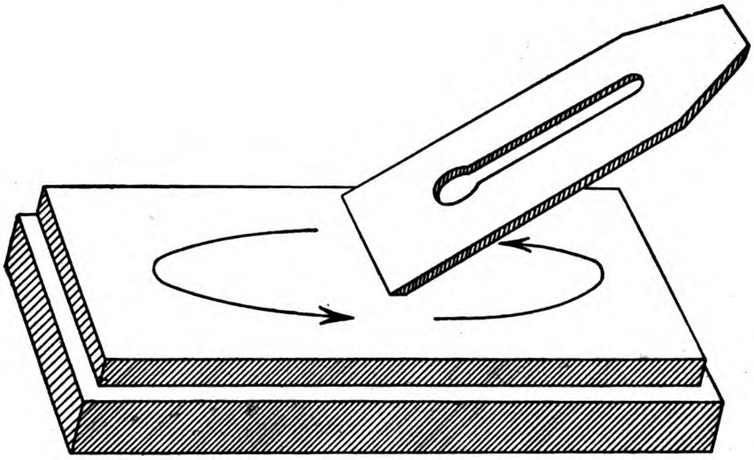


FIGURE 86.—How to use oilstone.

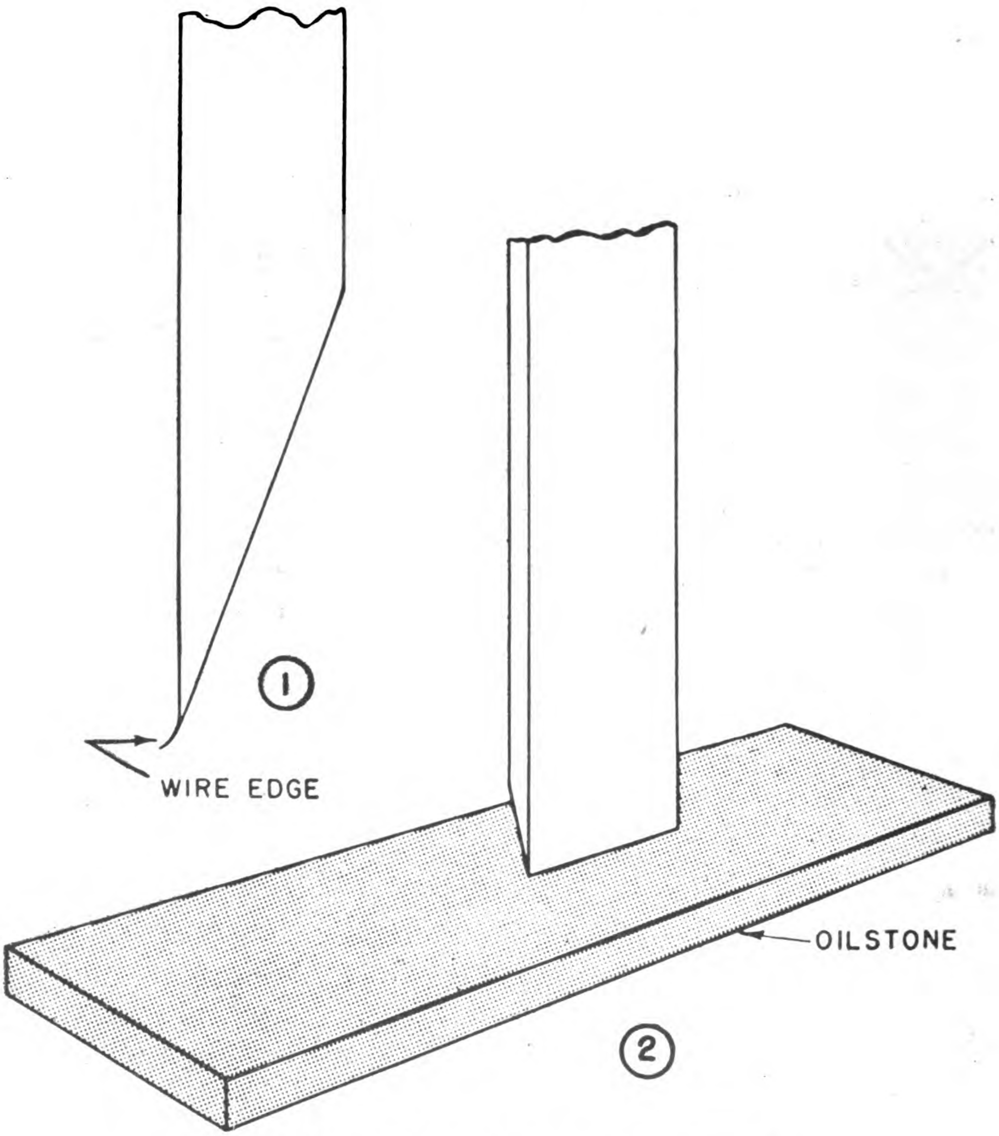


FIGURE 87.—Wire edge and method of removing.

too oily, it may be boiled in clear water; this will clean the stone satisfactorily.

(2) To use the stone, set it on a firm, smooth base and apply a few drops of machine oil or other thin lubricant. The tool which is to be sharpened must be free from all spurs or sharp corners as these may gouge the stone. Holding the tool at the desired angle, push and pull it in a circular motion, applying enough pressure to cause the stone to cut (fig. 86).

(3) If the tool is sharpened too much on one side a *wire edge* may be formed. A wire edge is a cutting edge ground so thin as to have lost its strength. (Fig. 87①.) It can be removed by rubbing each side of the tool alternately against the stone. The wire edge may also be removed by using the stone directly against the cutting edge (fig. 87②). A wire edge is avoided by reversing the tool often while it is being sharpened.

c. Care.—Avoid striking the stone with a hard object; this may break or chip it. Attempt to secure even wear on the stone so that irregular depressions are not formed.

69. Hand-saw sharpening tools.—*a. Saw clamp.*—Saw clamps are special-purpose vises used to hold the saw in place while the

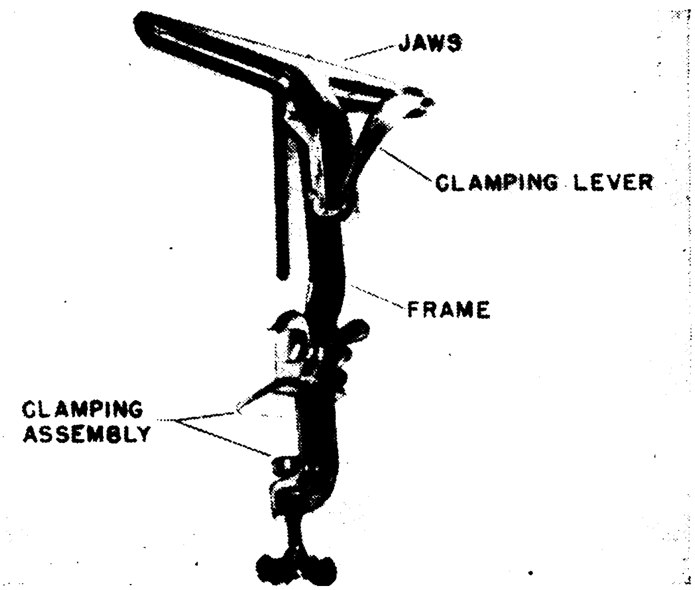


FIGURE 88.—Saw clamp.

teeth of the saw are being sharpened. Saw clamps are composed of two long jaws, one stationary, the other hinged and tightened with thumbscrews or clamping lever (fig. 88). When regular issue steel clamps are unavailable, wooden clamps may be improvised. Since steel clamps are made of cast metal, they should not be closed too tightly or the jaws may be broken. To obtain the best results in saw-filing, the vise should be about waist high.

b. Saw set.—(1) The saw set is an instrument used to set the teeth of a saw at the proper uniform angle. It is composed of the following parts: anvil, setscrew, plunger, spring, frame, guide, hinged handle, and stationary handle (fig. 89).

(2) To use the instrument, set the anvil at the desired angle, place the slot over the saw so that the anvil is behind the tooth, and squeeze

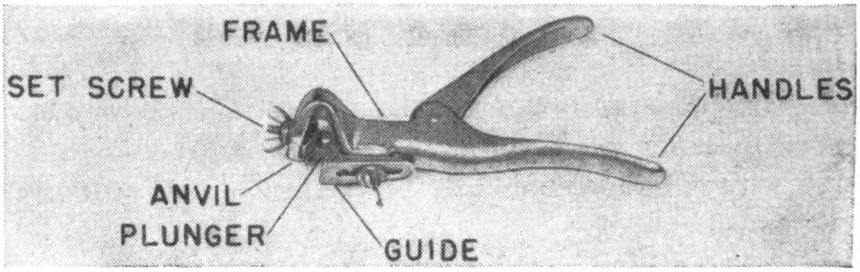


FIGURE 89.—Saw set.

the handles together. This causes the plunger to force the tooth outward to correspond with the angle of the anvil. Release the pressure and proceed to the next tooth.

(3) Since the set is made of cast iron, care must be taken lest it be broken by a sharp blow of any kind.

70. Two-man crosscut sharpening tools.—A set of tools is supplied to the carpenter for sharpening hand saws and the two-man crosscut saws. The tools consist of a file clamp, a gage, a hand-saw file holder, and a setting tool for the two-man crosscut saw.

a. The file clamp or jointing tool is used to hold a flat file for jointing saws (fig. 90). The clamp slides along the side of the saw.

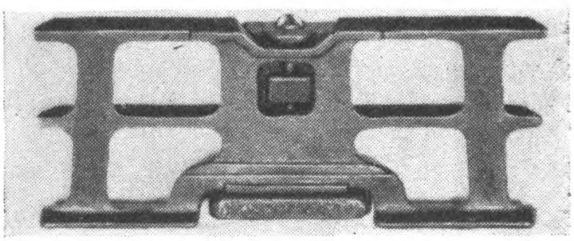


FIGURE 90.—File clamp.

b. The file holder is used to hold a tapered hand-saw file in the correct position for filing hand saws. By means of thumbscrews, the file can be set at any angle. The holder slides along the guide bar and is fitted to each tooth by moving it along the guide bar (fig. 91).

c. The gage is used to gage the amount of set in a two-man crosscut saw (fig. 92).

d. The setting tool or stumping tool used on the two-man crosscut saw is made of steel, with a long, flat surface beveled at one end (fig. 93). For a description of its use see paragraph 40*d*(2).

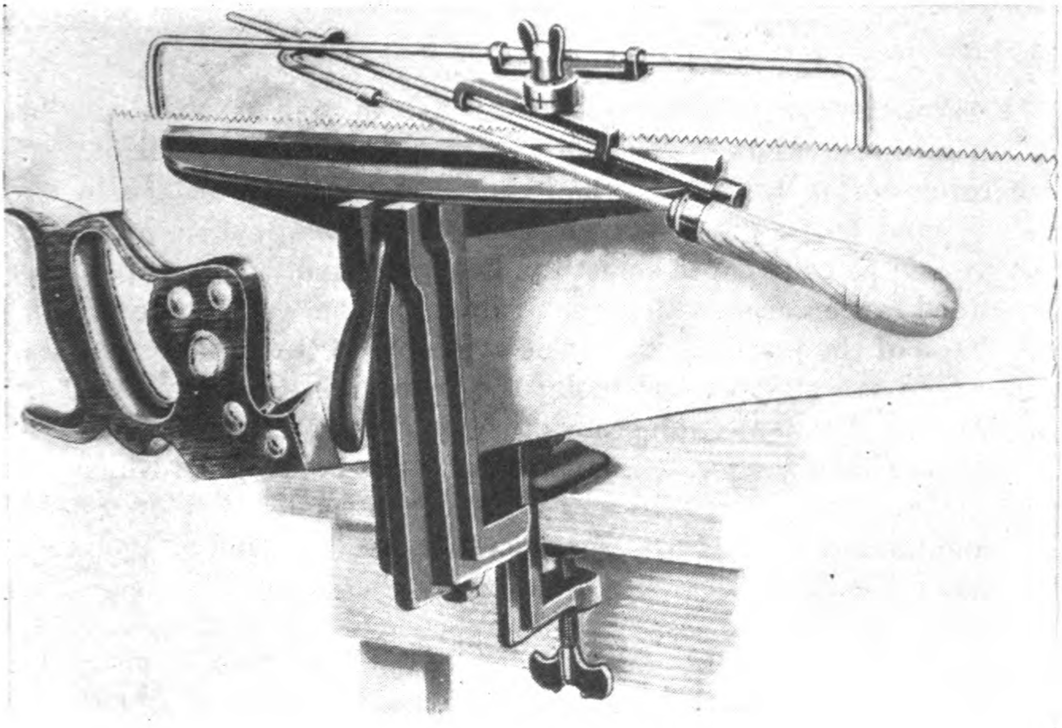


FIGURE 91.—File holder.

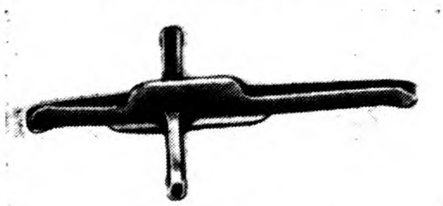


FIGURE 92.—Gage.

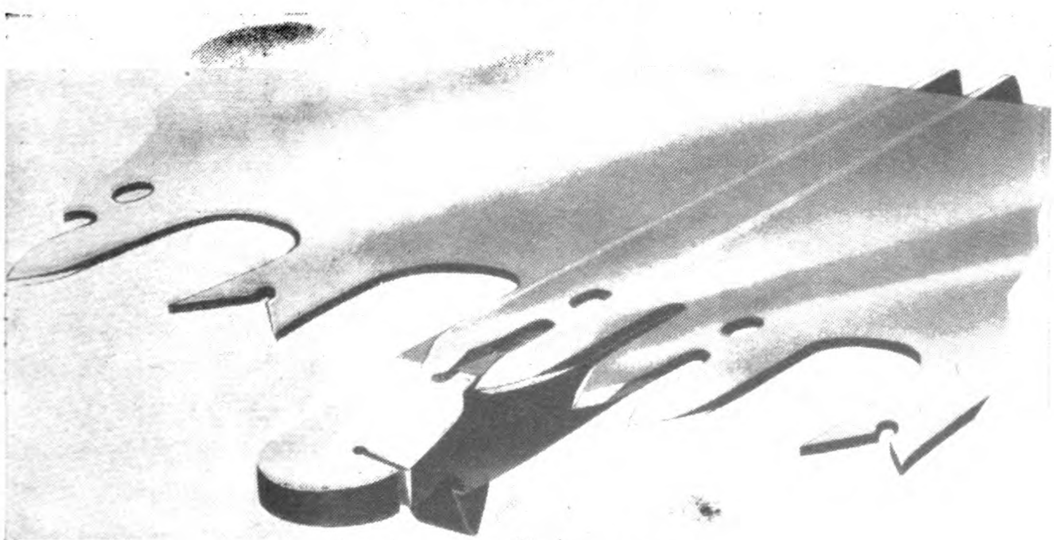


FIGURE 93.—Setting tool.

SECTION V

POWER-DRIVEN

71. Power-driven tools.—*a.* Power-driven tools save the carpenter much time and labor. They are not, however, substituted for skill or careful workmanship. In the hands of a carpenter skilled in the use of hand tools, power-driven tools can accomplish a job more quickly and perhaps more smoothly, but in the hands of a careless or ill-trained carpenter these tools can ruin a job and waste materials.

b. Most of the power-driven tools available to the Army carpenter in the field are air-operated tools; the power unit is the mobile air compressor. There are numerous other power-driven tools, gasoline-, electric-, and steam-operated, but the number of such tools which the general Army carpenter will find accessible is small. The operation, care, and maintenance of power-driven tools are discussed in Technical Manuals for each tool.

CHAPTER 4

BLUEPRINTS AND BILLS OF MATERIAL

SECTION I

BLUEPRINTS

72. General.—A blueprint is the carpenter's guide (fig. 94). It is the complete diagrammatic sketch, with dimensions of a structure, and when properly made, it contains all the information needed by the carpenter in his work. All carpenters should know how to read prints and to build by them. The purpose of this section is to give a working knowledge of how to read and use blueprints. Since most construction in the theater of operations is built according to blueprints, it is of great importance that the officer and carpenter be able to read, understand, and use such prints.

73. Definition.—A blueprint as used by carpenters is a reproduction of a working drawing transferred from the original to a sensitized sheet of paper by means of exposure to light and developed by being washed in plain water. The dark lines or objects in the original are white on the blueprint and the blank spaces are blue.

74. What a blueprint shows.—*a. Views.*—A blueprint is in a sense a picture of the structure which is to be built. This picture is made up of views; for example, the front or side view, the top view, and the end view (fig. 94). These views are made up of the lines which are visible when the structure is viewed from the various positions; for example, a front view consists of those lines which can be clearly seen if the observer views the structure from the front.

b. Dimensions.—The blueprint shows clearly and distinctly all of the essential dimensions of the structure; it also indicates the surface from which they are taken (fig. 94).

c. Lines.—There are several types of lines in a blueprint (fig. 94):

(1) *Working lines.*—The lines that represent the *edges of surfaces* are somewhat heavier than the other lines on the drawing and are known as working lines. These lines may be straight or curved, depending upon the shape and view of the object.

(2) *Dotted lines.*—Dotted lines are the same as working lines, except that the surface which is represented by dotted lines is hidden from sight when the object is viewed from the side shown.

(3) *Dimension lines.*—To show the size of any structure, or a part of it, dimension lines are used. These lines are light lines drawn between two working lines to show the dimension between two points. To indicate the place where the measurement begins and ends, each

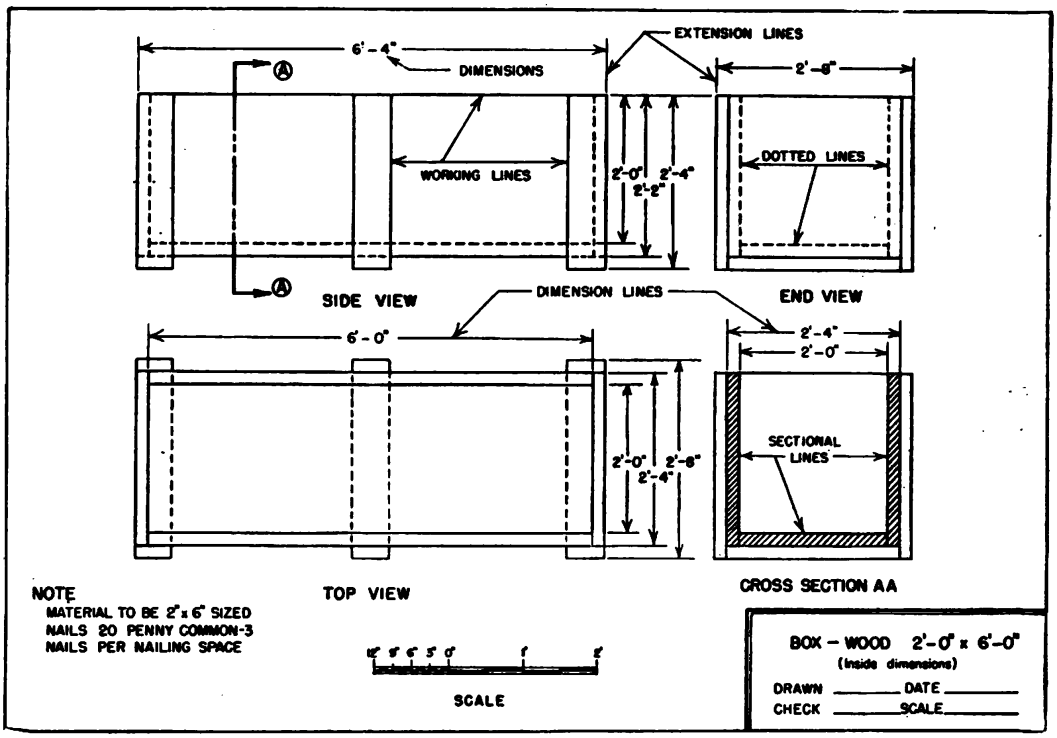


FIGURE 94.—Blueprint of wood box.

end of the dimension line has an arrowhead, the point just touching the line where the measurement starts or stops. Somewhere in the length of a dimension line are placed numerals which give the exact distance between the arrow points. In some cases, where the distance is too small to use a dimension line between the working lines, the dimension lines are placed on the outside with the dimension shown at the end of one of the lines.

(4) *Extension lines.*—If the dimension lines cannot readily be placed on the view, the working lines are lengthened or extended in order that the dimension line may be drawn. These lines are known as extension lines. The end of an extension line never touches the working line which it extends.

(5) *Section lines.*—A shaded area of a drawing, made by a series of parallel lines drawn close together at an angle to the working lines of the view, is sometimes found on a blueprint. These lines are known as section lines. They represent what would be seen if that part of the view covered by such lines were cut through and a portion removed.

d. Legend.—All blueprints have marginal data of various kinds. These include such items as the title or name of the object or structure represented, the scale, pertinent construction data, etc.

e. Scale.—By scale is meant the relative size of the pictured object or structure to the actual size of the finished product; that is, the length of the working lines in the blueprint has a definite and accurate proportion to the length of the line of the work itself. For example, a full-scale drawing means that the lines on the print represent the actual length of the object drawn. The scale ¼″=1′ means that ¼ inch in the drawing equals 1 foot in the actual structure.

75. Reading blueprints.—To be able to read a blueprint is as essential to a workman's success as to be able to read printed matter. To read blueprints readily he must know some of the principles of making drawings and what each type of line of the drawing represents. Learning to read drawings is somewhat equivalent to learning to read printed matter. The workman should understand that a blueprint is a record of instructions and that to interpret the language of the draftsman the carpenter must know how to read lines.

76. How to read a blueprint.—Figure 1, appendix III, is a typical blueprint. It is given to illustrate the process of blueprint reading.

a. To read a blueprint, first read the title and learn what is to be constructed. The title should give the carpenter a mental picture of the object and make clear what the lines represent. The title in figure 1, appendix III, is shown in fig. 1⑤: "Structure 20 ft by 20 ft. Wood.

b. The next step is to read the lettered data at the lower edge of the paper. These notes give the type and size of certain materials and other pertinent data concerning the structure.

c. The scale is next considered. This is found in most cases at the bottom of the print, in the right-hand corner. The scale in figure 1④, appendix III, is a graphic scale.

d. When the title, scale, and lettered data are thoroughly understood the views are studied. In figure 1, appendix III, there are several views which give all the data needed to construct the building. The floor plan (fig. 1①) shows the size of floor joists and the spacing of the foundation piers, if any are used, also the stud spacing. Where wood floors are used, the floor joists, foundation piers, and sills appear in dotted lines (floor-plan (x) (fig. 1②) and (y) (fig. 1③)). In the elevation views, the framing is shown with the size, length, spacing, and type of covering. The rafters, plates, braces, and type of roof coverng are also shown. The front frame elevation (fig. 1⑤) indicates the size and location of the windows. The left end elevation (fig. 1④) shows the size and location of the door. Section A–A (fig. 1③), a cross section, shows the floor, wall, and roof framing, and the beams that are to be used. This section is drawn as though the finished building had been cut at *AA*, as shown in the floor-plan Y (fig. 1③), by the letters *AA*. It reveals the details more clearly. For example, the location of the knee braces and the collar tiers are shown in their exact location; they are not shown so plainly in the frame elevation.

e. After the views have been mastered, the dimensions should be studied to obtain the size of the building and its different parts. These dimensions are placed on the dimension lines and are shown clearly and distinctly. Figure 1, appendix III, is a typical example of the dimensions and dimension lines.

f. Detail drawings are studied next to obtain the special information needed to frame certain parts of the building. Figure 1, appendix III, shows detail drawings of the footing of piers and the construction of sills and steps. Here the sections are drawn to a larger scale in order to give a clearer detail of the section.

g. On most prints, special notes give information as to the method of doing certain things. The notes in figure 1, appendix III, give information as to the way the center sill should be nailed, the way the floor should be nailed, etc.

77. Symbols, terms, and abbreviations.—Certain architectural symbols are used to facilitate blueprint reading and drawing. Some of the more common symbols will be given later. In appendix I will be found a list of abbreviations. Appendix II contains a list of carpenter and architectural terms and their meanings.

Section II

BILL OF MATERIALS

78. General.—A bill of materials is a tabulated list of the material requirements of a structure. Such a bill includes in detail the quantity, size, and purpose of all items needed to build the work. Such items as the quantities of lumber, hardware, nails, sashes, doors, brick, cement, lime, paint, plaster, and fixtures are contained in a bill of materials. Bills of materials are usually made out by the draftsman who makes the blueprint. Table V contains the bills of materials for the blueprint in figure 1, appendix III. Paragraph 79 explains how these bills are arrived at.

79. Calculating a bill.—*a.* At first glance the mass of detail in a bill of materials appears complicated and difficult to obtain. But such a table is built up easily from a study of the blueprint. The process of assembling the data is straightforward and logical. Note carefully the steps in the process.

b. First the *names* of the various members in the structure are listed. (Appendix II contains a list of structural nomenclature.) Their *dimensions* are taken from the drawing and the *quantity* of each piece is determined. Finally all pieces of similar *size* are listed together and an estimate is made of such items as nails, screws, etc.

80. Typical example.—For example, begin the detail of making a bill of materials for the building shown in the blueprint in figure 1, appendix III. The roof is bound with roll roofing and the walls are sheathed with wood, covered with building paper.

a. First examine floor plan (x) (fig. 1②). There are no piers or floor joists shown, so the floor will be earth.

(1) On floor plan (x) is a line of material all around the outside, labeled "sills." The size of these sills is not shown on floor plan (x). Look at the section GG (fig. 1①) where the size is given as 2 by 4's. The outside dimension of the building is given as 20 feet square, therefore the perimeter of the building is 80 feet. This necessitates eight 2 by 4's, each 10 feet long. Note the ends of the building; there are doors to consider. A sill cannot be joined in the center of the door because the splice will be above the floor. To overcome this, use a 12-foot 2 by 4 at each end of the building, with a 4-foot piece at each end of the 12-foot 2 by 4's to give the 20-foot total which is the length of the building. Make a temporary bill of materials as shown in table IV beginning with the material already figured, which is two 12-foot 2 by 4's and four 4-foot 2 by 4's.

(2) There are four joints to splice, two at each end; the splices are made with 2 by 4's 2 feet long. List the number of pieces and the size and length as shown in table IV. Material 8 feet long will be used where possible. Use two 8-foot 2 by 4's on each side with a piece 4 feet long to get the 20-foot total. List this in the table as four 8-foot 2 by 4's and two 4-foot 2 by 4's. To splice the four joints, four splices will be needed and will require four 2-foot 2 by 4's. This completes the list for the sills.

(3) Next, figure the amount of studs. Look at floor plan (fig. 1①). There are two studs at each corner and two studs between the corners or 16 studs in all, but their length is not known. Look at the front frame elevation (fig. 1⑤); this shows the dimension to be 7 feet 8 inches, which is the total distance from the bottom of the sill to the top of the plate. The stud length will be between 7 and 8 feet long, so 8-foot material must be used. Now we have sixteen 8-foot 2 by 4's for studs.

(4) From the elevation plan it is noted that there are girts nailed between the studs. Calculating these shows two 8-foot 2 by 4's and one 4-foot 2 by 4's on each side and two 8-foot 2 by 4's for each end, totaling eight 8-foot 2 by 4's and two 4-foot 2 by 4's for girts. The front and rear elevations show two windows each. There is a short stud beside each window and the length is shown as 3 feet 6 inches. Figure them as 4 feet long, the total being four 4-foot 2 by 4's for the window studs. In the section A–A a header (5′ 0″) is shown over the door. There are two doors, so one 12-foot 2 by 4 is ordered.

(5) The next material to be figured is that for the plates. Looking at cross section A–A, note that the plate across the end is joined as the sill. Two 12-foot 2 by 4's, four 4-foot 2 by 4's and four 2-foot 2 by 4's will be needed for the end plates. Note the front and rear elevation and determine the rafter spacing. It is 4 feet. Plates on the sides the same length as the side sills will be difficult to use because a splice will then come under a rafter. To avoid this, use 10-foot material. Four 10-foot 2 by 4's will be used for the side plates, plus two 2-foot 2 by 4's for splices. This concludes the list of material for the sills and frame wall.

(6) The rafter length is found on the end elevations and is shown as 12 feet. The total distance of 20 feet, divided by the spacing (4 ft), which totals five rafters. Add one for the end and the total is six per side. Twelve 12-foot 2 by 4's are needed for two sides.

b. This process is continued until the material for the entire building is figured. After the material for the entire building has been tabulated (table V), it is then compiled into a more concentrated form with all the pieces of the same length totaled. The short pieces such as those 2 and 4 feet long are allowed for by adding a sufficient number of 8-foot pieces. (See table V.) The process is further continued until all sections have been calculated and tabulated into a bill of material.

81. Aids in estimates.—*a. Nails.*—In figuring the amount of nails, there is no set rule, but in framing, if the size of the nail (for example 8-penny) is divided by 6 and the result multiplied by 10, the figure obtained will represent approximately the number of pounds used per thousand feet of framing. In sheathing and flooring, divide the nail size by 4 and multiply the result by 10. This is a rough rule-of-thumb, but it serves for a hasty estimation.

b. Flooring.—In estimating matched flooring, a square foot of flooring 7/8 inch thick is considered to be 1 foot board measure. If the flooring is 3 inches or more in width, add 1/4 to the assumed board measure to allow for the forming of the tongue and groove; if the flooring is less than 3 inches in width add 1/3.

c. Siding.—Siding is measured by superficial feet; 6-inch sidings normal width actually measure 5 5/8 inches as 1/4 must be added to take care of lap and the amount lost in sizing.

TABLE IV.—*Bill of material*

[Temporary tabulation]

Number of pieces	Size	Use
2	2″ x 4″ x 12′ 0″	Sills.
2	2″ x 4″ x 4′ 0″	Sills.
2	2″ x 4″ x 2′ 0″	Splices.
4	2″ x 4″ x 8′ 0″	Sills.
2	2″ x 4″ x 4′ 0″	Sills.
4	2″ x 4″ x 2′ 0″	Splices.
16	2″ x 4″ x 8′ 0″	Studs.
8	2″ x 4″ x 8′ 0″	Girts.
2	2″ x 4″ x 4′ 0″	Girts.
4	2″ x 4″ x 4′ 0″	Window studs.
1	2″ x 4″ x 12′ 0″	Door header.
2	2″ x 4″ x 12′ 0″	End plates.
4	2″ x 4″ x 4′ 0″	End plates.
4	2″ x 4″ x 10′ 0″	Side plates.
6	2″ x 4″ x 2′ 0″	Splices.
12	2″ x 4″ x 12′ 0″	Rafters.
152	7/8″ x 6″ x 8′ 0″	Wall sheathing.
124	7/8″ x 6″ x 8′ 0″	Roof sheathing.
6	7/8″ x 4″ x 12′ 0″	Rafter ties.
6	7/8″ x 4″ x 12′ 0″	Rafter splices.
8	7/8″ x 6″ x 6′ 0″	Knee braces.
4	7/8″ x 4″ x 3′ 0″	Window sills.
8	7/8″ x 2″ x 3′ 0″	Window stops.
8	7/8″ x 2″ x 3′ 4″	Window stops.
8	7/8″ x 2″ x 0′ 4″	Window stop backs.
8	7/8″ x 2″ x 2′ 6″	Window guide strips.
8	7/8″ x 2″ x 6′ 0″	Window guide strips.
4	7/8″ x 6″ x 3′ 0″	Board at head of window.
4	7/8″ x 4″ x 12′ 0″	Eave strip.
8	7/8″ x 3″ x 2′ 6″	Rails.
8	7/8″ x 3″ x 3′ 6″	Stiles.
8	7/8″ x 3″ x 3′ 0″	Rails.
8	7/8″ x 3″ x 3′ 0″	Stiles.

TABLE IV.—*Bill of material*—Continued

Number of pieces	Size	Use
4	⅞″ x 8″ x 8′ 0″	Door boards.
16	⅞″ x 6″ x 8′ 0″	Door boards.
4	⅞″ x 6″ x 8′ 0″	Door battens.
1	⅞″ x 6″ x 10′ 0″	Door battens.
2	⅞″ x 3″ x 8′ 0″	Cover strip.
10 lb	20d nails, common	Framing.
1 lb	10d nails, common	Framing, toenailing.
1.5 lb	8d nails, common	Framing, nailing inch material.
1.3 lb	6d nails, common	Nailing stops.
23.5 lb	8d nails, common	Sheathing siding.
1.2 lb	3d nails, lath	Lath.
4 lb	¾″ nails, roofing	Roofing.
1 lb	6d nails, common	Window sash.
1 lb	6d nails, common	Doors.
0.25 lb	4d nails, common	Doors.
208 lin. ft	32 in	Roofing.
2.2 lb		Cement roofing.
322 lin. ft	32 in	Paper, tar.
156 pc	4′ 0″ long	Wood lath.
13.7 lin. ft	36″ wide	Cel-O-Glass.
8 ea	10″	T-hinges.
4 ea	3″	Hooks and eyes.
2 ea	14″	Springs, coil.
25 lin. ft	No. 14	Wire, solid copper.
1	30 A,-125 V	Cut-out plug fuse.
1	10 A,-125 V	Fuse, plug.
1	250 W,-250 V	Receptacle.
8	No. 5½	Knobs, porcelain.
2	5/16″ x 3″	Tubes, porcelain.
1	25 W	Lamp, service.
18	No. 8	Screws.
1	3′ 0″	Cord, linen.

TABLE V.—*Bills of materials*

BILL NO. 1—FOR FRAME

Item	Quantity	Unit	Size	Length	Ft. bd. meas.	Description or where used
						LUMBER
1	16	Pc	2" x 4"	12' 0"	128	Rafters, plates, and sills.
2	5	Pc	2" x 4"	10' 0"	34	Sills, plates, and headers.
3	40	Pc	2" x 4"	8' 0"	214	Sills, studs, plates, girts.
4	2	Pc	⅞" x 6"	8' 0"	4	Boards at window heads.
5	12	Pc	⅞" x 4"	12' 0"	48	Rafter splices and ties, kneebraces, window sills.
6	6	Pc	⅞" x 2"	12' 0"	12	Window stops, window guide strips.
7	5	Pc	⅞" x 2"	10' 0"	9	Window stops, window guide strips.
						NAILS
8	10	Lb	20d	4"		Framing.
9	1	Lb	10d	3"		Framing, toenailing.
10	1. 5	Lb	8d	2½"		Framing, nailing inch material.
11	1. 3	Lb	6d	2"		Stops.

BILL NO. 2—SIDING, SHEATHING, ROOFING, ETC.

Item	Quantity	Unit	Size	Length	Ft. bd. meas.	Description or where used
1	276	Pc	⅞" x 6"	8' 0"	1, 104	Sheathing and siding.
2	4	Pc	⅞" x 4"	12' 0"	16	Eavestrips.
3	208	Lin. ft	32"			40# Grade B, Fed. Spec. SS-R-501.
4	2. 2	Lb				Cement, Roofing.
5	322	Lin. ft	32"			15# Type II Fed. Spec. HH-F-201.
6	156	Pc		4' 0"		Lath, wood.
7	23. 5	Lb	8d	2½"		Nails, sheathing and siding.
8	1. 2	Lb	3d	1¼"		Nails, lath.
9	4	Lb		¾"		Nails, roofing.

BILL NO. 3—FOR WINDOW SASH

Item	Quantity	Unit	Size	Length	Ft. bd. meas.	Description or where used
1	8	Pc	⅞" x 3"	12' 0"	24	Rails and stiles.
2	13. 7	Lin. ft	36"			Cel-O-Glass or equal.
3	1	Lb	6d	2"		Nails.

Table V.—*Bills of Materials*—Continued

BILL NO. 4—FOR DOUBLE DOORS

Item	Quantity	Unit	Size	Length	Ft. bd. meas.	Description or where used
1	4	Pc	7/8″ x 8″	8′ 0″	22	Door boards.
2	1	Pc	7/8″ x 6″	10′ 0″	5	Battens.
3	20	Pc	7/8″ x 6″	8′ 0″	80	Door boards and battens.
4	2	Pc	7/8″ x 3″	8′ 0″	4	Coverstrips.
5	1	Pc	7/8″ x 2″	8′ 0″	2	Bolt blocks.
6	1	Pc	3/4″	3′ 0″		Dowel, wood, for handles.
7	1	Lb	6d	2″		Nails.
8	.25	Lb	4d	1½″		Nails.
9	8	Ea		10″		T-hinges type 2209 Fed. Spec. F. F. H-116a, with 1½″ No. 14 Wood Screw.
10	4	Ea		3		Hooks and eyes, bright steel wire.
11	2	Ea		14″		Springs, coil, "Chicago" No. 283, or equal with screws.

BILL NO. 5—ELECTRICAL

Item	Quantity	Unit	Size	Length	Ft. bd. meas.	Description or where used
1	25	Lin. ft	No. 14			Wire R. C. S. B. solid copper.
2	1	Ea	30A 125V 10A			Cutout, plugfuse, 2 pole, mainline. Solid neutral No. H20 Graybar or equal.
3	1	Ea	125V			Fuse plug.
4	1	Ea	250V 250W			Receptacle, pull-porcelain, P&S No. 667 or equal.
5	8	Ea	No. 5½			Knobs, porcelain, split, double, grooved, nail assembled.
6	2	Ea	5/16	3		Tubes, porcelain.
7	1	Ea	25W			Lamp, general service.
8	18	Ea	No. 8	1¼		Screws, R. H. bright.
9		Lin. ft		3′ 0″		Cord, linen, for pull socket.

Note.—Lumber sizes specified are actual sizes required. All 7/8″ sizes are to be considered as 1″ stock. Number of pieces of wood sheathing must be adjusted when specified widths are not available. Allowance included for cutting waste only. To cover other losses, add for nails, screws, bolts, etc. 10 percent, for lumber and other materials, except finishing hardware, 3 percent. No allowance for losses is provided for electrical fixtures and fittings.

82. **Use.**—With the aid of the bill of material, the carpenter can find the required lengths of timber that are to be used in specified places. It saves a great deal of calculation as to where each piece of timber is to be used and avoids much confusion in construction. Some plans, or bills of material, furnish a nailing schedule to help the carpenter in deciding when a joint or splice is nailed sufficiently. Table VI is a typical nailing schedule.

TABLE VI.—*Nailing schedule*

Number	Size	Length	Application
*6	20d	4″	Splice to sill.
2	20d	4″	Sill to upright.
*6	20d	4″	Splice to plate.
2	20d	4″	Plate to upright.
2	20d	4″	Girt to upright.
2	20d	4″	Upright to girt.
2	20d	4″	Girt to window post.
2	20d	4″	Plate to window post.
2	20d	4″	Upright to window header.
15	20d	4″	Corner upright to corner upright.
2	10d	3″	Joining rafters at ridge.
2	20d	4″	Rafters top plate.
*6	8d	2½″	Rafter splice to rafters.
3	8d	2½″	Rafter tie to rafter.
3	8d	2½″	Knee brace to rafter.
3	8d	2½″	Knee brace to upright.
3	20d	4″	Knee brace block to upright.
3	20d	4″	Knee brace block to rafter.
3	8d	2½″	Knee brace to knee brace block.

*Total nails per splice.

CHAPTER 5

JOINTS, SPLICES, AND CONNECTIONS

SECTION I

GENERAL

83. General.—*a.* A structure is no stronger than its weakest point. Usually the weak points in a structure are the connections between materials. This is not necessary because connections can be made so that the strength of the structure at that point is unimpaired.

b. The connections between pieces of wood in carpentry are simple. Made properly, they are strong. The Army carpentry must learn to make these connections accurately and quickly.

84. Classification.—All connections between pieces of timber are classified either as joints or splices. *Joints* are connections between two pieces of timber which come together at an angle. *Splices* are connections between two pieces of timber which extend in the same line.

SECTION II

JOINTS

85. General.—Joints are classified into a number of types, the most common being square, plain, oblique, and miter joints. Each of these is used for a specific job. The carpenter should be familiar with each type and know when and where to use each to secure best results.

86. Square.—This is the most simple of all joints. It is made by placing two pieces of timber together with the end of the one against the side of the other and nailing them firmly to each other. The butt end should be square and the joined side smooth so that the pieces will be perpendicular to each other (fig. 95①). The nails are driven diagonally through both pieces. This operation is known as "toe-nailing"; the nails are driven home, or flush, using 8- or 10-penny nails. This type of joint is used where caps and sills are placed upon posts. This joint is used for compression, not for tension.

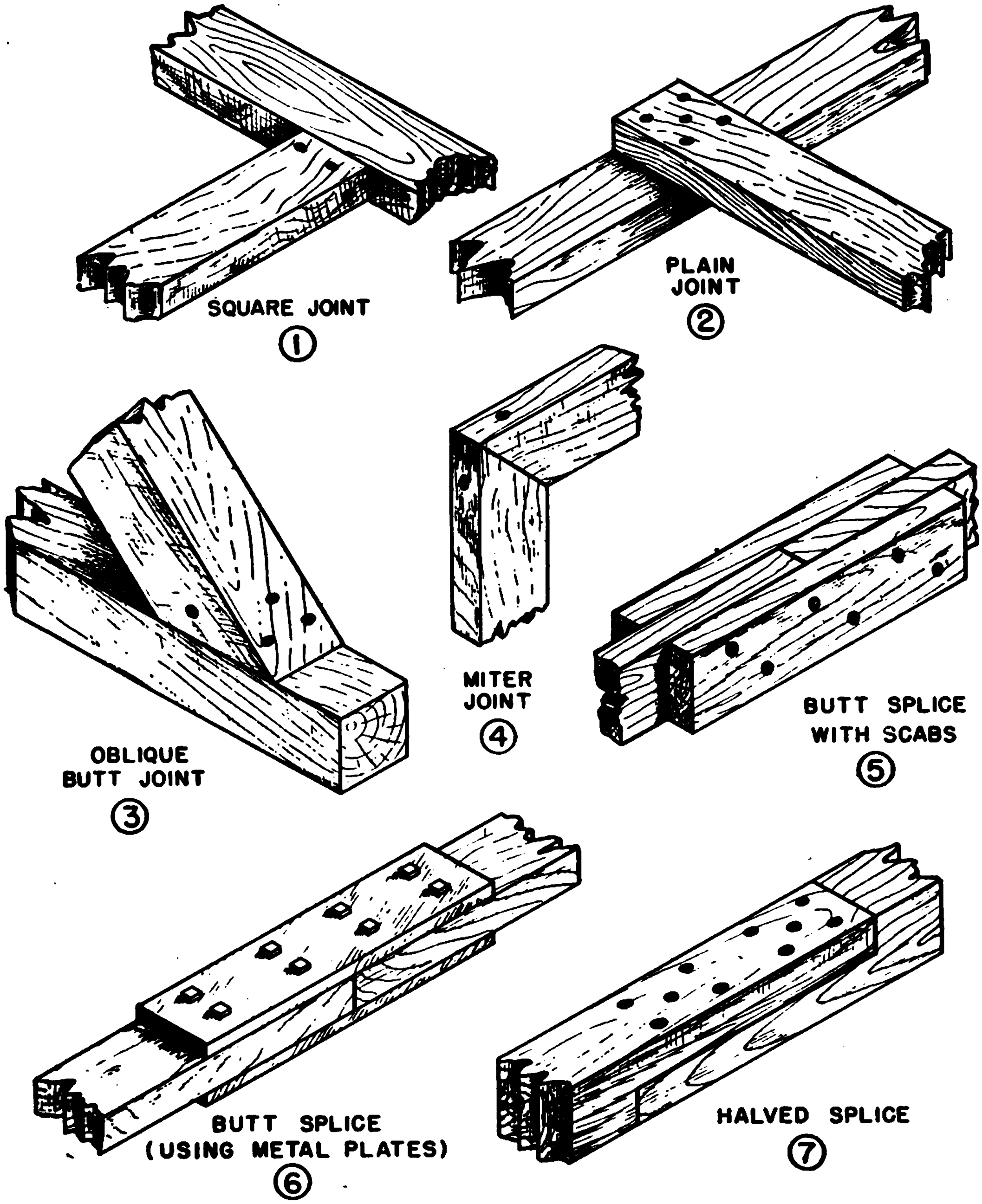


FIGURE 95.—Types of joints and splices.

87. Plain.—This type of joint can be used for either compression or tension, but it is not a very strong joint. It is for very hasty construction, and is made by lapping one piece over the other and nailing the two together (fig. 95②). There is no prescribed angle for this connection, and it requires no square ends or straight edges. When 2 by 4's are joined in this way about five 10- or 16-penny nails are sufficient; too many nails will weaken it.

88. Oblique.—This joint is made when two pieces of timber do not meet at right angles (fig. 95③). Bracing is a typical application for this joint. One piece is cut at an angle to fit the other and they are nailed securely. The joint depends upon the nailing for its strength and it should not be used where great strength is required. The size of the nails depends entirely upon the size of timber used. Avoid using too many nails.

89. Miter.—A miter is a joint between two pieces of timber which come together at a corner. Usually the angle is 90° (fig. 95④). This joint is used at corners where the square joint is not satisfactory, such as on an interior finish. This, as well as the oblique joint, is used extensively in bridge building. For a 90° miter, each piece is cut at a 45° angle so that when the two pieces are put together they will form a 90° angle. For making a miter joint of any angle, the angle of cut should be the same on both pieces.

Section III

SPLICES

90. General.—Splices are divided into three types: compression, tension, and bending. The function of a splice is to connect two or more pieces of timber in such a way that the joint will be as strong as a single timber of equivalent size. A splice which is efficient for compression is usually worthless for tension or bending, therefore, splices should be made to meet the requirements for which they are to be used. The carpenter should familiarize himself with each type of splice and be able to make and apply each properly.

91. Splices for compression.—*a. General.*—This type of splice is designed either to support weight or to exert pressure. There are several types of splice for compression; the fished splice and the halved splice are the most common. Compression splices will stand compression only.

b. Fished splice.—Two pieces of timber are squared at their ends and butted together, two short pieces (fishplates or scabs) are fastened, one on either side of the splice (fig. 95⑤). These short pieces serve to keep the splice straight and prevent buckling. The term "fishplates" usually refers to metal plates used for splicing. These plates are preferably fastened with bolts or screws (fig. 95⑥). The wood plates, commonly called "scabs," may be fastened with bolts, nails, or with ring connectors (see par. 100). For the best results the nails are staggered and driven at an angle away from the splice. Too many or too large nails weaken the splice.

c. Halved splice.—The halved splice is better for direct compression and when combined with fishplates or scabs may be used where some tension is required. This splice is made by notching each piece halfway to any desired length, and placing the two halved sections together. A splice may be fastened either by nailing or bolting the halved sections together, or by using fishplates or scabs (fig. 95⑦). The latter method of fastening is recommended and should be used when the material is available.

92. Splices for tension.—*a. General.*—There are several types of tension splices, the most common and simplest type being the square splice. These splices are made to resist tension and are used in tension members, such as trusses, braces, and joists, where the material available is too short.

b. Square splices.—The square splice is a modification of the compression halved splice. It has an extra notch to keep it from slipping (fig. 96①). More time is required to make this joint but if properly made it is very efficient. When the splice is fastened by a fishplate or scab with bolts or nails its strength is greatly increased (fig. 96②). For hasty construction this type of joint is not used since it requires a great deal of time to make it; a long plain joint is used instead (fig. 96③).

93. Splices for bending.—*a.* Sometimes a piece of timber subjected to a bending stress must be spliced. When a horizontal piece of timber supports a weight, the upper part is under compression and this has a tendency to crush the fibers, the lower part is in tension and this has a tendency to pull the fibers apart. To overcome this difficulty, a splice must be made which will combine the features of the compression and tension splices.

b. The parts are scarfed together as in other splices, but in this case the upper piece is cut off square to offer the maximum resistance to crushing, while the under piece is beveled on the end, since here there is no tendency to crush the timber (fig. 96④). To overcome the tendency to pull apart at the bottom part of the timber, a fishplate or

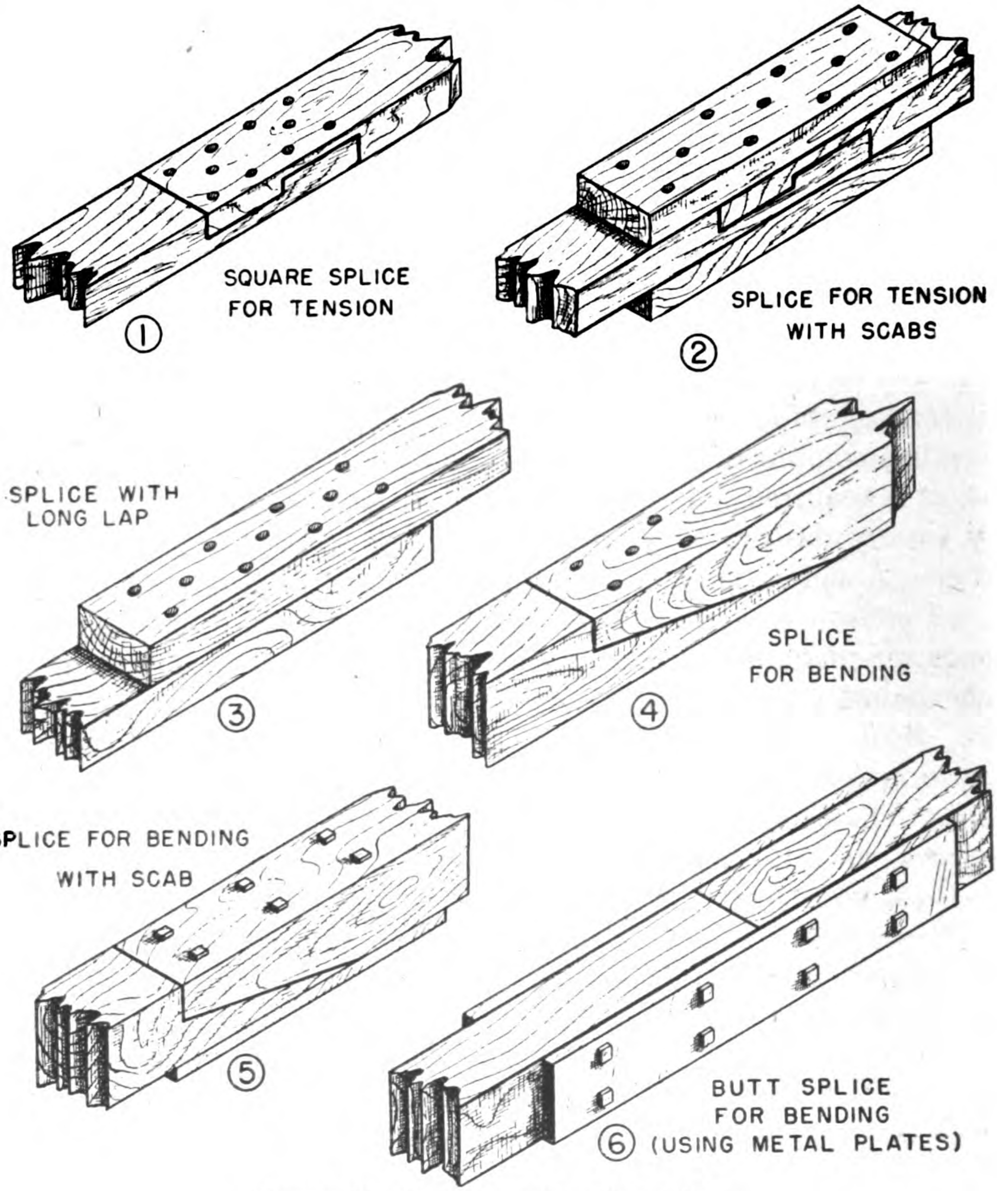


FIGURE 96.—Tension and bending splices.

scab is placed on the bottom and bolted there securely. There is no need for a fishplate or scab on the upper side as there is no tension and the bolts hold it in place (fig. 96⑤). Occasionally such a splice must be constructed in a member with tension in the upper part, such as overhanging or cantilever beams (fig. 47). In such a case the splice illustrated must be turned over.

c. In any case where it is not desirable to scarf the pieces in a splice subject to tension, a butt joint with fishplates or extra long scabs on the side may be made and fastened with bolts (fig. 96⑥).

Section IV

METHODS OF FASTENING

94. General.—The fasteners used in the theater of operations are made of metal. These may be classified as nails, screws, bolts, driftpins, corrugated fasteners, and timber connectors.

95. Nails.—*a. General.*—Nails are made of steel wire, with a flat driving head, either large or small, and a wood-piercing end, either

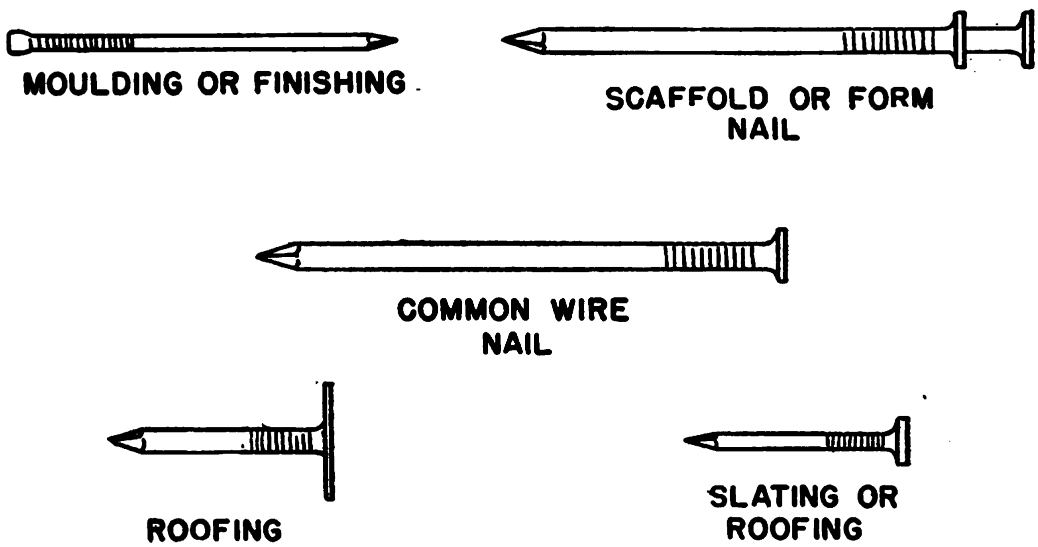


Figure 97.—Types of nails.

pointed or blunt. The carpenter generally uses nails to secure joints and splices.

b. Types.—Nails are classified as wire and cut nails. Either kind is used in both the common work and the finished work. A finishing nail is a wire nail with a small, inconspicuous head. Cut nails are not an item of Army supply.

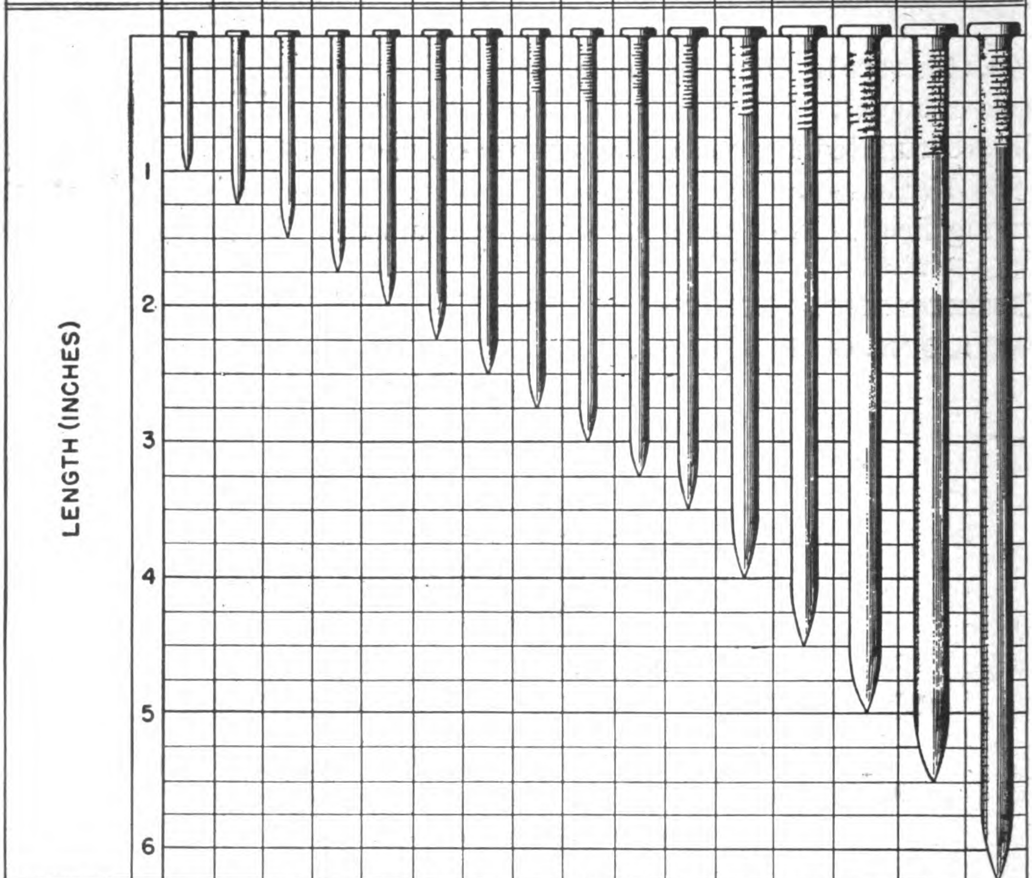
(1) *Cut nails.*—Cut nails are angular-sided, wedge-shaped, or blunt nails.

(2) *Wire nails.*—Wire nails (fig. 97) are round-shafted, straight, pointed nails, and are used more generally than cut nails. They are stronger than cut nails and do not buckle as easily when driven into hard wood, but usually split wood more easily than cut nails.

c. Use.—Nails are made with special finishes (blush, cement, or resin) to increase their holding power. They may be galvanized to prevent rust. Nails driven with the grain do not hold as well as nails driven across the grain.

d. Size.—Wire nails come in a variety of sizes. For framing, large nails from 3½ to 6 inches long should be used, depending upon the size of the timber. For rough exterior or interior finish, such as

Size	2 d	3 d	4 d	5 d	6 d	7 d	8 d	9 d	10d	12 d	16 d	20 d	30d	40 d	50 d	60d



Diameter (inches)	072	.08	.098	098	.113	.112	.131	.131	.148	.148	.162	.192	.207	225	.244	.262
Steel wire gage	15	14	12	12	11	11	10	10	9	9	8	6	5	4	3	2
Number per pound	900	615	322	254	200	154	106	85	74	57	46	29	23	17	14	11

FIGURE 98.—Nail sizes.

sheathing or rough flooring, nails 2½ to 3 inches long, should be used. For finished work, nails from 1 to 3½ inches long should be used. (See fig. 98 and table VII.)

TABLE VII.— *Size, type, and use of nails*[1]

Size	Length (inches)	Diameter (inches)	Remarks	Where used
2d	1	0.072	Small head	Finish work, shop work.
2d	1	.072	Large flat head	Small timber, wood shingles, lathes.
3d	1¼	.08	Small head	Finish work, shop work.
3d	1¼	.08	Large flat head	Small timber, wood shingles, lathes.
4d	1½	.098	Small head	Finish work, shop work.
4d	1½	.098	Large flat head	Small timber, lathes, shop work.
5d	1¾	.098	Small head	Finish work, shop work.
5d	1¾	.098	Large flat head	Small timber, lathes, shop work.
6d	2	.113	Small head	Finish work, casing, stops, etc., shop work.
6d	2	.113	Large flat head	Small timber, siding, sheathing, etc., shop work.
7d	2¼	.113	Small head	Casing, base, ceiling, stops, etc.
7d	2¼	.113	Large flat head	Sheathing, siding, subflooring, light framing.
8d	2½	.131	Small head	Casing, base, ceiling, wainscot, etc., shop work.
8d	2½	.131	Large flat head	Sheathing, siding, subflooring, light framing, shop work.
8d	1¼	.131	Extra-large flat head.	Roll roofing, composition shingles.
8d	1½	.131	Extra-large flat head.	Roll roofing, composition shingles.
9d	2¾	.131	Small head	Casing, base, ceiling, etc.
9d	2¾	.131	Large flat head	Sheathing, siding, subflooring, light framing
10d	3	.148	Small head	Casing, base, ceiling, etc., shop work.
10d	3	.148	Large flat head	Sheathing, siding, subflooring, framing, shop work.
12d	3¼	.148	Large flat head	Sheathing, subflooring, framing.
16d	3½	.162	Large flat head	Framing, bridges, etc.
20d	4	.192	Large flat head	Framing, bridges, etc.
30d	4½	.207	Large flat head	Heavy framing, bridges, etc.
40d	5	.225	Large flat head	Heavy framing, bridges, etc.
50d	5½	.244	Large flat head	Extra-heavy framing, bridges, etc.
60d	6¼	.262	Large flat head	Extra-heavy framing, bridges, etc.

[1] This chart applies to wire nails, although it may be used to determine the length of cut nails.

96. Screws.—*a. General.*—Screws have several advantages over nails; they may be easily withdrawn at any time without injury to the material, they hold the wood more securely, they can be easily tightened, and they are neater in appearance.

b. Types.—(1) Screws can be had in steel, copper, bronze, or brass. (2) Screws are made with round heads, flat heads, or oval heads (fig. 99). Each type has several kinds of finish. The screws most commonly used are:

Flat head—bright.	Oval head—blued.
Flat head—blued.	Oval head—brass.
Flat head—brass.	Round head—brass.

(3) The coach, or lag screw, is termed a screw although it is much larger and is driven with a wrench. It has a cone or gimlet

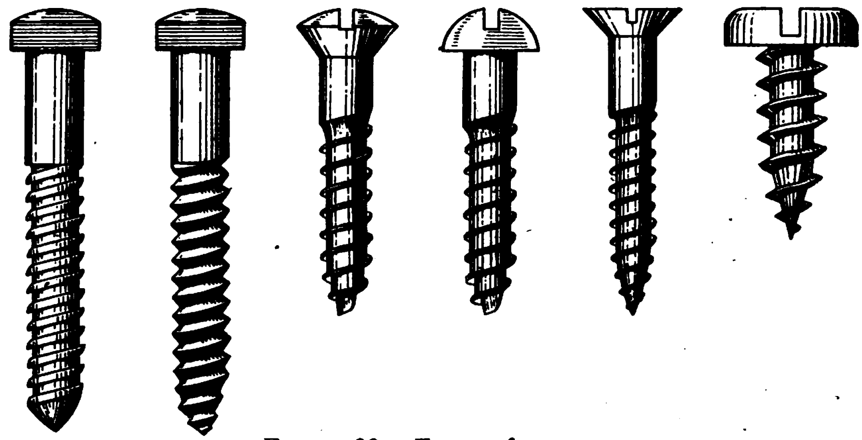


FIGURE 99.—Types of screws.

point. Lag screws are made in lengths of from 1 to 16 inches, and in diameters of 1/4 to 1 inch.

c. Size.—Screws also vary according to the size of the shaft and the length. Each length is made in a number of sizes. The size number is an arbitrary figure and represents no particular measurement but indicates relative differences in the screw diameters. For size, length, and gage of screws, see table IX; for lag screws, see table VIII.

TABLE VIII.—*Lag or coach screws*

Lengths (inches)	Diameters (inches)			
	1/4	3/8, 7/16, 1/2	5/8, 3/4	7/8, 1
1	x	x		
1½	x	x	x	
2, 2½, 3, 3½, etc., 7½, 8 to 10	x	x	x	x
11 to 12		x	x	x
13 to 16			x	x

TABLE IX.—*Screw sizes and dimensions*

Length (inches)	Size numbers																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30
¼	x	x	x	x	x																				
⅜	x	x	x	x	x	x	x	x	x	x															
½		x	x	x	x	x	x	x	x	x	x	x	x												
⅝		x	x	x	x	x	x	x	x	x	x	x	x	x	x										
¾			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
⅞			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
1				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
1¼					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
1½					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
1¾						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2¼						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2½						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2¾							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
3							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
3½									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
4									x	x	x	x	x		x		x	x	x	x	x	x	x	x	
4½													x		x		x		x	x	x	x	x	x	x
5													x		x		x		x	x	x	x	x	x	x
6															x		x		x	x	x	x	x	x	x

Gage and diameter																								
Steel wire gage	17	15	14	13	12	11	10	9	8	7	6½	6	5	4½	4	3	2½	2	1	0½	0	00	00½	000	0000
Diameter (inches)	0. 054	0. 072	0. 080	0. 091	0. 105	0. 120	0. 135	0. 148	0. 162	0. 177	0. 184	0. 192	0. 207	0. 216	0. 225	0. 243	0. 253	0. 262	0. 283	-----	0. 306	0. 331	-----	0. 362	0. 393

97. Bolts.—*a. General.*—Bolts are made of steel with either a round, square, or octagon head and a threaded shank. The threads may run the full length of the bolt, or they may stop a certain distance short from the head leaving a smooth upper shank. Bolts are used to fasten timber, steel, or other materials.

b. Types.—Bolts are made with either blunt or pointed ends (fig. 100). In two kinds of bolts, the tapered, pointed bolt and the bolt with hinged-shield nut, the nut is subject to an expanding action and

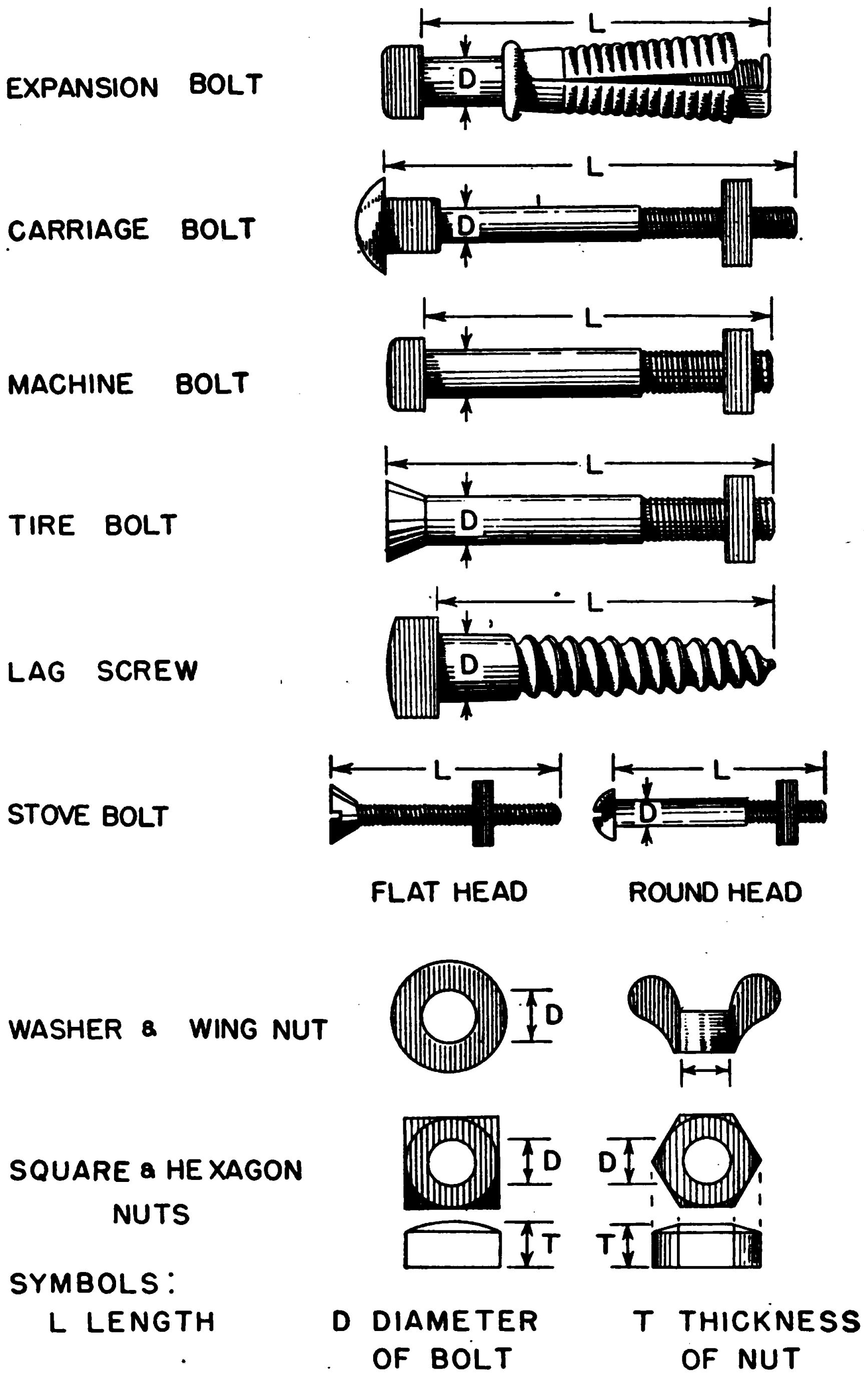


FIGURE 100.—Types of bolts (size designated by dimensions indicated).

is thereby fastened more securely. Bolts range in diameter from $\frac{3}{16}$ to $1\frac{1}{5}$ inches, and in length from $\frac{3}{4}$ to 30 inches. See tables X and XI for sizes and lengths of bolts.

c. Use.—To use a bolt, a hole as large as the bolt or a fraction larger is bored in the material; the bolt is placed in the hole with protective washers at either end, the nut put on and tightened.

TABLE X.—*Machine bolts*

Lengths (inches)	Diameters (inches)				
	3/16, 1/4, 3/8	7/16	1/2, 9/16, 5/8	3/4, 7/8, 1	1 1/8, 1 1/4
3/4	x				
1, 1 1/4	x	x	x		
1 1/2, 2, 2 1/2	x	x	x	x	
3, 3 1/2, 4, 4 1/2, etc., 9 1/2, 10 to 20	x	x	x	x	x
21 to 25			x	x	x
26 to 39				x	x

TABLE XI.—*Carriage bolts*

Lengths (inches)	Diameters (inches)			
	3/16, 1/4, 5/16, 3/8	7/16, 1/2	9/16, 5/8	3/4
3/4	x			
1	x	x		
1 1/4	x	x	x	
1 1/2, 2, 2 1/2, etc., 9 1/2, 10 to 20	x	x	x	x

98. Driftpins.—*a. General.*—Driftpins are long, heavy, threadless bolts used to hold heavy pieces of timber together (fig. 101).

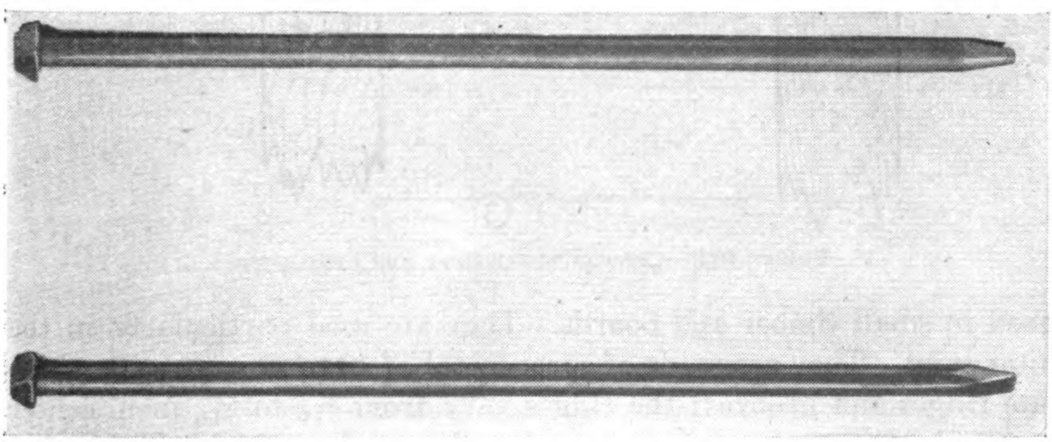


FIGURE 101.—Driftpins (Driftbolts).

The term "driftpin" is almost universally used in practice; however, for supply purposes the correct designation is "driftbolt."

b. Types.—Driftpins have heads and they vary in diameter from ½ to 1 inch, in length from 18 to 26 inches.

c. Use.—To use the driftpin, a hole slightly smaller than the diameter of the pin is made in the timber. The pin is driven into the hole and held in place by the compression action of the wood fibers.

99. Corrugated fasteners.—*a. General.*—The corrugated fastener is one of the many means by which joints and splices are fas-

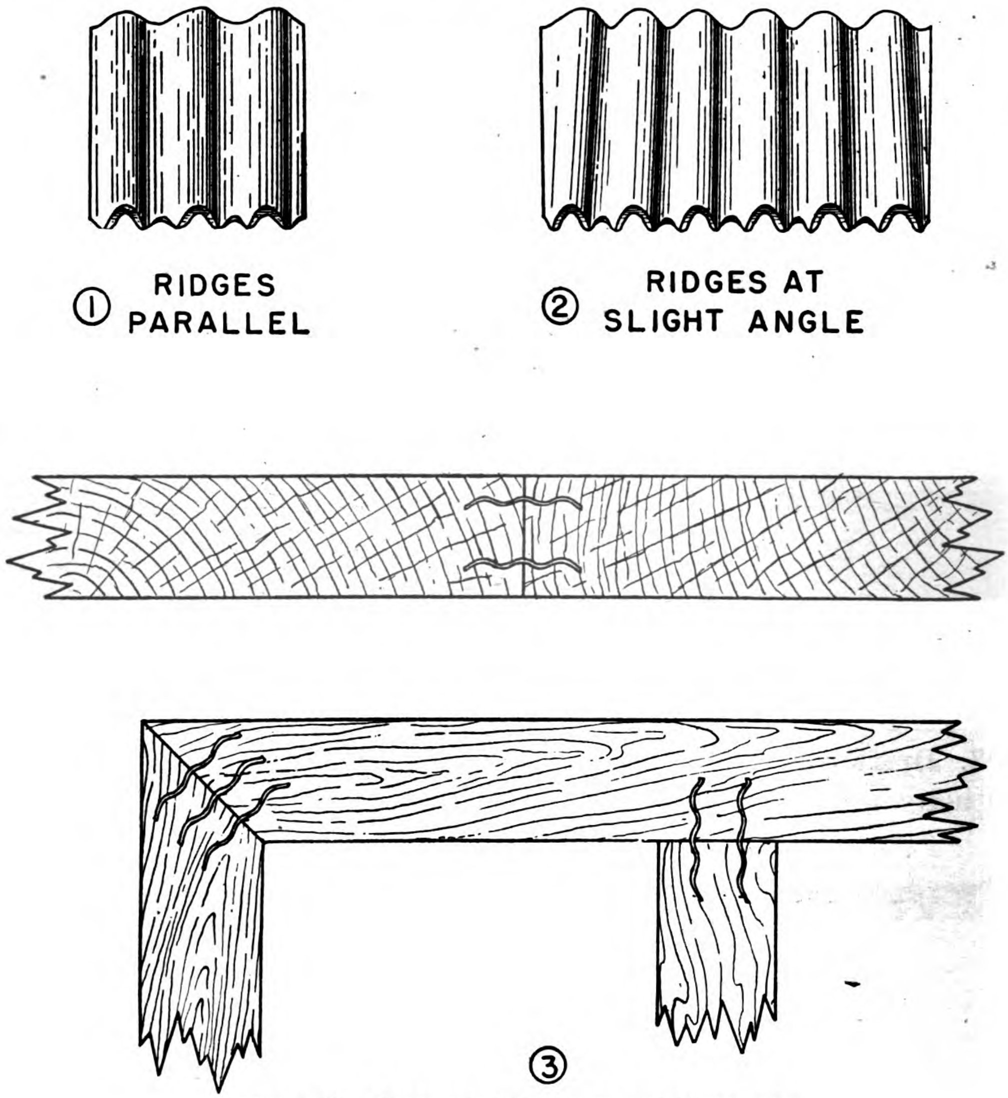


FIGURE 102.—Corrugated fasteners and their uses.

tened in small timber and boards. They are used particularly in the miter joint. They are made of sheet metal of 18 to 22 gage with alternate ridges and grooves; the ridges vary from 3/16 to 5/16 inch, center to center. One end is cut square; the other is sharpened with beveled edges (fig. 102① and ②).

b. Types.—There are two types of corrugated fasteners, one with the ridges running parallel (fig. 102①), the other with the ridges running at a slight angle to one another (fig. 102②). The latter type has a tendency to compress the material since the ridges and grooves are closer at the top than at the bottom.

c. Size.—These fasteners are made in several different lengths and widths. The width varies from $\frac{5}{8}$ to $1\frac{1}{8}$ inches, while the length varies from $\frac{1}{4}$ to $\frac{3}{4}$ inch. They are also made with different numbers of ridges, ranging from three to six ridges per fastener.

d. Use.—Corrugated fasteners are used in a number of ways: to fasten parallel boards together, such as in fashioning table tops; to make any type of joint; and to replace nails where nails may split the timber. The fasteners have a greater holding power than nails in

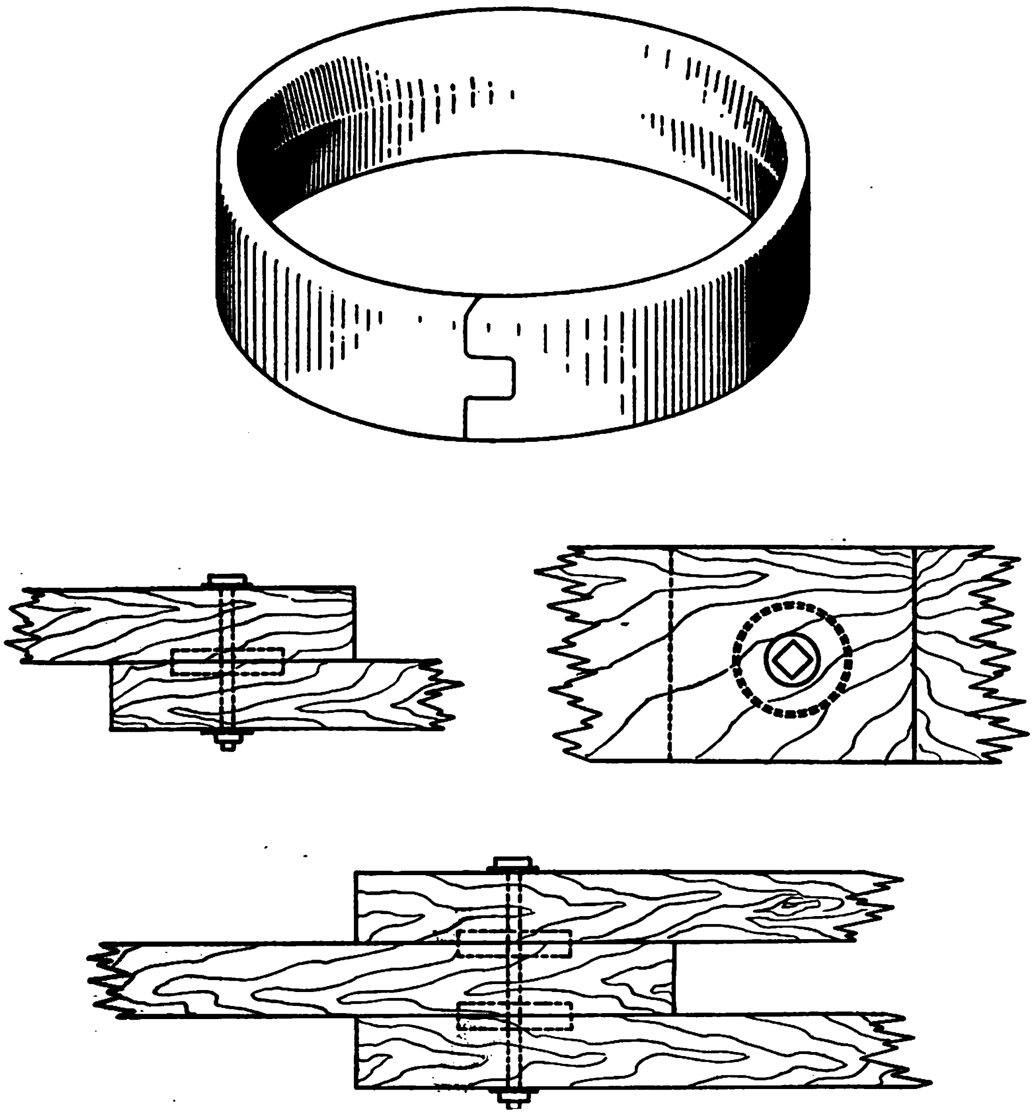


FIGURE 103.—Split ring and its installation.

small timber. Figure 102③ shows the proper method of using these fasteners.

100. Timber connectors.—*a. General.*—Timber connectors are metal devices for increasing the joint strength in timber structures. Efficient connections for either timber-to-timber joints or timber-to-steel joints are provided by the several types of timber connectors. The appropriate type for a specific structure is determined primarily by the kind of joint to be made and the load to be carried. These

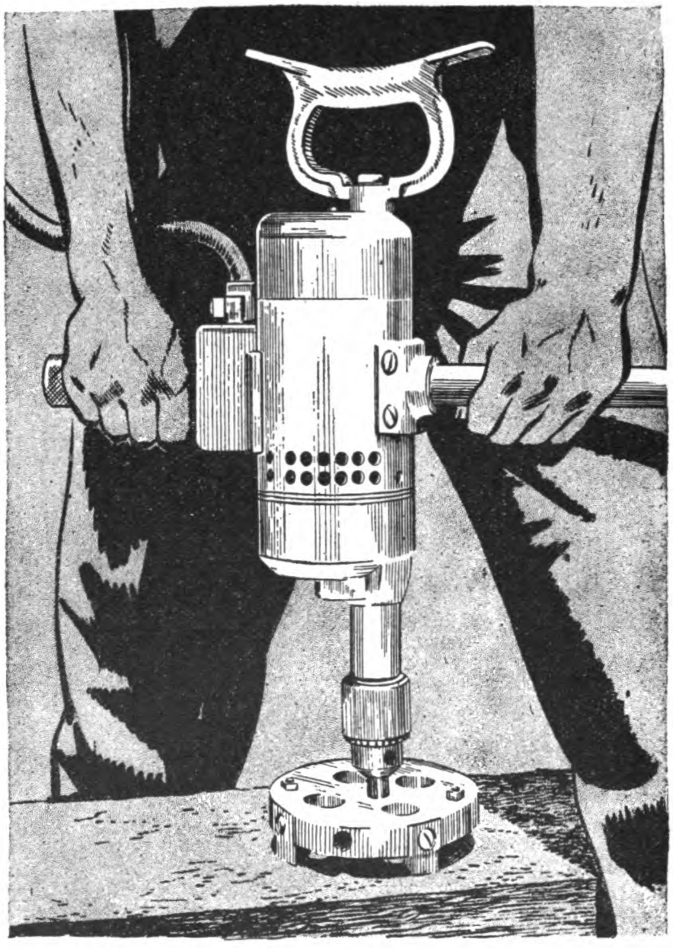


FIGURE 104.—Method of cutting grooves.

connectors eliminate much complicated framing of joints. Some of the important advantages are that they simplify the design of heavy construction, they give better efficiency of material, reduce the amount of timber and hardware used, and save much time and labor.

b. Types and uses.—(1) Split rings are made of low-carbon steel in sizes of 2½-, 4-, and 6-inch diameters. They are used between two timber faces for heavy construction. They fit into grooves which are cut half the depth of the ring into each of the timber faces (fig. 103). The grooves are made with a special bit used in an electric, air, or hand drill (fig. 104). The tongue-and-groove split in the ring permits simultaneous ring bearing against the cone wall and outer wall of the groove into which the ring is placed. The inside bevel and mill edge facilitate installation into and removal from the groove.

(2) Toothed rings are corrugated and toothed, and are made from 16-gage plate low-carbon steel. They are made in 2-, 2⅝-, and 4-inch

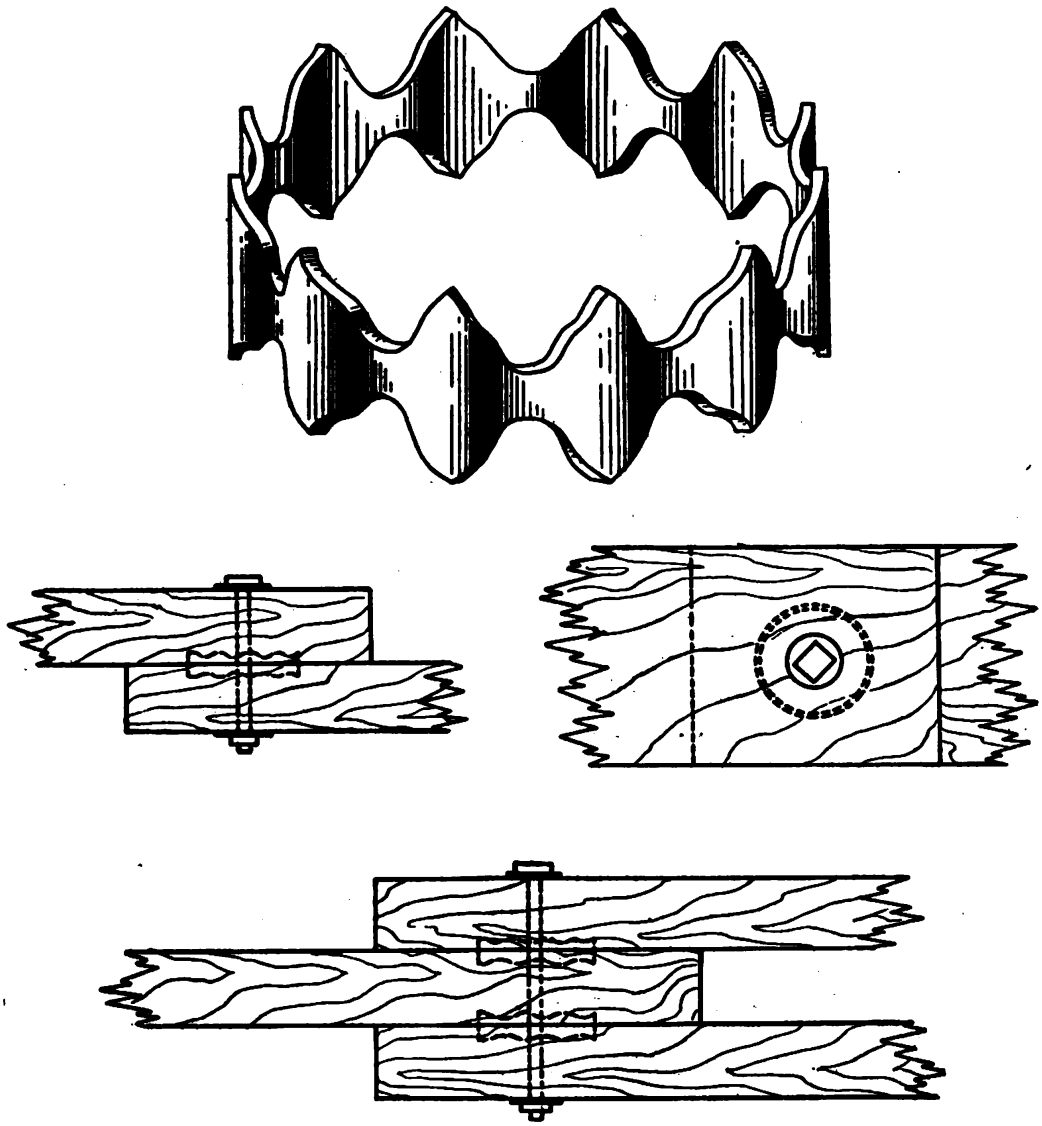


FIGURE 105.—Toothed ring and its installation.

diameters (fig. 105). They are used between two timber frames for comparatively light construction and are embedded into the contact faces of the joint members by means of pressure (fig. 106).

(3) Claw plates are made of malleable iron; one side is clawed and one smooth (fig. 107). They are used either in pairs or for

timber-to-timber connections. The female plates are adaptable for use when the connector must lie flush with the surface of the timber. Claw plates are installed by forcing the teeth into the wood beyond the depth of the circular dap, cut to receive the rim and plate portion. The dap cut is made by a special bit (fig. 108).

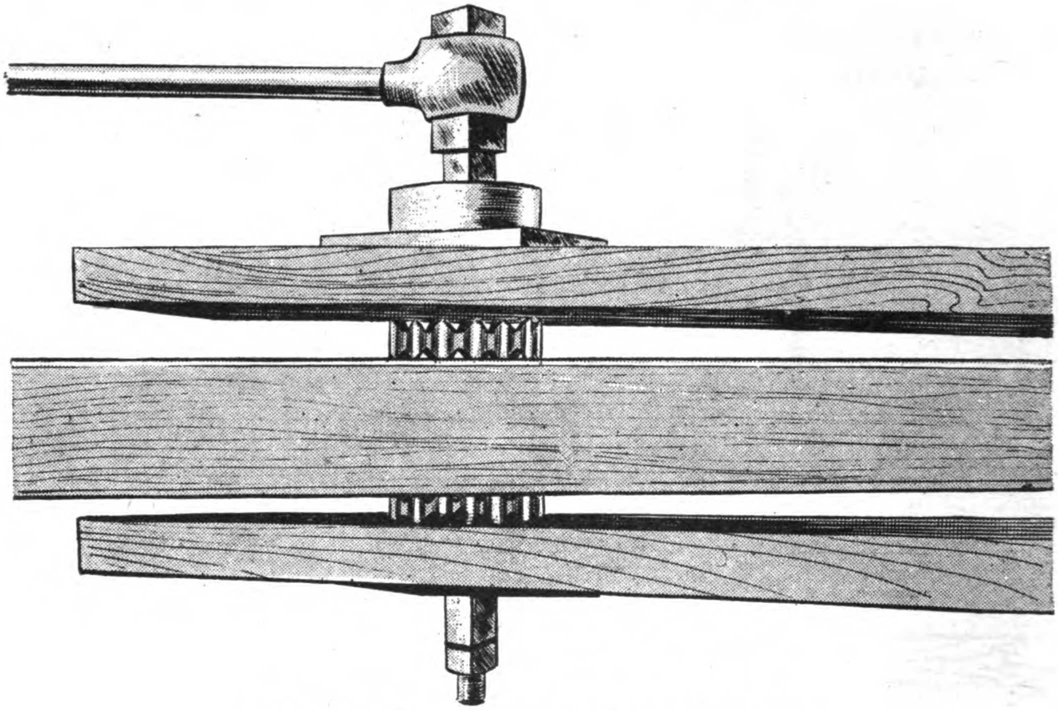


FIGURE 106.—Method of installing toothed rings.

(4) Shear-plates are made of pressed steel or malleable iron with an outer ring (fig. 109). When installed, they lie flush with the timber surface. They are used either as units, in pairs, or singly in timber-to-metal joints, with the plate placed with its back toward the metal. The plates fit into the daps cut in the timber faces by means of a special bit (fig. 108).

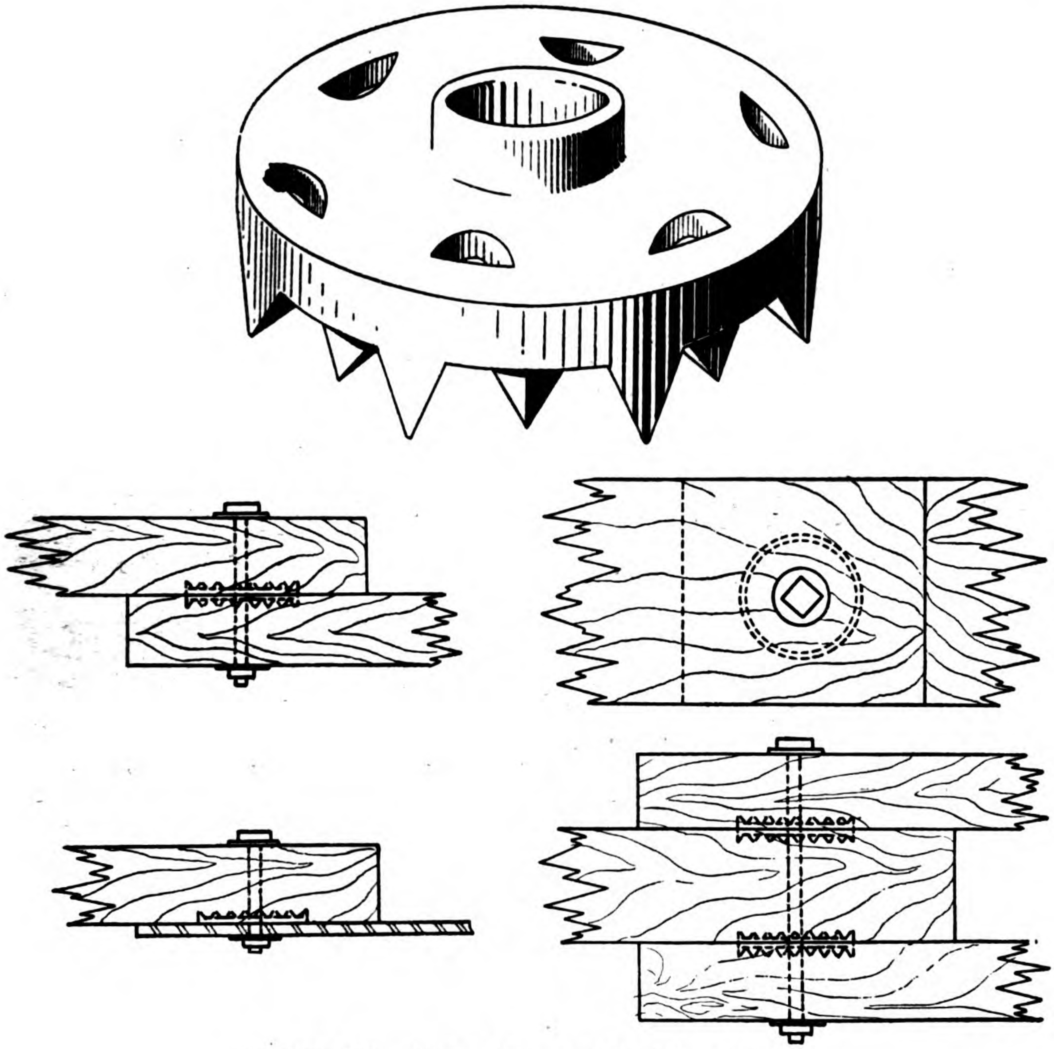


FIGURE 107.—Claw plates and their installation.

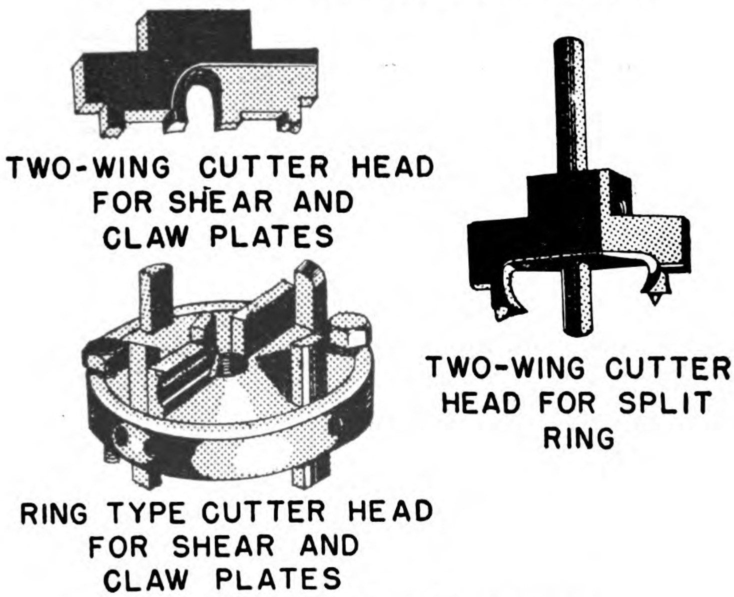


FIGURE 108.—Bits for cutting grooves.

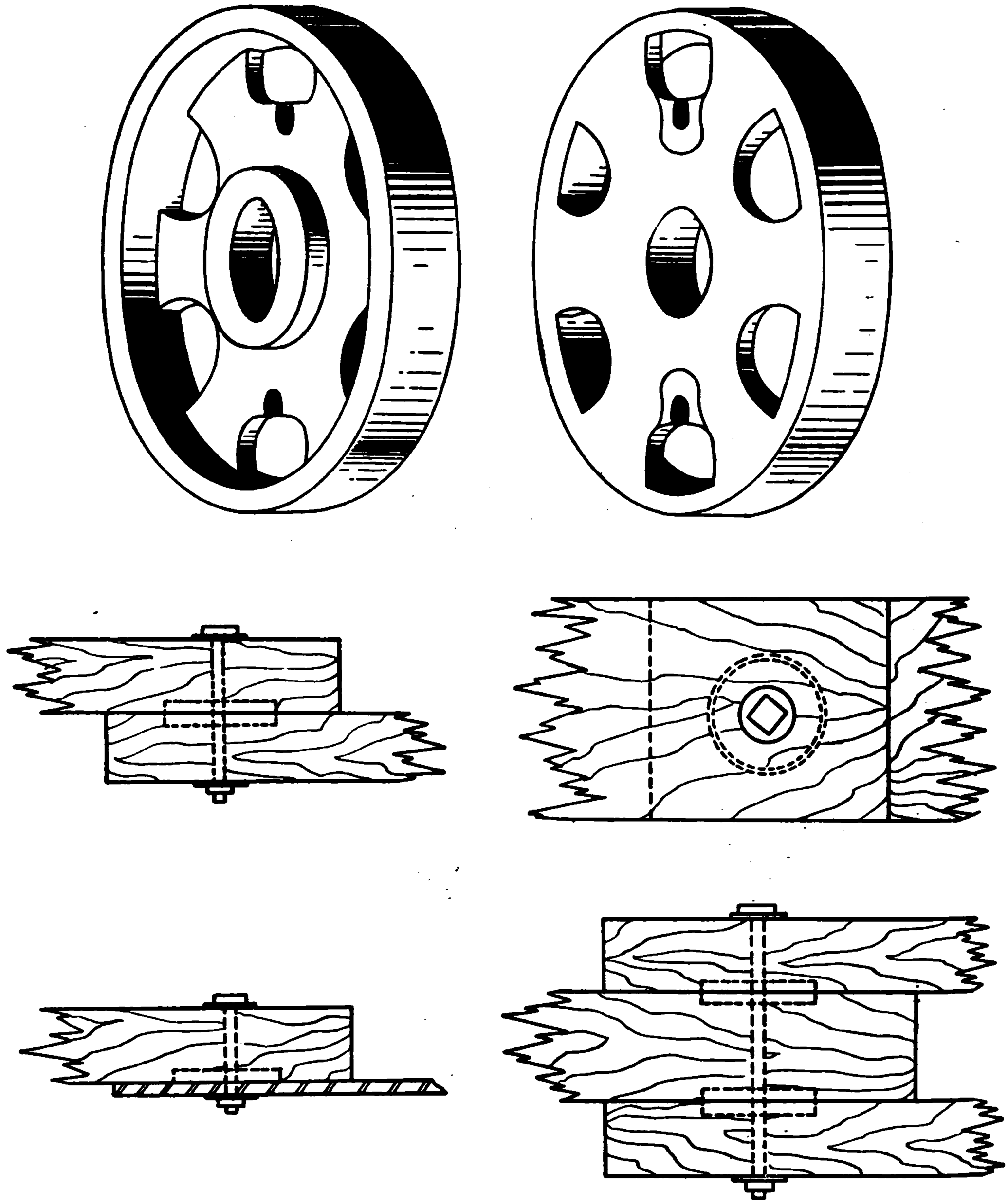


FIGURE 109.—Shear plates and their installation.

(5) Spike grids are made of malleable cast iron and are of three types: flat, single curved, and double curved (fig. 110). They are used primarily in pier and trestle construction between either flat or curved surfaces. The flat grids are used to join two flat faces of lapped timbers; the single-curved grid, to join a member with a flat surface to one with a curved surface; the double-curved grid, to join two parallel members with curved surfaces. They are embedded into the wood surfaces by means of the pressure exerted by tightening the bolt (fig. 110).

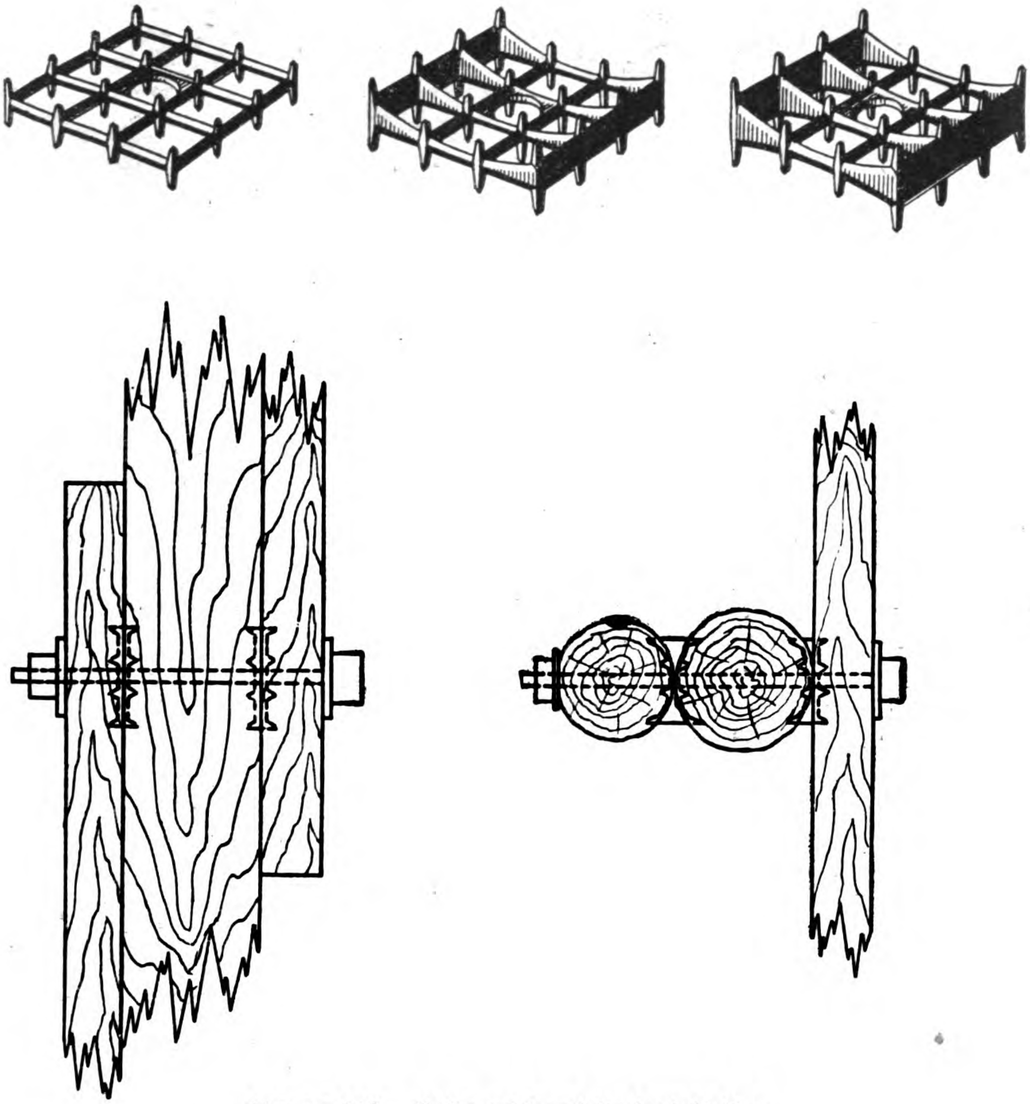


FIGURE 110.—Spike grid and its installation.

(6) Clamping plates are made of sheet metal with a central bolt hole. The *plain plate* has teeth which project from each side and which run parallel to the grain. The *flanged plate* has teeth on one side only with flanges bent in a direction opposite from that of the teeth (fig. 111). Clamping plates are used as railroad tie-spacers, between ties and guard timbers, and to keep the ties properly spaced; they are used also where timbers overlap at right angles. They are forced into the timber by means of a driving ram and protector plate (fig. 112) or by the use of bolts.

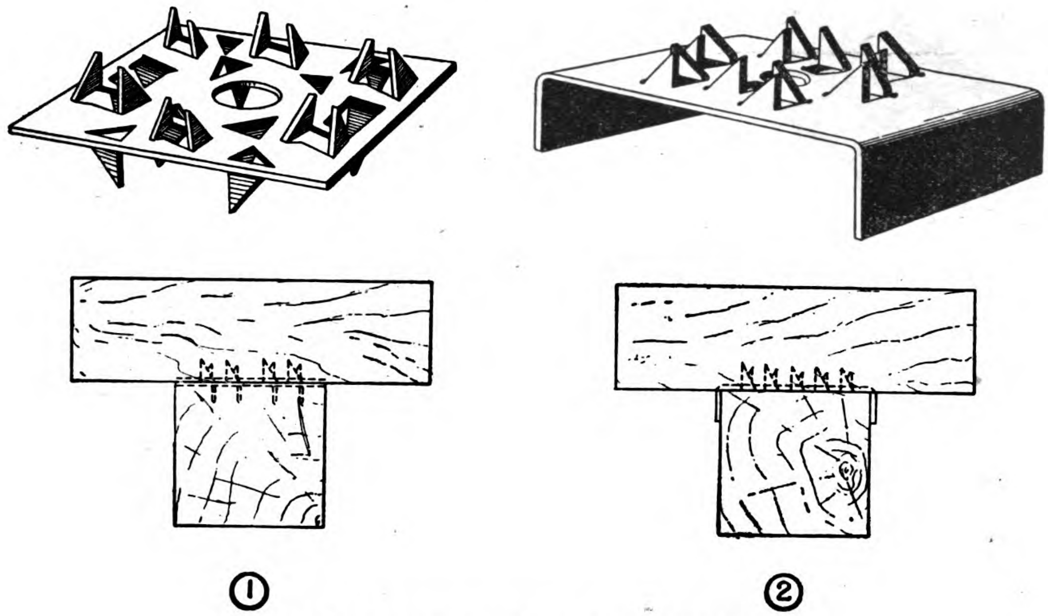


Figure 111.—Clamping plates and their installation.

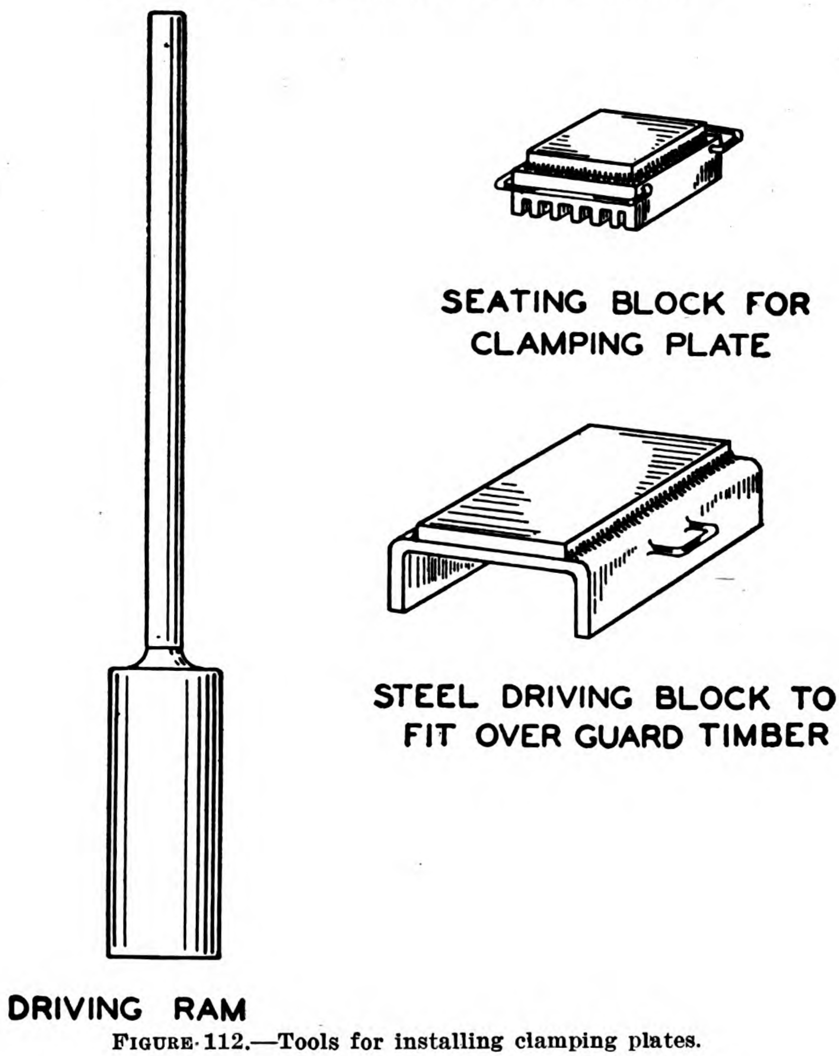


Figure 112.—Tools for installing clamping plates.

CHAPTER 6

LAY-OUT AND FOUNDATIONS

SECTION I

LAY-OUT

101. Staking out.—*a. General.*—When the location and alinement of a building has been determined, it should be staked out. This includes marking corners with stakes (fig. 113), and installing batter boards to provide a ready reference for measurements, especially in construction of foundations.

b. Batter boards.—Batter boards are erected 3 feet outside each corner stake as shown in figure 113. They should be firmly anchored; if more than 3 feet high, they should be braced. They are leveled with a transit, line level, or carpenter's level. The line level is a bubble level which is hung in the center of a line in order to level the ends. A carpenter's level may be leveled on a steady base and sighted over; this method is not very precise but will serve as an expedient. The batter boards support the chalklines which outline the building. After the final lay-out has been checked, saw cuts are made in the *outside edges* of batter boards to hold the lines in place; sawing to the inside edges will lower the lines.

c. Procedure (fig. 2, app. III).—(1) Drive stake *A* in alinement with and at prescribed distance from other buildings. (When foundation is not required to be in line with other building, stake *A* should mark corner of the foundation located on highest ground.) Measure length of new building from stake *A* parallel to adjacent building, and mark point with stake *B*. Erect batter boards, 1, 2, 3, and 4. Place a chalkline shown by line *X* on batter boards 1 and 3 over stakes *A* and *B* and parallel to adjacent building.

(2) Measure width of building from stake *A* perpendicular to line *X* and mark by stake *C*. A hasty perpendicular can be obtained by using a framing square. Erect batter boards 5 and 6. From batter board 2, stretch line *Y* over stakes *A* and *C* to batter board 6.

(3) From stake *C* measure length of building parallel to line *X* and mark by stake *D*. Erect batter boards 7 and 8.

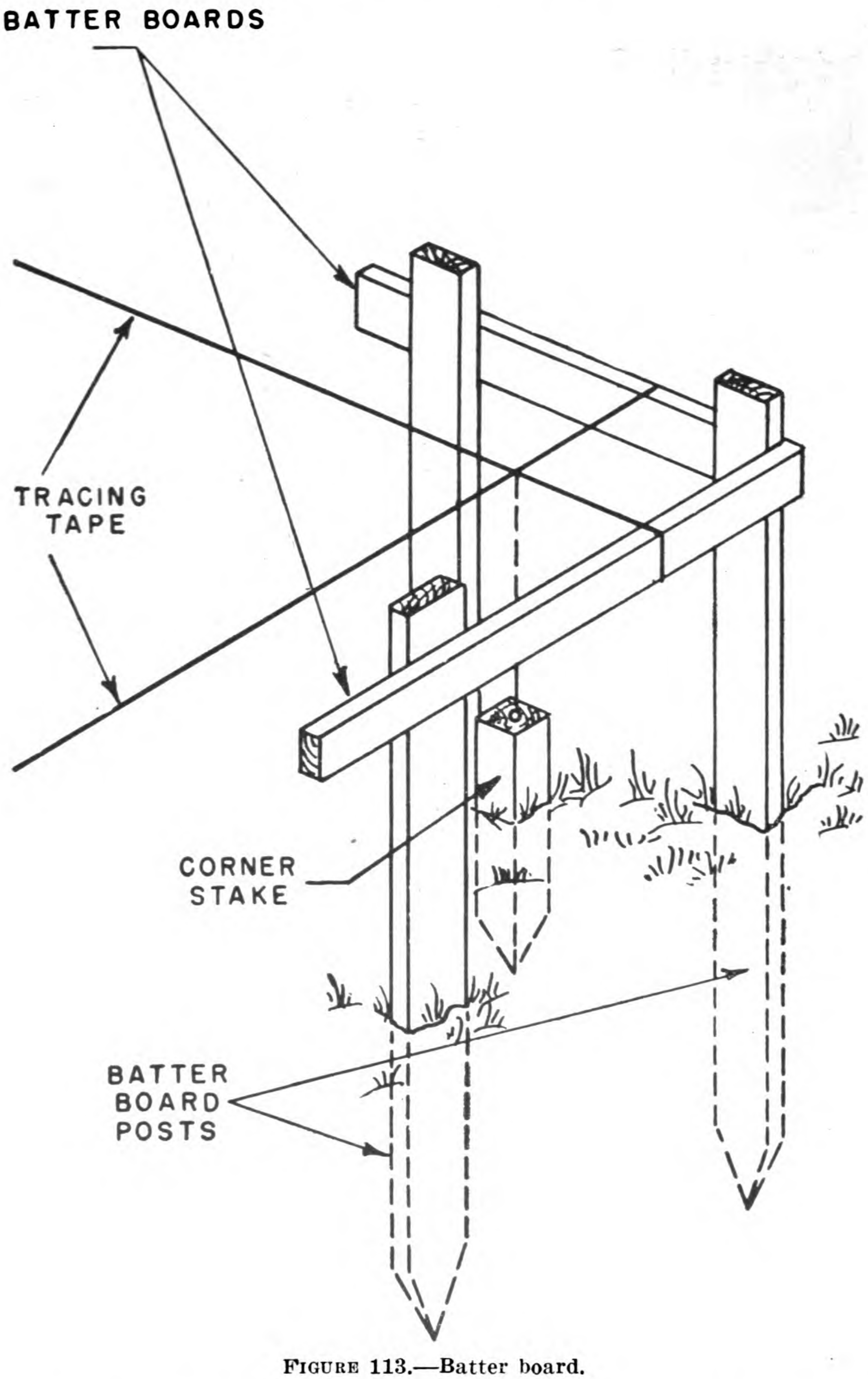


FIGURE 113.—Batter board.

(4) From line X on batter board 1, measure width of building and mark on batter board. Stretch line Z from this mark over stakes C and D to batter board 7.

(5) From line Y on batter board 2, measure length of building and mark on batter board 4. From line Y on batter board 6, measure

length of building and mark on batter board 8. From point on batter board 4, stretch line *O* to point on batter board 8.

d. Checking.—(1) To check the lay-out, measure the diagonals. If all side dimensions are correct, and diagonal measurements are equal, the building is "square"; if not, lines must be adjusted until diagonals check.

(2) Another check is as follows: measure 12 feet on line *X* from intersection of *X* and *Y*; measure 16 feet on line *Y* from same point. If building is square, the distance between the 12-foot and the 16-foot marks will be 20 feet. If not, position of side lines must be adjusted until distance is correct.

(3) Another rapid method of checking is by means of a right-angled template, constructed by laying out a triangle with sides respectively 3, 4, and 5 feet long.

e. Finishing the lay-out.—Where foundation walls are wide at the bottom and extend beyond the outside dimensions of the building, the excavation must be larger than the size laid out. To lay out dimensions for this excavation, measure out as far as required from the building line on each batter board, drive a nail at the correct point, and stretch lines between these points and outside first lay-out.

f. Tools and materials.—(1) *Tools.*—The most common tools used in the lay-out of a building are sledge hammer or maul, post-hole auger, hand saw, carpenter's level, chalk line, tape, square, ax or hatchet, brush-hook or machete, hammer; and for important buildings, level and transit.

(2) *Materials.*—The material should be straight and sound. Posts or stakes should be of 2 by 4's, or 4 by 4's, batter boards of 1 by 4's or 1 by 6's.

Section II

FOUNDATION

102. Excavation.—In the theater of operations, there is little excavation for building, but what must be excavated requires a set procedure. In excavating for a building with earth floors, all that is necessary is a small trench to contain the sill (fig. 114①). The building may then be constructed and the grading on the inside done later, if necessary. In excavating for bombproof shelters and other underground building, care should be taken to make the excavation large enough to permit working outside the structure, unless the bank itself is to act as a form wall. This can be done where earth is compact

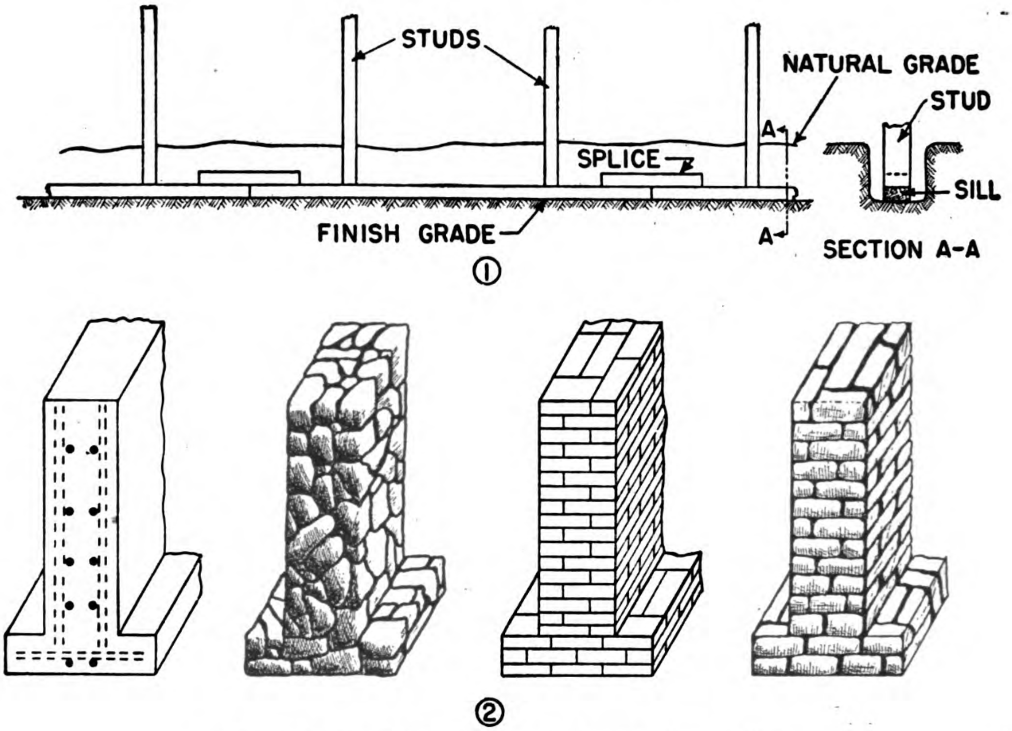


FIGURE 114.—Excavation and foundation walls.

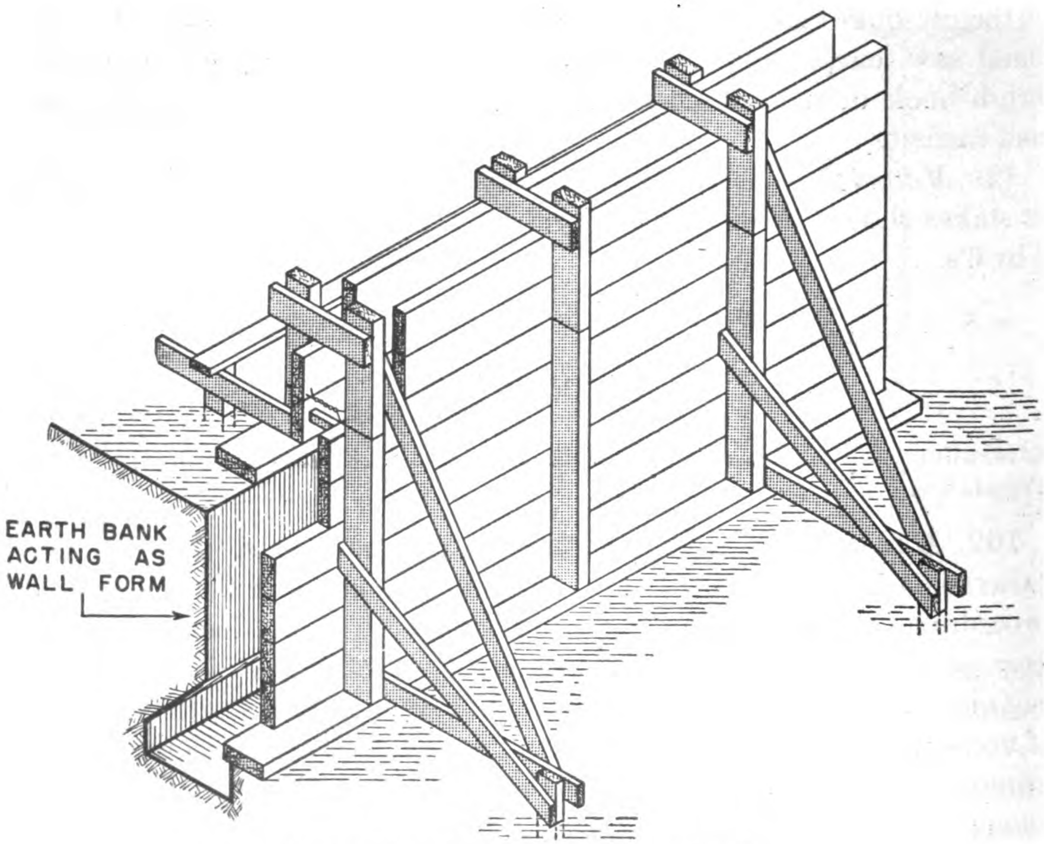


FIGURE 115.—Earth and wood form walls.

enough to remain in place unsupported (fig. 115), for either one or both walls. In small buildings where there are no wood floors, the earth should be thrown on the inside to raise the earth level above the outside and to prevent water seepage. When wood floors are laid on the ground, the excavated earth should be used to raise the floor level. The pick and shovel should be used to dig small foundations; large foundations may be dug either by hand or with machinery. In digging, care should be taken that the batter boards are not disturbed.

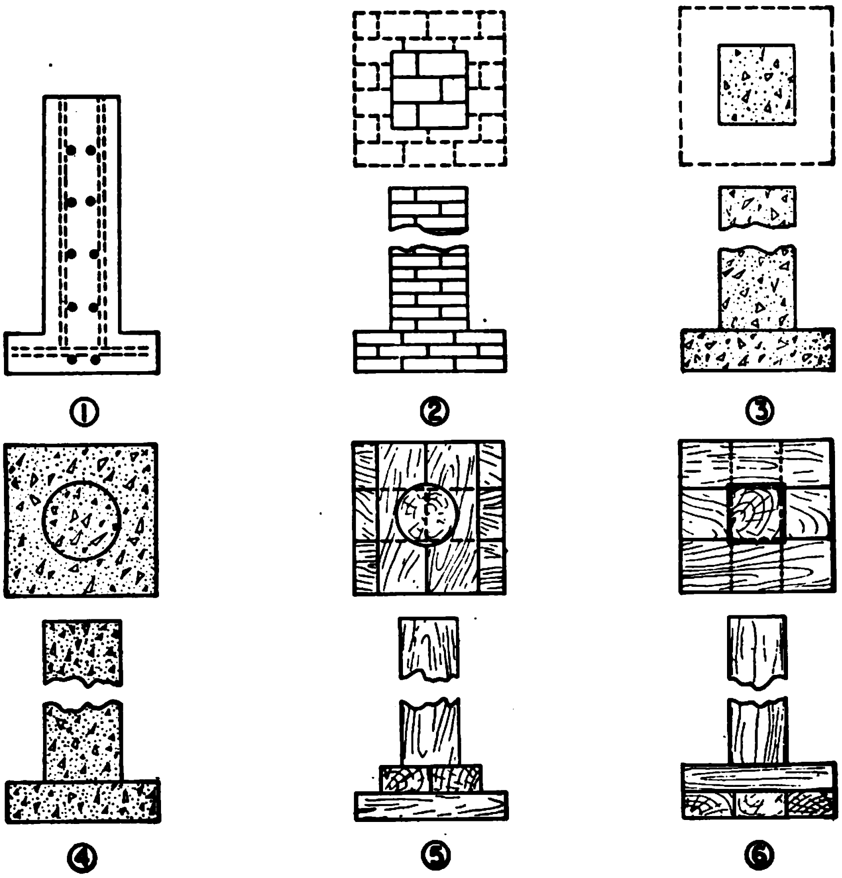


FIGURE 116.—Columns or piers.

A bulldozer may be used to level the ground when wood or concrete floors are to be laid.

103. Foundation.—Foundations vary according to their use and type of material available. The material may be cut stone, rock, brick, concrete, tile, or wood, depending upon the weight which the foundation is to support. Foundations may be classified as wall or column (pier) foundations.

a. Wall foundations are built solid, the walls of the building being of continuous heavy construction for their total length. Solid walls are used where there are heavy loads to be carried or where the earth has low supporting strength. These walls are made of concrete, rock, brick, or cut stone, with a footing at the bottom (fig. 114②). For the construction of concrete forms see chapter 9. Because of the time, labor, and material required to build it, this type of wall will be used in the theater of operations only when other types cannot be used. Steel rod reinforcements should be used in all concrete walls (fig. 116①).

b. Column or pier foundations save time and labor. They may be constructed from masonry or wood. The piers or columns are spaced according to the weight to be carried. In most cases the spacing is from 6 to 10 feet. Figure 116 shows the different types of piers with different types of footing. Wood piers are generally used since they are installed with the least time and labor. Where wood piers are 3 feet or more above the ground, braces are necessary (fig. 3, app. III).

CHAPTER 7

FRAMING

SECTION I

GENERAL

104. General.—After the building has been laid out and the batter boards set in place, the carpenter constructs the framing of the building. Framing is a skeleton, or framework, upon which the covering is to be placed. Just as the bony skeleton is the basic supporting structure of the body, so the framework of a building contains its fundamental strength. Framing consists of the foundation walls, upper walls, floors, and roof.

105. Floors.—After the foundation, the floor is constructed.

a. Wooden.—Wooden floors must be framed with one governing consideration: they must be strong enough to carry the load. The type of building and the use for which it is intended determines the

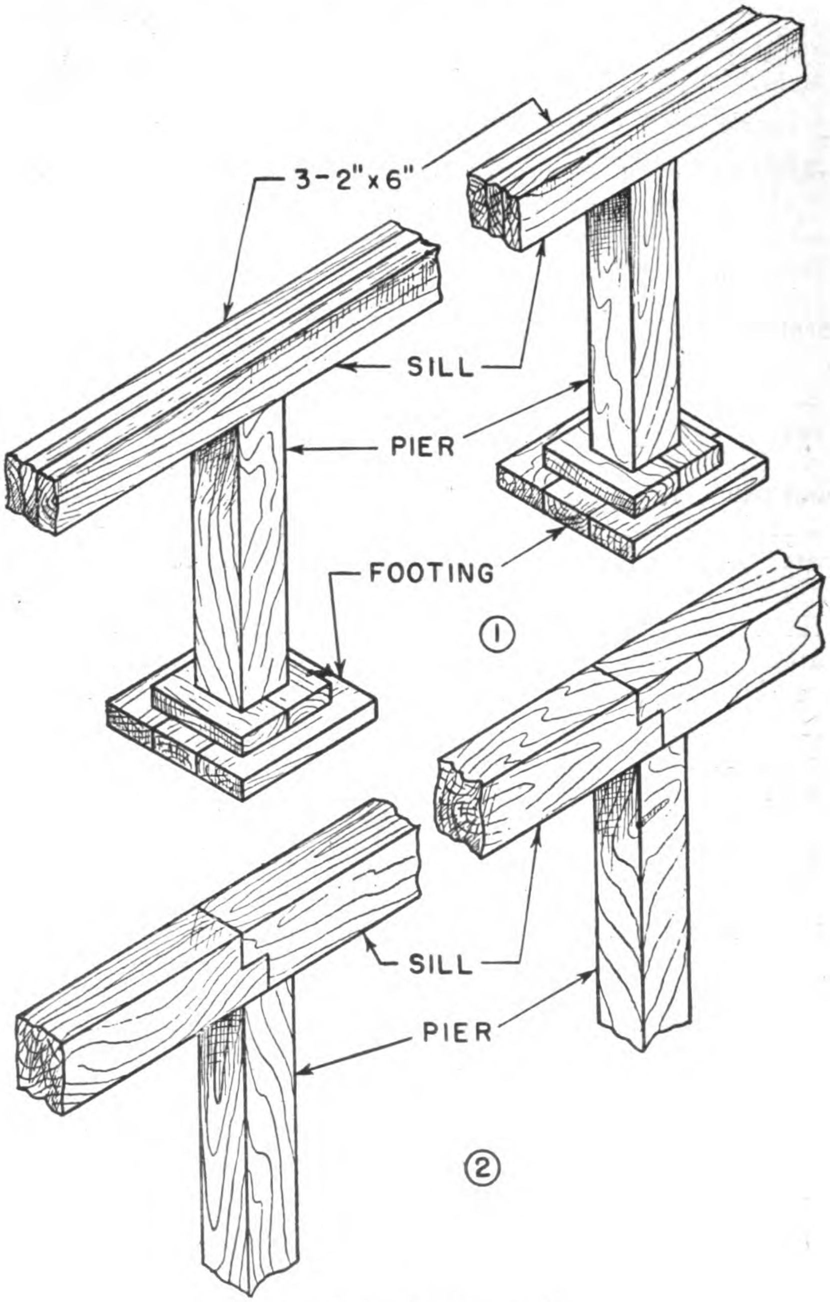


FIGURE 117.—Types of sills.

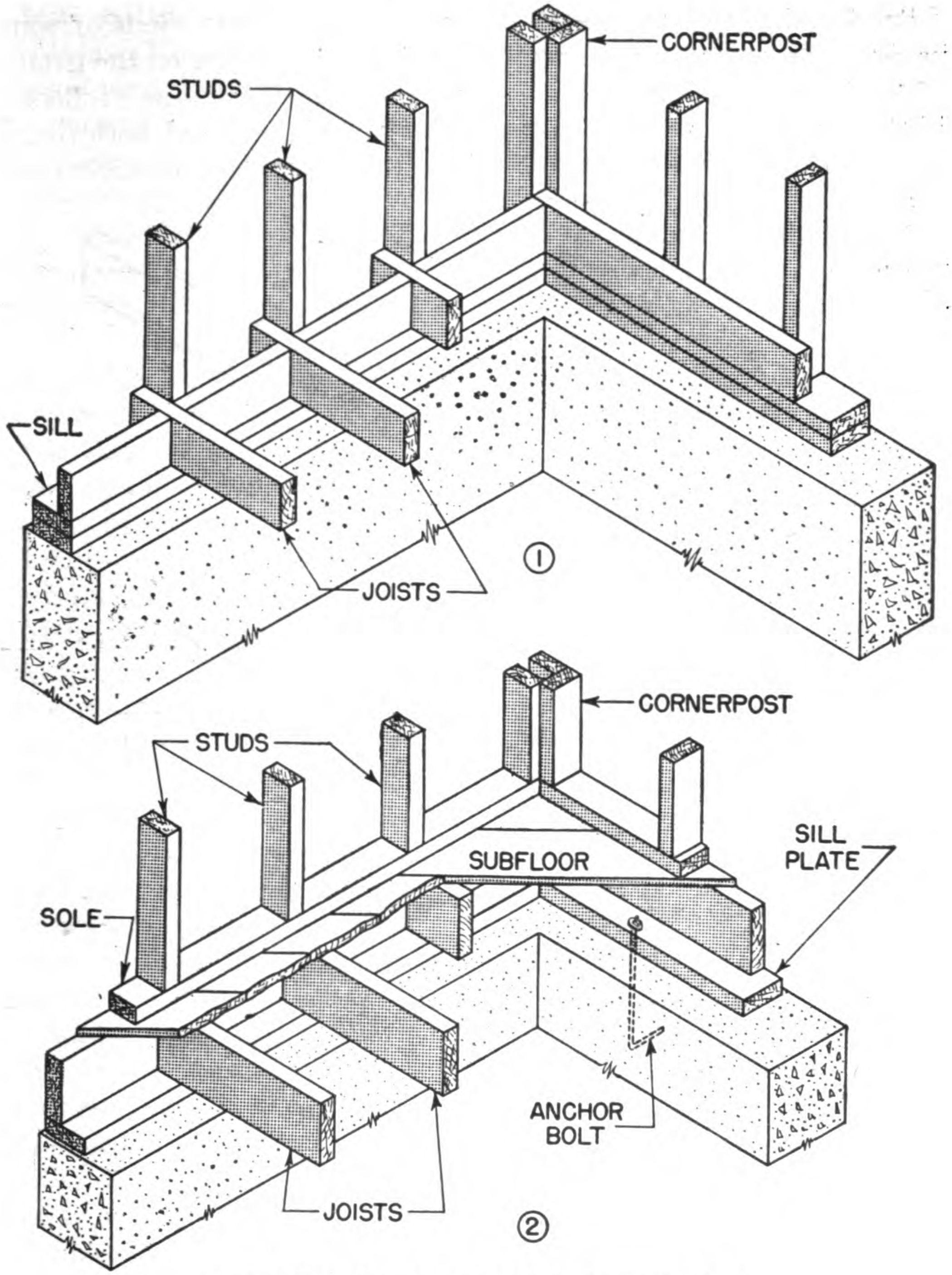


FIGURE 118.—Types of sills and their construction.

general arrangement of the floor system, thickness of the sheathing, and approximate spacing of the joists. Floors are usually formed of girders and beams, or joists. The girder is a heavy timber and used to support the lighter joists between the outside walls.

b. Concrete.—Concrete floors may be constructed for shops where earthen or wooden floors are not suitable, such as in repair and assembly shops for airplanes and heavy equipment, and certain kinds of warehouses. These floors are made by pouring the concrete on the ground after the earth has been graded and tamped. This type of floor is likely to be damp unless protected. Drainage is provided, both for the floor area and for the area near the floor, to prevent flooding after heavy

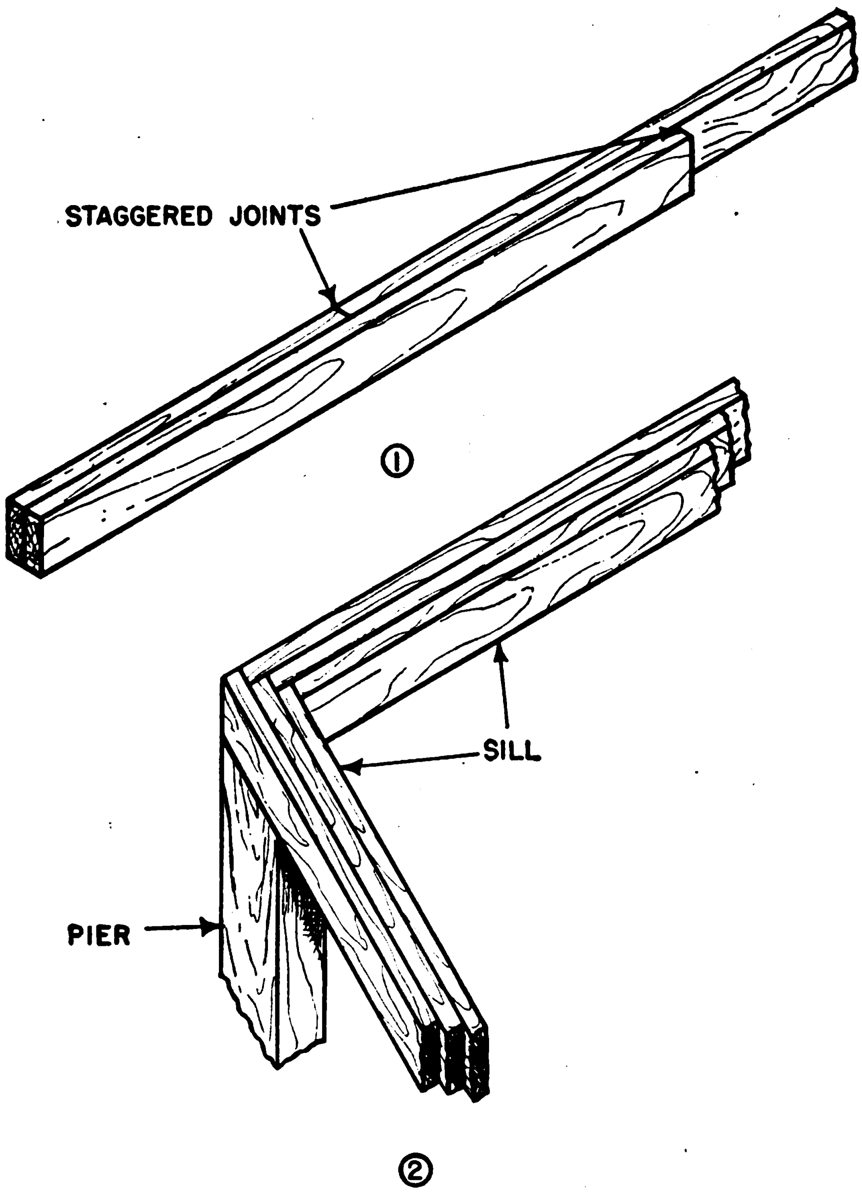


FIGURE 119.—Sill fabrication.

rains. The floor should be reinforced with steel or wire mesh. Where concrete floors are to be poured, a foundation wall may be poured first and the floor poured after the building is completed. This gives protection to the concrete floor while it sets and eliminates the waiting period before construction of the building.

106. Sills.—*a.* The sills are the first part of the frame to be set in place. They rest either directly on the foundation piers or on the ground, and may extend all around the building; they are joined at the corners and spliced when necessary. Figures 117 and 118 show the most common types of sills. Where built-up sills are used, the joints are staggered. The corner joints are made as shown in figure 119. Often box sills are used, either with or without the sill plate. In this type of sill, the part that lies on the foundation wall or ground is called the sill plate. The sill is laid edgewise on the outside edge of the sill plate (fig. 118).

b. If piers are used in the foundation, heavier sills are used. These sills are of single heavy timbers or are built up of two or more pieces of timber. Where heavy timber or built-up type sills are used, the joints should occur over piers. The size of the sill depends upon the load to be carried and upon the spacing of the piers. The sill plates are laid directly on graded earth or piers or, where earth floors are used, the studs are nailed directly to the sill plate (fig. 117①).

107. Girders.—*a.* A girder may be either a single beam or a composite section. Girders usually support joists; the girders themselves are supported by columns or bearing walls (fig. 3, app. III). When a girder is supported by a wall or pier it must be remembered that such a girder delivers a large concentrated load to a small section of the wall or pier; therefore care must be taken to see that such a wall or pier is strong enough in its column action to carry the load imposed upon it by the girder. Girders are generally needed only where the joist will not safely span the distance. The size of these girders is determined by the span and the load to be carried. In general, the size of a beam or girder varies directly as the square of the length of the span; thus, if using two spans, one of which is twice as great as the other, the girder for the longer span should be four times as strong as the girder for the small span.

b. Girders are often built up by placing two or more joists side by side and nailing them together as shown in figure 3, appendix III. For a girder of two joists, 16-penny nails should be used, while for a girder of three joists, 20-penny nails should be used; for girders of four or more joists, 20- or 30-penny nails should be used. The nails must be placed about 1½ inches from the top and bottom edges of the joist, spaced about 24 inches apart, and staggered; they should be driven from both sides of the girder alternately.

108. Joists.—Joists are the light pieces which make up the body of the floor frame and the flooring or subflooring is nailed to them. They are usually 2 or 3 inches thick and the depth is varied to suit the conditions. Joists as small as 2 by 6 inches are sometimes used in light buildings, but these are too small for floors with span over 10 feet. This size is frequently used for ceiling joists. Joists usually carry a uniform load composed of the weight of the joists themselves, plus the flooring, plus superimposed loads of materials and personnel. The latter loads are commonly termed "live loads," the weight of joists and floors is called a "dead load." The joists carry the flooring directly on their upper surface and they are supported at their ends by sills, girders, bearing partitions, or bearing walls (fig. 3, app. III). They are spaced 16 or 24 inches apart, center to center; sometimes the spacing is 12 inches, but where such spacing is necessary heavier joists should be used. Joists of 2-inch material more than 12 inches in depth should not be used.

109. Joist connections.—Joists are connected to sills and girders by several methods. In modern construction, the method that requires the least time and labor and yet gives the maximum efficiency is used. The same rule is followed in the theater of operations.

a. With sills.—In joining joists to sills, always be sure that the connection is able to hold the load that the joists will carry. Figure 120① shows the joist resting upon the sill. This method is the most commonly used because it gives the strongest possible joint. The method shown in figures 120 ② and ③ are used where it is not desirable to use joists on top of the sill. The ledger plate should be securely nailed and the joist should not be notched over one-third of its depth. There are several other methods, but those mentioned above are more or less standard. In the theater of operations it is up to the officer in charge or the carpenter to determine the method to be used; he must keep in mind that time, labor, and material are of vital importance.

b. With girders.—The framing of the joists to the girders may be accomplished in several ways, depending upon the position of the girder. The placing of the girders is an important factor. The joists must be level, therefore if the girder is not the same height as the sill, the joist must be notched as shown in figure 120③. If the girder and sill are of the same height, the joist still must be connected to the sill and girder to keep the joist level. Joists are connected to girders as shown in figure 120. In placing joists, always have the crown up since this counteracts the weight on the joist; in most cases there will be no sag below a straight line. Joists should not be joined to sills or girders as shown in figure 120④. Overhead joists are joined to plates as shown in figure 121①. The inner end of the joist rests on the plates of the partition walls. When a joist is to rest on plates or girders, either the joist is cut long enough to extend the full width of the plate or girder, or it is cut so as to

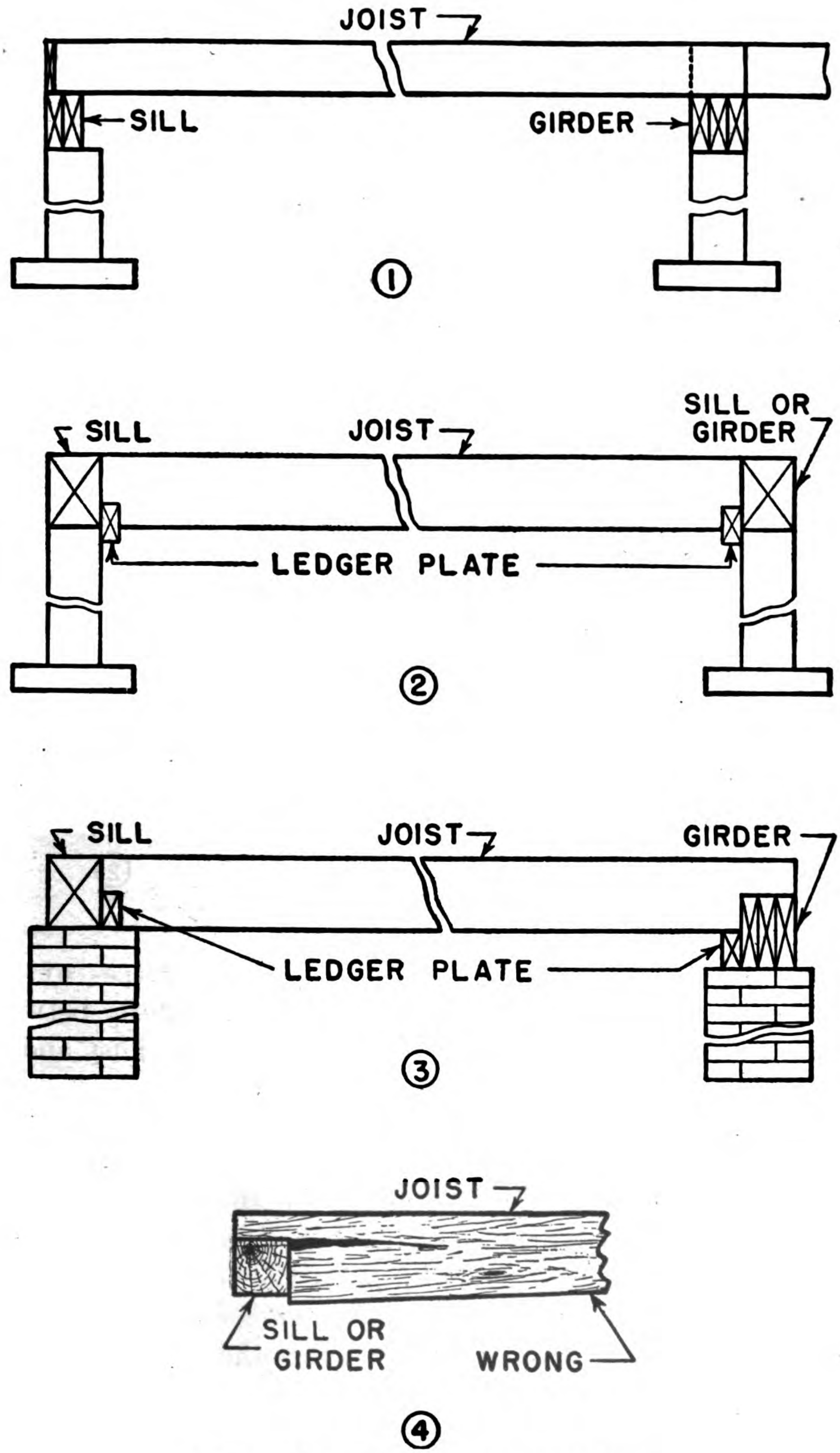


FIGURE 120.—Sill and joist connections.

meet in the center of the plate or girder and is connected with a scab as shown in figure 3, appendix III. Ceiling joists that lie beside rafters on a plate are cut at a slope corresponding to the pitch of the rafter, flush with the top of the rafter (fig. 121②). Where two joist ends lay side by side on a plate, they should be nailed together (fig. 121①).

110. Bridging.—Floor frames are bridged in order to stiffen the floor frame, to prevent unequal deflection of the joists, and to enable an overload joist to receive some assistance from the joists on either side of it. Bridging is of two kinds: horizontal bridging and cross bridging (fig. 122). Cross bridging is the one most generally used; it is very effective and requires less material than horizontal bridging.

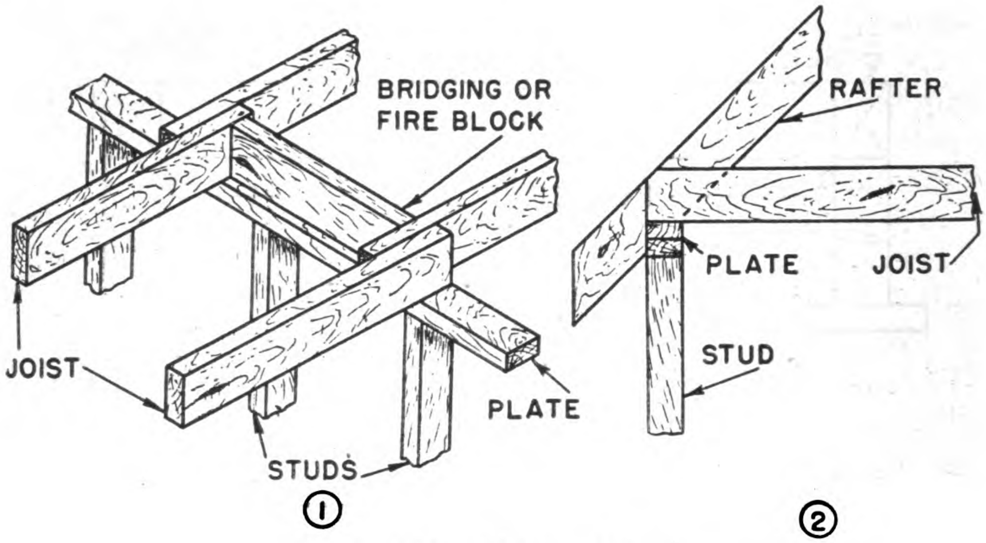


FIGURE 121.—Joist connections.

Cross bridging looks like a cross and consists of pieces of lumber, usually 1 by 3 or 2 by 3 inches in sizes, cut in diagonally between the floor joists. Each piece is nailed to the top of one joist and to the bottom of the next. Two pieces are nailed to the top of each joist and form a cross between the joists. These pieces between joists should be placed as near to each other as possible (fig. 122②). Bridging should be nailed with two 8- or 10-penny nails at each end. The tops should be nailed and the bottoms left until the subfloor or finish floor is laid. This permits the joists to adjust themselves to their final positions. The bottom ends of bridging may then be nailed, forming a continuous truss across the whole length of the floor and preventing any overloaded joist from sagging below the others. Cutting and fitting the bridging by hand is a slow process; a power saw should be used if it is available. After the joists have once been placed, a pattern may be made and used to speed up the process of cutting. On joists over 8 feet long, one line of bridging should be placed and on joists over 16 feet long two lines.

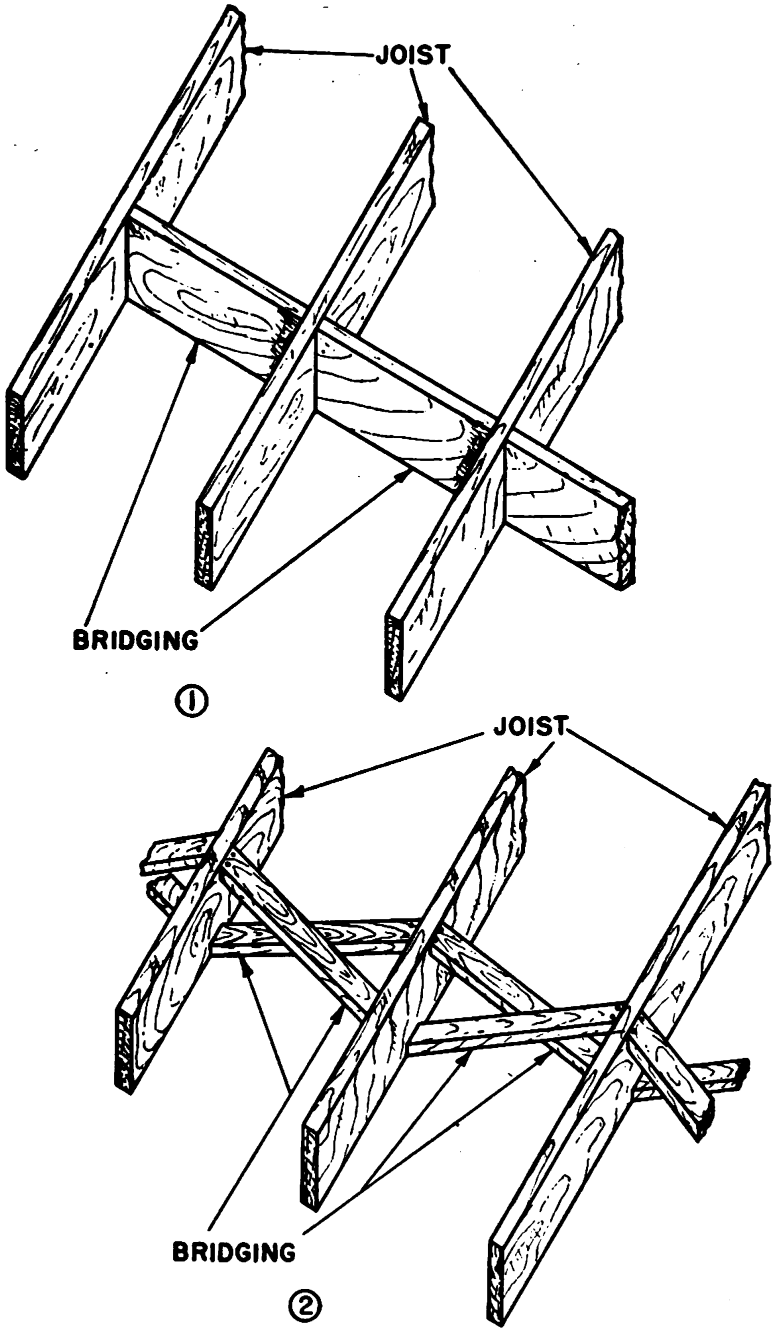


FIGURE 122.—Types of bridging.

111. Subfloor.—Subfloor, if used, is laid diagonally on the joists and nailed with 8- or 10-penny nails, the number of nails depending upon the width of the boards. Boards 8 inches wide or over should have three or more nails per joist. Where the subfloor is over 1 inch thick, larger nails should be used. By the use of subflooring, floors are made much stronger since weight is distributed over a wider area. Figure 3, appendix III, shows the method of laying a subfloor. It may be laid before or after the walls are framed, preferably before; it can then be used as a floor to work on while framing the walls.

112. Stairs or steps.—Stairs or steps are built on a frame called a stringer or a carriage. The stringers or carriages may consist of material 2 or 3 inches thick and 4 or more inches wide which are cut to

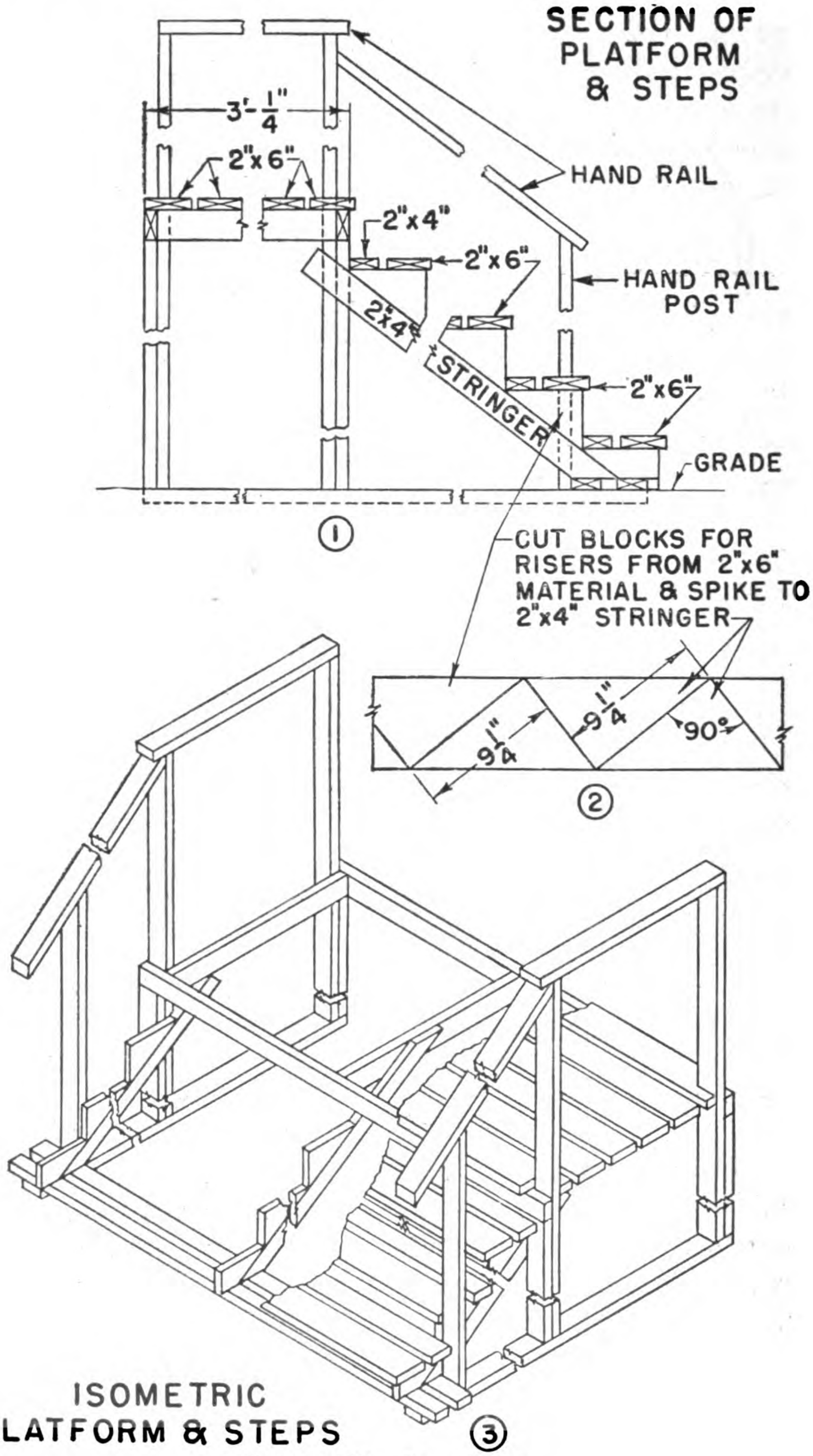


FIGURE 123.—Step details.

form the step of the stairs, or blocks nailed on to form the steps. There are usually three of these stringers to a stair, one at each of the two outer edges and one at the center.

a. Step or stair stringers may be made of 2 by 4's, with triangular blocks nailed to one edge to form the stringer. The blocks are cut

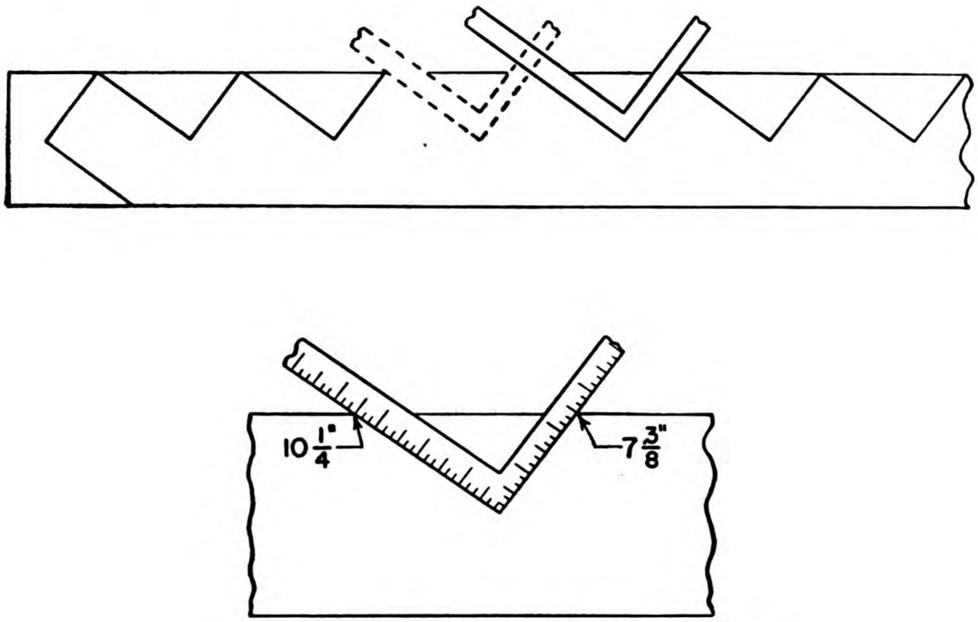


FIGURE 124.—Method of laying out step stringers.

from 2 by 6's as shown in figure 123②, and nailed to the 2 by 4, as shown in figure 123①. The step stringers are fastened at the top and bottom as shown in figure 123①. Figure 123 shows the foundation and gives the details of the sizes of the step treads, handrails, the

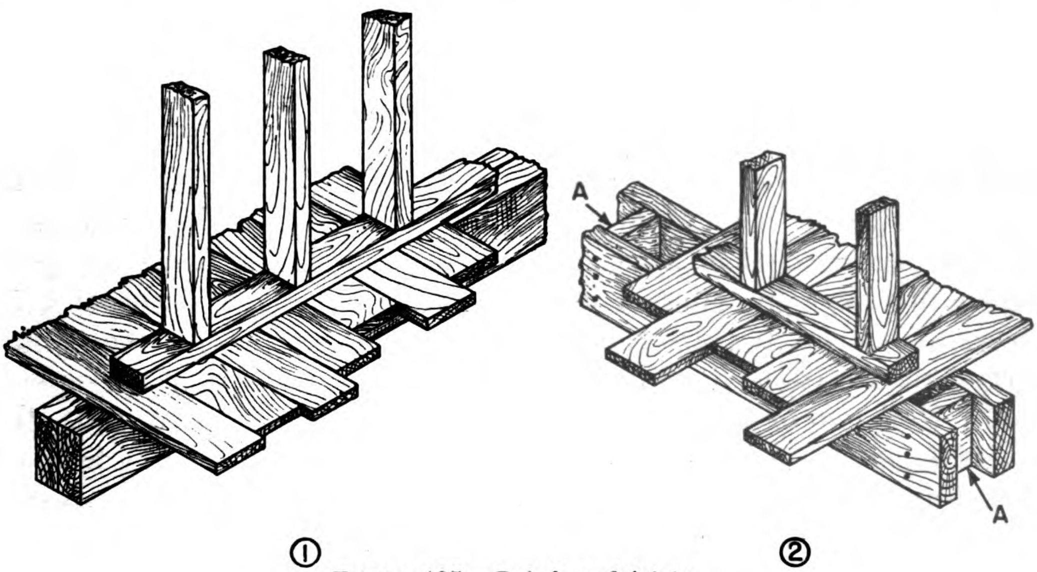


FIGURE 125.—Reinforced joists.

method of installing them, and the post construction. This type of step is most common in field construction.

b. When timbers heavier than 2 by 4's are used for stringers, they are laid out and cut as shown in figure 124.

113. Supports.—In certain parts of the floor frame, in order to support some very heavily concentrated load or a partition wall, it may be necessary to double the joist or to place two joists together. (See fig. 125.)

114. Headers and trimmers.—A girder may also be necessary in a floor when an opening is to be left in the floor for some other structure. The timbers on each side of such an opening are called

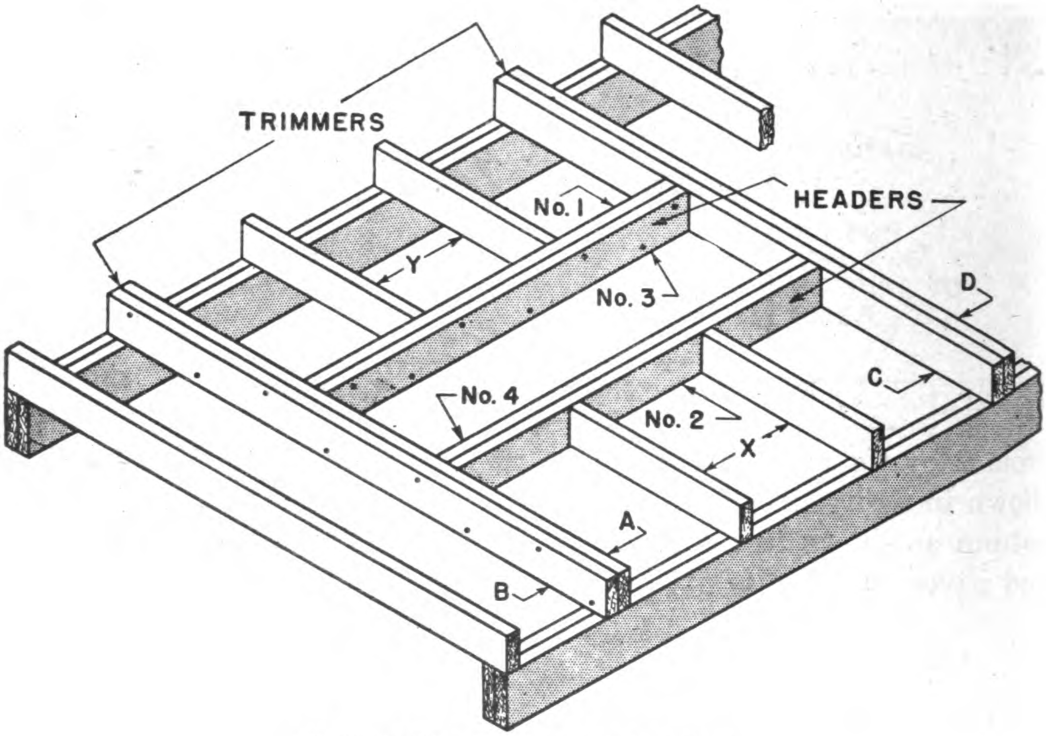


FIGURE 126.—Headers and trimmers.

"trimmers" and these must be made heavier than the ordinary joists. A piece called a "header" must be framed in between them to receive the ends of the short joists as shown in figure 126. To frame an opening of this type, first install joists *A* and *C* (fig. 126), then cut four pieces of timber that are the same size as the joists with the length corresponding to the distance between the joists *A* and *B* at the outside wall. Nail two of these pieces between the joists at the desired distances from the ends of the joist; these pieces are shown as headers Nos. 1 and 2 in figure 126. Install short joists *X* and *Y*, as shown. The nails should be 16- or 20-penny nails. By omitting headers Nos. 3 and 4 and joists *B* and *D* the short joists *X* and *Y* can be nailed in place through the header and the headers can be nailed through the joists *A* and *B* into its end. After the header and short joists have been securely nailed, headers Nos. 3 and 4 are nailed beside Nos. 1 and 2. Then joist *B* is placed beside joists *A* and joist *D* beside joist *C*, and all are nailed securely.

115. Walls.—Walls and partitions in which the structural elements are wood are classed as framed constructions. Their structural elements are usually closely spaced, slender, vertical members, called studs. These are arranged in a row with their ends bearing on a long horizontal member, called a bottom plate or sole plate, and their tops capped with another plate, called a top plate. The bearing strength of stud walls is determined by the strength of the studs.

116. Corner posts.—After the sill and first-floor joists are in place, the first floor is roughly covered to give a surface upon which

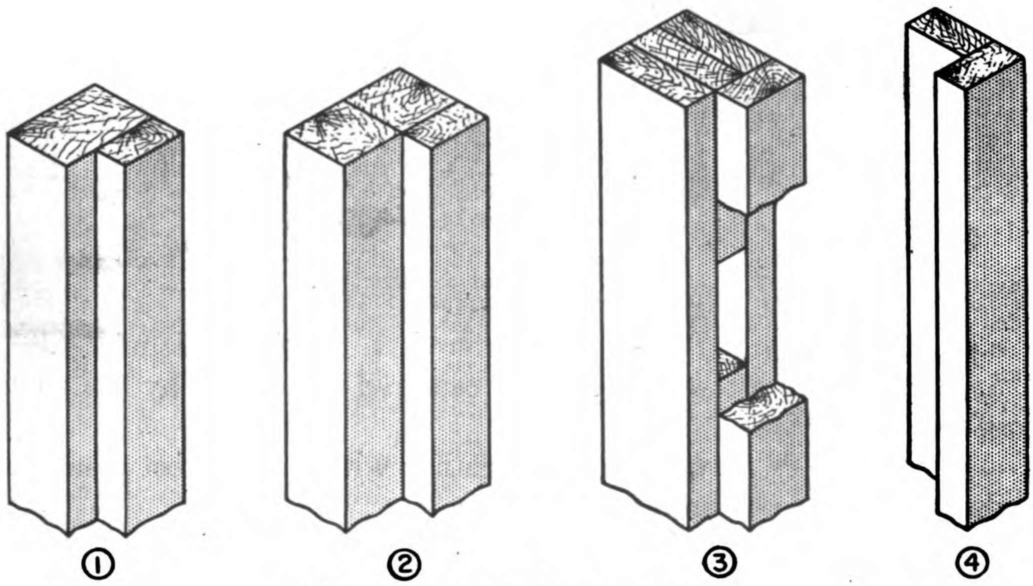


FIGURE 127.—Corner post construction.

to work. The corner posts are set up, plumbed, and braced temporarily. The corner posts may be made in several different ways. (See fig. 127.)

a. A corner post may consist of a 4 by 6 with a 2 by 4 nailed on the board side, flush with one edge. This type of corner is for a 4-inch wall. Where walls are thicker, heavier timber is used.

b. A 4 by 4 may be used with a 2 by 4 nailed to two of the adjoining sides.

c. Two 2 by 4's may be nailed together with blocks between and a 2 by 4 flush with one edge.

d. A 2 by 4 may be nailed to the edge of another 2 by 4, the edge of one flush with the side of the other. This type is used extensively in the theater of operations where no inside finish is required.

117. T-Posts.—Whenever a partition meets an outside wall, a stud wide enough to extend beyond the partition on both sides is used; this affords a solid nailing base for the inside wall finish. This type of stud is called a "T-post" and is made in several different ways. (See fig. 128.)

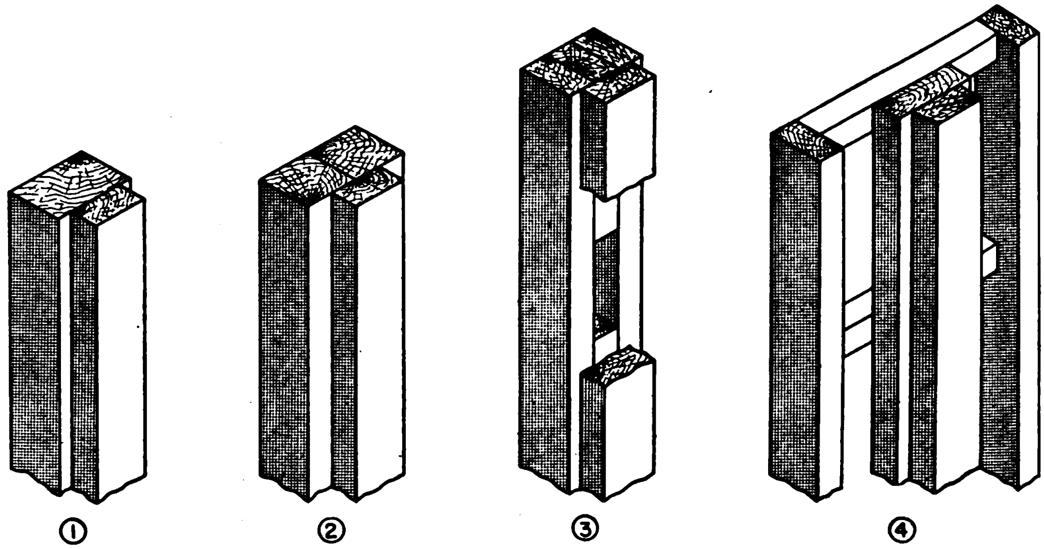


FIGURE 128.—T-post construction.

a. A 2 by 4 may be nailed and centered on the face side of a 4 by 6.

b. A 2 by 4 may be nailed and centered on two 4 by 4's nailed together.

c. Two 2 by 4's may be nailed together with a block between them and a 2 by 4 centered on the wide side.

d. A 2 by 4 may be nailed and centered on the face side of a 2 by 6, with horizontal bridging nailed behind them to give support and stiffness.

e. Where the partition is finished on one side only, the post consists of a simple stud, set in the outside wall, in line with the side of the partition wall, and finished as stud *A* in figure 129①. These posts are nailed in place along with the corner post. The exact position of the partition walls must be determined before the posts are placed. Where the walls are more than 4 inches thick, wider timber is used.

f. In special cases, for example where partition walls cross, a double T-post is used. This is made by using methods *a*, *b*, or *c*, above, and nailing another 2 by 4 to the opposite wide side, as shown in figure 129②, ③, and ④.

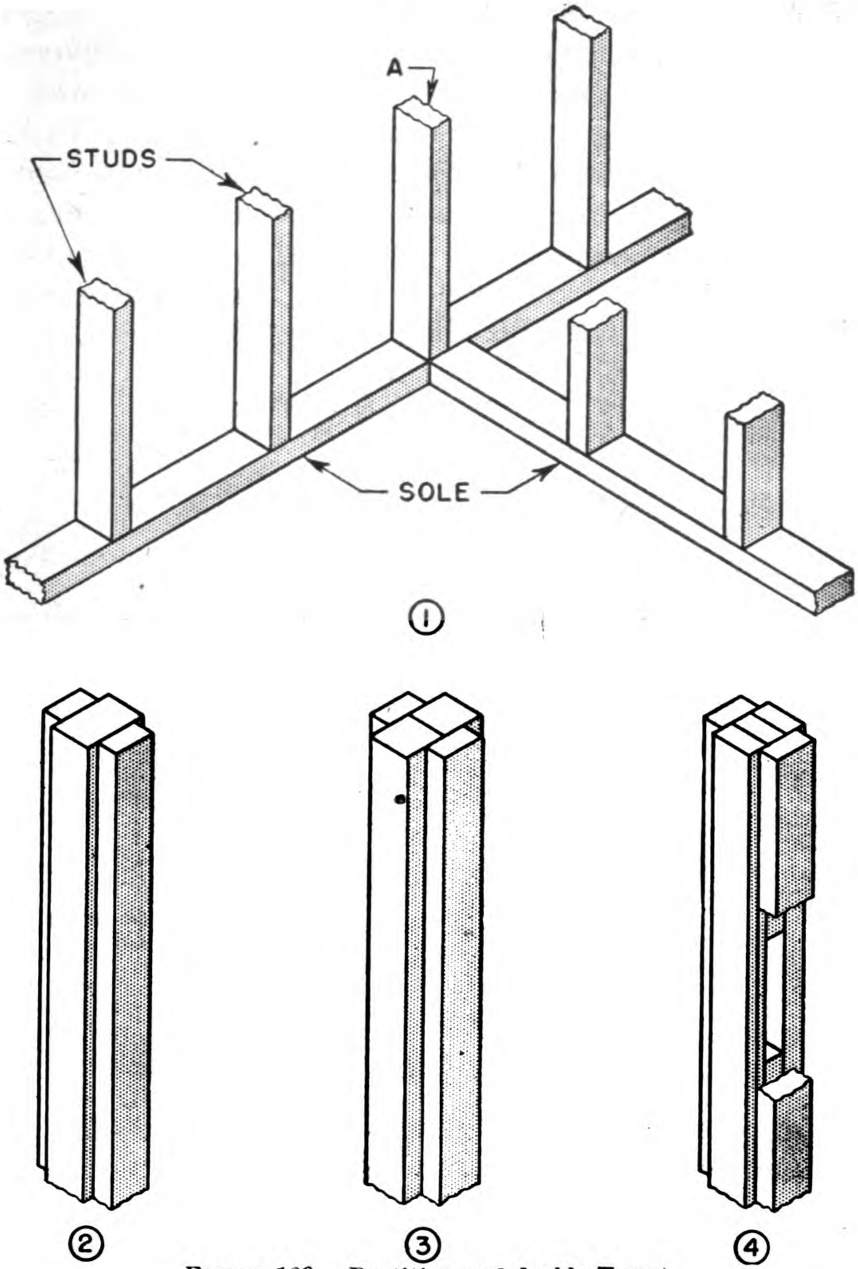


FIGURE 129.—Partition and double T-post.

118. Girts.—Girts are always the same width as the studs and are flush with the face of the stud, both outside and inside. Girts are used in hasty construction where the outside walls are covered with vertical siding. Studs are placed from 2 to 10 feet apart, with girts, spaced about 4 feet apart, running horizontally between them (fig. 4, app. III). The vertical siding acts in the same manner as do studs and helps to carry the weight of the roof. This type of construction is used extensively in the theater of operations.

119. Ledger plate.—In connecting joists to girders and sills where piers are used, a 2 by 4 is nailed to the face of the sill or girder, flush with the bottom edge; this is called a "ledger plate" (fig. 130). These pieces should be nailed securely with 20-penny nails about 12 inches apart. Where 2-by-4 or 2-by-8 joists are used it is better to use 2 by 2's to prevent the joists from splitting at the notch. When joists are 10 inches deep or deeper, 2 by 4's may be used without reducing the strength of the joists. If a notch is used joist ties may be used to overcome this loss of strength, as shown in figure 130. These ties are short 1 by 4 boards nailed across the joist; the ends of the boards are flush with the top and bottom edge of the joists.

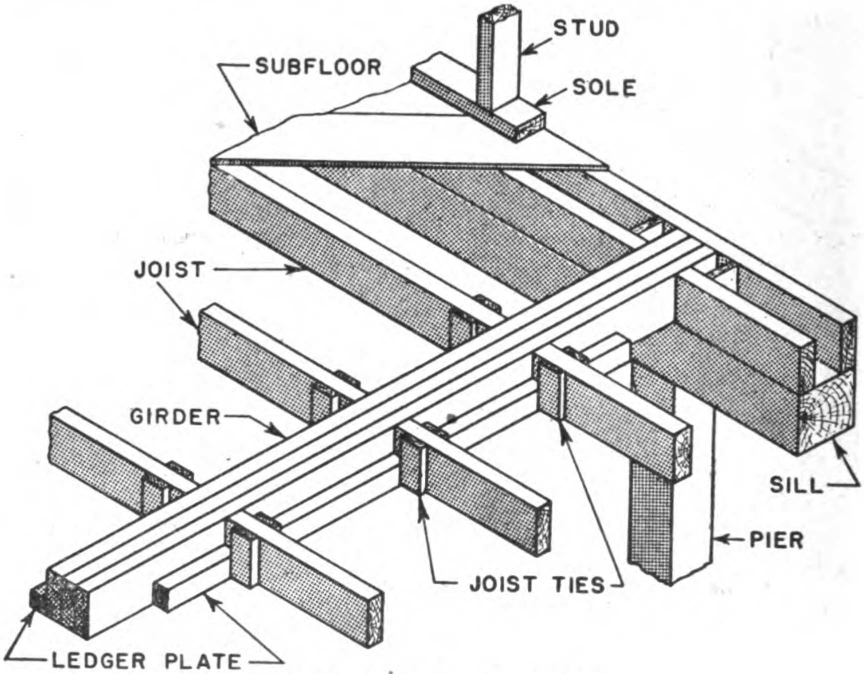


FIGURE 130.—Floor framing.

120. Top plate and sole plate.—*a. Top plate.*—The top plate serves two purposes, to tie the studding together at the top and form a finish for the walls and to furnish a support for the lower ends of the rafters (fig. 4, app. III). The top plate serves as a connecting link between the wall and the roof, just as the sills and girders are connecting links between the floors and the walls. The plate is made up of one or two pieces of timber of the same size as the studs. In cases where the studs at the end of the building extend to the rafters, no plate is used at the end of the building. When it is used on top of partition walls it is sometimes called the cap. Where the plate is doubled, the first plate or bottom section is nailed with 16- or 20-penny nails to the top of the corner posts and to the studs; the connection at the corner is made as shown in figure 131①. After the single plate is nailed securely and the corner braces are nailed into place, the top part of the plate is then nailed to the bottom section by means of

16- or 20-penny nails placed either over each stud, or spaced with two nails every 2 feet. The edges of the top section should be flush with the bottom section and the corner joints lapped as shown in figure 131②.

b. Sole plate.—All partition walls and outside walls are finished either with a 2 by 4 or with a piece of timber corresponding to the thickness of the wall; this timber is laid horizontally on the floor or joists. It carries the bottom end of the studs (fig. 4, app. III). This 2 by 4, or timber, is called the "sole" or "sole plate." The sole should be nailed with two 16- or 20-penny nails at each joist that it crosses.

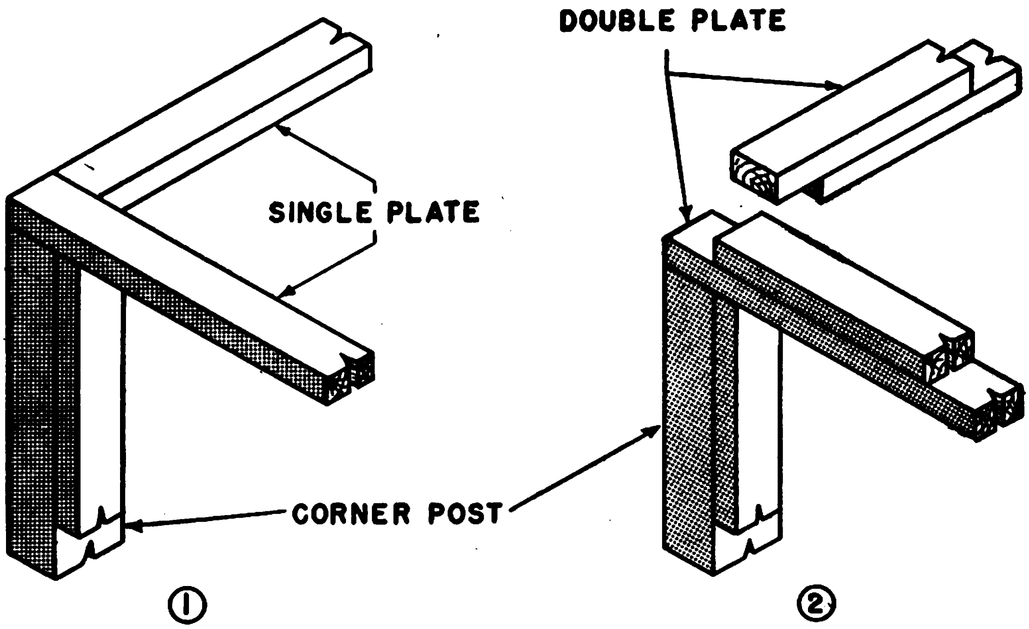


FIGURE 131.—Plate construction.

If it is laid lengthwise on top of a girder or joist, it should be nailed with two nails every 2 feet.

121. Braces.—Braces are used as permanent parts of the structure and serve to stiffen the walls, keep the corners square and plumb, and prevent the frame from being distorted by a lateral force, such as wind. These braces are placed wherever the sills, girts, or plates make an angle with a corner post or with a T-post in the outside wall. The brace extends from the sill or sole plate to the top of the post, forming an angle of approximately 60° with the sill or sole and an angle of 30° with the post. After the posts have been plumbed, the braces should be nailed with three 10-penny nails or two 16- or 20-penny nails. The material used for these braces should be the same size as the stud. In some hasty construction the braces are not placed in the stud wall but are nailed to the studs on the inside of the building. This method is used in warehouses and other types of buildings where no inside finish is required on inside walls, as it saves much time and labor.

122. Studs.—*a.* After the sills, posts, plates and braces are in place, the studs are placed and nailed with two 16- or 20-penny nails through the top plate. Before the studs are set in place the window and door openings are laid out. Then the remaining or intermediate studs are laid out on the sills or soles by measuring from one corner the distances the studs are to be set apart. Studs are set from 1 to 12 feet apart, depending upon the type of building and the type of outside and inside finish. Where vertical siding is used, studs are set wider apart since the horizontal girts between them afford nailing surface.

b. When it is desirable to double the post of the door opening, first place the outside studs into position and nail them securely. Then cut short studs, or *filler studs*, the size of the opening and nail these to the

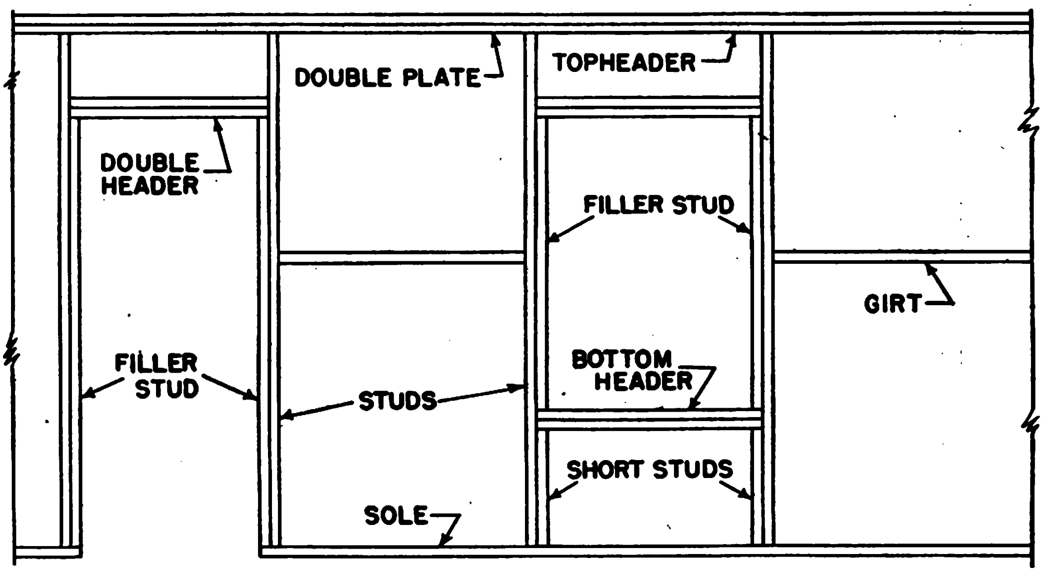


FIGURE 132.—Door and window framing.

inside face of the outside studs as shown in figure 132. In making a window opening, a bottom header must be framed; this header is either single or double. When it is doubled, the bottom piece is nailed to the opening studs at the proper height, and the top piece of the bottom header is nailed into place flush with the bottom section. The door header is framed as shown in figure 132. The filler stud rests on the sole at the bottom.

123. Methods of plumbing and straightening walls.—*a.* After the corner post, T-post, and intermediate wall studs have been nailed to the plates or girts, the walls must be plumbed and straightened so that the permanent braces and rafters may be installed. This is done by using a level or plumb bob and a chalk line.

b. Plumb one corner post with the level or plumb bob and nail temporary braces to it to hold the post in place (fig. 133). Repeat this procedure for all corner posts. Fasten a chalk line to the outside of one post at the top and stretch the line to the post at the opposite end of the building, fastening the line to this post in the same manner as for the first post. Place a small ¾-inch block under each end of line as shown in figure 133 to give clearance. Place temporary braces at

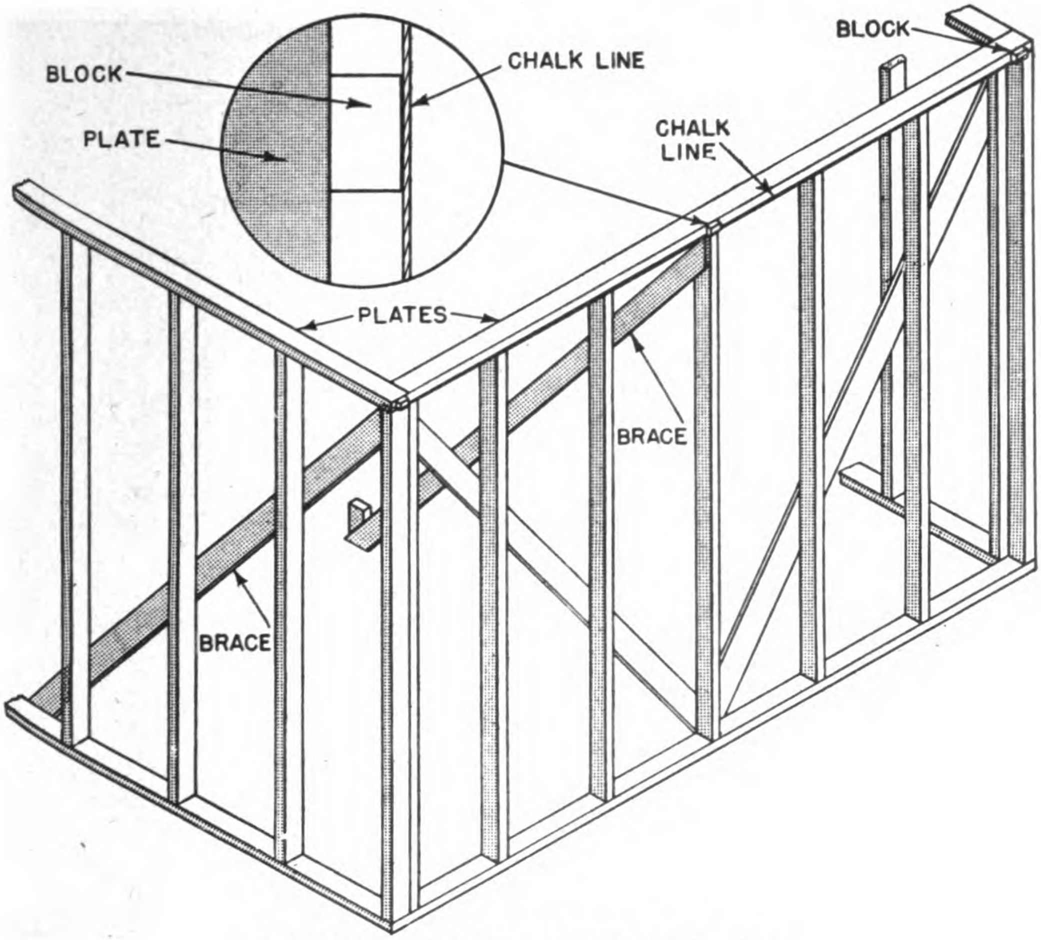


FIGURE 133.—Method of straightening walls.

intervals small enough to hold the wall straight. When the wall is far enough away from the line to permit a ¾-inch block barely to slide between the line and the plate, the brace is nailed (fig. 133). This procedure is carried out for the entire perimeter of the building. Inside partition walls should be straightened in the same manner.

c. To plumb a corner with a plumb bob, first attached to the bob a string long enough to extend to or below the bottom of the post. Lay a rule on top of the post so that 2 inches of the rule extends over the post on the side to be plumbed, then hang the bob-line over the rule so that the line is 2 inches from the post and extends to the bottom of it (fig. 134). With another rule, measure the distance from the post to the center of the line at the bottom of the post; if it does not measure 2 inches, the post is not plumb. Move the post inward or outward until the distance from the post to the center of the line is exactly 2 inches, then nail the temporary brace in place. Repeat this procedure for the other outside face of the post. The post is then plumb. This process is carried out for the remaining corner posts of the building. If a plumb bob or level is not available, a rock, a half-brick, or some small piece of metal may be used instead.

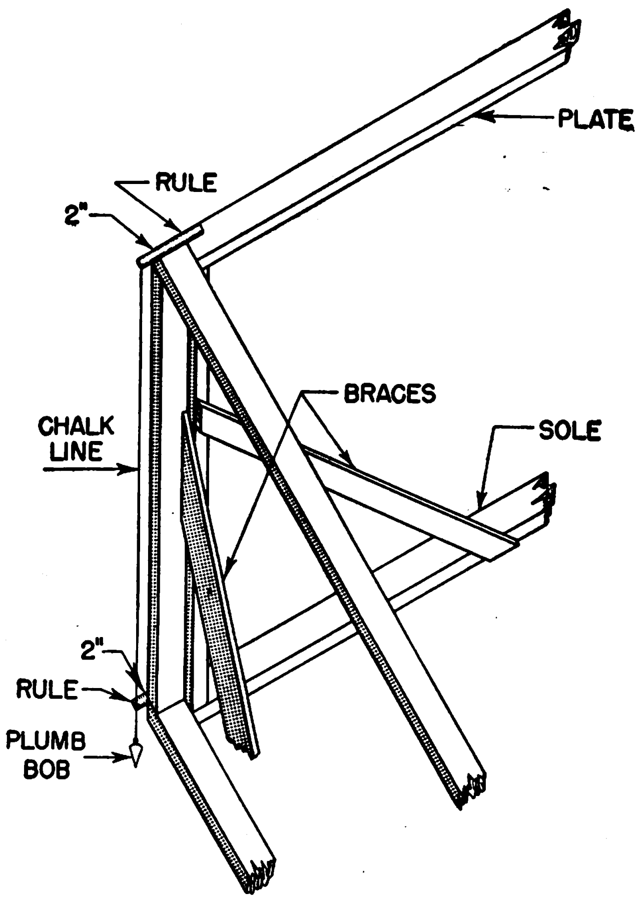


FIGURE 134.—Method of plumbing posts.

124. Partitions.—Partition walls are any walls that divide the inside space of a building. These walls in most cases are framed as part of the building. In cases where floors are to be installed after the outside of the building is completed, the partition walls are left unframed. There are two types of partition walls, the bearing and nonbearing types. The bearing type supports ceiling joists. The nonbearing type supports only itself. This type may be put in at any time after the other framework is installed. Only one cap or plate is used. A sole plate should be used in every case as it helps distribute the load over a larger area. Partition walls are framed in the same manner as outside walls and door openings are framed as outside openings. Where there are corners or where one partition wall joins another, corner posts or T-posts are used as in the outside walls; these posts provide nailing surfaces for the inside wall finish. Partition

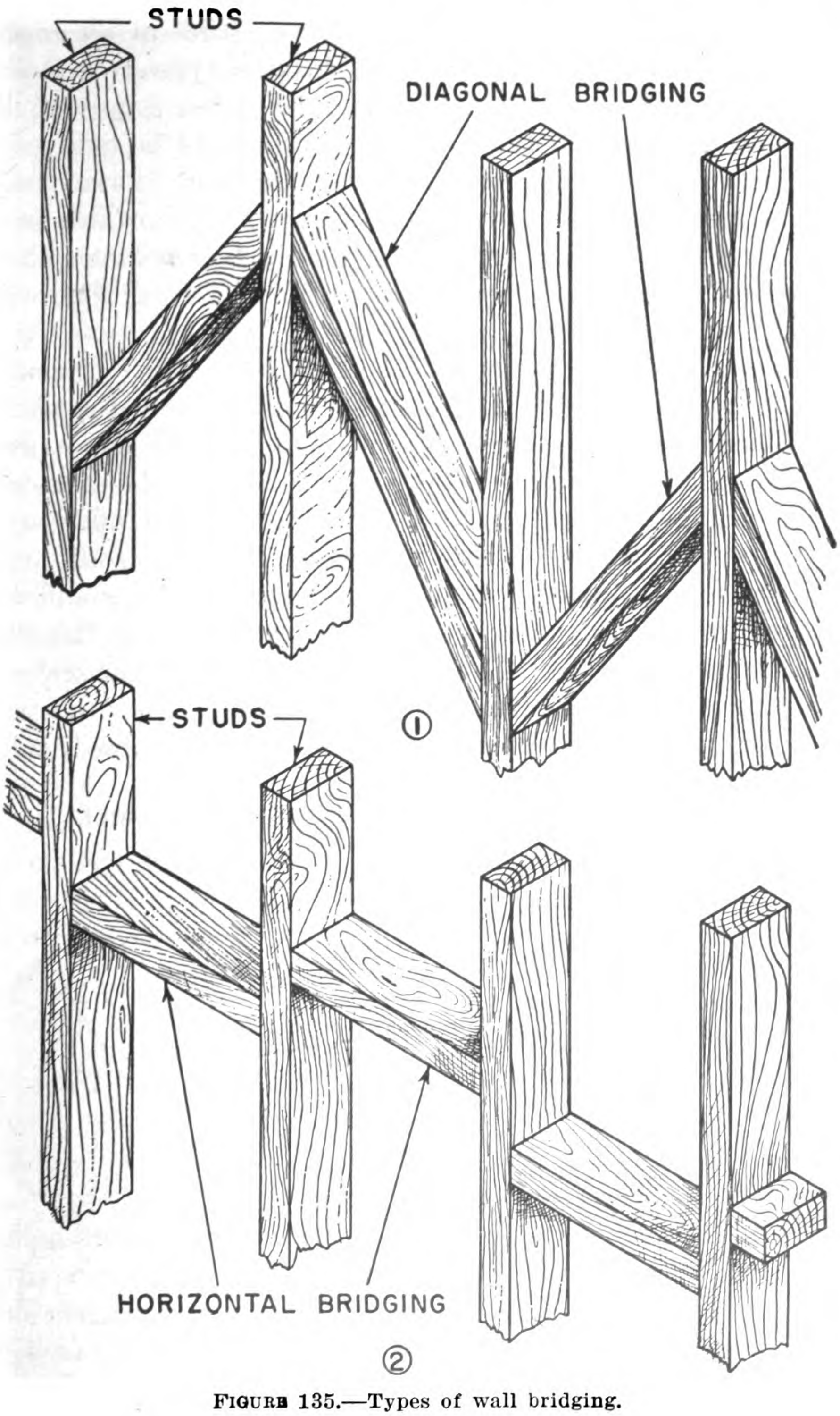


FIGURE 135.—Types of wall bridging.

walls in the theater of operations one-story building may or may not extend to the roof. The top of the studs has a plate when the wall does not extend to the roof, but when the wall extends to the roof the studs are joined to the rafters.

125. Bridging of walls.—Frame walls are bridged, in most cases, to make them more sturdy. There are two methods of bridging:

a. Diagonal bridging is nailed between the studs at an angle (fig. 135①). It is more effective than the horizontal type since it forms a continuous truss and tends to keep the walls from sagging. Whenever possible, both inside and outside walls should be bridged alike.

b. Horizontal bridging is nailed between the studs horizontally and halfway between the sole and the plate (fig. 135②). This bridging is cut to lengths which correspond to the distance between the studs at the bottom. Such bridging not only stiffens the wall but will also help straighten studs.

126. Roofs.—The primary object of a roof in any climate is to keep out the rain and the cold. The roof must be sloped so as to shed water. Where heavy snows fall covering the roofs for long periods of time, roofs must be constructed more rigidly to bear the extra weight. They must also be strong enough to withstand high winds.

127. Types of roofs.—There are many kinds of roofs, varying from the flat roof to the complicated combination of hips and valleys. The most common roofs used by the Army are the near-flat, shed or lean-to, and pitch or gable. The hip or valley roof is very seldom used since it is complicated and requires much time and labor to construct. The near-flat roof is used where large buildings are framed under one

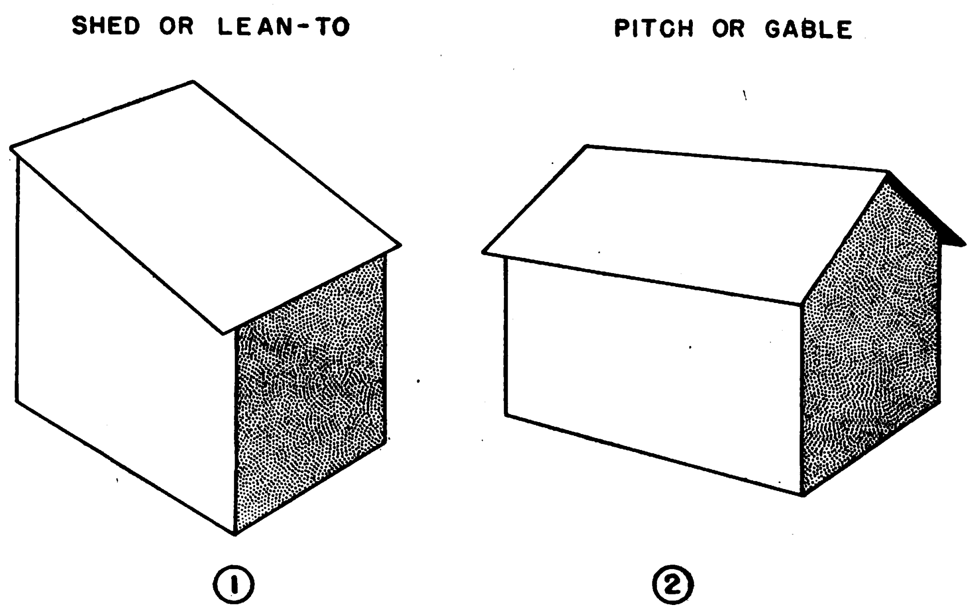


FIGURE 136.—Types of roofs.

roof; it is supported by means of trusses and has a slight pitch or slope. The shed or lean-to roof is for hasty or temporary construction, when sheds or additions to buildings are built; the pitch is in one direction only (fig. 136①). The roof is held up by the walls or posts on the four sides; one wall or the posts of one side are at a higher level than those opposite. The position in which the roof is supported enables the rain water to drain freely from it in one direction. The pitch or gable roof is the next simplest roof to construct. It consists of a sloping surface on each side of the center line of the building which forms a ridge at the middle. This form of roof (fig. 136②) is the one most commonly used by the Army, since it is simple in design and economical, and is a kind of roof that may be used on any type of structure.

128. Pitch of roofs.—The slope of the roof surface is called the "pitch" of the roof. The pitch of a roof is the angle which the roof surface makes with a horizontal plane. The surface may vary from absolutely flat to a steep slope. The usual way to express roof pitch is by means of numbers, for example: 8 and 12, 8 being the rise and 12 the run. On blueprints it is shown as in figure 137①. The following terms are used in connection with roofs:

a. Span.—The span of any roof is the shortest distance between the two opposite raft seats. Stated in another way, it is the measurement between the outside plates measured at right angles to the direction of the ridge of the building (fig. 137①).

b. Total rise.—The total rise is the vertical distance from the plate to the top of the ridge (fig. 137①).

c. Total run.—The term "total run" always refers to the level distance over which any rafter passes. For the ordinary rafter this would be one-half the span distance (fig. 137①).

d. Unit of run.—The unit of measurement, 1 foot or 12 inches, is the same for the roof as for any other part of the building; by the use of this common unit of measurement, the framing square is employed in laying out large roofs (fig. 137① and ②).

e. Rise in inches.—The rise in inches is the number of inches that a roof rises for every foot of run.

f. Pitch.—Pitch is the term used to describe the amount of slope of the roof.

g. Cut of roof.—The cut of a roof is the rise in inches and the unit of run (12 inches). See figure 137②.

h. Line length.—The term "line length" as applied to roof framing is the hypotenuse of a triangle whose base is the total run and whose altitude is the total rise (fig. 137②).

i. Plumb and level lines.—These terms have reference to the direction of a line on a rafter and not to any particular rafter cut. Any

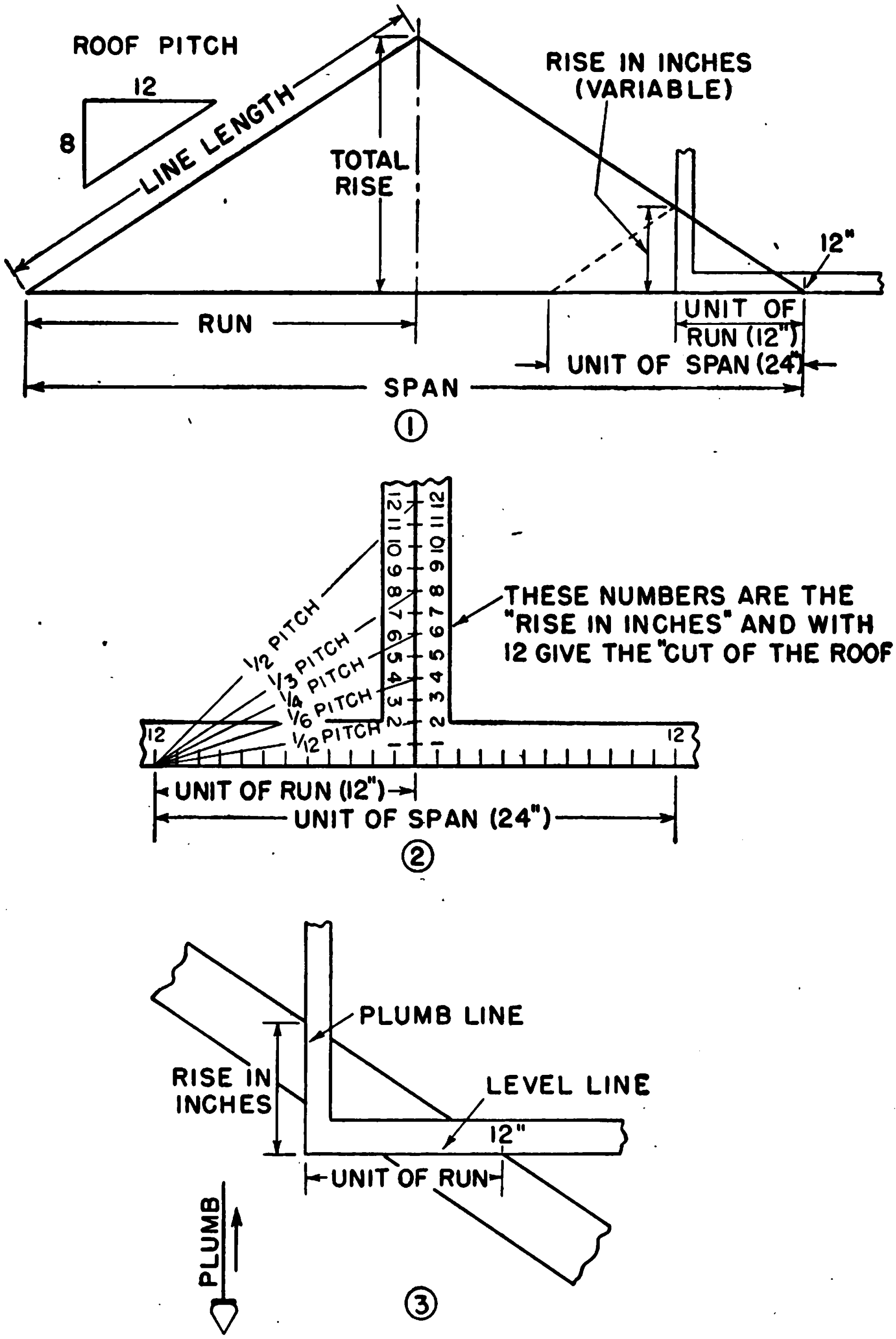


FIGURE 137.—Rafter lay-out terms.

line that is vertical when the rafter is in its proper position is called a plumb line. Any line that is level when the rafter is in its proper position is called a level line. (See fig. 137③.)

129. Rafters.—*a. General.*—In all roofs, the pieces which make up the main body of the framework are called the rafters. They do for the roof what the joists do for the floor or the studs for the wall. The rafters are inclined members spaced from 16 to 48 inches apart which rest at the bottom on the plate and are fastened at the top in various ways according to the form of the roof. The plate forms the connecting link between the wall and the roof and is really a part of both. The size of the rafters varies, depending upon the length and the distance at which they are spaced. The connection between the rafter and the wall is the same in all types of roofs. The rafters are not framed into the plate but are simply nailed to it, some being cut to fit the plate, others (in hasty construction) merely laid on top of the plate and nailed in place. The rafters may or

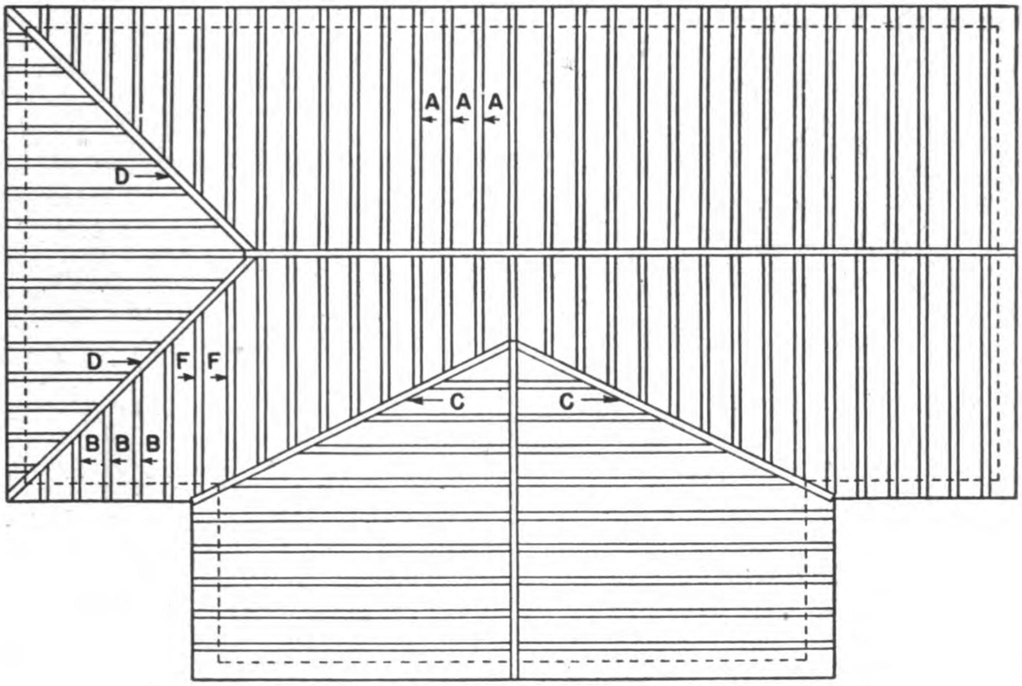


FIGURE 138.—Roof plan showing types of rafters.

may not extend out a short distance from the wall to form the eaves and to protect the sides of the building.

b. Types.—There are five different kinds of rafters used in framing roofs. Most roofs are framed with only the simpler forms. In figure 138 all kinds of rafters are illustrated. *AAA* are the common rafters which run from the plate to the ridge in the center of the building and are not connected or crossed by any other rafter. *BBB* are jack rafters and are shorter than the common rafters which do not extend from the plate to the ridge but are connected at one end to the hip rafter. *CC* are the valley rafters, which are needed at every corner between the main building and a projection. *DD* are hip rafters. *FF* are the cripple rafters. They are so called because they have no foot, that is, no bearing on the wall plate. In the theater of operations, most building roofs are framed with the common rafters, although in special types of buildings the others requiring more time and labor may be used. The common rafter is the only type discussed here.

c. Terms.—Terms commonly used in connection with rafters are as follows (fig. 139):

(1) *Ridge cut* is the cut of a rafter that fits against the opposite rafter at the ridge.

(2) *Seat cut* is the notch which is cut in the rafter to fit on the plate.

(3) *Tail cut* is the cut on the lower end of the rafter.

(4) *Overhang* is that part of the rafter that projects beyond the side of the building.

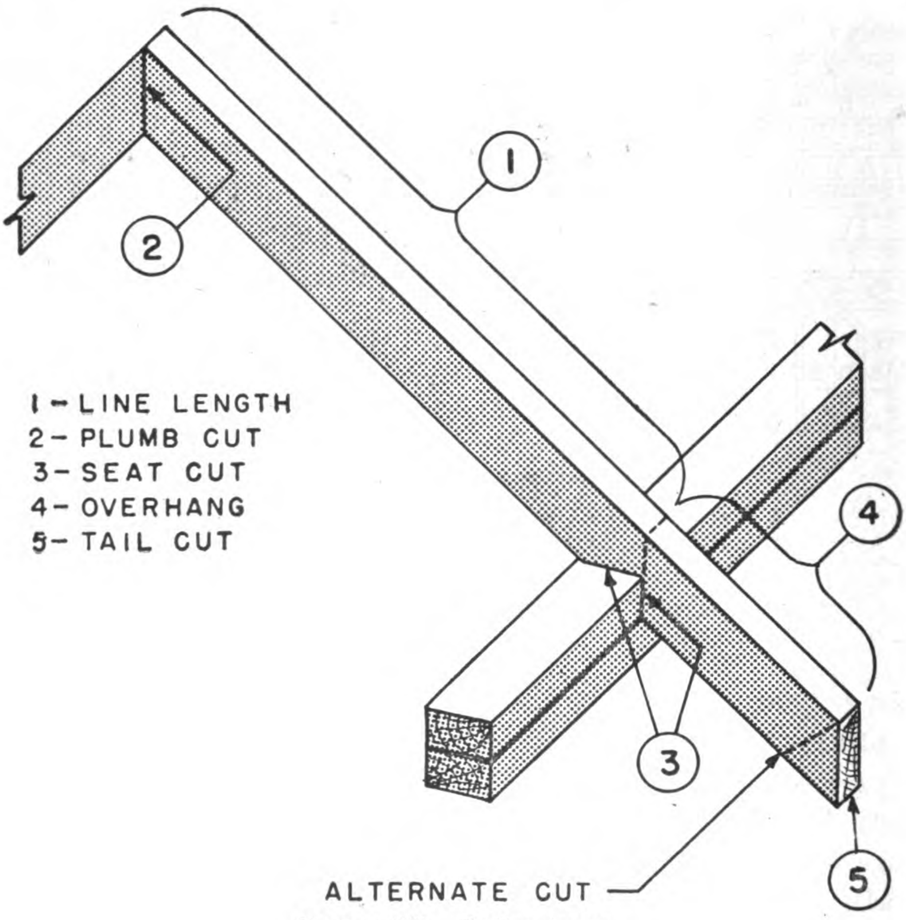


FIGURE 139.—Rafter terms.

130. Methods of laying out rafters.—Rafters must be laid out and cut with slope, length, and overhang exactly right so that they will fit when placed in the position they are to occupy in the finished roof.

a. Scale or measurement methods.—The carpenter first determines the length of the rafter and the length of the piece of lumber from which the rafter may be cut. If he is working from a set of plans which includes a roof plan, the rafter lengths and the width of the building may be obtained from this plan. If no plans are available, the width of the building may be measured with a tape.

(1) To determine the rafter length, first find one-half of the distance between the outside plates. This distance is the horizontal distance which the rafter will cover. The amount of rise per foot has yet to be considered. If the building to be roofed is 20 feet wide,

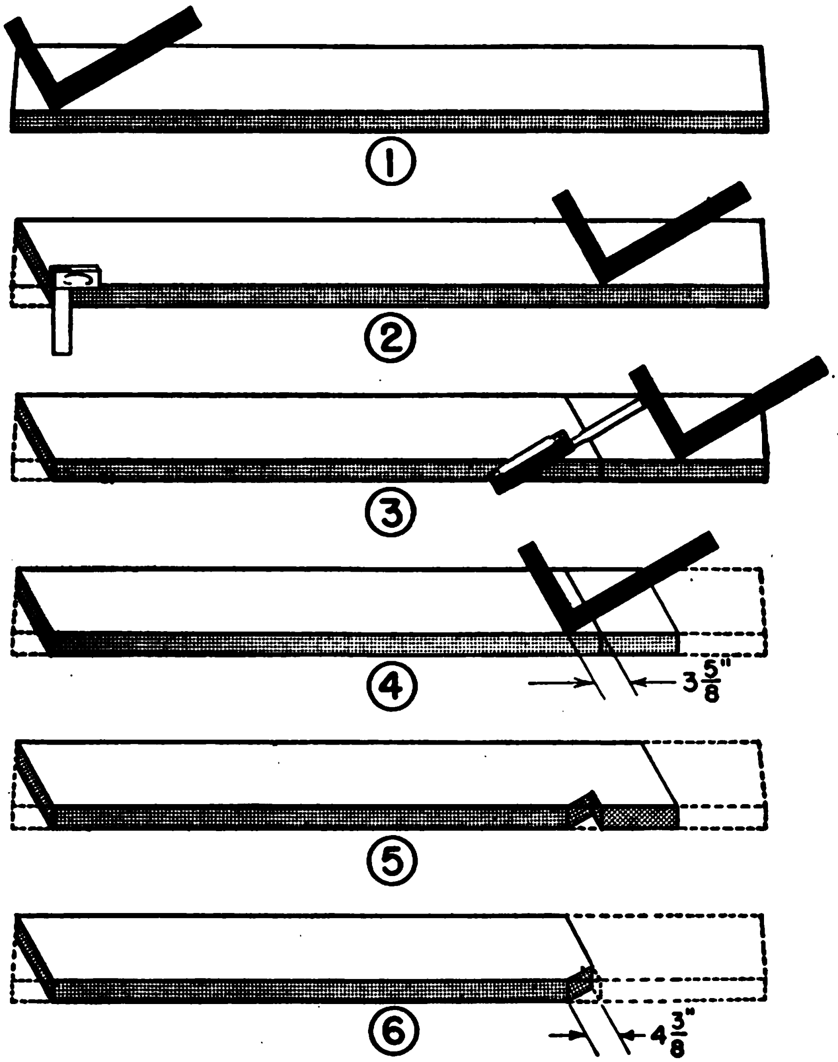


FIGURE 140.—Rafter lay-out.

half the span will be 10 feet. For example the rise per foot is to be 8 inches. To determine the approximate over-all length of rafter, measure on the steel carpenter square the distance between 8 on the tongue and 12 on the blade, because 8 is the rise and 12 is the unit of run. This distance is $14\frac{5}{12}$ inches, and represents the line length of a rafter with a total run of 1 foot and a rise of 8 inches. Since the run of the rafter is 10 feet, multiply 10 by the line length for 1 foot. The answer is $144\frac{2}{12}$ inches, or 12 feet and $\frac{2}{12}$ inches. The amount of overhang must be added if an overhang is to be used; it is often 1 foot. This makes a total of 13 feet for the length of the rafter, but 13 feet is an odd length for timber so 14-foot timber is used.

(2) After the length has been determined, the timber is laid on saw horses, sometimes called "saw benches," with the crown or bow (if any) as the top side of the rafter. If possible, select a straight piece for the pattern rafter. If a straight piece is not available, have the crown toward the person laying off the rafter. Hold the square with the tongue in the right hand, the blade in the left, the heel away from the body, and place the square as near the upper end of the rafter as possible. In this case, the figures 8 on the tongue and 12 of the blade are placed along the edge of timber which is to be the top edge of rafter as shown in figure 140①. Mark along the tongue edge of square, which will be the plumb cut at the ridge. Since the length of rafter is known to be 12 feet, measure that distance from the top of the plumb cut and mark it on the timber. Hold the square in the same manner with the 8 mark of the tongue directly over the 12-foot mark. Mark along the tongue of the square to give the plumb cut for the seat (fig. 140②). Next measure off, perpendicular to this mark, the length of overhang along the timber and make a plumb-cut mark in the same manner, keeping the square on the same edge of the timber (fig. 140③). This will be the tail cut of the rafter; often the tail cut is made square across the timber.

(3) The level cut or width of the seat is the width of the plate, measured perpendicular to the plumb cut, as shown in figure 140④. Using the try square, square lines down on the sides from all level and plumb-cut lines (fig. 140④). Now the rafter is ready to be cut.

b. Step-off method.—If a building is 20 feet 8 inches wide, the run of the rafter would be 10 feet 4 inches, or half the span. Instead of using the above method, the rafter length may be determined by *stepping it off* by successive steps with the square as shown in figure 141. Stake the same number of steps as there are feet in the run, which leaves 4 inches over a foot. This 4 inches is taken care of in the same manner as the full foot run, that is, with the square at the last step position, make a mark on the rafters at the 4-inch mark on the blade, then move the square along the rafter until the tongue rests at the 4-inch mark. With the square held for the same cut as before, make a mark along the tongue. This is the line length of the rafter. The seat-cut and hangover are made as described in *a* above. When laying off rafters by any method, be sure to recheck the work carefully. When two rafters have been cut, it is best to put them in place to see if they fit. Minor adjustments may be made at this time without serious damage or waste of material.

c. Table method, using rafter table on framing square.—The framing square may have one or two types of rafter tables on the blade. Figures 142 and 143 are illustrations of the two types. One type gives both the line length of any pitch or rafter per foot of run and the line length of any hip or valley rafter per foot of run. The difference in length of the jack rafter spaced 16 or 24 inches (on center) is also shown in the table. Where the jack rafter, hip, or valley rafter requires side cuts, the cut is given in the table. The other

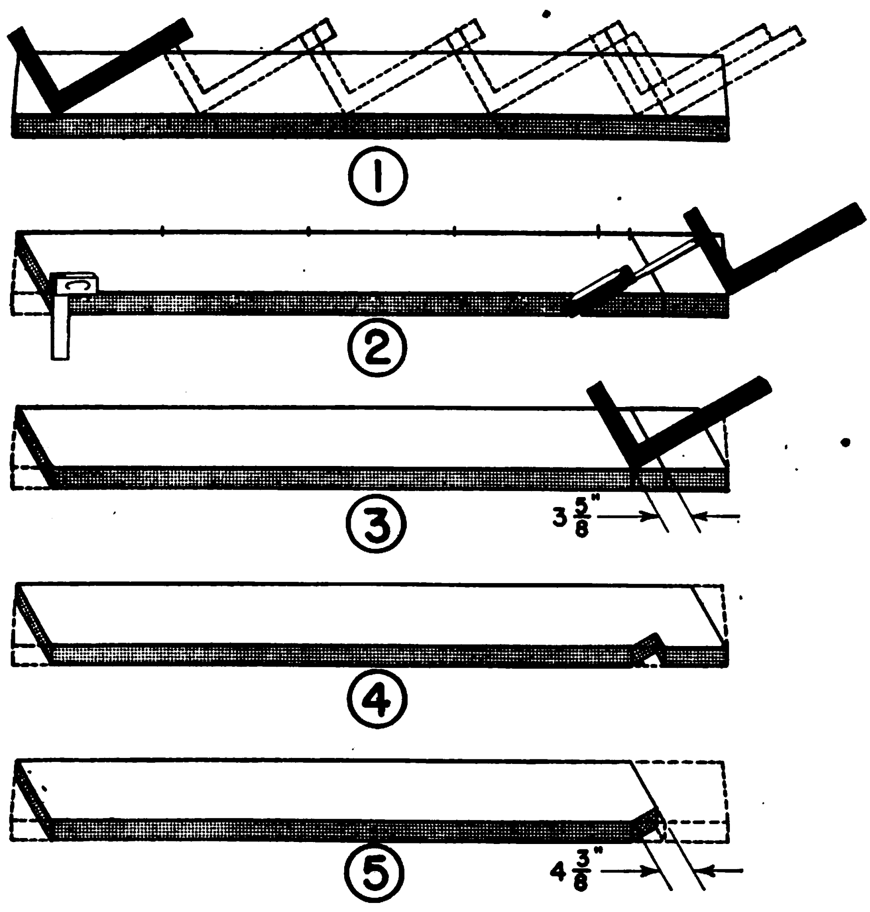


FIGURE 141.—Rafter lay-out.

table gives the actual length of rafter for a given pitch and span.

(1) The first type of table (fig. 142) appears on the face of the blade. It is used to determine the length of the common, valley, hip, and jack rafters, and the angles at which they must be cut to fit at the ridge and plate. To use the table, the carpenter first must become familiar with it and know what each figure represents. Study this table in figure 142. The row of figures in the first line represents the length of common rafters per foot of run, as the title indicates

at the left-hand end of the blade. Each set of figures under each inch division mark represents the length of rafter per foot of run with a rise corresponding to the number of inches over the number. For example, under the 16-inch mark appears the number 20.00 inches. This number equals the length of a rafter with a run of 12 inches and a rise of 16 inches, or, under the 13-inch mark appears the number 17.69 inches which is the rafter length for a 12-inch run and a 13-inch rise. The other five lines of figures in the table will not be discussed as they are seldom used in the theater of operations.

(2) To use the table for laying out rafters, the width of the building must first be known. Suppose the building is 20 feet 8 inches wide and the rise of the rafters is to be 8 inches per foot of run. The total run of the rafter will be 10 feet 4 inches. Look in the first line of figures; under the 8-inch mark appears the number 14.42, which is the length in inches of a rafter with a run of 1 foot and a rise of 8 inches. To find the line length of a rafter with a total run of 10 feet 4 inches, multiply 14.42 inches by $10\frac{1}{3}$ and divide by 12 so as to get the answer in feet. 14.42 inches by $10\frac{1}{3}=149.007$ inches. $149.007 \div 12 = 12\frac{5}{12}$. Therefore 12 feet 5 inches is the line length of the rafter. The remaining procedure for laying out the rafters after the length has been determined is described in *a* above.

(3) (*a*) The second type of rafter table appears on the back of the blade of some squares. This shows the run rise and the pitch of rafters of the seven most common pitches of roof (fig. 143). The figures are based on the length of the horizontal measurement of the building from the center to the outside. The rafter table and the outside edge of the back of the square, both the body and tongue, are in twelfths. The inch marks may represent inches or feet, and the twelfth marks may represent twelfths of an inch or twelfths of a foot. The rafter table is used in connection with the marks and figures on the outside edge of the square. At the left end of the table are figures representing the *run*, the *rise*, and the *pitch*. In the first column, the figures are all 12. These may be used as 12 inches or 12 feet as they represent the *run* of 12. The second column of figures represents various rises. The third column of figures, in fractions, represents the various *pitches*.

(*b*) These three columns of figures show that a rafter with a run of 12 and a rise of 4 has one-sixth pitch, 12 and 6 has one-fourth pitch, and 12 and 12 has one-half pitch. To use this scale for a roof with one-sixth pitch (or the rise of one-sixth the width of the building) and a run of 12 feet, find $\frac{1}{6}$ in the table, follow the same line of figures to the right until directly beneath the figure 12, which is the run of the rafter. Under the figure 12, appear the numbers 12, 7, 10,

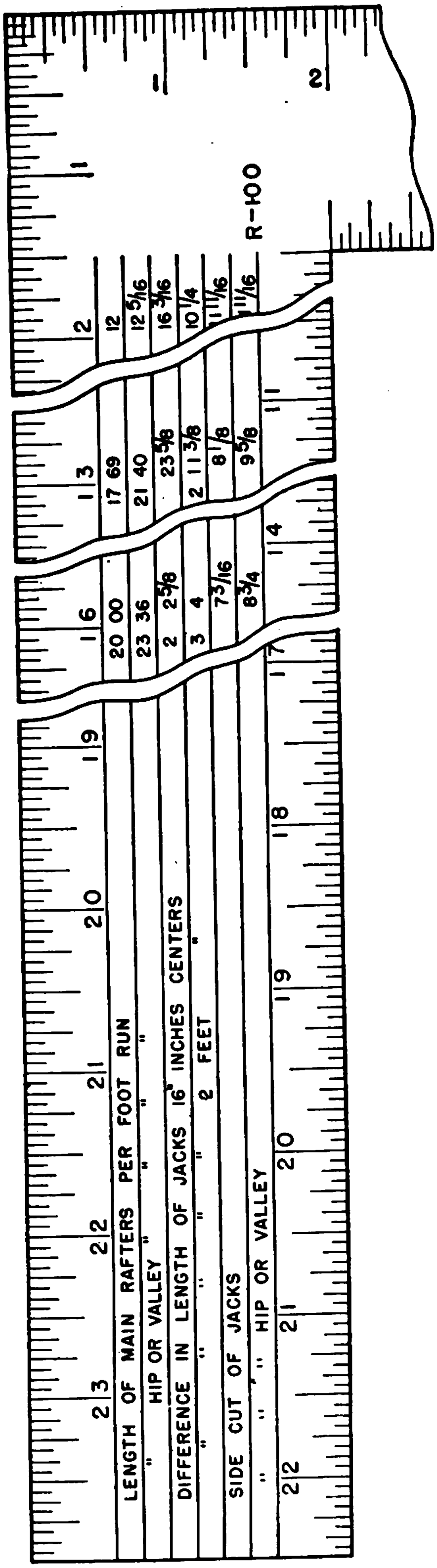


FIGURE 142.—Rafter table.

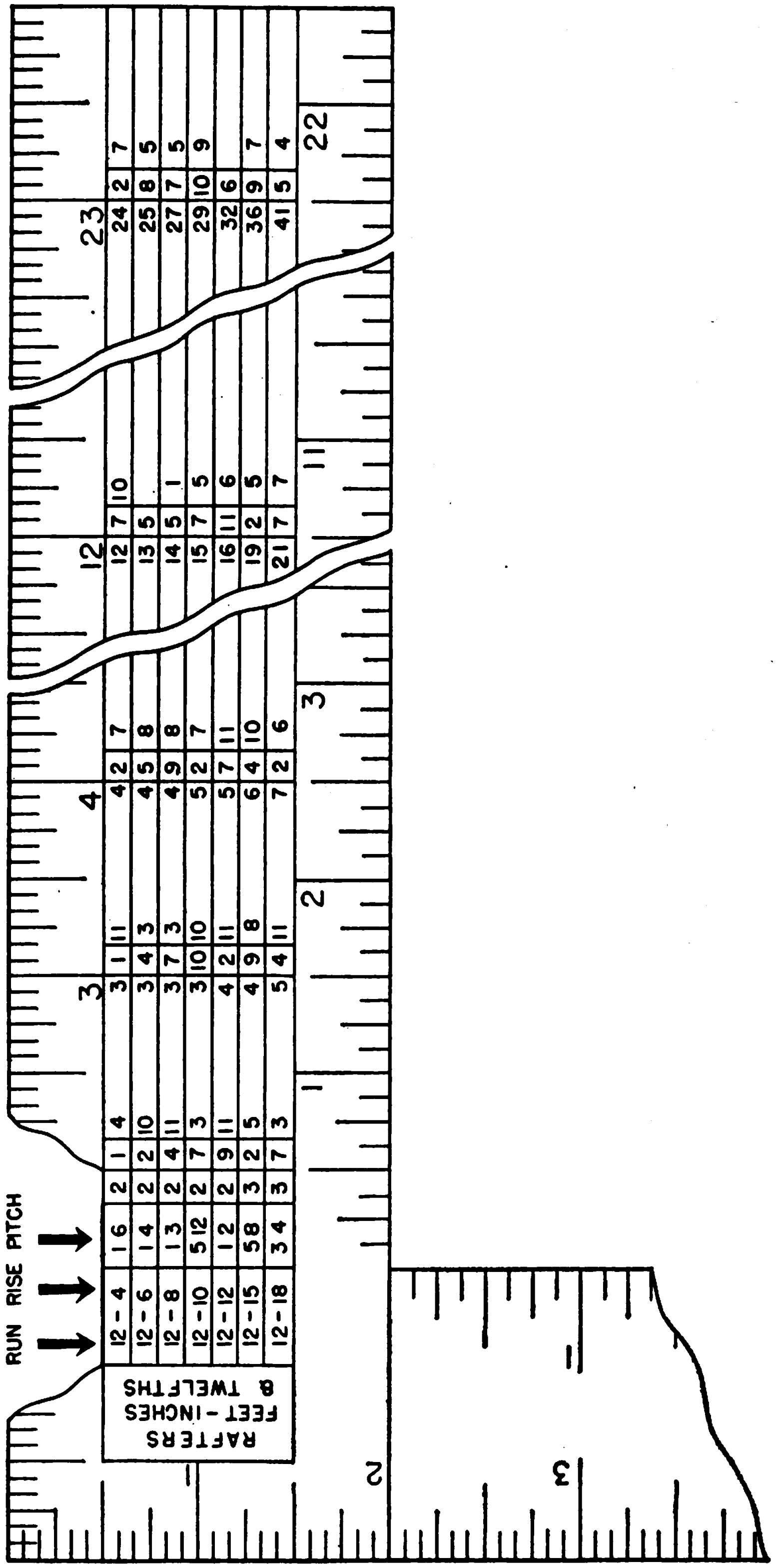


FIGURE 143.—Rafter table.

which is the rafter length required, and represents 12 feet, 7 inches, and 10/12 of an inch. They are written as follows: 12 feet, 7 10/12 inches. For a pitch of one-half (or a rise of one-half the width of the building) and run of 12 feet, the rafter length is 16, 11, 6, or 16 feet, 11 6/12 inches.

(*c*) If the run is over 23 feet, the table is used as follows: Using a run of 27 feet, find the length for a run of 23 feet, then find the length of 4 feet and add the two. The run for 23 feet with a pitch of one-fourth is 25 feet, 8 5/12 inches. For 4 feet, the run is 4 feet, 5 3/4 inches. The total run for 27 feet is 30 feet, 2 1/12 inches. When the run is in inches, the rafter table reads inches and twelfths instead of feet and inches. For example, if the pitch is one-half and the run is 12 feet, 4 inches, add the rafter length of 12-foot run to that of a rafter length of 4-inch run, as follows: For a run of 12 feet and one-half pitch, the length is 16 feet, 11 6/12 inches. For a run of 4 inches and one-half pitch, the length is 5, 7, 11. In this case the 5 is inches, the 7 is twelfths, the 11 is 11/12 of 1/12 which is nearly 1/12. Add it to the 7 to make it 8, making a total of 5 8/12 inches, then add the two lengths together which totals 17 feet, 5 2/12 inches. The lengths that are given in the table are the line lengths; the overhang must be added. After the length of the rafter has been found, the rafter is laid out as explained in *a* above.

(*d*) When the roof has an overhang (fig. 140), the rafter is usually cut square to save time. When the roof has no overhang, the rafter is cut as shown in figure 4, appendix III. Here the cut is plumb, but no notch is cut in the rafter for a seat. The level cut is made long enough to extend across the plate and the wall sheathing. This type of rafter saves material, although little protection is given to the side wall.

131. Method of erecting rafters.—*a*. Rafters will seldom be put up singly; they are usually assembled into trusses, as shown in figure 4, appendix III. Two rafters are connected at the top by using a collar tie well nailed into both rafters. Before any ties or chords are nailed, the rafters should be spread at the lower end to correspond to the width of the building. This may be accomplished by a template, or by measuring the distance between the seat cuts with a tape. A chord of 1 by 6's is nailed across the rafters at the seat cut to tie them together. This chord forms a truss with the two rafters. A vertical member of 1 by 6 is nailed to the rafter joint and this extends to the chord at midpoint, thus tying the rafter to the chord. If no additional bracing is required, the pair of rafters is ready to be set in place on the plates. If additional bracing is required, a knee brace is nailed to the chord. The knee brace forms an angle of 45° with the wall stud. Another brace is nailed to the rafter at its midpoint; this extends to the chord at its midpoint (see fig. 144). To avoid hindrance in erection, the knee braces may be omitted until the rafter truss is set in place.

b. After the rafters have been assembled into trusses, they must be placed on the building. In most cases, the first set of rafters will be assembled in the end section of the building. The rafter trusses are raised by hand into position and nailed to the plate with 16- or

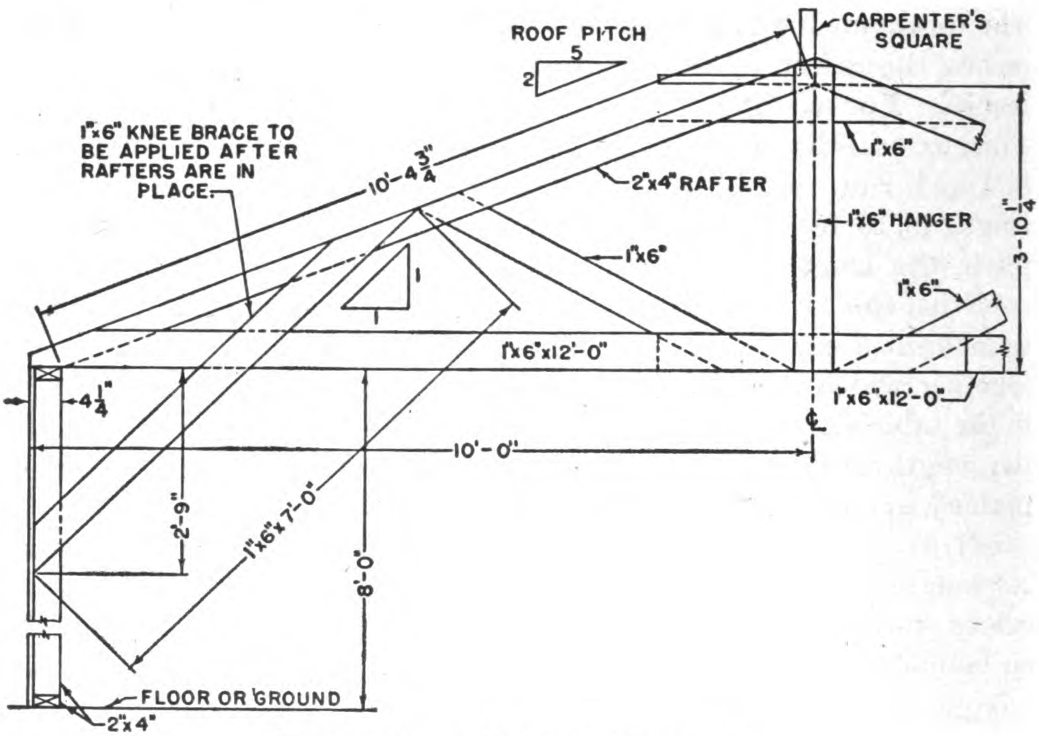


FIGURE 144.—Rafter construction detail.

20-penny nails. These trusses are temporarily braced to the end section of the building, until the sheathing is applied. Temporary workbenches may be built for the workers to stand on while erecting these trusses as this will save time. The knee braces may be applied before or after the sheathing is applied. Knee braces are not used on every rafter truss unless climatic conditions require them.

132. Purlins.—Purlins are used in roof construction where corrugated sheet metal is used, or to support the sheathing where roofs are framed with trusses. In small roofs, short purlins are inserted between the rafters and nailed through the rafters as shown in figure 1⑤, appendix III. They are used to support the sheet metal. Where heavy trusses are used, the purlins are continuous members which rest on the trusses and support the sheathing. This type of purlin is used only in large buildings. In small buildings, such as barracks, mess halls, and small warehouses, 2 by 4's are used for purlins, with the narrow side up.

133. Bracing of rafters.—*a. General.*—In small roofs which cover only narrow buildings and in which the length of the rafters is short, there is no need for interior support or bracing. In long spans, the roof would sag in the middle if it were not strengthened in some way. To support long rafters, braces or other types of supports must be installed.

b. Types.—(1) *Collar beams.*—A collar beam or tie is a piece of stock (usually 1 by 4, 1 by 6, or 1 by 8) fastened to a pair of rafters in a horizontal position at some desired location between the plate and the ridge of the roof. This beam tends to keep the building from spreading. The lower the collar beam or chord, the better it fulfills its purpose. This type of bracing is used on small roofs where no ceiling joists are used and the building is not wide enough to require a truss.

(2) *Truss.*—In wide buildings, where the joists or chords must be spliced and there is no support underneath, the rafter and joists support one another by means of the truss method (fig. 144).

134. Roof sheathing.—*a.* Nearly all forms of roof covering should have continuous surfaces to support them. Types that do not require continuous support include all types of corrugated sheet steel, asbestos boards, and precast concrete slabs. In general, the solid deck is to be preferred; only when corrugated sheet metal is used is it advisable to have a slat-sheathed roof. Where the climate is very cold and sheet metal is used, the roof is sheathed solidly.

b. Wood sheathing is supported on rafters for sloping roofs and on joists for flat roofs. It should be seasoned wood 1-inch thick, and from 4 to 8 inches wide. It is nailed with two or more 8- or 10-penny nails. The joints should be made on the rafters and staggered to prevent a weak spot in the roof. Where the roof is sheathed solid, the sheathing may be square-edged, tongued-and-grooved, or shiplapped. It should be sized on one side and two edges. Where green or wet sheathing is used and it is to be covered with roll roofing, the sheathing should be nailed securely so that when the sheathing dries out the shrinkage will not tear the roofing. After the roof has been sheathed solidly, the ends of the sheathing are cut off smooth, leaving the correct amount of overhang. Where there is no overhang, it is cut flush with the outside edge of the end rafters.

c. Where corrugated sheet metal is used for covering, either sheathing should be spaced from 1 to 3 feet apart, or the purlins should be used as shown in figure 1, appendix III (front frame elevation). These purlins are nailed between the rafters flush with the top edges of the rafters. They are of 2 by 4 material.

135. Roofing.—*a. General.*—A good roof is just as essential as a safe foundation. A perfect foundation secures the building against destruction which begins at the bottom. A good roof affords protection for the building itself and that which the building contains, and prevents deterioration which begins at the top. In selecting a roof covering the general requirement is to provide a material that will keep out the rain.

b. Types of roof covering.—Of the many types of roof covering which are used, this manual covers only the types used by the Army in the theater of operations: corrugated sheet metal and prepared roofing.

(1) *Corrugated roofing.*—The corrugated sheet metal covering of the standard type has corrugation 2½ inches wide and ⅝ inch deep. The sheets are 26 inches wide and vary in length from 6 to 12 feet. They are either painted or galvanized, to prevent corrosion.

(2) *Prepared roofing.*—There are several brands of prepared roofing, all similar in type. They are composed of either paper, felt, or asbestos paper, and are saturated with different brands of waterproofing compounds. They are assembled at the factory, along with asphalt cement, into strips about 1 yard wide and 12 yards long. These roofing materials are equivalent to 2-ply or 3-ply built-up roofing (built-up roofing consists of layers of tar paper laid on flat roofs and bound together with layers of tar). The roofings may have a plain surface, or they may be surfaced with crushed slate, sand, mica, or other mineral surfacing. This type of roofing is furnished in rolls and is sometimes called "roll roofing."

c. Methods of installation.—(1) Corrugated sheet metal may be nailed to either solid or slatted wood sheathing, or it may be supported directly by wood purlins spaced from 1 to 3 feet apart (fig. 1⑤, app. III). The sheets are overlapped one or two corrugations on the sides and 6 or 8 inches on the ends, depending upon the slope of the roofs. To nail this type of roofing securely, a special type nail should be used, such as lead-headed or galvanized nails. Common wire nails may be used but they rust easily and may cause slight leaks, while lead-headed or galvanized nails seal the hole when they are driven into the metal. The side laps should be nailed every 2 feet, while the end laps should be nailed every foot. This type of roofing should not be used on roofs with slopes of less than 4 inches per foot.

(2) Prepared roofing is nailed to roofs which are sheathed solidly. Special nails with large heads are used along the edges, 3 inches on

centers. The edges of the roofing are lapped not less than 4 inches, depending upon the slope of the roof. These edges are cemented with tar before nailed (fig. 145). The end laps should be at least 8 inches and are cemented in place. Prepared roofing may be laid parallel either to the eaves or to the slope (fig. 145). This type of

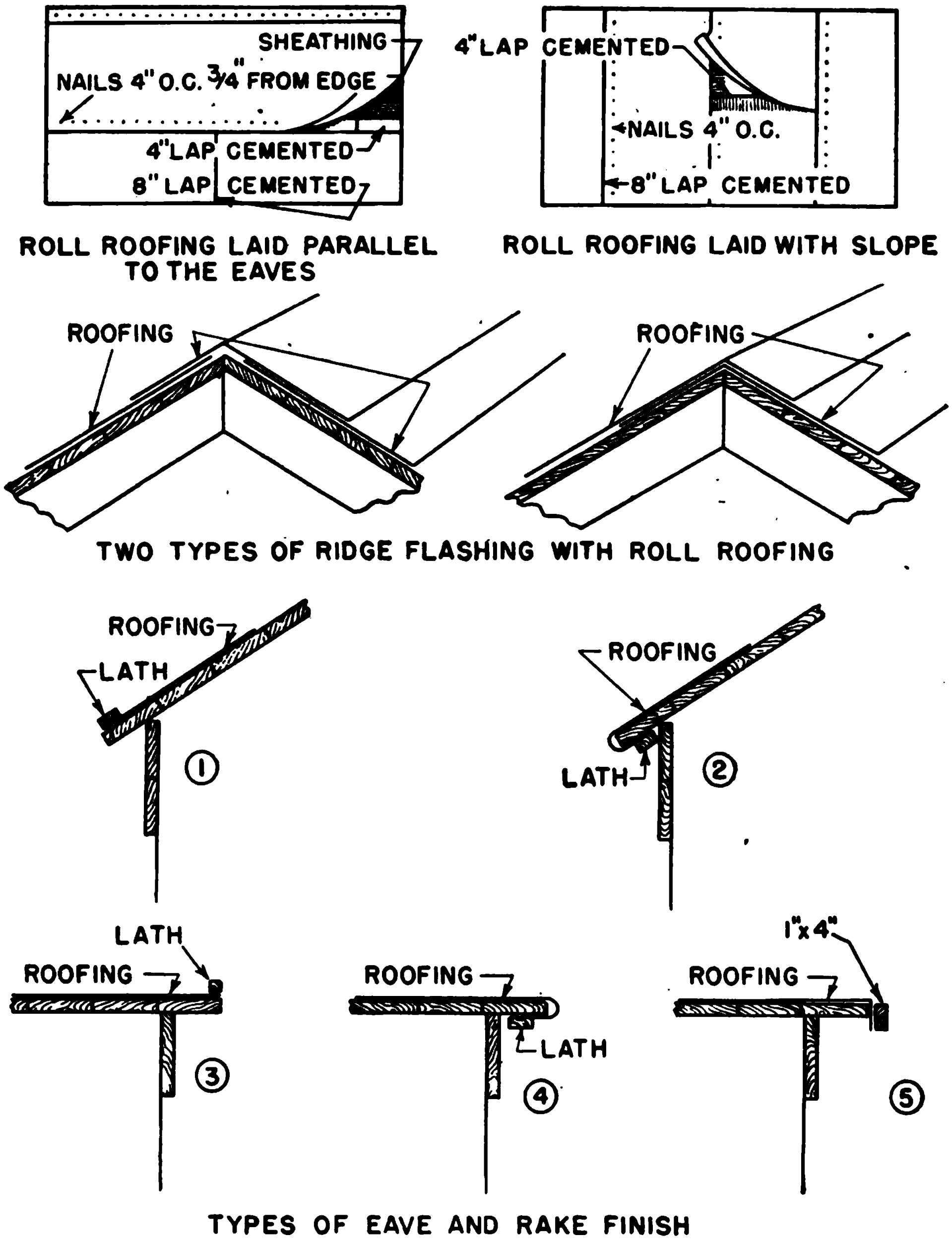


FIGURE 145.—Types of roof finish.

roof may be used on any slope greater than 2 inches per foot. On flatter slopes great care must be taken to have the joint well cemented. To save time and labor, the roofing at the eaves and at rake or gable ends may be fastened with wooden strips (fig. 145).

136. Hood or canopy.—The hood or canopy is used in tropical climates to afford protection to the screened opening at the ends of the buildings. They are framed to the end walls with short rafters which are nailed to the building with knee braces, as shown in figure 146. The rafters are nailed to the wall, the bottom edge flush with the bottom of the end plate. The rafters and braces are of 2 by 4's nailed with 8- or 10-penny nails. The sheathing is the same material as the roof sheathing and is covered with roll roofing. The hood should extend about 2½ or 3 feet from the building.

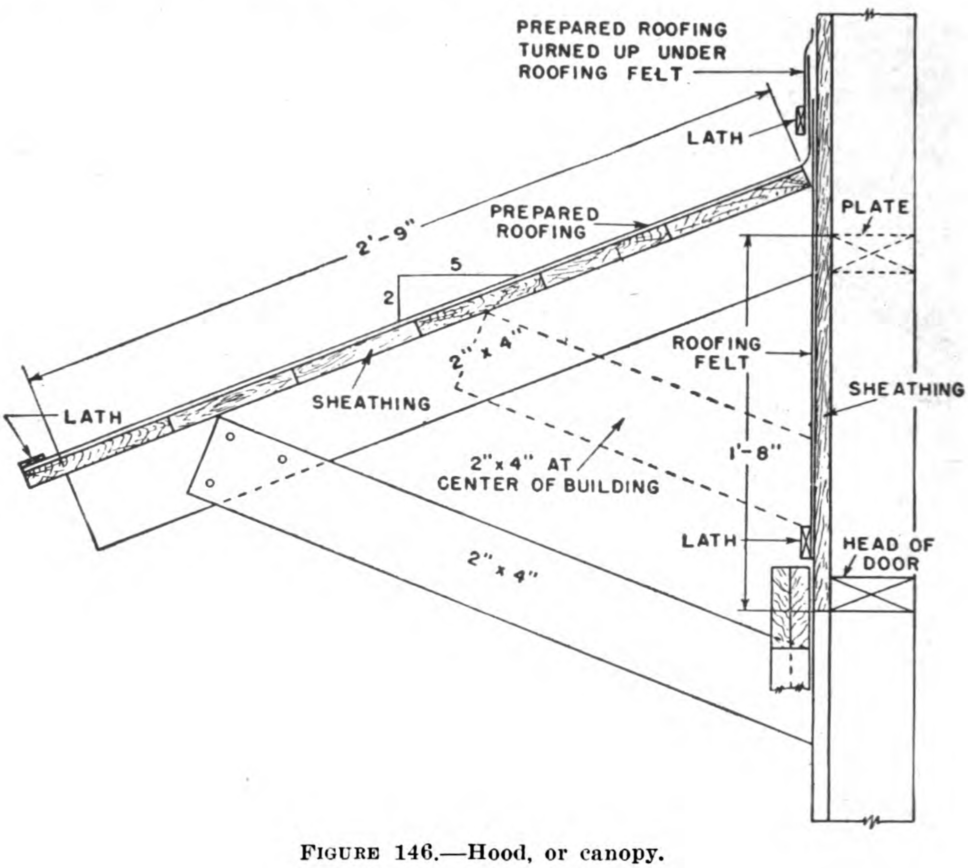


FIGURE 146.—Hood, or canopy.

SECTION II

SPECIAL

137. Heavy beams and girders.—In the theater of operations, extra heavy beams and girders are sometimes used. Single timbers large enough to be used as heavy beams and girders are seldom available. Two or more pieces of timber are fastened together with bolts, lag screws, timber connections, or nails to form a beam or girder. When possible, the joints in these beams or girders should be supported on a post or wall, and should be staggered. Figure 147 shows several types of beams and indicates their classification as to support. These beams and girders are used in airplane hangars, large repair buildings, warehouse buildings, etc.

138. Timber trusses.—*a. General.*—For long spans, instead of heavy steel beams, laminated beams of wood are used wherever pos-

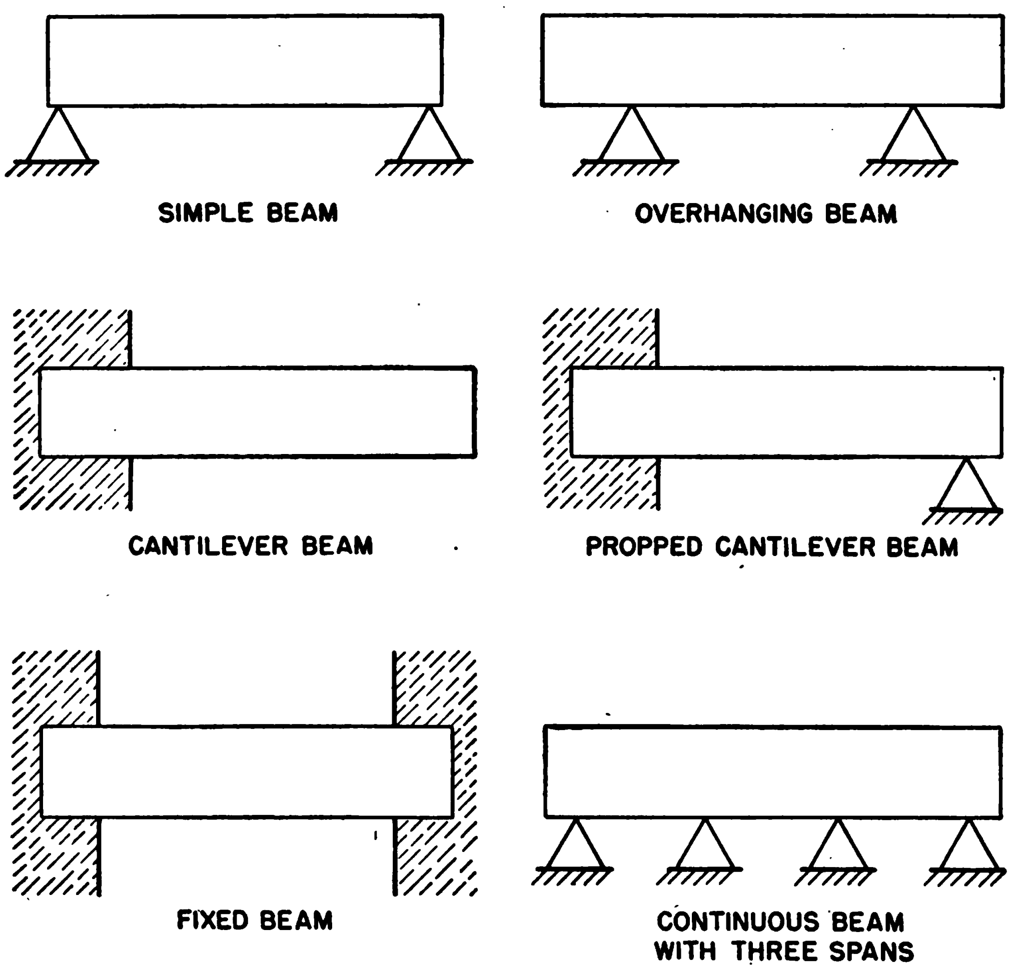


FIGURE 147.—Types of beams, according to support.

sible. This type of beam can be constructed in place as this saves times and special transportation.

b. Terms used in connection with trusses.—(1) *Bottom chord* is a member which forms the lower boundary of the truss.

(2) *Top chord* is a member which forms the upper boundary of the truss.

(3) *Chord member* is a member which forms part of either the top or bottom chord.

(4) *Member* is the component which lies between any two adjacent joints of a truss; it can be of one or more pieces of structural material.

(5) *Webb member* is a member which lies between the top and bottom chords.

(6) *Joint* is any point in a truss where two or more members meet and is sometimes called a "panel point."

(7) *Panel length* is the distance between any two consecutive joint centers in either the top or bottom chords.

(8) *Pitch* is the ratio of the height of truss to the span length.

(9) *Height of truss* is the vertical distance at midspan from the joint center at the ridge of a pitched truss, or from the center line of the top chord of a flat truss to the center line of the bottom chord.

(10) *Span length* is the horizontal distance between the joint centers of the two joints located at the extreme ends of the truss.

c. Definition.—A truss is a framed or jointed structure composed of straight members connected only at their intersections in such a way that if the loads are applied at these intersections the stress in each member is in the direction of its length.

d. Types.—The web members of a truss divide the truss into a number of triangles. It is possible to arrange innumerable types of trusses, but certain types have proved to be more satisfactory than others, and each of these types has its special uses. The various types of trusses used in building construction are illustrated by line diagrams in figures 148 and 149. The members indicated by heavy lines normally carry compressive stresses, and those indicated by light lines normally carry tensile stresses for vertical loads. In most cases the compression members are the shortest members in the truss, while the tension members, shown by the light line, are the longest. This results in a great saving of material, for a compression member requires a greater sectional area for a given stress than a tension member. Sometimes the top chords of these trusses are slightly sloping in one or two directions for roof drainage, but this does not change the type of truss. Figure 148③ and ⑥ are typical examples. The necessary number of subdivisions or panels depends upon the length of the span and the type of construction.

e. Use.—Timber trusses are used for large spans to provide wide unobstructed floor space for such large buildings as shops and hangars. The Howe and Fink trusses are the ones most commonly used. Sometimes small buildings are trussed to save material; these small trusses act as rafters and give the roof rigidity.

f. Supports.—Trusses are supported by bearing walls, posts, or other trusses. When it is desired to brace a truss to a wall or post, knee braces are used as shown in figure 149⑥, ⑧, and ⑨. These braces tend to make a truss of the entire building by tying the wall to the roof.

139. Lay-out and construction of a Howe truss (fig. 150).—*a. Lay-out.*—In laying out a truss, the first task is to get the material to a level spot of ground where workbenches will be approximately

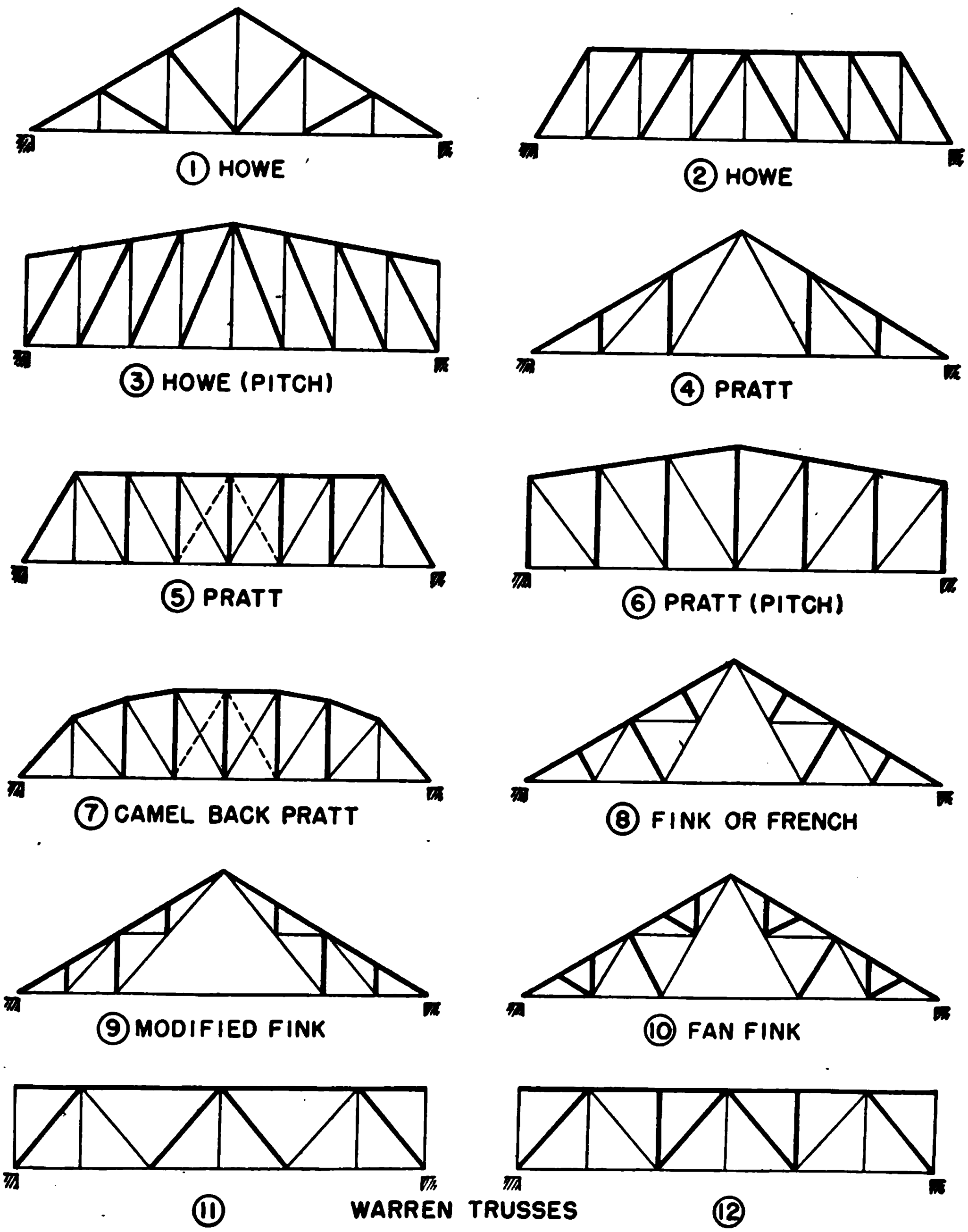


FIGURE 148.—Types of trusses.

level. Obtain from the blueprints the necessary measurements of all pieces that are to be used in the truss. Lay out the length on the different sizes of timber and cut them. Care must be taken that the lengths are cut accurately. After all the lengths of different sizes of material for a truss have been cut, lay the pieces in their correct position to form a truss and nail them together temporarily. After the truss is assembled in this manner, lay out the location of all holes to be bored, then recheck the measurements to be sure that they are correct; after this is done, bore the holes to the size called for on the print. They may be bored with a brace and bit, or with the wood-

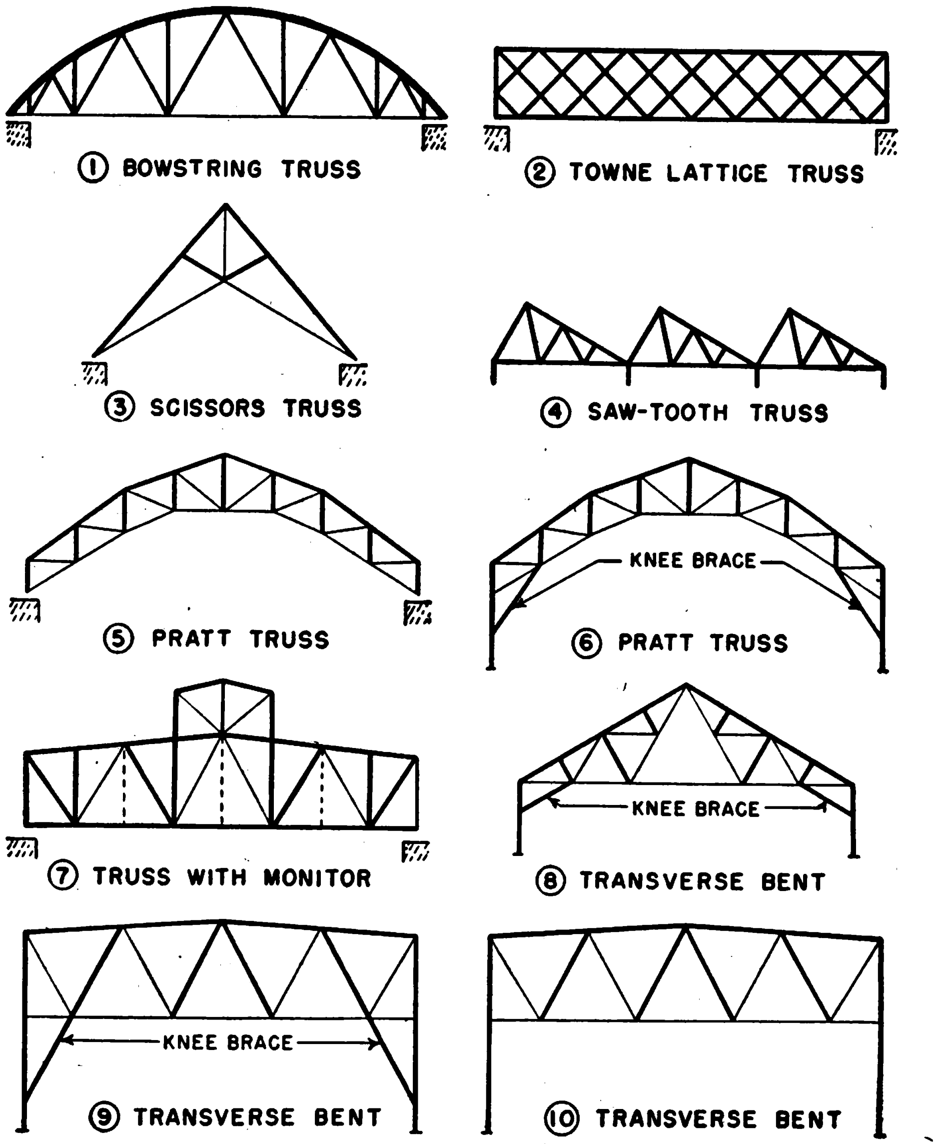


FIGURE 149.—Types of trusses.

borer which accompanies the air compressor. They should be bored perpendicular to the face of the timber. After the holes have been bored, the truss is dismantled and the nails withdrawn.

b. Construction.—The assembling of a truss after it has been cut and bored is simple. In most cases, timber connectors are used where the different members of the truss join. These connectors are installed as

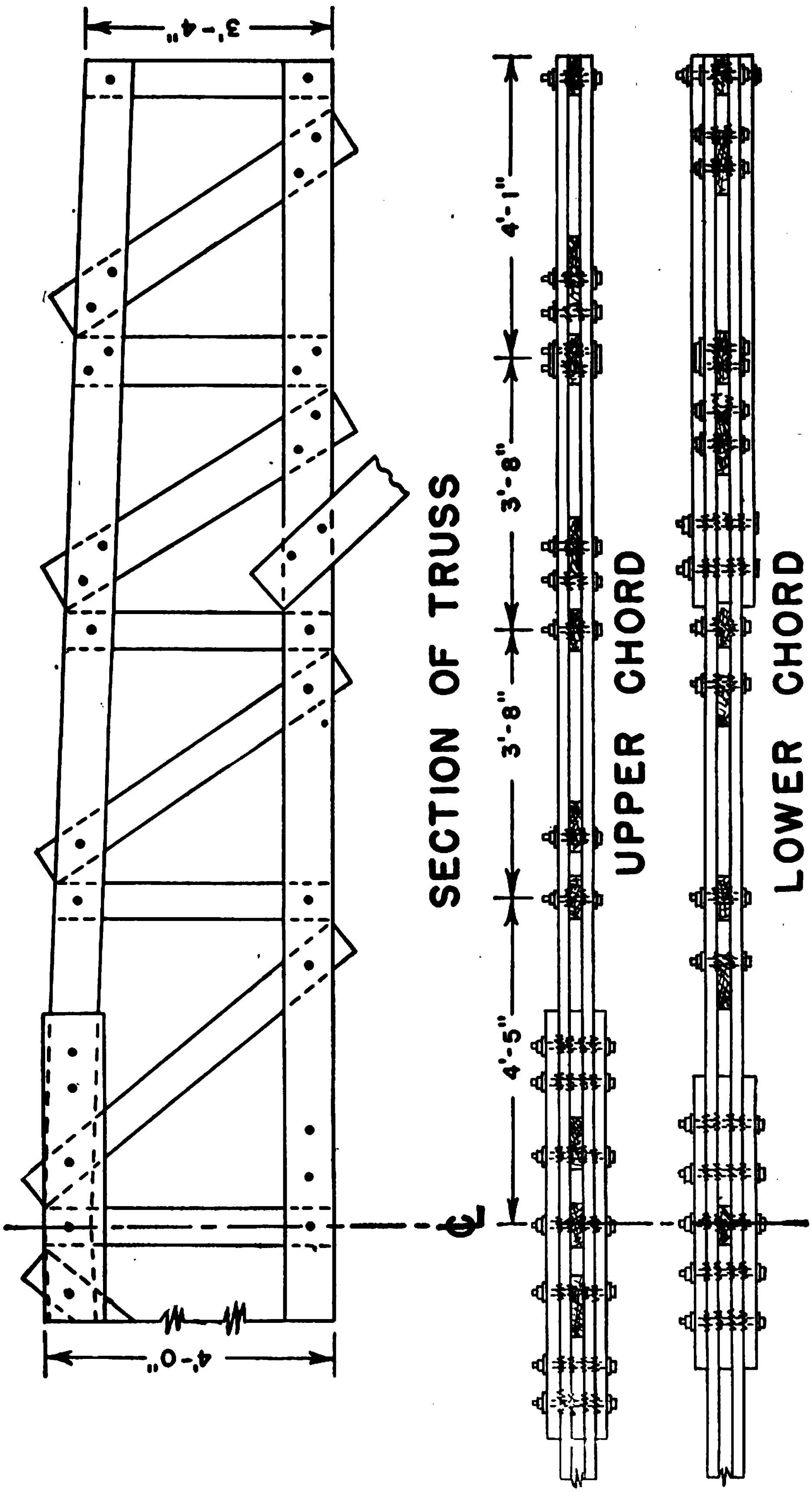


FIGURE 150.—Section of Howe truss.

described in paragraph 100. The truss is again assembled as it was for boring holes, with the timber connectors in place. The bolts are then placed in the holes and tightened, a washer being placed at the head and nut ends of each bolt. Figure 150 shows a section of a Howe truss assembled, with the dimensions of the truss, spacing of holes, etc. Straight and sound timber should be used in trusses to avoid weak places.

140. Lay-out and construction of a rafter truss.—This type of truss is used extensively by the Army in the construction of small buildings in the field. It is simple to construct and requires a very

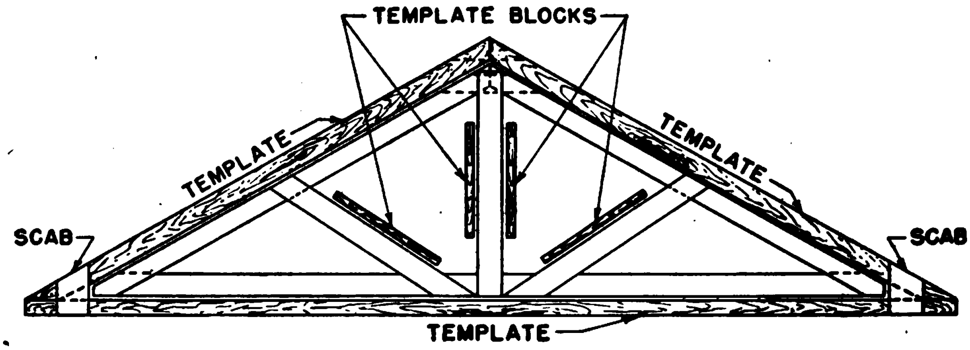


FIGURE 151.—Template for truss construction.

small amount of material and time. The rafters are cut as described in paragraph 130. The bottom chord and web members are cut to the length, and from the size of timber specified in the blueprints. Figure 144 shows a section of this truss. After the material has been cut, it is assembled and nailed or bolted together. If several trusses are to be made, a template may be made and used to save time and labor. Figure 151 shows a template of this type. To make erection easier the knee braces are left off the truss until it is placed on the wall plates.

SECTION III

WALL FINISH

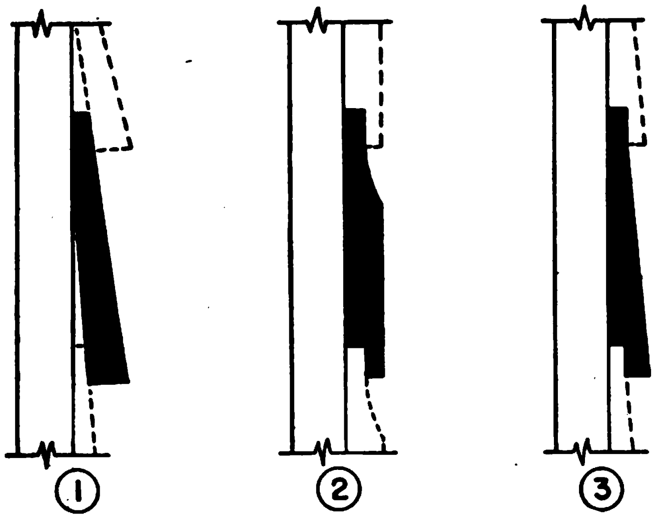
141. Exterior.—The exterior surfaces of a building may consist of vertical or horizontal sheathing, composition roofing, sheet-metal, or corrugated roofing.

a. Wall surfaces.—Exterior wall surfaces may consist of one or more of several types of finish, the most common being vertical sheathing, siding, and corrugated iron.

(1) *Vertical sheathing.*—This type of coverage is nailed to girts. The cracks are covered with wood strips called "battens." The sheath-

ing is nailed securely with 8- or 10-penny nails. The vertical sheathing requires less framing than siding since the sheathing acts as a support for the plate. To make this type of wall more weatherproof, some type of tar paper or light roll roofing may be applied over the entire surface and fastened with roofing nails and battens (fig. 1, app. III).

(2) *Siding.*—Siding may be classified into three types: beveled siding, drop siding, and shiplap. They are applied horizontally and nailed to studs with two or more 8- or 10-penny nails, and may be used with or without sheathing behind as shown in figure 152. To make



1 BEVEL SIDING
2 DROP SIDING
3 SHIPLAP SIDING

FIGURE 152.—Types of siding.

this siding more weatherproof, building paper may be used on the studs and nailed either to the siding, after it has been applied, or between the sheathing and siding if sheathing is also used. The methods of application for the different types are similar. The drop and shiplap type have a rabbeted edge to give the proper lap. The lap must be measured each time in applying the beveled siding, which requires much time.

(3) *Use of corrugated iron.*—Corrugated iron is used extensively as wall coverage as little framing, time, and labor are required to install it. It is applied vertically and nailed to girts, the nails being placed in the ridges. Sheathing may be used behind the iron with or without building paper. Since tar paper used behind metal will cause the metal to rust, a resin-seized paper should be used.

(4) *Building paper.*—(*a*) Building paper is of several types according to content, the most common being the resin-sized. It is

generally red or buff in color (sometimes black) and is put up in rolls, usually 36 inches wide, each roll carrying 500 square feet, and weighing from 18 to 50 pounds. Ordinarily it is not waterproof. Another type is of heavy paper saturated with a coal-tar product sometimes called sheathing paper. It is waterproof and provides protection against heat and cold.

(*b*) In wood-frame buildings, whether covered with siding, shingles, or iron, building paper is used when it is desired to protect against heat, cold, or dampness. In applying it to side walls, with or without sheathing, care should be taken not to tear the paper. The paper should be tough enough not to tear when handled. The laps should be made toward the ground and nailed with roofing nails at the laps. The waterproof-type paper is used also in the built-up roof where the roof is nearly flat. Several layers are used with tar between each layer.

b. Roof finish.—(1) The lines in which the sloping roofs meet the vertical wall are called the eaves. In hasty construction the eaves are usually finished as shown in figure 145. This method should be used wherever possible. The roof should have a hangover at the eaves to give protection to the sides of the building. The space between the rafters on top of the plate should be closed with boards.

(2) Where rafters have no overhang the first piece of sheathing is placed on the rafters so that it hangs over the rafters 3 or 4 inches. A fascia board is placed under the sheathing at the end of the rafters and is nailed securely to close the opening between the rafters. This board should be at least 4 inches wide. (See fig. 157.)

(3) At the ridge of a roof where two slopes meet, some provision must be made to finish the covering so that it will not leak. When a roof is covered with roll roofing the finish can be made as shown in figure 145. This is a simple method and saves time.

(4) The gable or rake finish may be finished as shown in figure 145 when roll roofing is used. The roofing in this case is rolled around the edge of the sheathing and back on the under side far enough so that a 1- by 2-inch strip can be nailed to hold the roofing, or it may be cut flush with the end of the sheathing and the strip nailed on top as shown in figure 145. When corrugated iron is used, the metal should overhang the sheathing from 1 to 2 inches to give it protection. The sheathing may overhang on the gable as it does on the eaves, to give added protection to the walls.

(5) If the sheathing does not overhang at the gables, the gable rake is finished with the sheathing ending at the rafter's edge, as shown in figure 145. The wall sheathing ends at the top edge of the rafter. The roofing is lapped over the end of the building and is

fastened by a 1 by 4 board nailed over the roofing along the gable, with the top edge even with the top of the rafter.

142. Interior.—*a. Walls.*—The interior surface of exterior wood-stud walls and both surfaces of wood-stud partitions may be constructed of wood, plaster board, or fiber board.

(1) Wood finish on the inside wall in most cases is the ceiling, which is nailed horizontally to studs or vertically to girts, depending upon the type of framing (fig. 153). The type ceiling used by the

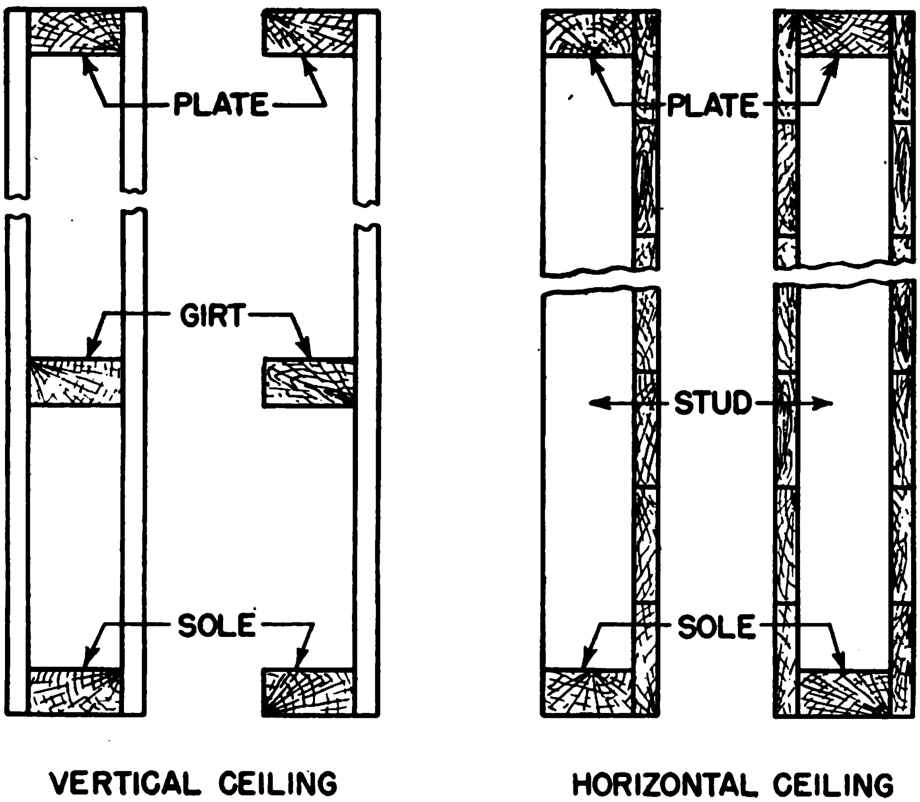


FIGURE 153.—Partition wall finish.

Army is $5\frac{1}{4}$ inches wide with a plain face and no grooves or beads on the side. It is sometimes called "roofer."

(2) There are several types of wall board: plywood, gypsum board, fiber board, and others. This board cuts labor and time in construction and is used extensively for partition walls just as it comes, in sheets $\frac{1}{2}$ inch by 4 feet by 8 feet. It is used on outside walls and underneath roofs to provide insulation against heat or cold.

b. Door frames.—(1) Outside door frames are constructed in several ways. In most hasty construction the frames will be as shown in figure 154. This type requires no frame as the studs on each side of the opening act as a frame. The outside finish is applied to the wall before the door is hung. The casing is then nailed to the sides of the opening, set back the width of the stud. A ¾- by ¾-inch piece is nailed over the door to act as a support for the drip cap and is also set back the width of the stud. Hinge blocks are nailed to the casing where the hinges are to be placed. The door frame is now

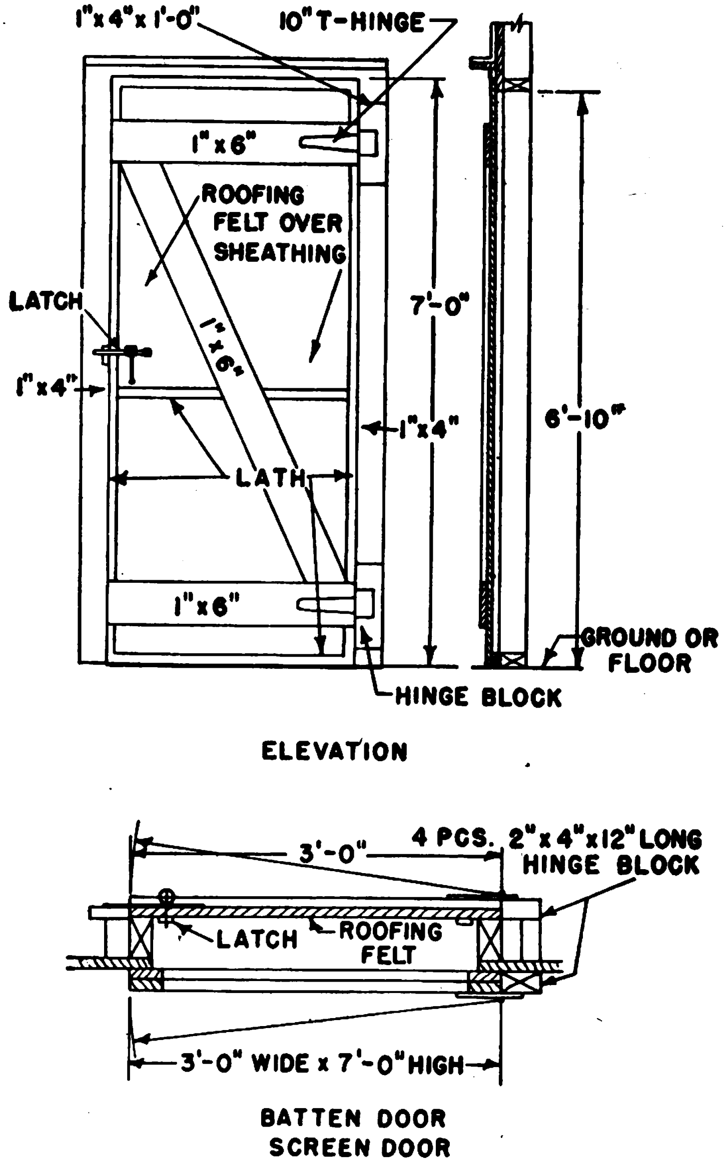
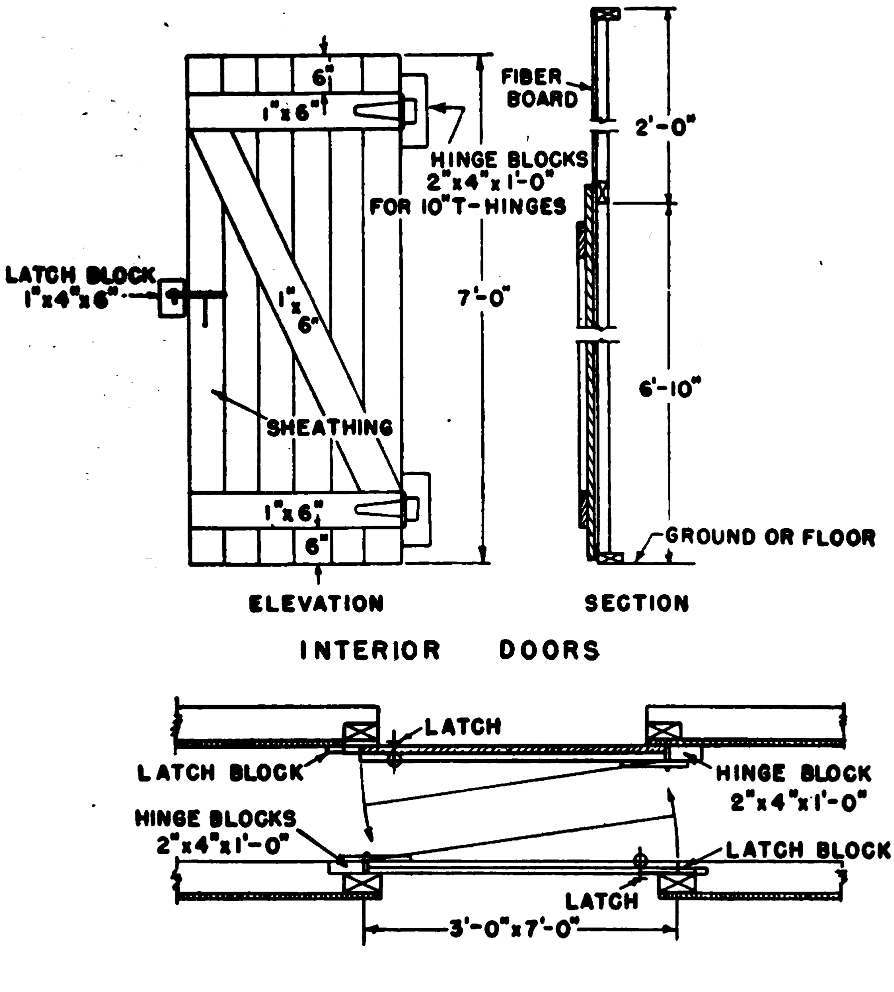


FIGURE 154.—Single outside door.

complete and ready for the door to be hung. Figures 154 and 156 show the elevation and cross section of a single and double door frame.

(2) Inside door frames, like outside frames, are constructed in several ways. In most hasty construction the type shown in figure 155 will be used. The interior type is constructed like the outside type except that no casing is used on inside door frames. Hinge

blocks are nailed to the inside wall finish, where the hinges are to be placed to provide a nailing surface for the hinge flush with the door. Figure 155 shows the elevation of a single inside door. Both the outside and inside door frames may be modified to suit a climatic condition.



PLANS OF INTERIOR DOORS

FIGURE 155.—Single inside door.

c. Doors.—In hasty construction, the carpenter who erects the building makes the doors from several boards with battens and braces as shown in figure 154. These boards are 1 by 6's, laid close together and nailed to battens. The battens are placed with their edges 6 inches from the ends of the door boards. A brace is placed between the battens, beginning at the top batten end opposite the hinge side of the door, and running to the lower batten diagonally across the door. These battens and braces are well nailed. If the door is used as an outside door, roofing felt is used to cover the boards on the weather side. The battens and braces are nailed over the felt. Wooden laths are nailed around the edges and across the middle of the door to hold the roofing felt in place. The battens and braces are nailed over the felt. The battens and braces on doors are of 1 by 6's and are nailed securely to the door boards. In hanging these doors, T-strap hinges are used. The hinges are fastened to the battens of the door and to the hinge

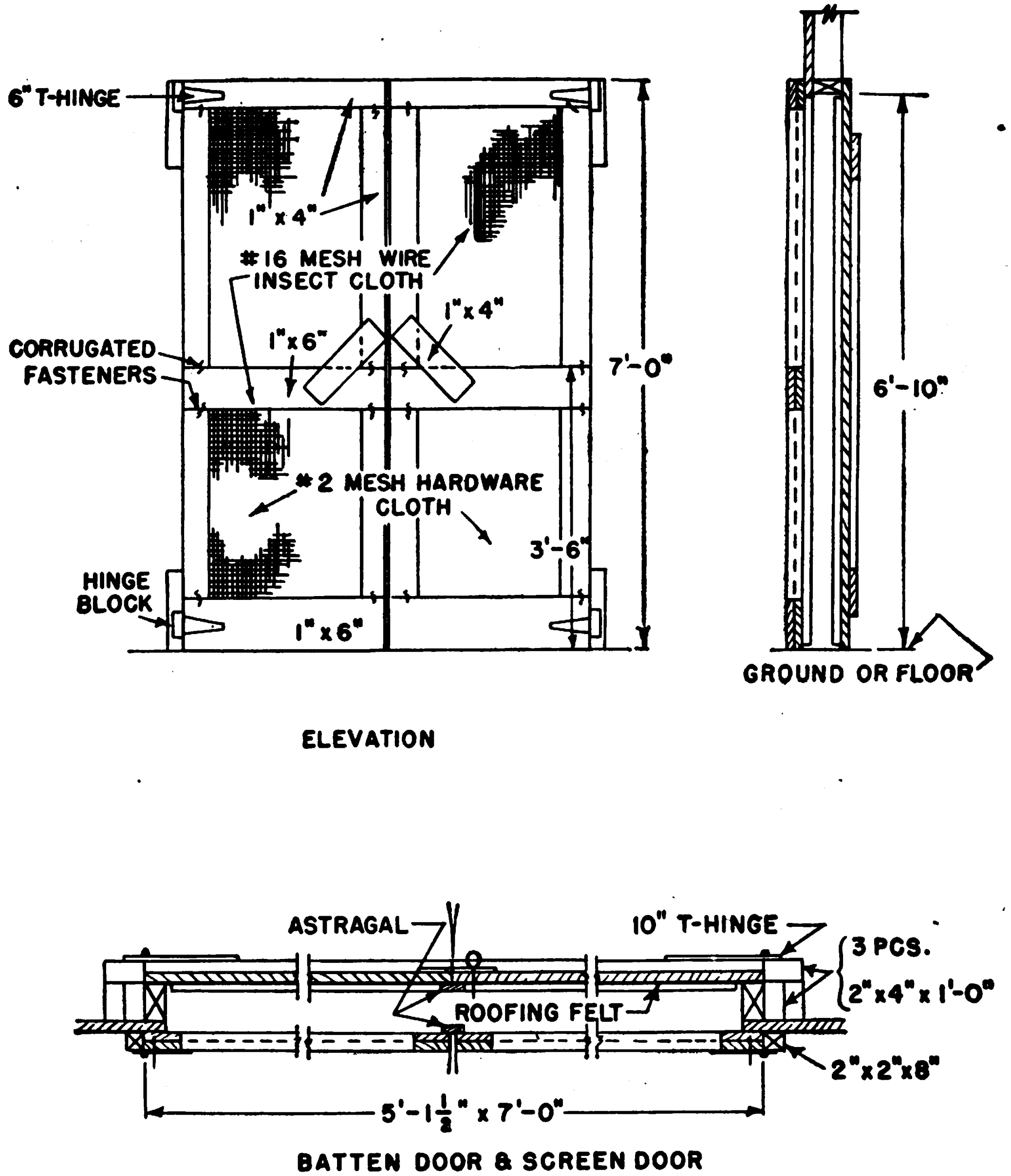


FIGURE 156.—Double outside door.

blocks on the door casing or post. One quarter of an inch clearance should be left around the door to take care of expansion.

d. Window frames.—In hasty construction, millwork window frames are seldom used. The window frames are mere openings left in the walls with the stops all nailed to the stud. The sash may be hinged to the inside or the outside of the wall, or constructed so as to slide. The latter type of frame is the most common in Army construction as it requires little time to install. Figure 157 shows the section

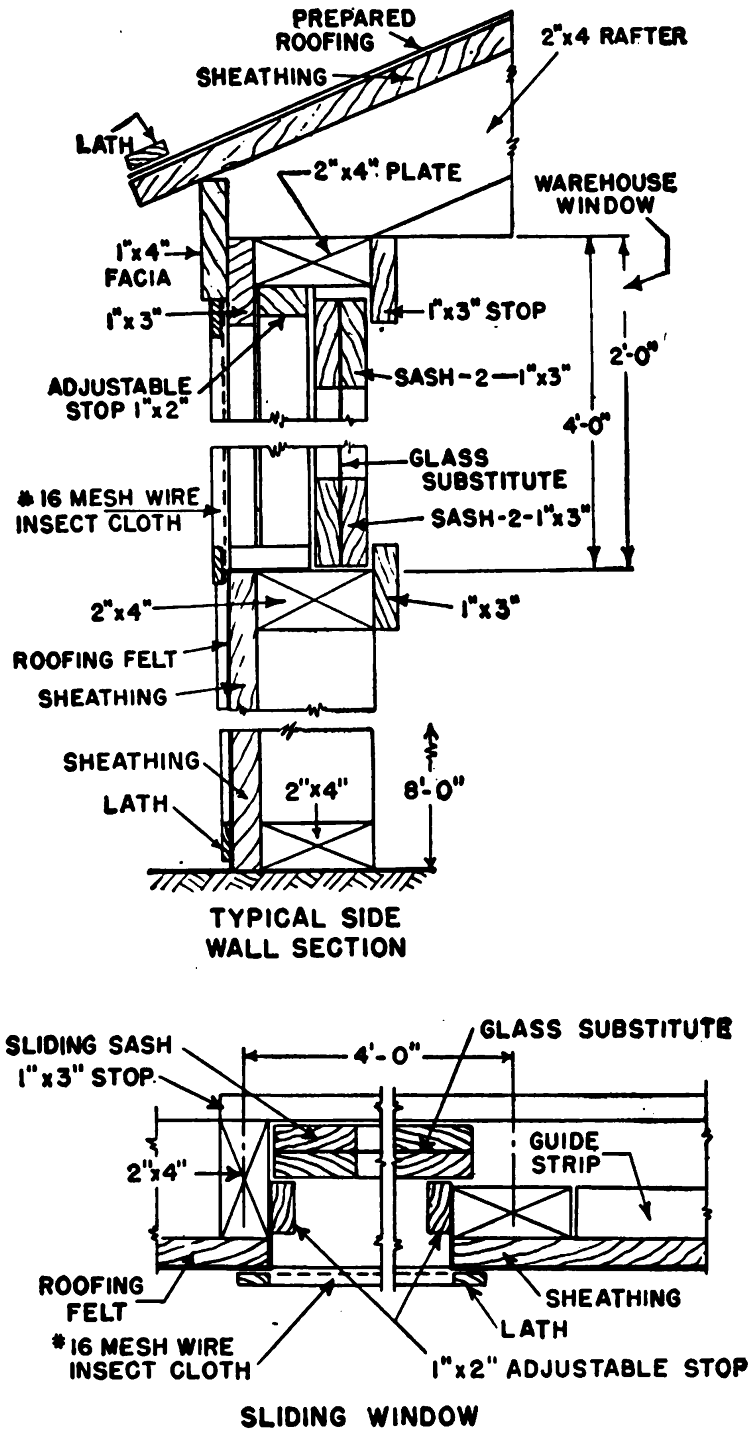


FIGURE 157.—Detail of wall section with window frame and sash.

and plan of a window and window frame of the type used in the field. After the outside walls have been finished, a 1 by 3 is nailed on top of the girt at the bottom of the window opening to form a sill. A 1 by 2 is nailed to the bottom of the plate and on the side studs and acts as a stop for the window sash. A guide is nailed at the bottom of the opening flush with the bottom of the girt, and one nailed to the plate with the top edge flush with the top of the plate. These guides are 1 by 3's, 8 feet long. Stops are nailed to the bottom girt and plate, between the next two studs, to hold the sash in position when open (fig. 157).

e. Window sashes.—A sash can be made of 1- by 3-inch material, with Cel-O-glass or an equivalent, installed as shown in figure 158. Since Cel-O-glass does not break as easily as glass, careful handling in transporting is not required. Cel-O-glass is obtained in rolls, as screen wire or roll roofing, and can be cut to any desired size with a sharp-edged tool. Two frames are made with the glass substitute installed on one; the two frames are then nailed together. In making these frames the side pieces are all cut the same length, the length being the height of the sash less the width of one piece of material. The top and bottom pieces are cut the same length of the window, less the width of the material. They are fastened at the joints with corrugated metal fasteners. When the two frames are nailed together, they should be turned so that the joints are not over each other. This staggers the joints and gives the sash more strength. If the sash is too large for the glass substitute to cover, a muntin may be placed in the sash to hold the glass substitute and should be fastened with corrugated metal fasteners. Where long sashes are made, a muntin should be placed in the center to give added strength.

f. Wainscoting.—Wainscoting is used at the bottom of walls which are finished with insulating board that will not stand rough treatment. The wainscoting completes the finish at the bottom and makes a more substantial wall (fig. 159). This finish is used in hospitals. The wainscoting is preferably tongued and grooved.

g. Flooring.—A finish floor in the theater of operations, in most cases, is of ¾-inch material, square edged or tongued and grooved, and varying from 3¼ to 7¼ inches wide. It is laid directly on floor joists or on a subfloor and nailed with 8-penny cut nails in every joist. If these nails are not obtainable, 8-penny common nails may be used (fig. 160). When wide flooring is used, it should be face-nailed in every joist as shown in figure 160. When laid on a subfloor, it is best to use building paper between the two floors to keep out dampness and insects (fig. 4, app. III). In warehouses, where heavy loads are to be carried on the floor, 2-inch material should be used. The flooring is face-nailed with 16- or 20-penny nails. It is not tongued and grooved and it ranges in width from 4 to 12 inches. The joints are made on the center of the joist.

h. Hardware.—(1) The term "hardware" is used to designate locks, hinges, sash cord, weights, pulleys, checks, pulls, fasteners, etc. These

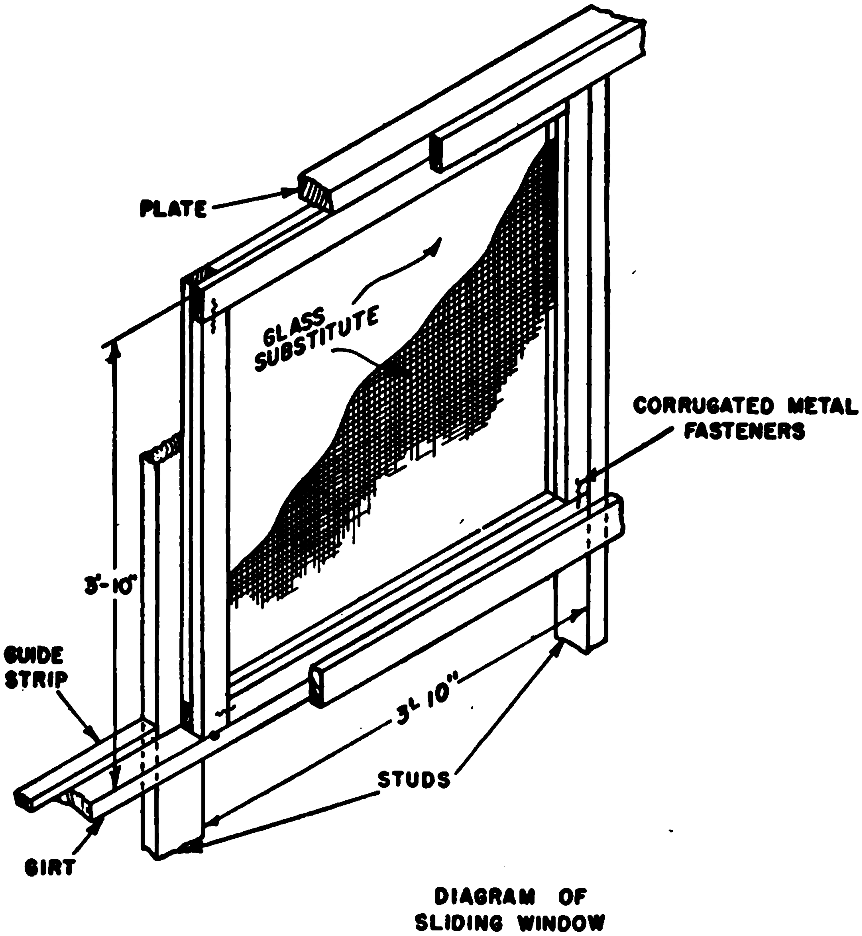


FIGURE 158.—Window frame and sash detail (sliding window).

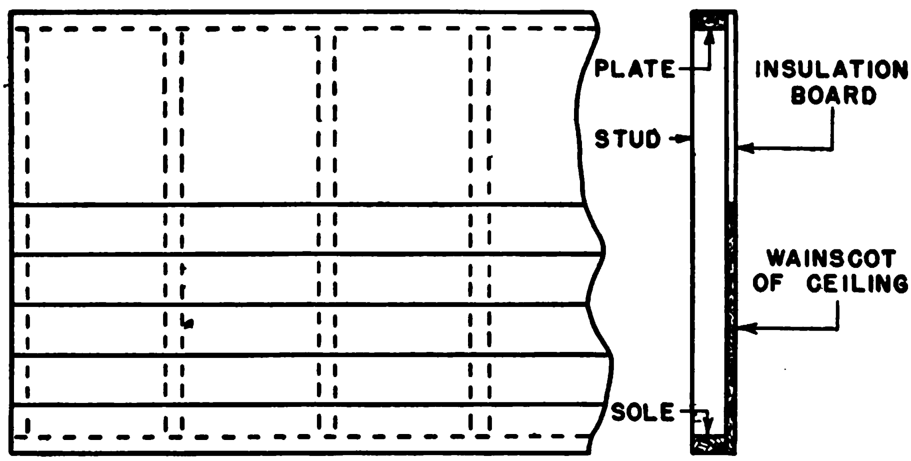


FIGURE 159.—Wainscot installation.

items are divided into two classes, rough hardware and finish hardware.

(2) Rough hardware includes such items as padlocks, used to fasten

doors; strap hinges, used to hang doors and other items; sash cord, weights, and pulleys, used for double-hung windows; track assemblies for sliding or rolling doors; and screen wire used for protection against insects. In most cases all these items are easily installed. In

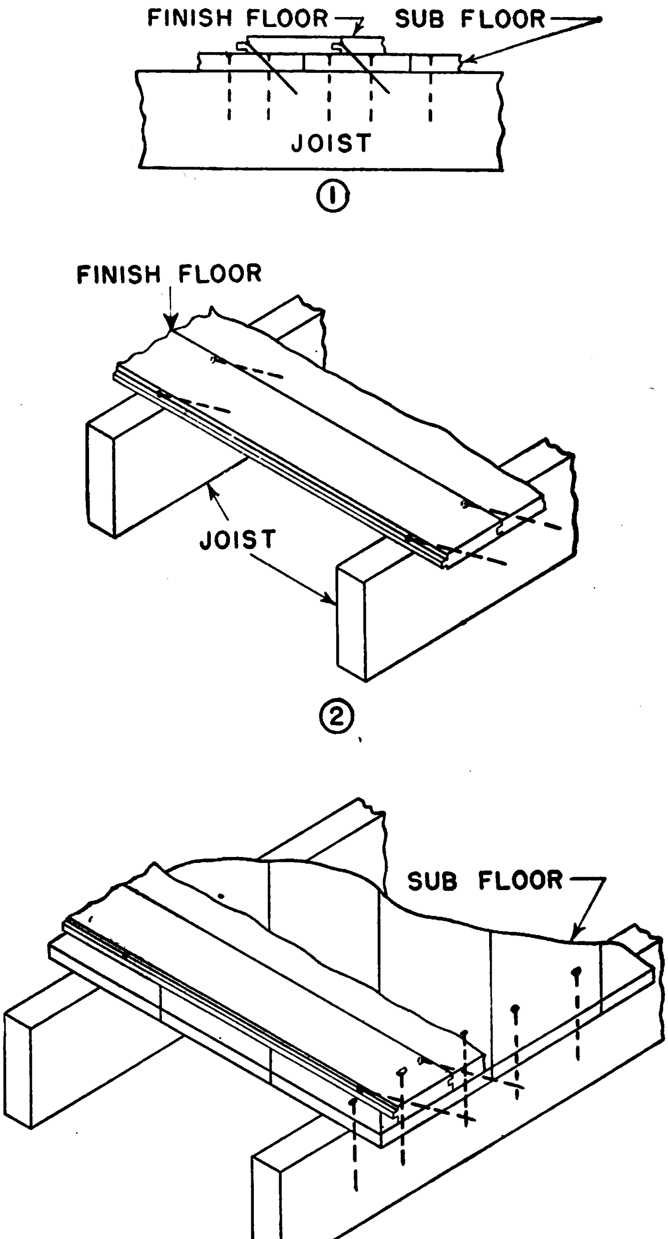


FIGURE 160.—Methods of nailing tongued and grooved flooring.

the theater of operations, hinges and screen wire are the most common hardware.

i. Screens.—Screens are placed on door and window openings. These screens are made and installed at the job site. Door screens are made as shown in figure 156. Two separate frames are made of 1 by 4 material for the sides and top, and 1 by 6 material for the bottom and middle pieces. The first frame is made of two side pieces the full length of the door; the crosspieces are the width of the door less the width of the two side pieces. This frame is put together with corrugated metal fasteners then the screen wire is applied. The second frame is made with the crosspieces the full width of the door. The side pieces are cut to correspond with the distance between the crosspieces. The second frame is placed over the first frame and nailed securely. For push-and-pull plates, two short braces of 1 by 4 are nailed to the side opposite the hinge side.

SECTION IV

MISCELLANEOUS

143. Framing for fire prevention around stovepipes.—*a.* Since fire is always a danger in wooden buildings, precautions must be taken to prevent loss. The carpenter must know where to insulate against intense heat and how far wood framing must be placed from stoves, stovepipes, flues, and chimneys, in order to prevent fires.

b. Framing around stovepipes is the major precaution to be taken by the carpenter in the theater of operations since stoves are the usual method of heating buildings. The pipes are carried out of the building by several methods. Figure 161 shows the pipe carried through the ridge of the roof. Here the sheathing must be cut to form an opening 12 inches larger than the pipe. The stove should be set so that the rafters need not be cut. The ceiling joist or tie beams must likewise be considered. Figure 161 gives a detailed description of the method of framing a pipe through the ridge. Where a smoke jack is not used, the sheathing and other wood should be at least 6 inches from the pipe. If some type of insulation board is available, the wood should be covered with this. Figure 162 shows the pipe through the roof when the slope is in one direction. The framing is placed as stated above. In many cases stovepipes are carried to the outside of the building through the side wall. This eliminates flashing and waterproofing around the pipe or roof jack (fig. 163). Here the sheathing on the side is cut back 6 inches from the pipe and some type of insulating material is used, if possible.

144. Flashing.—Where a pipe passes through the roof, some form of flashing must be used to make the opening waterproof. When proper tools and materials are not available, this is very difficult.

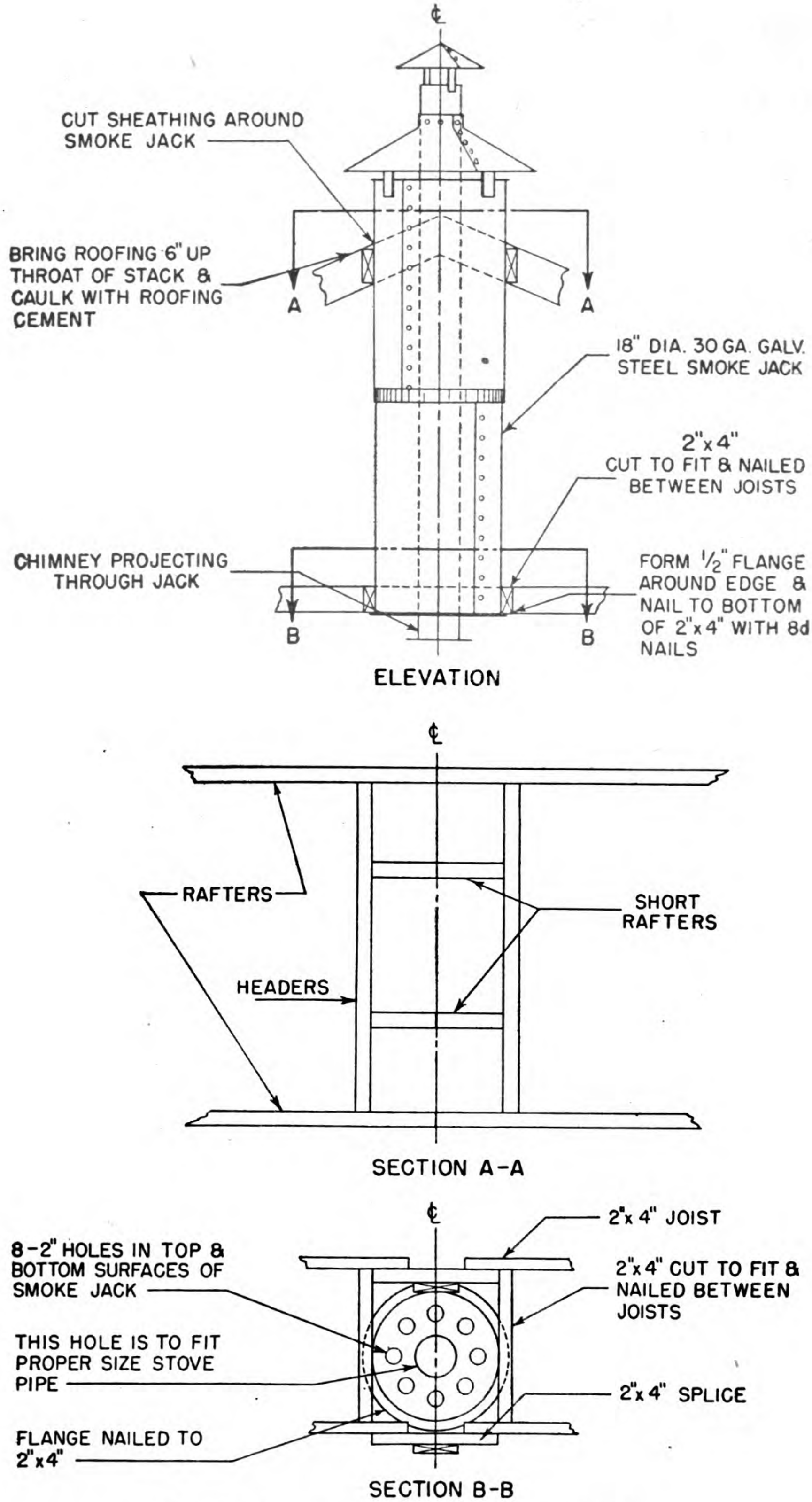


FIGURE 161.—Smoke pipe installation details.

a. Stovepipes.—(1) Where stovepipes are carried through the roof, roof jacks are used with flashing attached (figs. 162 and 163). In most cases these are installed over the roof and nailed. Fibered tar cement is used around the edges and over the nail heads, and the jack is soldered to the stovepipe, if practicable. If the smoke jack is used on a metal roof, it is soldered to the roof if practicable; otherwise, the tar cement is used around the edge after it has been nailed securely (fig. 162). Where no roof jack is used, the hole is covered

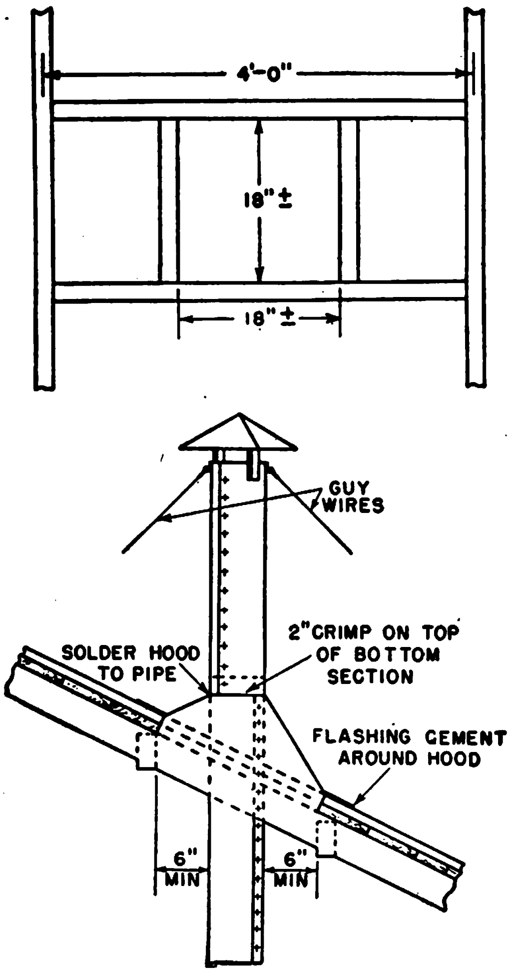


FIGURE 162.—Smoke pipe installation details.

with a piece of sheet metal which has a hole cut to the size of the stovepipe. The sheet metal is placed over the roofing at the bottom edge, and under it at the top edge. Where a metal roof is used, the flashing is soldered to the roof or fastened by means of tar cement. When the stovepipe does not go through the roof but out through the wall, no flashing is required; only one piece of sheet metal with a hole the size of the pipe is necessary. This is nailed over the opening in the wall (fig. 163).

(2) Where a stovepipe goes through sheet metal, a hole must be cut. The best method is to mark a circle on the metal ½ inch larger in diameter than the pipe, then make another circle on the inside with a diameter 2 inches less than the diameter of the first. With a

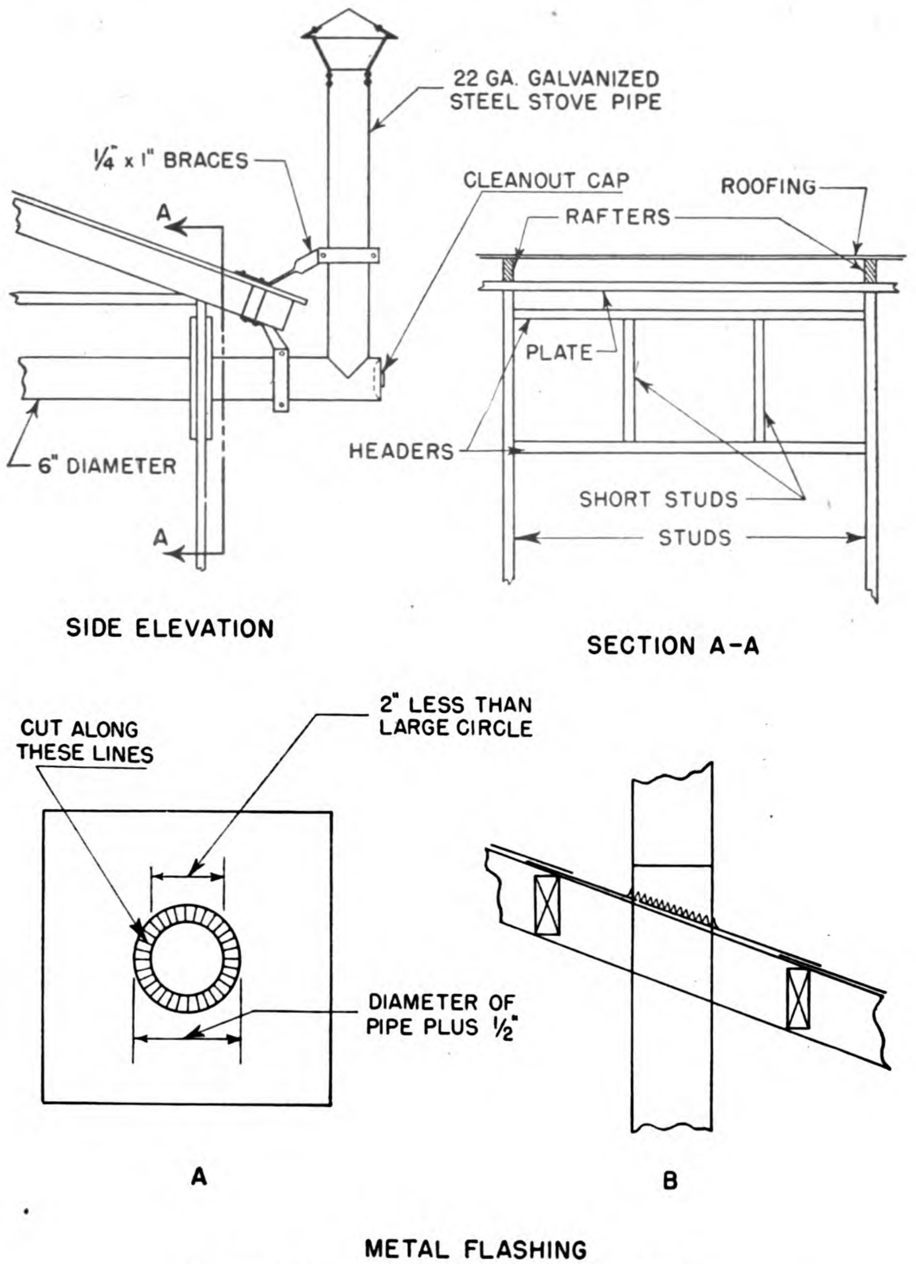


FIGURE 163.—Smoke pipe installation details.

straightedge, draw lines through the center of the circle from the outside. These marks should be from ½ to ¾ inch apart along the outer circumference. Cut out the center circle, then cut to the outside of the circle along the lines drawn. After the lines have been cut, bend the metal strips outward at a 45° angle and force the pipe through the hole to the desired position. Very little water will leak around this joint. (See fig. 163.)

b. Flashing.—(1) Where two roofs come together at right angles, a valley is formed and some type of covering must be used. A hasty and yet satisfactory method is to use two layers of roll roofing in the valley, one 14 inches, another 22 inches wide, or a strip of sheet metal

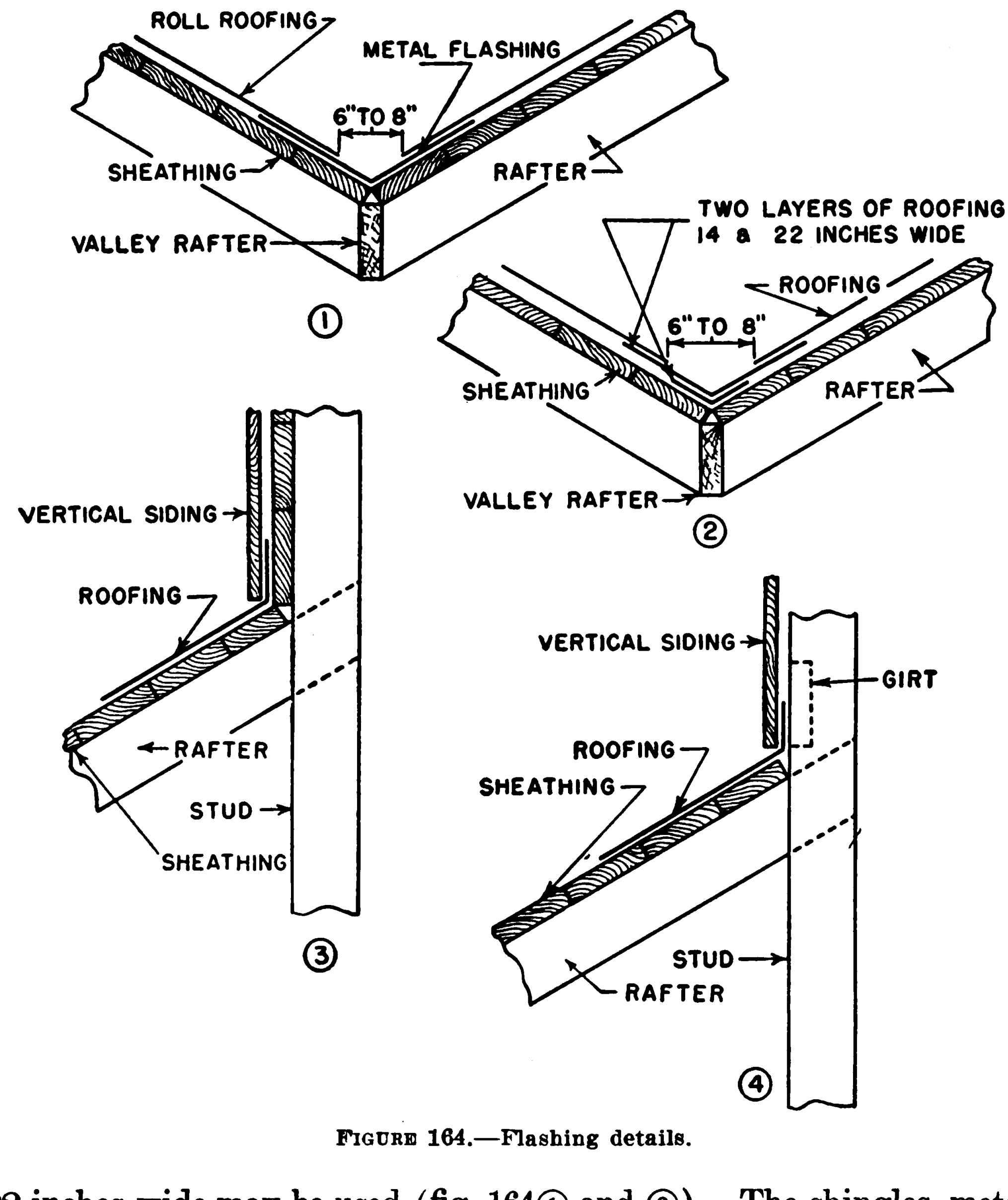


FIGURE 164.—Flashing details.

22 inches wide may be used (fig. 164① and ②). The shingles, metal, or roll roofing should be cut back from the center of the valley 3 or 4 inches, as shown in figure 164① and ②.

(2) Where a roof intersects a vertical wall, flashing should be used as shown in figure 164③ and ④. Metal or roll roofing may be used as the flashing. Where wall sheathing is not used, a 2 by 4 girt should

be installed between the studs, as shown in figure 164④, to support the flashing. Roll roofing may be used as a continuous piece for roofing and flashing.

145. Towers and water-tank platforms.—In many cases engineers must build water tanks and towers for railways, and platforms for water tanks at purification units. Where these towers and platforms are built, care should be taken to make a firm foundation as the

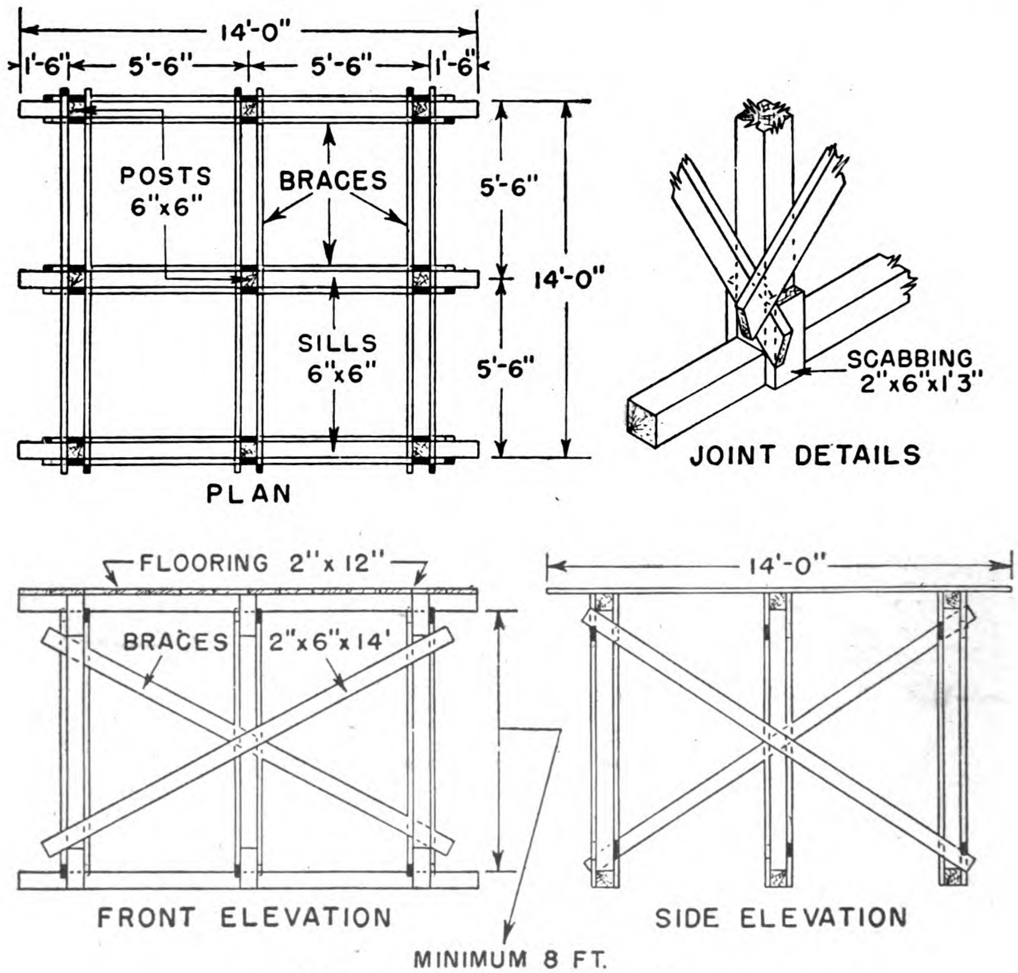


FIGURE 165.—Water-tank platform.

weight on the foundation is extremely great. The bearing stress of the soil should be taken into consideration so that the proper footing may be installed. Where large tanks are supported by a tower, the foundation should be concrete if possible. The foundation should be placed low enough in the ground to be on firm soil or rock. The framing should be large enough to carry the weight of the tank plus the contents. The corner posts should be inclined to the center about 7 inches per 10-foot rise and should be well braced. The joints in the posts and braces may be fastened with bolts or toothed rings to give greater strength to the joint. In the construction of towers it is important to be certain that the foundation is level and that the framework is fastened securely as the tower is built. In the platform for small canvas tanks the posts are not inclined at an angle but are plumbed and braced as shown in figure 165. These platforms are seldom less than 8 feet in height and are supported by nine posts with diagonal bracing. Care should be taken to use material that is structurally sound and of good bearing power. The foundation of the small tower is 6- by 6-inch timbers laid on graded earth; if the soil has low bearing power, footings should be used. A small tower may be constructed in three sections, each similar to a trestle bent for a bridge. After the three sections have been constructed, they are raised and braced as shown in figure 165. The flooring is then laid to support the tank.

Chapter 8

METHODS OF ERECTION

146. General.—The method of erecting buildings directly affects the quantities of time, labor, and material required. Different methods are used in different types of buildings and under different conditions of climate and terrain. These methods may be divided into two types:

a. The method whereby each piece is separately erected in its proper place.

b. The method whereby a complete section is built up as a unit and then set in the structure in the proper place. This latter method is used extensively as it makes for greater speed, better control over working parties, use of more manpower, and of a standard list of sizes for each similar section. By using standard plans issued by the Chief of Engineers, construction in the field is greatly simplified.

147. Single piece method.—In this method the procedure is as follows:

a. The officer in charge of the construction divides the men into working parties, the size of a party varying according to the work to be done. The duties may be divided among the parties as follows:

(1) Laying out for the foundation.

(2) Grading and excavation.

(3) Laying out and cutting various sizes of material.

(4) Carrying material to the cutting and erecting parties.

b. If a party completes its task before the building is completed, it is assigned a new task. For example, if the party laying out for the foundation nears completion of its work before erection of the building is begun, it is assigned a new duty such as cutting rafters or any other task that is to be done. The erecting party starts from the ground and continues until the roof has been completed. Parts are built in the following order: footings, piers, sills, joists, floor, soles, studs, plates, girts, rafters, bracing, siding, sheathing, roofing, doors, windows, steps, and inside finish (if used).

148. Sections.—This is known as the preassemble method. Most Army buildings are now erected by this method. The general procedure is as follows:

a. Before measurement and cutting of the lumber, the number and size of like sections should be determined from the blueprint. This is to insure planning for the correct numbers of each piece. This information is given on the plans for the building to be constructed. The carpenter secures the information needed from the blueprints and assigns a crew of men to cut and assemble one section. In most cases a template is made to be used as a guide for assembling the section. Figure 166 shows a typical template used in assembling a wall section. The template should be built square, correct in size, and level, to insure that the section is of the correct size when assembled in the template.

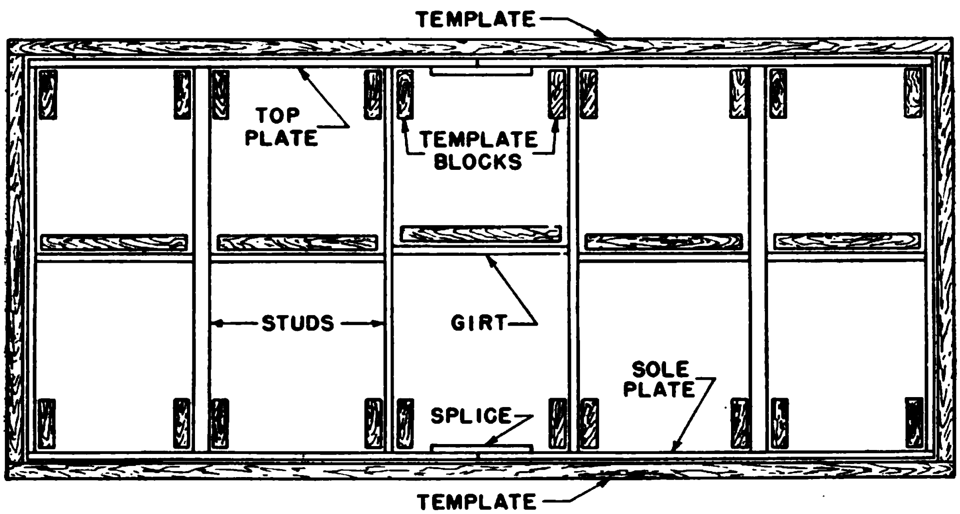


FIGURE 166.—Template for framing walls.

b. The number and size of each piece of timber that is to be used in a section is taken from the blueprint and given to the man in charge of the cutting party. The cutting party cuts the timber to the correct length by the use of the handsaw or power saws. The length is measured by the use of square and tape. After one piece has been cut to the correct size, it may be used as a pattern for marking the remaining pieces. The pattern is set up by nailing two blocks to the piece of correct size, one near each end, as shown in figure 167. These blocks act as stops to hold the pattern in place on the timber to be marked. Several cutting and assembling parties may be used at one time on different types of sections.

c. A party is used to assemble the sections, which is very simple when templates are used. The plate and sole are placed in the template with the studs and girts between, then the door and window posts, if any, are placed (fig. 166). The girts, sole and plate are nailed to the studs with 16- or 20-penny nails. If the insulation board is used, it and the wall sheathing are applied to the section before it is taken out of the template. By applying the wall finish before raising the section, time is saved since no scaffold or ladders need be used.

d. The method described in *c* above does not apply to floors and roofs, as they seldom are assembled in sections. Rafters may be assembled as described in paragraph 140.

e. Assembled sections are erected by an erecting party. This party sets the sections into place, braces them temporarily, and nails them together. The end section should be the first section erected, and may be erected on graded earth, or on type *X* or *Y* floors (fig. 1, app. III). The sidewall sections are next erected and should be so erected as to

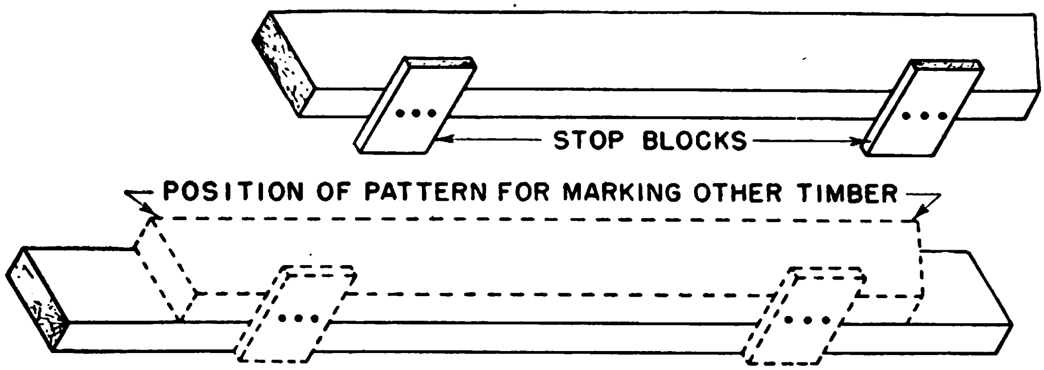


FIGURE 167.—Marking pattern.

keep the two walls even. The rafter party can then place the rafters on the walls. The carpenter should know how to divide the construction into parts so as to use the maximum number of men with the minimum loss of time. Parties should be set up as follows: lay-out party, cutting party, assembling party, carrying party, erecting party for side walls, erecting party for rafters, sheathing party, roofing party, and door-and-window party.

f. The preassembly method of erection may be used for all types of small buildings, also for bridges and large warehouses. When this method is used for the latter, cranes or gin poles are used to place sections too heavy to be handled by hand. Where machinery is used to erect sections, caution should be observed in fastening the cable or ropes to avoid damaging the section.

CHAPTER 9

CONCRETE FORMS

149. General.—In the theater of operations, concrete forms are built for the pouring of the concrete in fortifications, foundation footings, walls, and piers. This type of construction is the reverse of other construction as the inside of the form is the finish, whereas in ordinary wood buildings the outside of the walls is the finish. Since the dimensions are all inside dimensions, the carpenter must have a different mental picture of the work from that of ordinary construction. Seldom does a blueprint show how the forms are to be constructed. The finished work is shown without the form. The type, method of construction, and amount of material for the forms must be determined by the man in charge.

150. Design.—In the design of forms, careful consideration must be given to the probable method of removal, that is, the design should be such that the forms may be taken down with a minimum effort and with the least possible damage to the parts involved. The forms should conform to the shape, lines, and dimensions of the concrete called for on the plans. They should be substantial, sufficiently tight to prevent leakage of mortar, braced so as to maintain position and shape, and strong enough to sustain the weight of the concrete. In vertical members the hydrostatic pressure of green concrete may be 145 to 150 pounds per square foot, per foot of height. There are four essential features that should be considered in designing forms:

a. Obtaining the strength and stiffness necessary to support the dead load of the concrete, plus the construction live load, without sagging or bulging.

b. Building durably if the forms are to be used a number of times.

c. Obtaining light construction by economy of material, using the minimum amount of lumber consistent with safe and strong design.

d. Reducing labor to a minimum in both erection and stripping.

151. Footing.—*a. Rectangular forms for columns or piers.*—(1) Footings for columns are nearly always rectangular. The four sides may be conveniently built up as panel units. The panel for one pair of opposite sides is made to exact footing width from sheathing fastened to vertical cleats which are spaced 2 feet on centers. If 2-inch dressed lumber is used for these cleats, a cleat should be

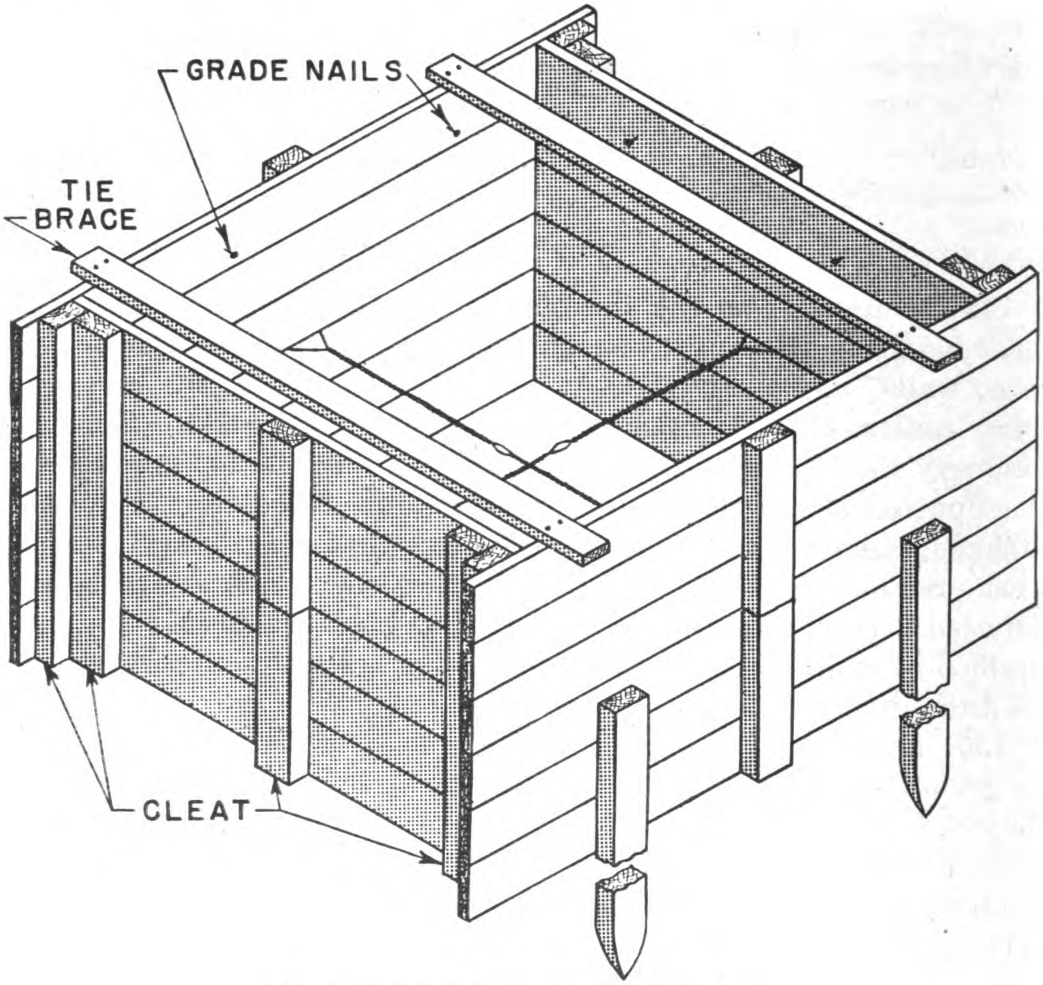


FIGURE 168.—Rectangular footing form.

placed 2 inches from either end of the panel with a slight allowance for clearance as shown in figure 168. The other pair of panels, with cleats on the inside, spaced the length of the footing plus at least twice the sheathing thickness, will then fit snugly against the first pair of panels, and the panels will support each other. A cleat is placed on the outside of the longer panels, midway between the inside cleats. The forms are held together with wire as shown in figure 168. The holes are bored on each side of the center cleat, and should be no more than ½ inch in diameter to prevent the seepage of concrete. The wire is crossed and then twisted on the inside. The form may be temporarily held in place with form nails on the outside until the wire is installed. All nails should be driven from the outside if possible, and driven only partially so that they may be drawn easily for the removal of the forms. When the forms are 4 feet square, or larger, stakes are driven at the bottom on the outside of the long forms to prevent spreading and tied across the top with 1 by 6 boards as shown in figure 168. If reinforcement is used in the concrete, this should be placed before the wire is installed. The depth of these panels need not be cut down to the exact footing depth since nails can be placed to mark the top of the concrete.

(2) *Small footings.*—Where footings are 2 feet square or less, and 1 foot or less in depth, the forms are constructed without cleats. Boards for two opposite sides are cut to a length corresponding to the finished concrete. Boards for the other two sides are cut longer by twice the thickness of the sheathing (fig. 169①). These boards are nailed together with form nails, or with common nails partially driven; thus they are easily drawn for the removal of the form. No wire is required to tie the forms together. They may be braced as shown in figure 169② and ③.

b. Stepped footings.—The form units for stepped footings are similar to the one shown in figure 170. For the upper step form, a support must be provided which does not interfere with the concreting of the lower step. The method shown in figure 170 is a common one. In this method, two pieces of 2 by 4 inches or 4 by 4 inches are placed across the top of the lower step on either side of the upper step form. The upper step form is then nailed to these pieces with its bottom at the concrete level of the bottom step. The bottom section of the form is poured and left for 2 or 3 hours, then the top section is poured. This permits the concrete in the bottom to set enough so that the concrete in the top form will not seep under the bottom of the top form.

c. Combination column and footing, small.—Where small columns are used on small footings, forms may be constructed as shown in figure 171. Here the small footing form, as shown in figure 169, is used with a column form and constructed as explained in *a*(2) above. The column form is made by four boards nailed together. Two boards of opposite sides are ripped to the exact size of the finished column, the other two to this size plus twice the thickness of the sheathing. Two ties long enough to reach across the footing form are nailed edgewise to the two wide sides of the column. The column form is then centered over the footing form and the two ties nailed to the footing form as shown in figure 171. Ties should be nailed on the column form at every 3 feet of height to prevent bulging. They are placed on the sides with the narrow sheathing and nailed into the edges of the wide sheathing (fig. 171). Two stakes are driven at the bottom to hold the footing form in place. After it has been set in the correct position, the column form is braced as shown in figure 171

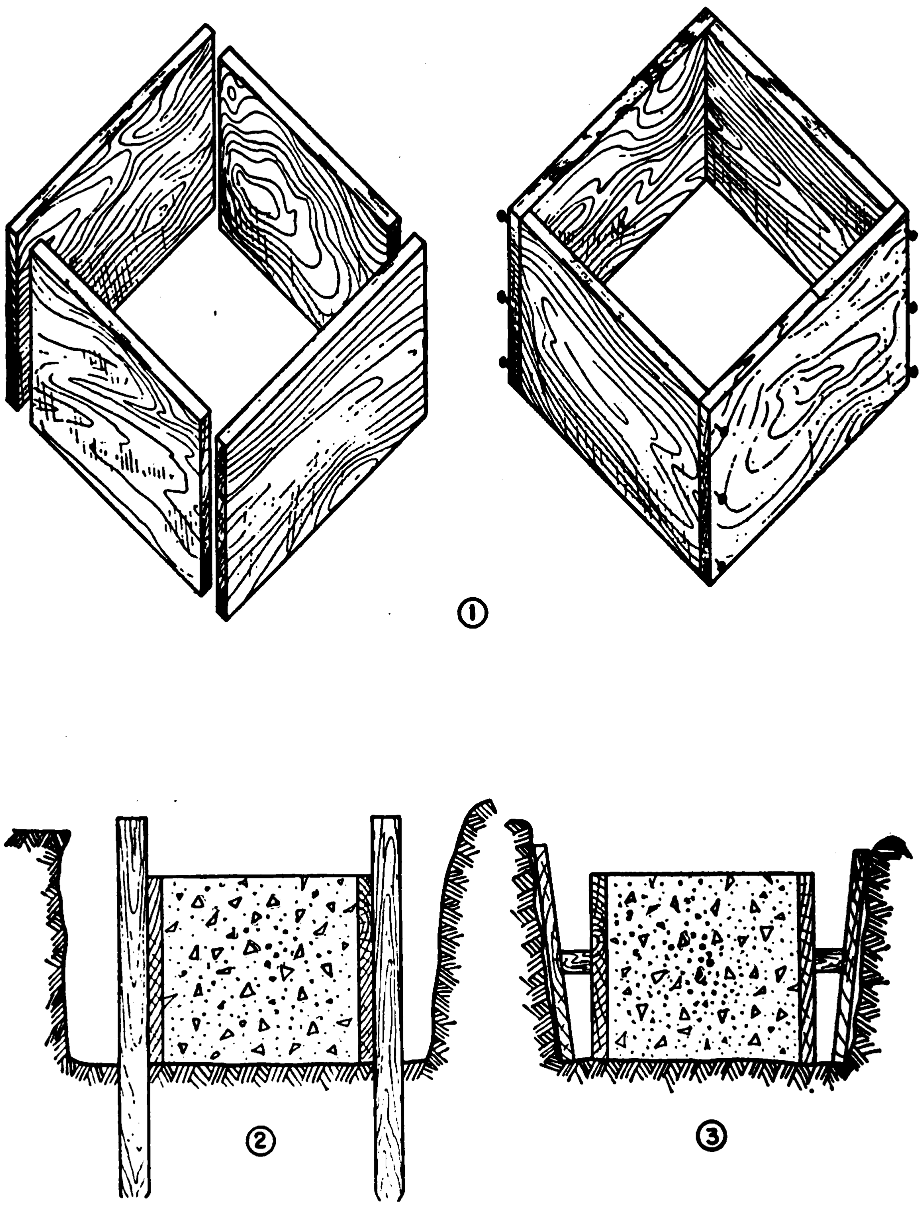


FIGURE 169.—Rectangular footing form.

by stakes driven into the ground and boards nailed from the column form to the stake. Where long lines of column forms are set, they are braced to each other with boards while the two end forms are braced to stakes.

d. Rectangular forms for walls.—Where walls and footings cannot be poured at the same time, forms for the footing must be constructed and poured before the wall forms can be placed (fig. 172). If reinforcement is used it may be suspended with wire tied to the spreader or ties (fig. 173①). Frequently a form is not required for the footing because the ground is stable enough to permit excavating a hole or trench of the right size for the footing; if so, the concrete can be poured directly into the hole or trench (fig. 173②).

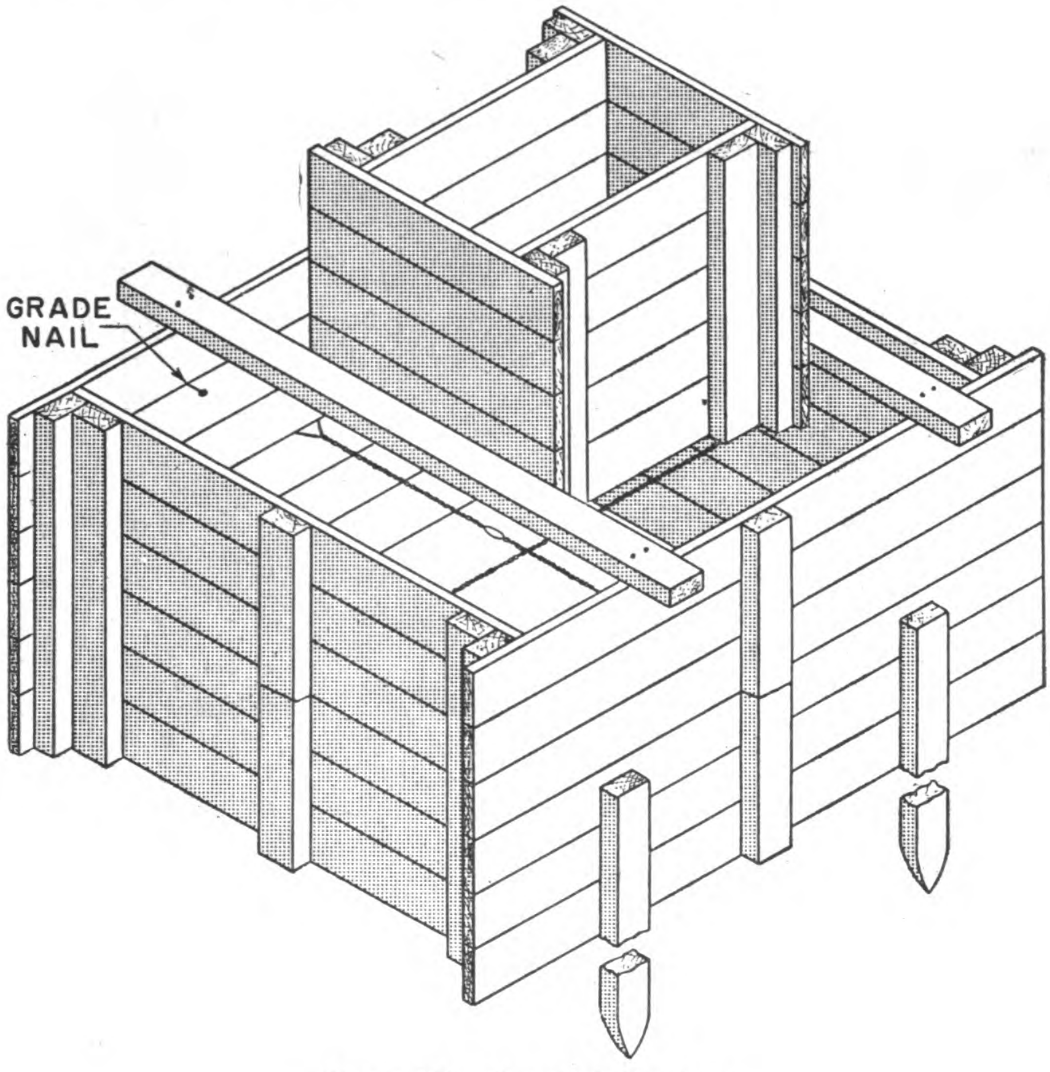


FIGURE 170.—Stepped footing form.

152. Column.—*a. Construction.*—If the forms for the column sides are constructed in units, the larger pair of opposite panels should be built first. The width of these panels is the width of the column plus twice the thickness of the sheathing. The length of the yokes is the width of the column plus twice the thickness of the sheathing and yoke plus 8 inches. This length is proper for each side of the column. The end board of the panel is then nailed to the yokes, with the outside edge of the board one-half the width of the column plus the thickness of one sheathing board from the center of the yoke. Yokes are spaced 2 feet on centers and are made of 2- by 2- or 2- by 4-inch material. The yokes at the top and bottom of the column should not be more than 9 inches, respectively, from the top and bottom of the column form. The yoke pieces on the two opposite sides should be nailed on the

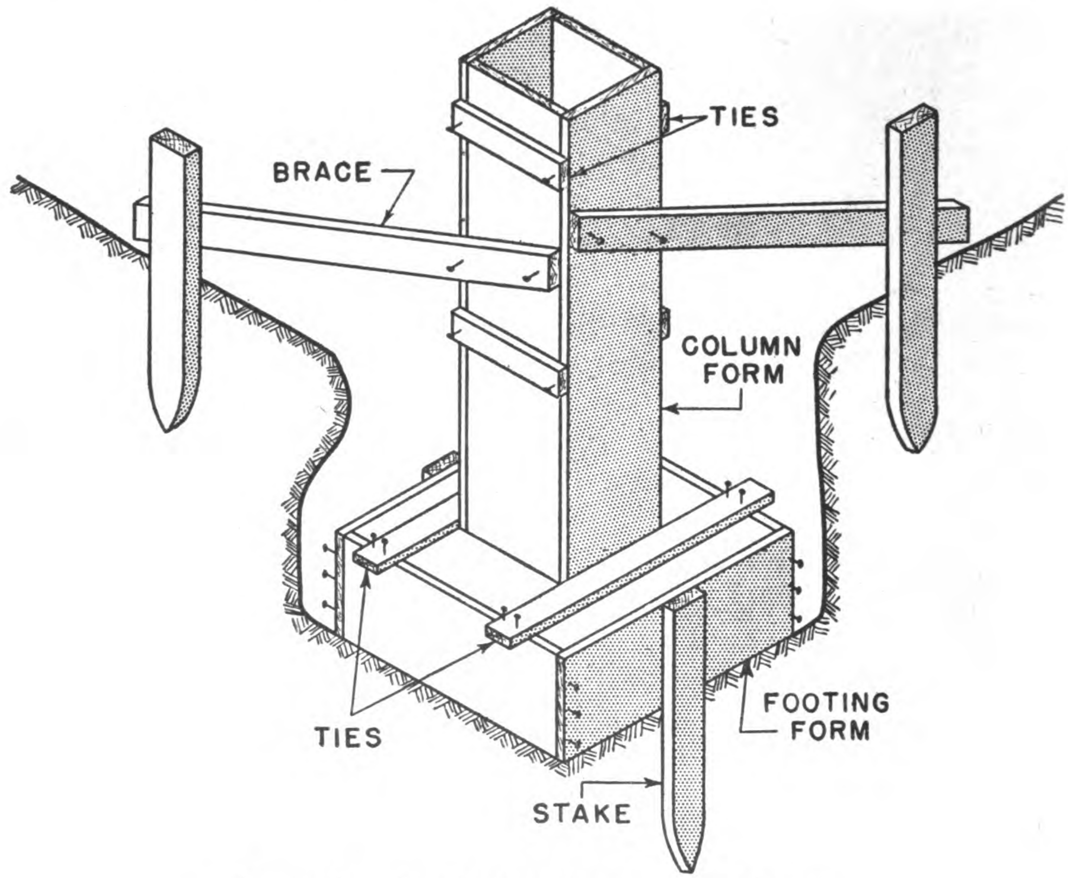


FIGURE 171.—Combination column and footing form.

panels at the same distance from the ends. The other boards are pushed up tight against the first board and nailed. The last board is ripped to the correct width before it is nailed to the yoke. The remaining panels are assembled in a similar manner. They have the same width as the column, the yokes being placed at the thickness of the yoke above or below the yokes on the other panels. This is done so that they can be nailed together after the panels are assembled (fig. 174①). It is a good practice to assemble and nail the panels where they are to be set up if they are not too heavy and clumsy to handle as single units. This method saves labor, time, and some bracing that would be necessary if each panel were put up separately. Methods of fastening yokes around columns are shown in figure 174. The panels may be fastened with nails partially driven to hold the panels in place until the yokes have been nailed. The bottom of the form should be cut off to fit the surface upon which it rests.

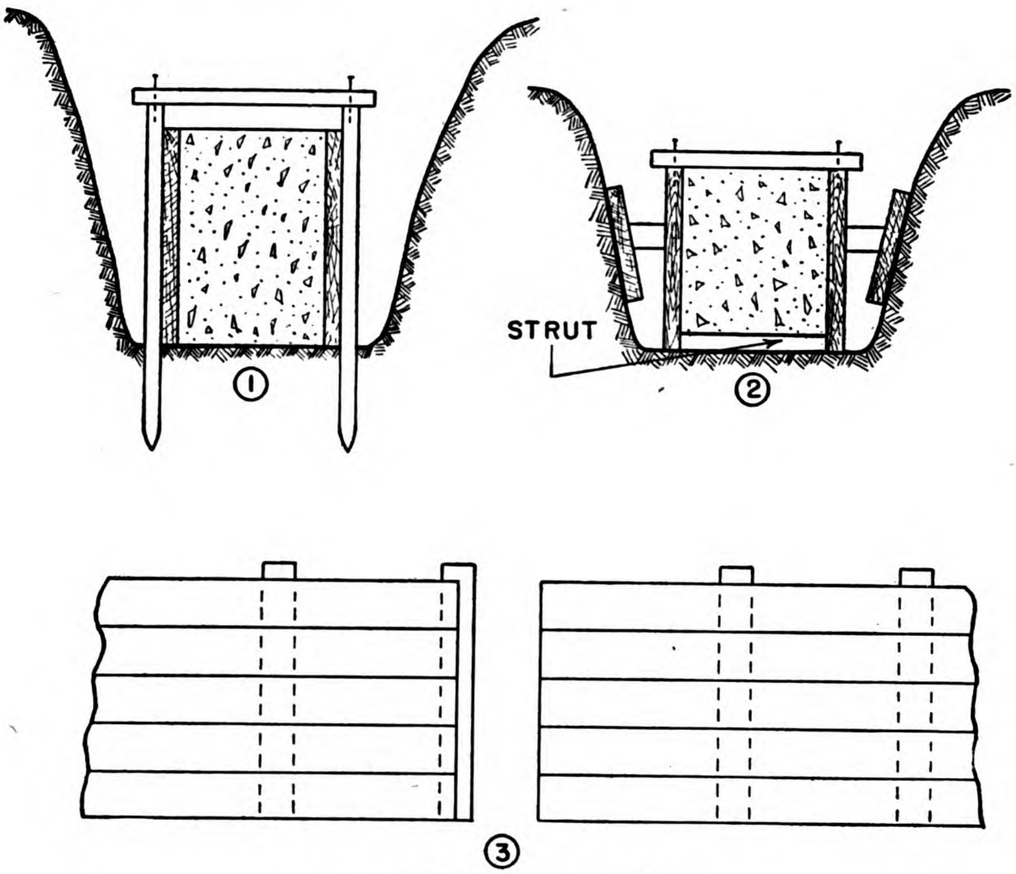


FIGURE 172.—Wall footing forms.

b. *Bracing*.—In bracing column forms always remember to make the bracing amply strong enough to resist the force of falling concrete, the pressure of the concrete, the vibration caused by tamping, etc.

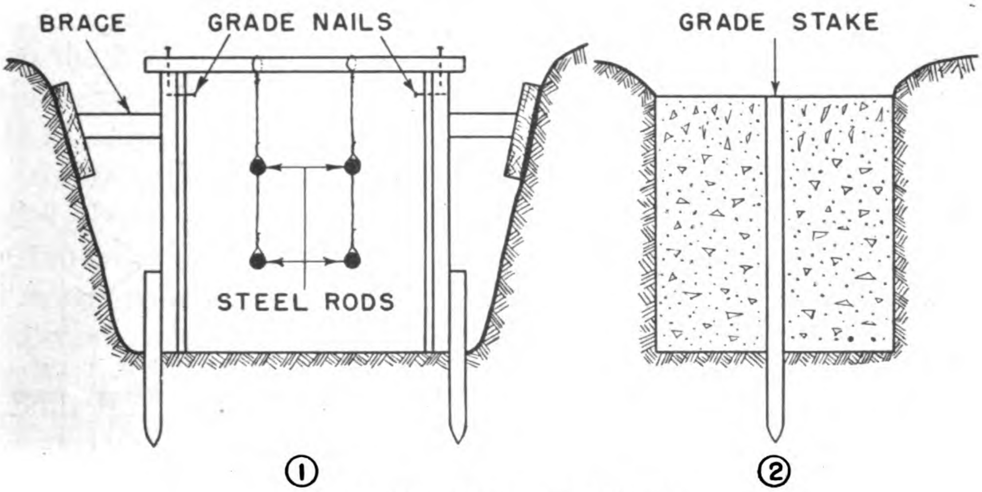


FIGURE 173.—Wall footing forms.

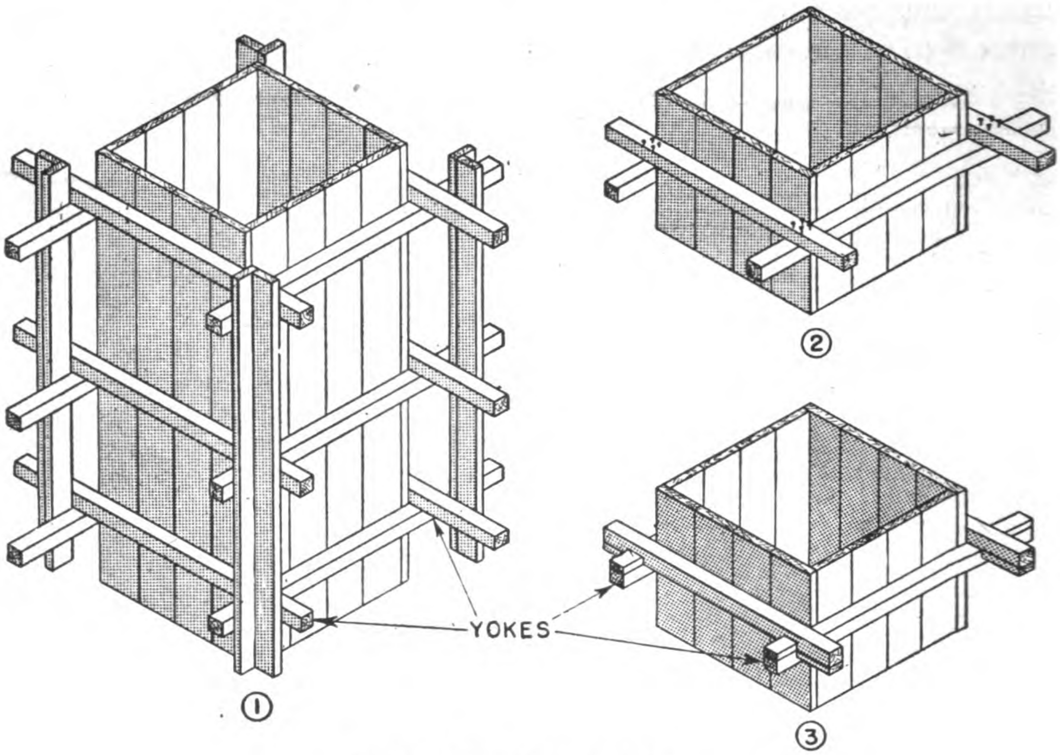


FIGURE 174.—Column forms.

Once a form bursts or gives after the concrete is poured, it is almost impossible to restore it to its original shape. The large column forms can be braced as shown in figure 171 or where the ground is too soft to hold it can be braced as shown in figure 175.

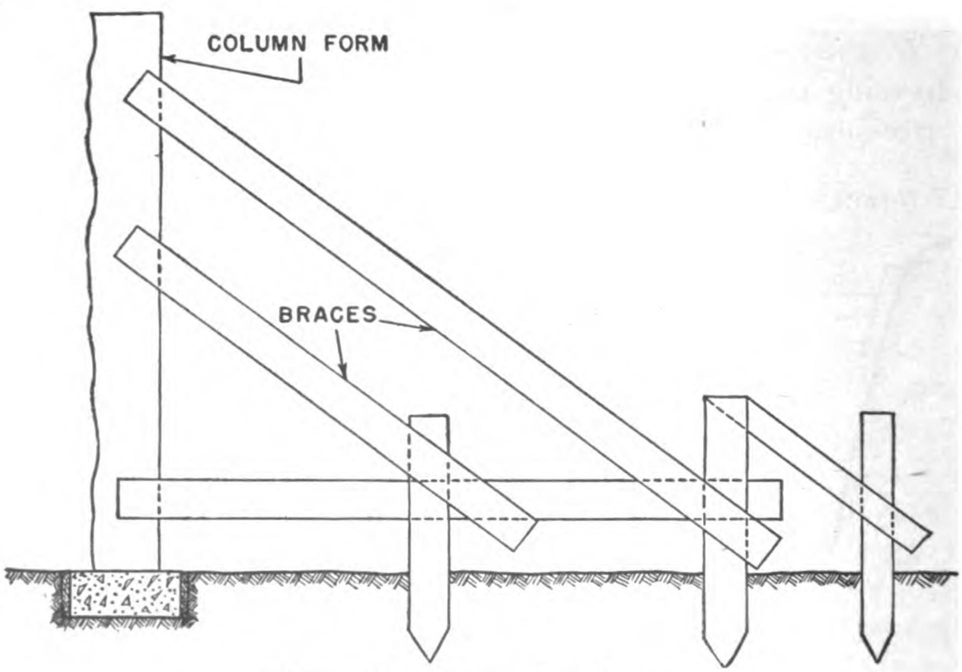


FIGURE 175.—Column form braces.

c. Material.—The material to be used in column forms depends upon the height and cross section of the form. If forms are 18 inches square or more, it is advisable to use 2-inch material which requires less bracing and fewer yokes. It is better to use sized material as this reduces the amount of time and labor required in the construction. The braces should be 1 by 6 inches or 2 by 4 inches. The yokes should be 2 by 2 inches or larger. Where ¾- or 1-inch material is used, it is better to use shiplap or tongued and grooved material of that thickness, as it is stronger. Plyboard used on cleats or studs makes excellent forms, but it should be at least ⅝ inch thick.

153. Wall.—The building and setting of forms is simple when the carpenter has a mental view of the structure to be built. The first step in construction forms is to obtain the approximate dimensions of the forms. This is done to determine the dimensions of the studs. If the walls are thick the studs must be larger or spaced at closer intervals. Usually the sheathing is ¾-inch material, smooth on four sides (with square edges, tongued and grooved, or shiplap). This material is nailed to the studs with 6- or 8-penny nails, the form corresponding in length to the concreted size if the length is less than 16 feet. If walls are longer than 16 feet the forms are made in sections, each with a stud flush with the end of the sheathing. This permits the forms to be fastened together by nailing the studs of adjoining frames. These forms are made on saw benches, carried to the location, and set in place by hand if they are not over 6 or 8 feet high. If they are higher, it is better to build them in place. Sometimes the form rests on a concrete footing that has been previously poured (fig. 176). If the footing and wall are to be poured at the same time the bottom of the form must be designed as shown in figure 177. The footing is 4 inches wider on each side than the wall. This is accomplished by two methods: one method is to nail 2 by 8 blocks on the side of the regular studs with a notch the size of the offset in the wall cut in the bottom (fig. 177②), the other method is to use short studs of the same cross section as the regular studs, scabbing them to the studs as shown in figure 177①.

a. Studs.—The studs used in form work are generally 2 by 4's and only studs of sound lumber should be used. Where wales are used (fig. 176), the studs should be sized so that all may be of the same size. The spacing of form studs is an important part of form building. Good standard practice is to space them 2 feet on centers. The strength of ¾-inch boards and their resistance to bending determine the distance to be allowed between studs. Forms more than 6 feet high require that studs be spaced closer than 2 feet to prevent deflection in the finished wall. It is good practice to form the entire wall around the building. When 4 or 5 feet of concrete is to be poured in a short length of time, the form should be built to withstand 1½ times as much as when it is poured slowly. When wheelbarrows are used to convey the concrete from mixer to form, the studs should be cut off nearly flush with the top of the sheathing.

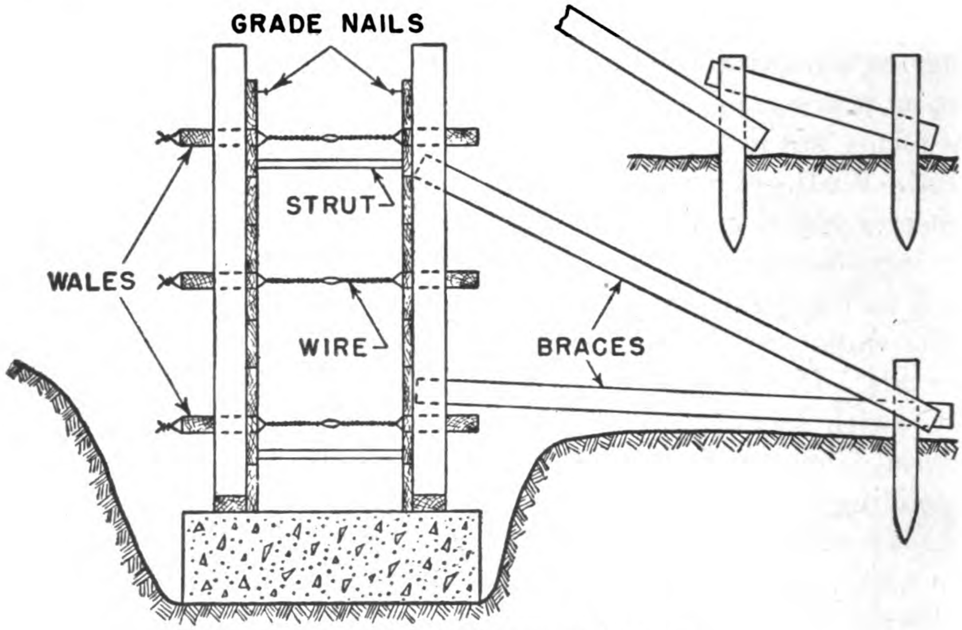


FIGURE 176.—Wall form and braces.

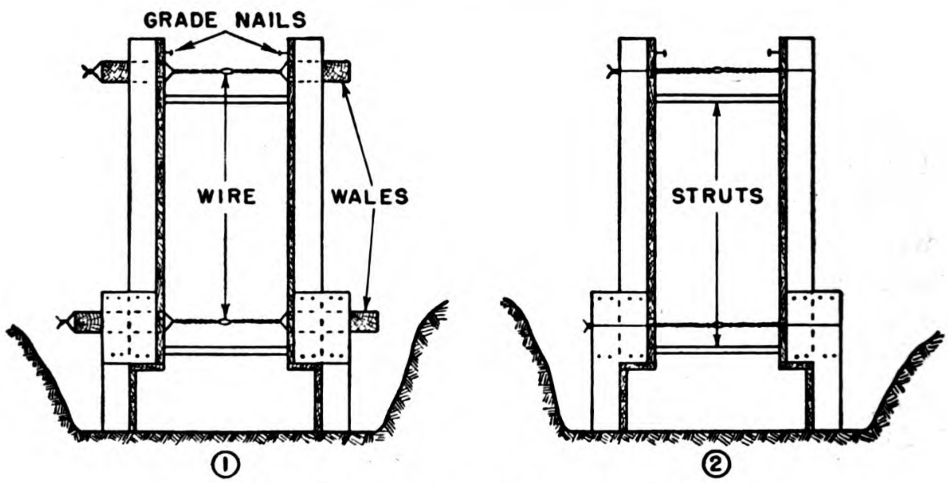


FIGURE 177.—Wall form with wire and wales.

b. Wales.—The wales are generally the same size as the studs. They should be straight and free from twist. The wales may be placed against the studs and nailed temporarily to hold them in position previous to wiring. The ends should be butted and the joints spliced with pieces of board 3 feet long, so as to form a continuous support horizontally along the form.

c. Wiring.—Soft black annealed iron wire should be used for wiring concrete forms, since it must be able to withstand severe twisting strains without breaking. Figure 178 shows a good method of wiring wales. No. 8 or 9 wire is best for this work. After the wales have been tacked in position a piece of wire cut to the proper length is passed through the holes which have been bored in the forms and crossed back upon itself, then the ends twisted together around the outside of the wales. A small bar of iron or a large nail is inserted between the two parts of the wire at the point where they cross, and the wire twisted tight in the manner of a Spanish windlass or twister. Before the wire is threaded into the holes, spreaders should be placed between the forms to hold them apart. They are usually made of ¾-inch strips,

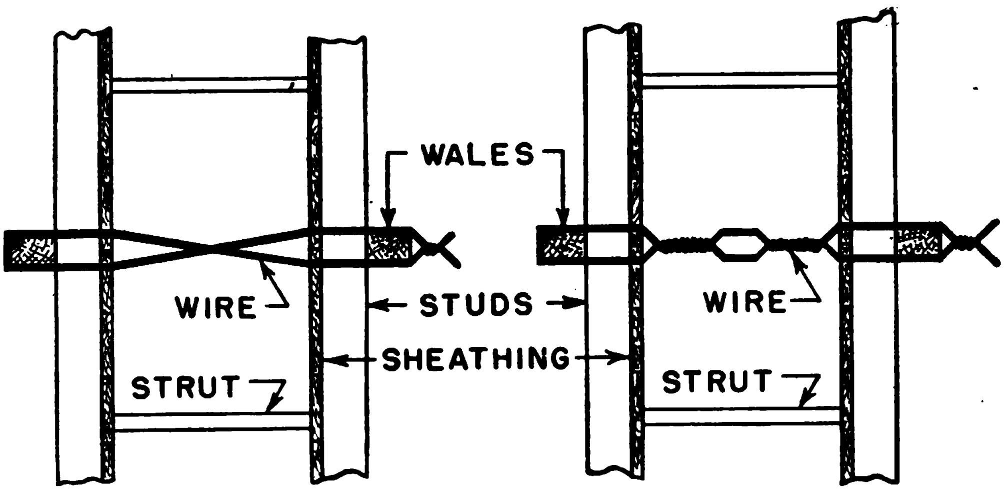


FIGURE 178.—Forms, ties, and struts.

cut to a length to correspond with the thickness of the concrete. The wire spacing varies with the thickness and height of the concrete. Thick or high walls require closer spacing of the wire. Ordinarily the spacing should be 3 feet along the wales.

d. Bracing.—When concrete forms are wired, the braces may consist of boards nailed to the form studs and to stakes driven into the ground (fig. 176). These stakes should be driven well into the ground to prevent movement when pressure is applied. The braces should be nailed low on the stakes. Where one stake will not hold, two may be driven and tied together with a board, as shown in figure 176. If wales are used on the forms, the braces may be spaced about 8 feet apart; if not, the braces should be about 4 feet apart. If necessary, the forms are braced on both sides, as described above. In cases where only one wood form is used, this form must be braced more than usual to prevent movement and bulging.

e. Miscellaneous form details.—(1) The top of concrete forms should be a few inches higher than the top of the concrete. Before the concrete is poured, the height to which it is to be poured is marked by nails partially driven into the form every 4 or 5 feet. The forms are filled with concrete up to these points.

(2) In figure 179① the stud on the outside corner and the one on the inside corner are set back from the concrete the thickness of the sheathing to allow for the sheathing of the other form. This is a detail which must be provided for when building forms in sections prior to their erection. Figure 179② shows a typical form section. Notice that at each end the studs are flush with the ends of the boards. This brings two studs together when two form sections are joined. These are nailed to hold the form together.

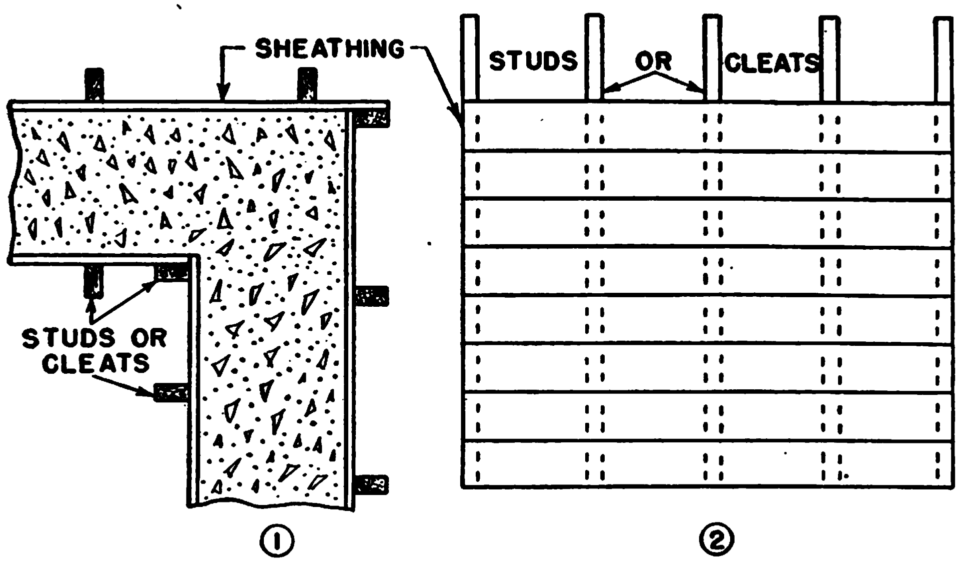


FIGURE 179.—Corner and panel details of form.

(3) If forms are too large to pour in one day, or if some other factor prevents pouring them in this time, joints must be made in concrete. Figure 180 shows the most commonly used vertical or horizontal joint. The V should always be made in the previous pouring. If no reinforcement is used in the concrete, dowels should be used in the joints. Figure 180① shows a joint in a concrete floor. It is made in the same way as the one for walls.

(4) In certain types of foundation, such as those required for columns and heavy machinery, anchor bolts are set to secure the steel columns or machinery. A template made from a piece of board, or a 2 by 4 of suitable length, is marked with center lines, and holes are bored with the proper spacing for the anchor bolts. The center line for the bolts is marked on the forms, then the center line of the template is placed over the center line of the form. Figure 181 shows the method of installing a template for anchor bolts. To allow for

small adjustments of bolts after the concrete has set, pipe sleeves may be used (fig. 181). The size of these sleeves should be approximately twice the diameter of the bolt and two-thirds its length, and should be filled with sand, waste, or oakum to keep the concrete from filling in.

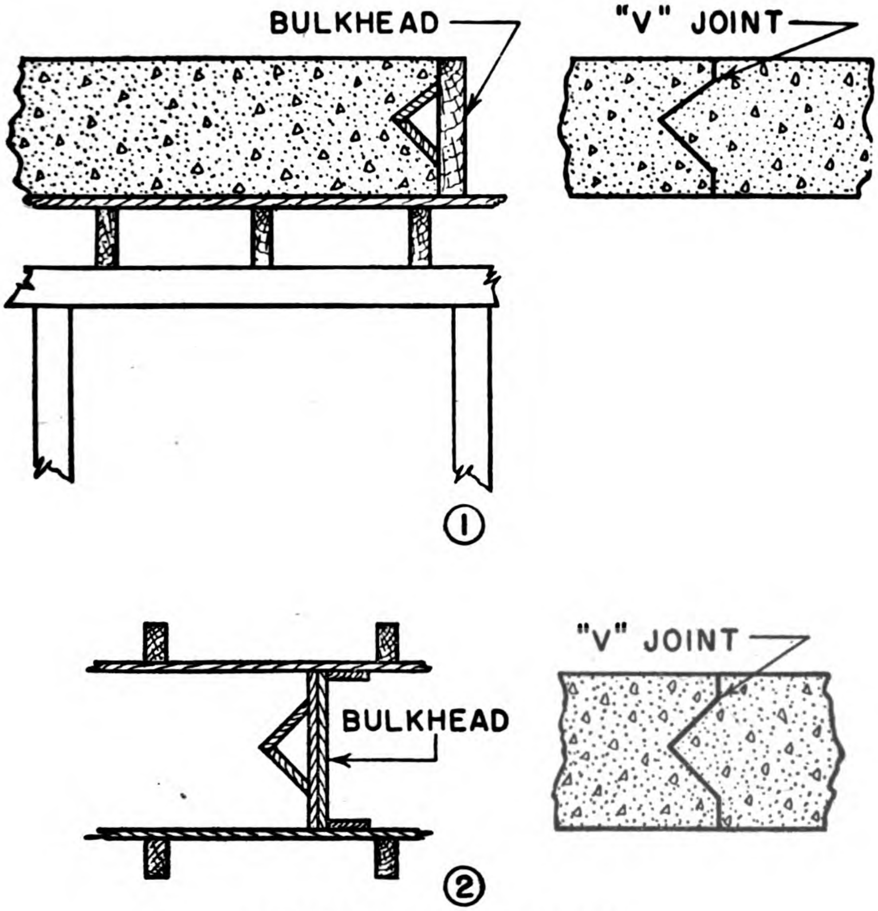


FIGURE 180.—Joint construction.

(5) Where the concrete is conveyed from the mixer to the form by wheelbarrow, runways must be built to and around the form. Figures 182 show the construction of runways around a form. These runways greatly increase the speed of pouring and reduce the amount of labor.

154. Slab.—The slab forms that are usually built by soldiers are not complicated with beams and girders. In most cases the slab form is made by the use of a joist resting on studs and sheathing nailed to the joist. Figure 183 shows a typical flat slab; the side walls have been poured and the slab rests on the side wall. The post or studs should be cut short enough to permit the use of two wedges underneath. The wedges are used to level the form and to make its removal easy. The joists should be 2 by 6's spaced 2 feet on centers; the post and girders should be 4 by 4's spaced according to the thickness of the slab and the length of the span. Figure 184① shows the two steps in pouring floor, walls, and roof or slab. The first step is to pour the floor and 1 foot of the wall; the outside wall forms are built high enough for the complete structure, and are set in place for the first pouring. The inside wall forms are 1 foot high, suspended to the spreaders as shown. After the concrete is set sufficiently for the removal of the inside forms, the new forms are built and set in

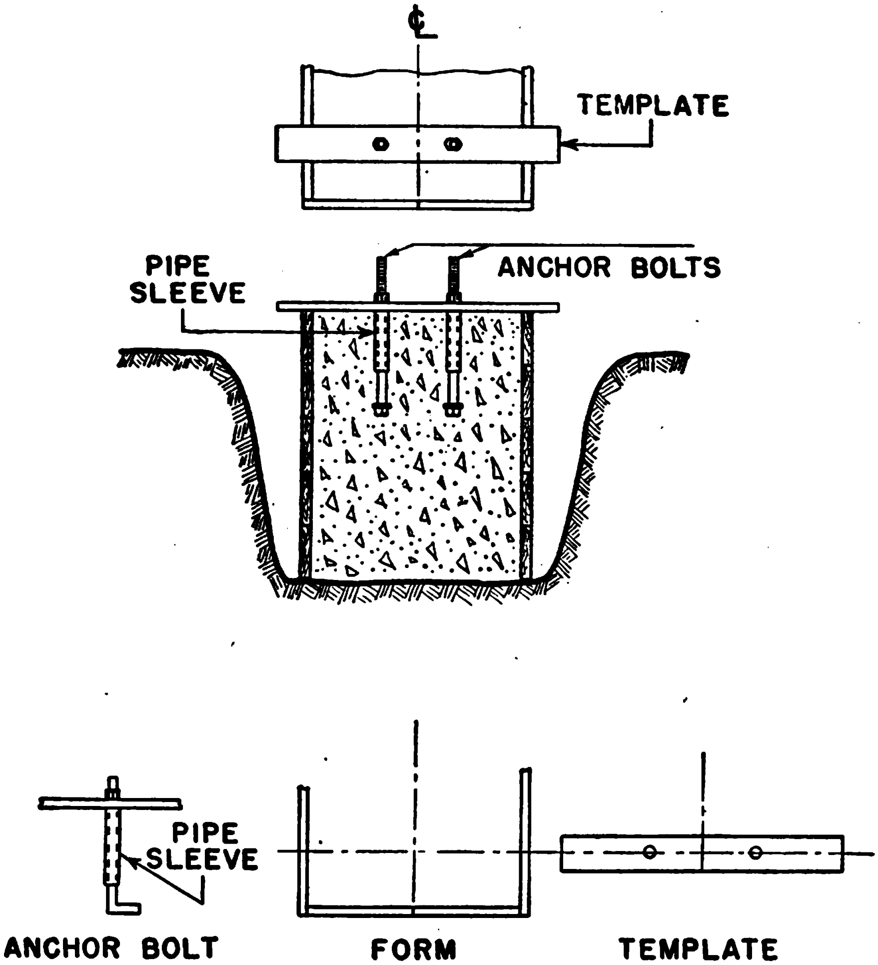


FIGURE 181.—Detail of anchor bolt installation.

place. These are made 2 to 3 inches shorter in height to permit the use of wedges underneath. The joists for the slab are nailed to the side of the stud and blocks are nailed underneath to give added support. After the forms have been nailed together, they are raised to the correct position by the use of wedges under the studs. Spreaders are nailed to the studs at the bottom to keep the inside forms tight against the wall. Where spans exceed 6 feet, girders are placed on posts as shown in figure 184② to help carry the load. Spreaders are put between the outside and inside wall forms to hold them apart when the wire is tightened. The wire and wales are installed as shown in figure 184②. The outside forms should be tied together at the top with 1 by 6 boards to keep the forms from spreading, or

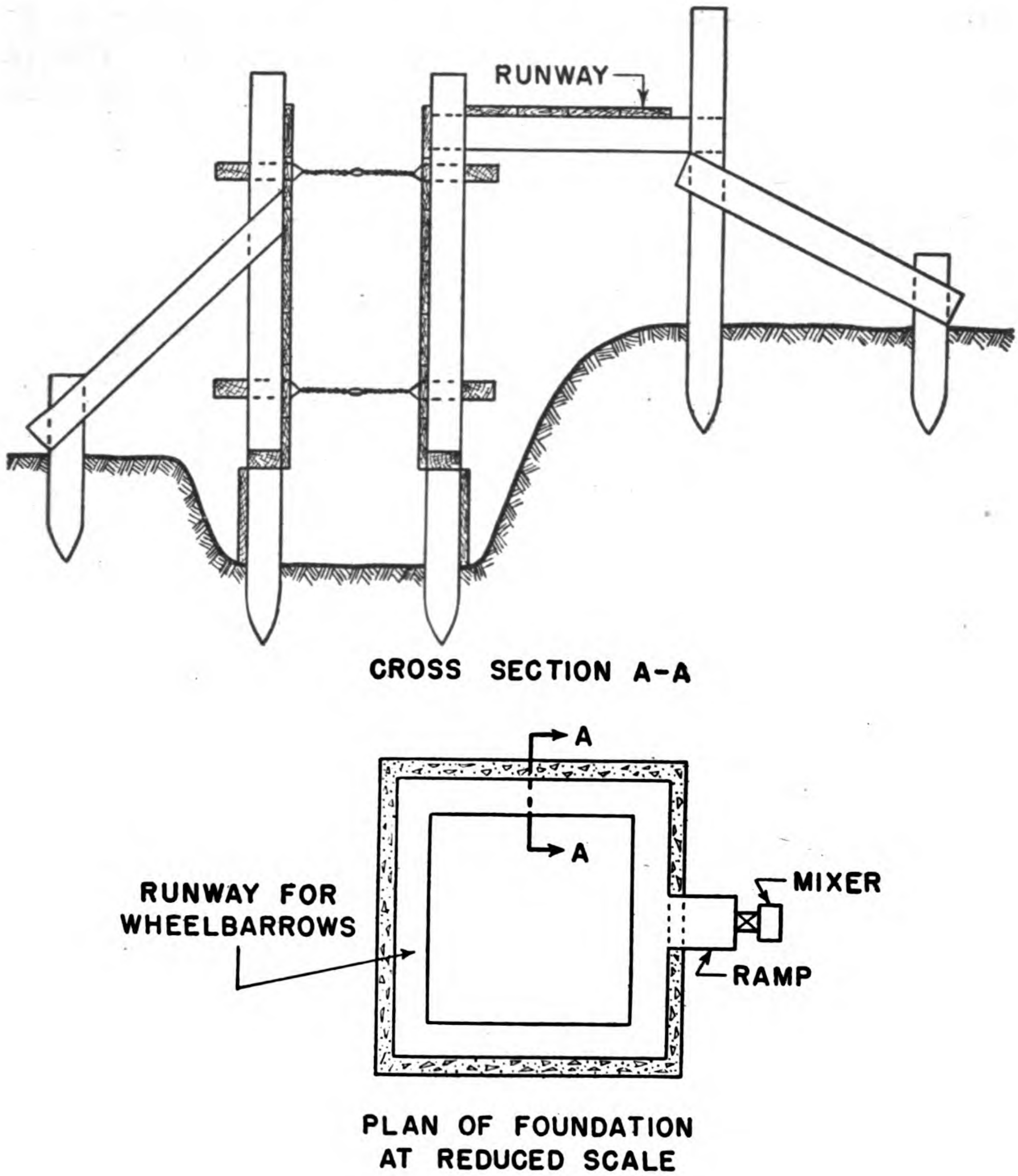


FIGURE 182.—Runway details.

braced to stakes driven in the ground. The ties or braces should be approximately 6 feet apart.

155. Screeds.—To obtain a level surface or definite grade and correct thickness at all points, a suitable system of guides must be provided. An arrangement of screeds is usually installed so that a straightedge worked with a sawlike motion across them levels off the concrete. When a floor is to be laid on earth or cinder fill, the screeds may be constructed as in figure 185①. These may consist of a strip of board, or a 2 by 4 supported on suitable stakes driven into the subgrade. Where the floor is to be laid on wooden form boards, the screeds may be constructed as shown in figure 185②. They are supported on legs or blocks with two shallow saw-cuts where the wire is to cross and are wired to the form with 16-gage wire. This permits the wire to lie below the concrete surface without interfering with the smoothing of the concrete. In either case concrete may be

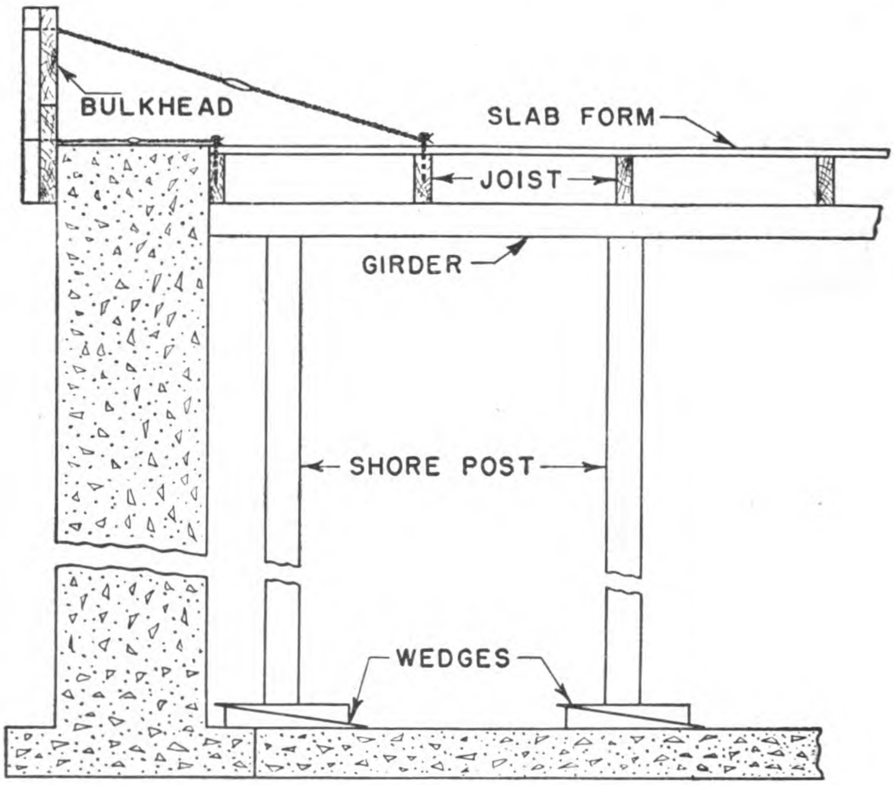


FIGURE 183.—Slab form.

placed on both sides of the screeds embedding the supports temporarily in fresh concrete. Before the concrete has set firmly, the screeds should be removed and the holes left by the supports of the screeds filled with fresh concrete. Figure 185 shows the method of installation and the use of these screeds.

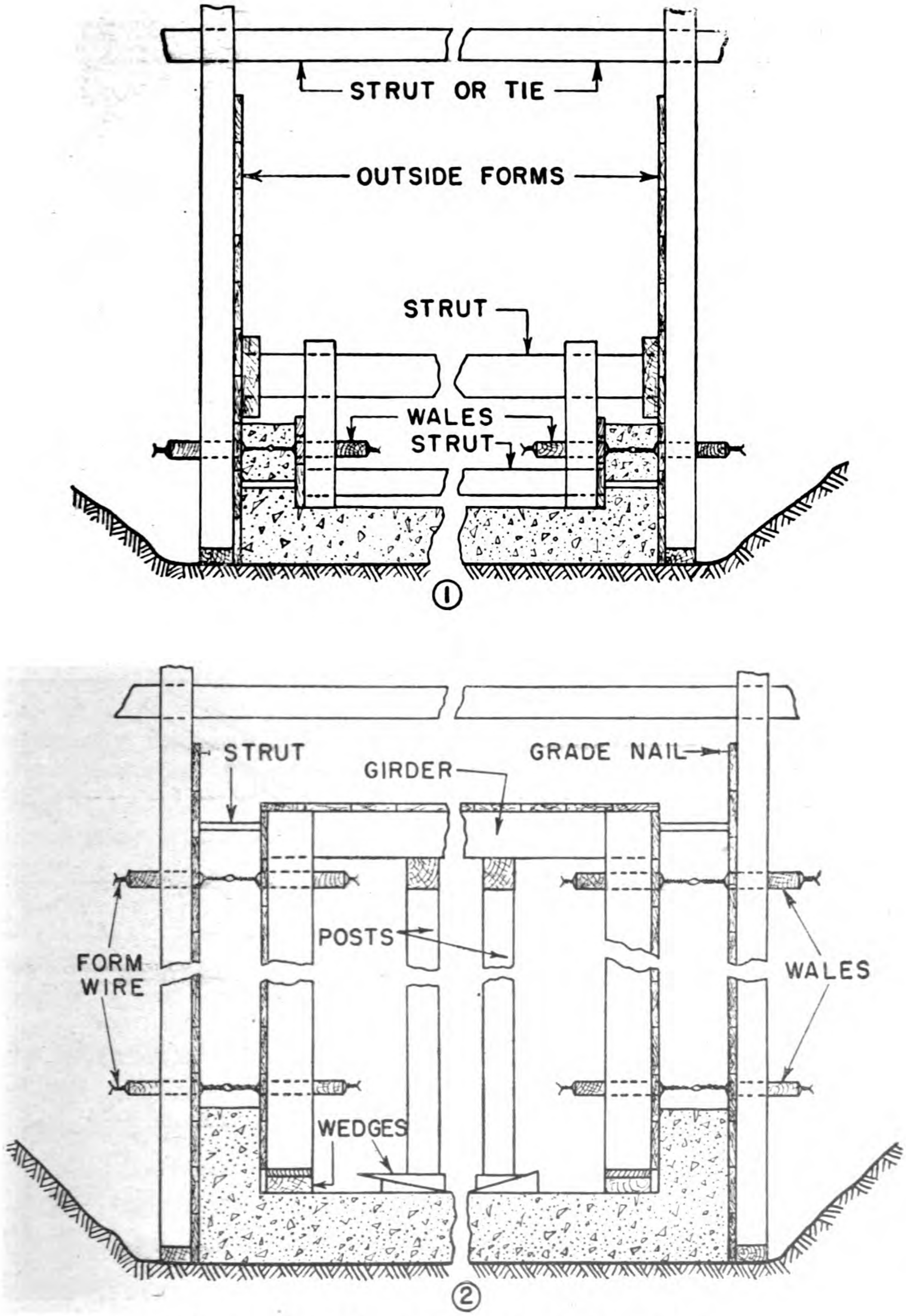


FIGURE 184.—Floor, wall, and slab form detail.

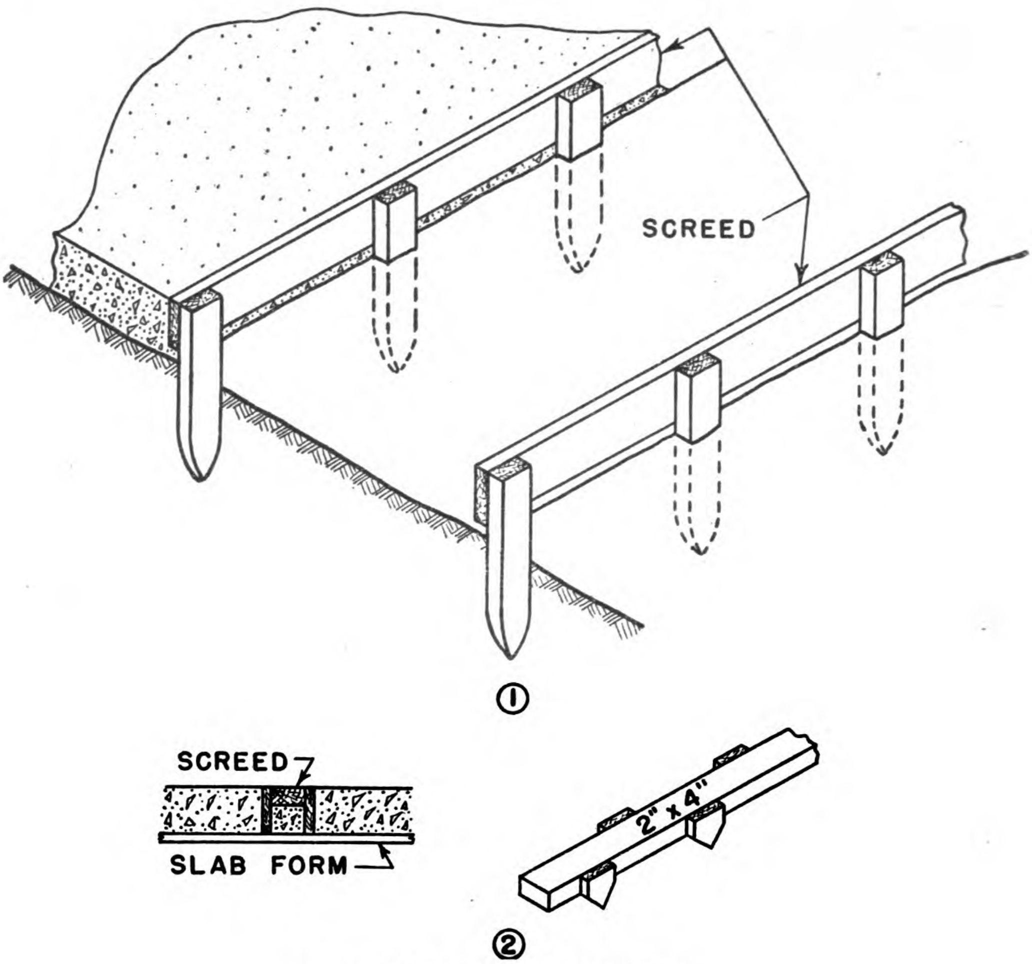


FIGURE 185.—Screed installation.

CHAPTER 10

BRIDGES

SECTION I

GENERAL CONSTRUCTION

156. Standard military bridges.—The standard type bridge that the carpenter constructs is the nonfloating standard timber bridge. It is usually a simple timber trestle-bent bridge with wooden stringers in spans not exceeding 15 feet, or steel stringers in spans greater than 15 feet but not exceeding 25 feet.

157. Bridge nomenclature.—*a. General.*—The essential, basic components of a bridge are the substructure and the superstructure. Included in the substructure, in addition to the abutments and the foundation, are the supports upon which the superstructure is carried. These may take the form of piers or bents. The superstructure constitutes the remaining upper part of the structure, including the stringers, flooring, curb, and handrail.

b. Definition.—Some of the more common words used in connection with the subject of standard trestle bridges may be defined as follows:

(1) *Abutment.*—The ground support of the superstructure at an end of the bridge.

(2) *Bent.*—An intermediate transverse support consisting of a framework of horizontal and vertical members, usually requiring external bracing for stability. (Short pile bents do not require longitudinal bracing.)

(3) *Flooring.*—The deck covering which forms a roadway for traffic across a bridge.

(4) *Footing.*—The arrangement whereby loads from supports or bridge seats are distributed over a greater ground area as a means of reducing unit pressures.

(5) *Girder.*—A simple or built-up beam of wood or steel, designed to carry floor loads to pier or abutment.

(6) *Pier.*—An intermediate support constructed of masonry, reinforced concrete, or cribwork, or consisting of several bents so constructed as to form an integral unit which needs no additional bracing for stability.

(7) *Sill.*—The member of a support which rests directly upon the ground or a footing.

(8) *Span.*—The portion of a bridge between centers of two adjacent supports; or the distance between such centers.

(9) *Trestle.*—Same as a bent; often referred to as "trestle bent."

158. Staking out.—*a.* The first task of actual bridge construction by the carpenter is that of staking out the bridge. Given the center-line location for the bridge, a line is stretched across the stream, gulch, or ravine and placed where the center line of the bridge is to be. The line is held in place by driving stakes into the ground and fastening the line to these. The stakes should be driven at least 15 feet behind the location of the abutment sill (fig. 186). The sill is then laid at approximately its correct location, with the center of the sill under the line.

b. To square the sill with the line a rope or tape is used to measure the distance from the stake to one end of the sill, then the distance to the other end of the sill. If the two distances are the same, the sill is square with the center line. If the distances do not correspond, the sill must be moved. Figure 187 shows the method of squaring a sill with a center line.

c. Where possible, the abutment sills at each end of the bridge should be at the same elevation. This may be accomplished by the use of a level laid on a steady object. The level is adjusted and the carpenter sights along the top edge of the level to the far end of bridge site. In some cases, where leveling of the sills cannot be accomplished without a great deal of extra work, the bridge may be built with a small incline.

d. In night construction the center line is the only means of keeping the bridge level or straight; therefore the center line should be level and taut. If the bridge is built on an incline the same slope should be maintained throughout.

e. After the position of the abutment sill on the near side has been established, the position of the first trestle may be located. Using

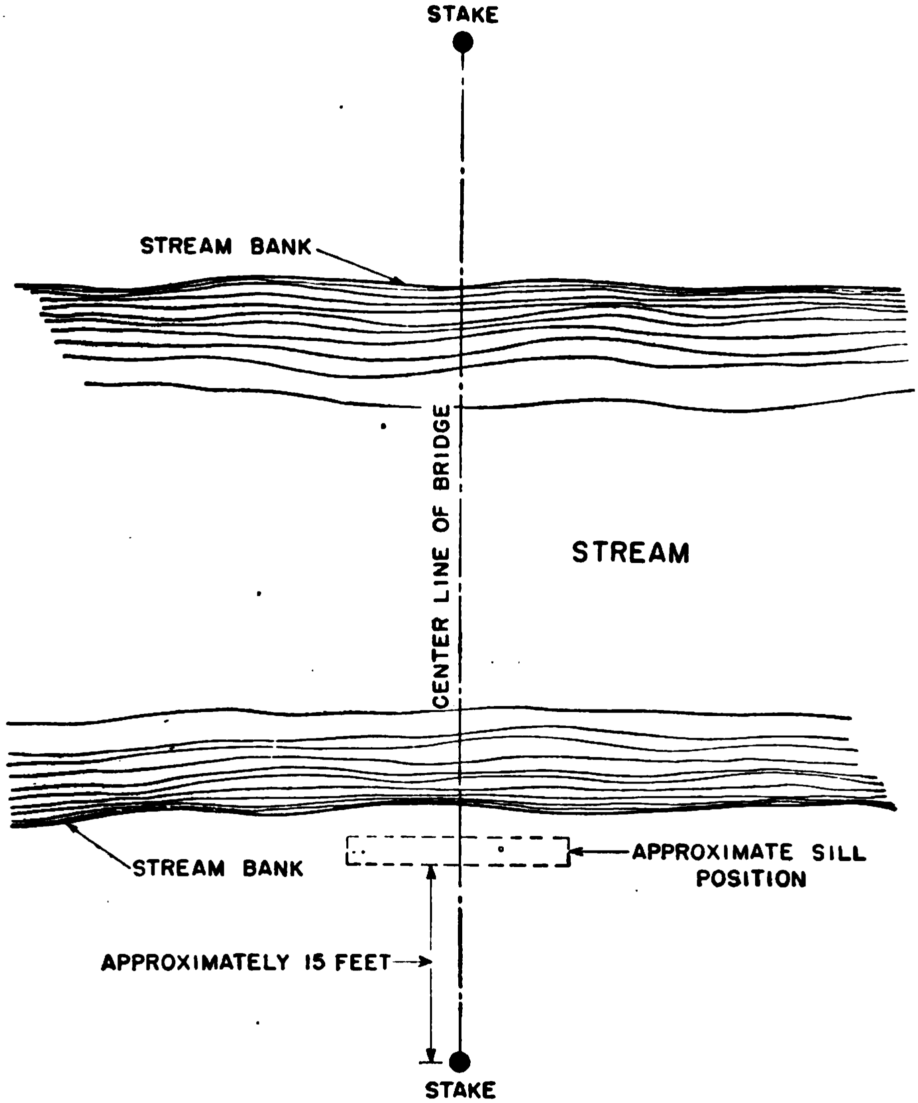


FIGURE 186.—Staking out bridge.

tape, the length of the first span is measured horizontally from the center of the abutment sill and a small stake is driven under the center line of the bridge. This marks the center of trestle No. 1, the first trestle. Where the ground is sloping, a plumb bob must be used to determine the correct point (fig. 188). From the center of the first trestle, the horizontal distance of the next span is measured and a small stake is driven. This marks the center of the second trestle. This method is continued until the position of the abutment sill on the far bank has been established.

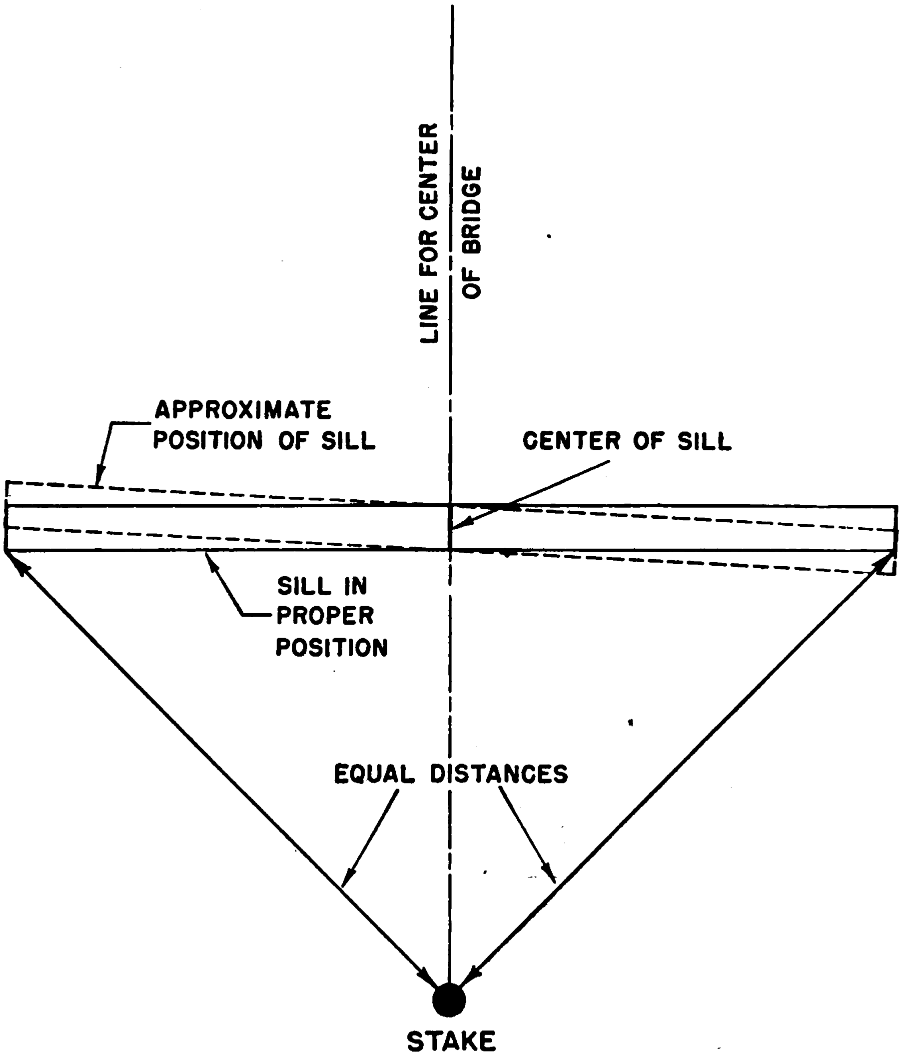


FIGURE 187.—Method of squaring sill with center line.

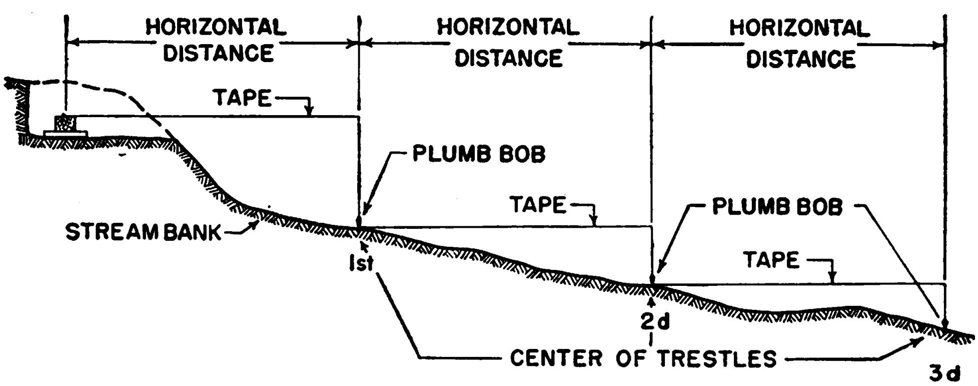


FIGURE 188.—Method of measuring trestle-bent spacing.

f. After the centers of the trestles and sills have been determined, the size of the foundation must be laid out. The length of the footing plank may be from 2 to 6 feet, with a thickness in inches corresponding to the length in feet. The excavation behind the sill must be half the length of the footing plank, plus 3 or 4 inches, in order to center the planks under the sill. Figure 189 shows the lay-out of a footing for an abutment. The bottom of the footing should be level, and to allow for drainage, should continue out to the surface. The depth of the foundation for the abutment depends upon the size of the timber used. For example: flooring of two layers, each 3 inches thick; stringers 12 inches in depth; sill 6 by 8, 8-inch side horizontal; footing plank, 3 inches thick. The total depth of these parts when

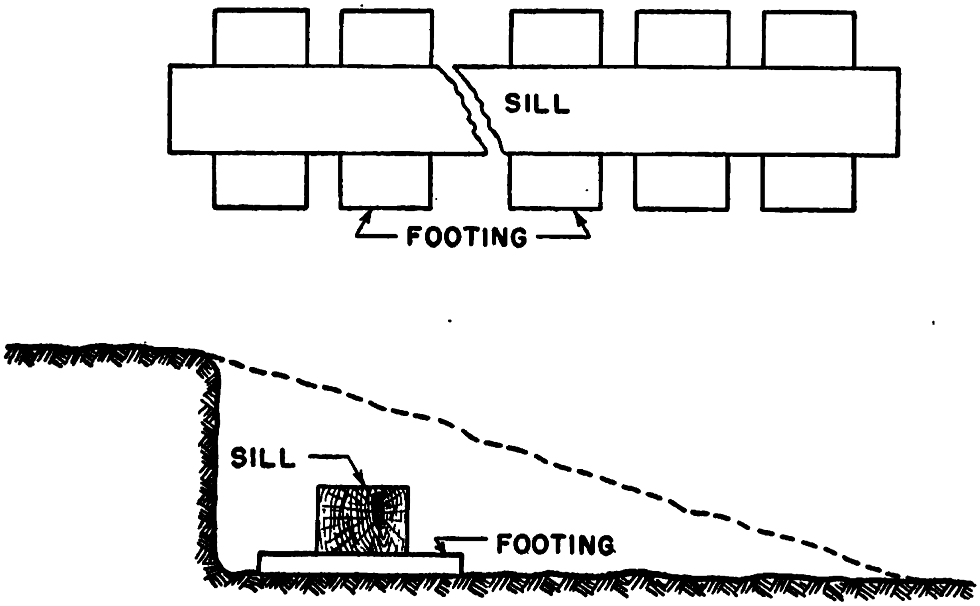


FIGURE 189.—Bridge seat.

in place is 3+3+12+6+3=27 inches. With an allowance of 2 inches for settlement, the excavation must be 25 inches below the surface.

g. There is no definite depth of excavation for trestle bents. The depth will depend upon the type of soil. If possible, trestle bents should be deep enough to be in a good firm soil. The footing is laid out as for the abutment and must be large enough to take care of the footing plank. If the excavation for the footing is too deep, it should not be filled with loose soil but extra footing planks should be used to raise it. The excavations for trestle bents are made before the measurements for the over-all heights are taken.

159. Excavation for abutment and trestle foundation.—The excavation for the footing should be done carefully to avoid excavating a hole too large or too deep. The excavation is done by a part of the bridge crew, with pick and shovel. Seldom does the earth to be removed require a bulldozer or power shovel. The loose earth removed should be thrown to the ends and upper side of the abutment so that it may be used later for the approach.

160. Construction of footing for abutment sill.—The following general procedure should be observed in placing timber footings:

a. Set the footing on level excavation about 2 inches higher than the final desired position to allow for settlement, making certain that the footing is level in two directions (fig. 190).

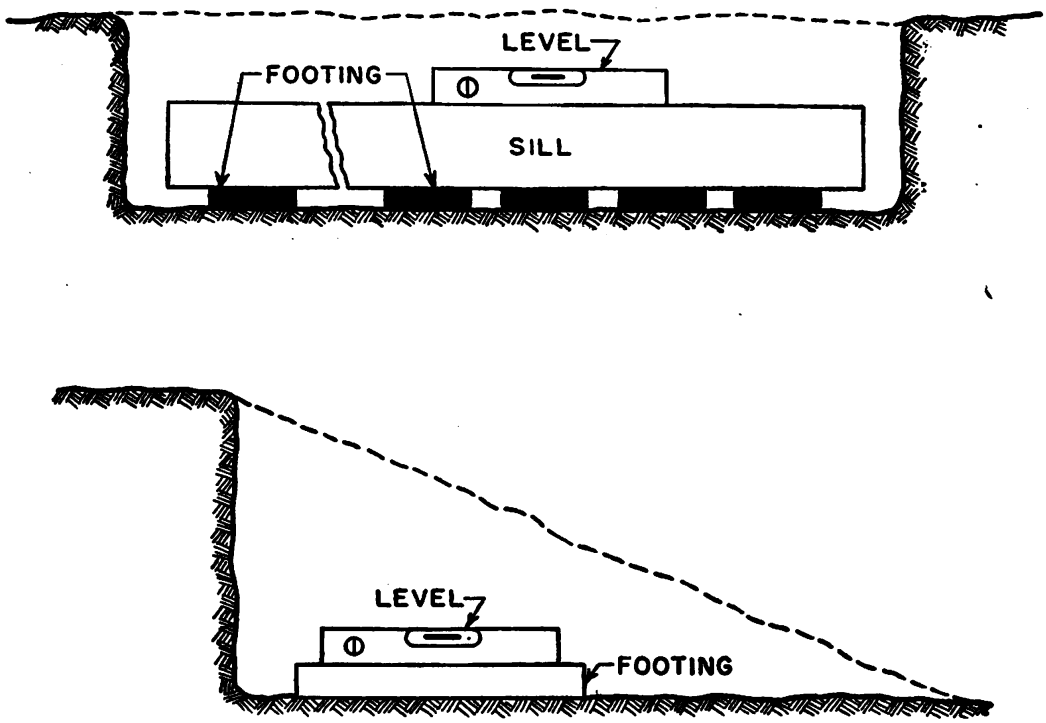


FIGURE 190.—Leveling bridge seat.

b. Do not dig too deep into the bank. If this is done by mischance, raise the seat by planking rather than by backfilling with earth.

c. Place the pieces of the lower footing course parallel to the axis of the bridge.

d. Place the abutment sill square with the center line so that the load comes on the middle of the footing course and for greater bearing surface it should be laid with the wide side up.

e. Drive stakes on the bridge side of the abutment sill, if ground conditions permit, to prevent the sill from moving. No stakes are needed on the back side as the earth against the end dam will hold the sill.

f. If the abutment is on a shelf excavation, provide for drainage, and tamp earth around footing.

g. Have the projection area of a footing such that the safe bearing pressure of the ground is not exceeded.

h. Use timber of sufficient cross section to withstand crushing and bending.

161. End dam.—After the bank seat has been built and the stringers and flooring are in place, an end dam should be placed at the end of the stringers to prevent the approach road from caving in between the stringers (fig. 191). Flooring is generally used to make the end dam; one piece of flooring is laid on its edge on the footing beside the sill and nailed to the stringers; a second piece is laid on its edge on top of the first and nailed to the stringers and flooring, the length being the same as that of the bridge flooring. When standard stringers, sills, and flooring are used, two pieces of standard-size flooring, laid on edge as described above, will be flush with the top layer of flooring. For

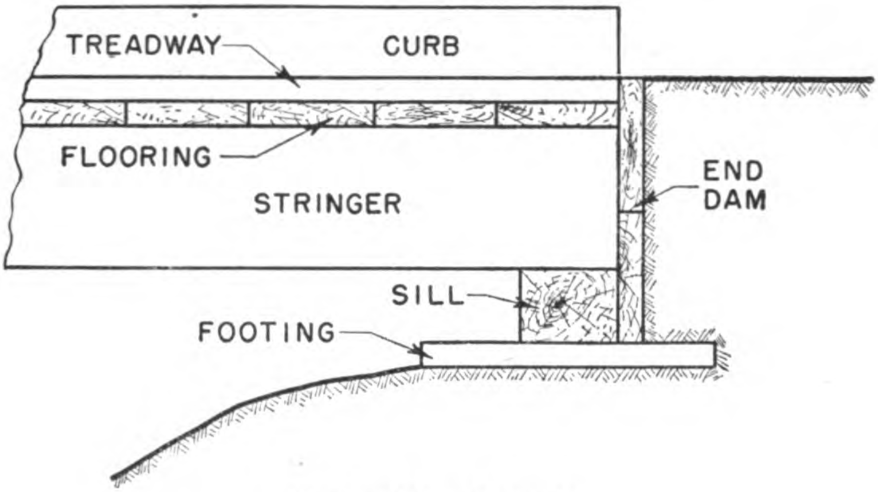


FIGURE 191.—Abutment.

methods of figuring the size of footing and for the table of bearing pressure of soil, see **FM** 5–10 and 5–35.

162. Retaining walls.—When bridge abutments must be built on stream banks that have a tendency to slough at high-water level, or on banks that are not firm enough to hold together without crumbling, retaining walls are used. These retaining walls, filled in with soil and stone, can be used to shorten a bridge span. Retaining walls may be built by driving short piling into the ground and using boards on the siding to form a wall. To keep the walls from being pushed over by the backfill, anchor cables are fastened at one end to the piling and at the other end to a deadman behind the retaining wall as shown in figure 192. The piling should be driven at least 4 feet into the ground. The plank used for the walls should be thick enough to withstand the pressure of the backfill and, if possible, should be as high as the high-water mark; otherwise, the backfill should be covered with stone revetment to prevent sloughing at high-water level.

Where the retaining wall is built near the water's edge to shorten a span, the backfill should be of stone, gravel, and clay, well tamped to give a firm foundation. If sawed timber is not available for building a retaining wall, logs may be used, fastened to the piling with driftpins or wire cables (fig. 192).

163. Revetment.—Revetment often is employed to prevent undue scour around or beneath the bank seat. The revetment may be made of stone, timber, or brush. The material is laid on the banks of the stream between the low- and the high-water level. When rocks are used, they are tamped into the earth to prevent movement by the high velocity of the water. Brush mats often are used; they are held in

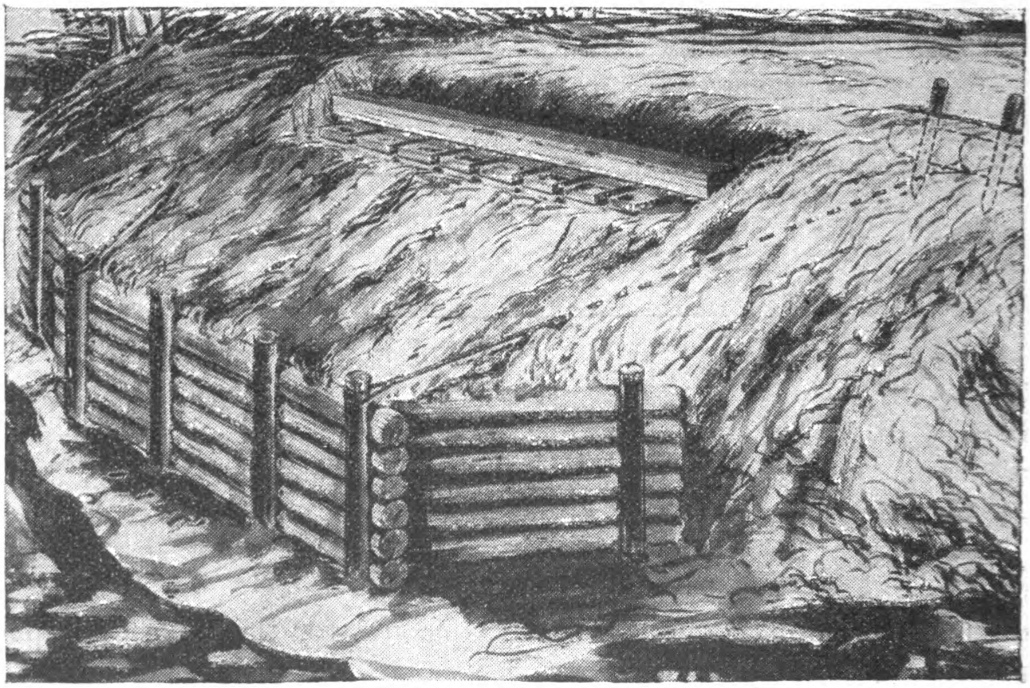


FIGURE 192.—Retaining wall.

place by stakes. There are several methods whereby a bank may be secured to prevent scour. In hasty construction, time does not permit the placing of revetments. Brush and logs fastened to the bank to withstand the high velocity of the water often serve the purpose.

164. Trestle bent.—*a. Component parts.*—A trestle bent consists of the following distinct parts:

(1) *Footings.*—The footings are the planks placed under the sill to distribute the load over a greater bearing area.

(2) *Sill.*—The sill is a horizontal member used at the bottom of the trestle as a support for the posts. It rests upon the footings and transfers the load from the posts to the footings.

(3) *Posts.*—The posts are the vertical members of a trestle used to support the cap. They transfer the cap load to the sill.

(4) *Cap.*—The cap is a horizontal member that rests upon the top of the post and supports the ends of the stringer. It transfers the stringer load to the post.

(5) *Bracing.*—The bracing, used on trestles 8 feet high or over, is nailed or bolted diagonally across the trestle to prevent swaying of the trestle. It is often called lateral or sway-bracing. It extends diagonally from the sill to the cap.

(6) *Scabs.*—Scabs are short pieces of plank nailed over the joint where the post joins the sill or cap to prevent slipping of the post.

b. Construction of trestle.—The bridge line is a line temporarily placed across the stream, ravine, or gulch at the height of the finished bridge and fastened to a stake on each side.

(1) *Height of trestle.*—To obtain the total height of the trestle, measure from bridge line to the bottom of the excavation, add 2 inches to allow for settlement, and subtract the thickness of the flooring, stringers, and footing. If steel beams are used with nailing strips of wood 4 inches thick their depth will, in most cases, be greater than that of wood stringers. The trestle bent must then be made shorter. Wood filler blocks are used to raise the wood joist to the level of the steel-stringer nailing strip.

(2) *Length of trestle.*—To obtain the correct length of timber for the post, the combined height of the sill and the cap must be deducted from the total height of the trestle. Four posts, a sill, and a cap are required. The cap and the sill are 12 feet long.

(3) *Lay-out.*—On the cap and sill lay out the positions of the posts. The centers of the two outside posts should be 12 inches from the ends of the sill and cap, the remaining posts should be spaced 3 feet, 4 inches on centers (fig. 193). Twelve scabs are required to splice the joints of the post to the cap and sill. These should be 2 by 8 by 18 inches, or 3 by 6 by 18 inches.

(4) *Assembly.*—Lay the four posts parallel, on level ground, with the 8-inch side horizontal, and place the cap at one end of the posts, then place the sill at the other end, with the 8-inch sides horizontal. Nail the scabs to the posts and sills with large nails at the proper place. After the post has been connected to the cap and sill, apply sway bracing, if the trestle is 6 feet or more in height. Bracing acts as a scab where the outside post joins the sill or cap (fig. 193). If no bracing is required, four extra scabs should be used to splice the remaining joints.

c. Methods of fastening.—The cap, sill, scabs, and braces may be fastened together in a number of ways.

(1) *Cap and sill.*—(*a*) The cap and sill may be fastened to the post by scabs nailed over the joints with large nails as shown in figure 193.

(*b*) Driftpins may be used. A hole a little smaller in diameter than the driftpin is bored into the sill or cap and also into the post (fig. 193). In boring these holes, the sill or cap should be held in the correct position on the post so that the drill bores into the post after it passes through the sill or cap.

(*c*) Holes may be bored at an angle through the side of the post into

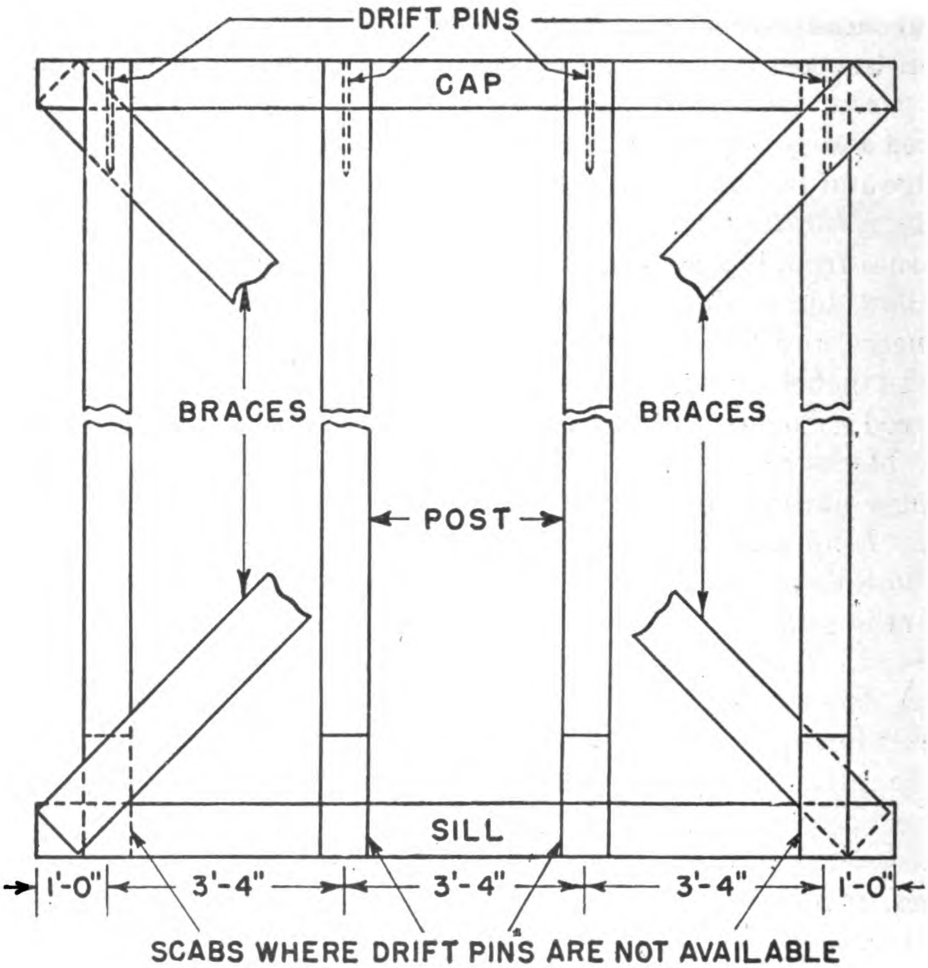


FIGURE 193.—Trestle bent construction.

the sill and driftpins used. Two driftpins should be used, one on each of the narrow sides (fig. 193).

(*d*) Where extra strength is required, (*a*) and (*b*) above may be used in combination.

(*e*) To hold the cap and sill to the post, bolts may be used to bolt the scabs over the joints.

(2) *Braces.*—(*a*) The braces may be fastened to the sill, cap, and post by means of large nails.

(*b*) Bolts or lag screws are used to fasten braces.

d. Methods of erection.—(1) There are several ways that a trestle bent may be set in place after it has been assembled. The method used is determined by the local situation.

(2) The trestle can be carried to the site by hand, when it is not too large, and raised into position by hand.

(*a*) After the trestle bent is raised to a standing position, it is placed in the correct position. To accomplish this, measure off the correct distance from one end of the stream side of the abutment sill to the corresponding end of the stream side of the trestle, then place this end of the trestle in the correct position. Correct the other end by the same method. The distance should be measured horizontally. Once the trestle is in the correct position, it should be plumbed and braced horizontally. On the bank side of the first trestle, stakes are driven to which the horizontal braces may be nailed. The trestle bent is plumbed, and temporary braces nailed on the inside of the outside post near the top. This is done in order that the temporary braces may not interfere with the permanent braces that are to be installed later. For the other trestle bents, the temporary bracing is not required, as each trestle can be braced horizontally to the preceding trestle.

(*b*) If the bent is too heavy to be handled by hand, it can be moved into place by rollers placed underneath.

(*c*) Where the conformation of the ground does not permit the use of rollers, the trestle bent may be built near the place of erection and lifted into place by a gin pole.

(*d*) There are several other ways by which trestle bents may be erected. Each trestle bent presents one or more problems of erection. In water the problems are greater than on land.

e. Longitudinal cross-bracing.—Longitudinal cross-bracing is used between two trestle bents to resist motion set up by moving vehicles and other forces that tend to move the trestles. The bracing is nailed to the outside post of a trestle with one end of the brace nailed to the bottom of one trestle post and to the top of other other trestle post. Two pieces are used to form a cross. Where the trestle bents are less than 20 feet apart, bracing is used only on the outside post; if over 20 feet, it is used on every post. The bracing is nailed with large nails or secured with bolts or lag screws. Where timber is not long enough to span the distance, the bracing is spliced with a long lap joint or a butt joint with scabs. The braces should extend beyond the post so as to prevent the nails from splitting them at the ends.

f. Expedients.—(1) Trestle bents may be built of material other than sawed timber. Round logs can be used to good advantage. The cap and sill, if made of logs, must be flattened on two sides to make a good joint.

(2) Large iron pipes with flange plates on top and bottom make

good posts. The cap and sill should be sawed timber or flattened round logs.

(3) If large timber is not available, four 2 by 6's can be nailed together to form the correct size post, caps, or sills. A 3 by 12, ripped

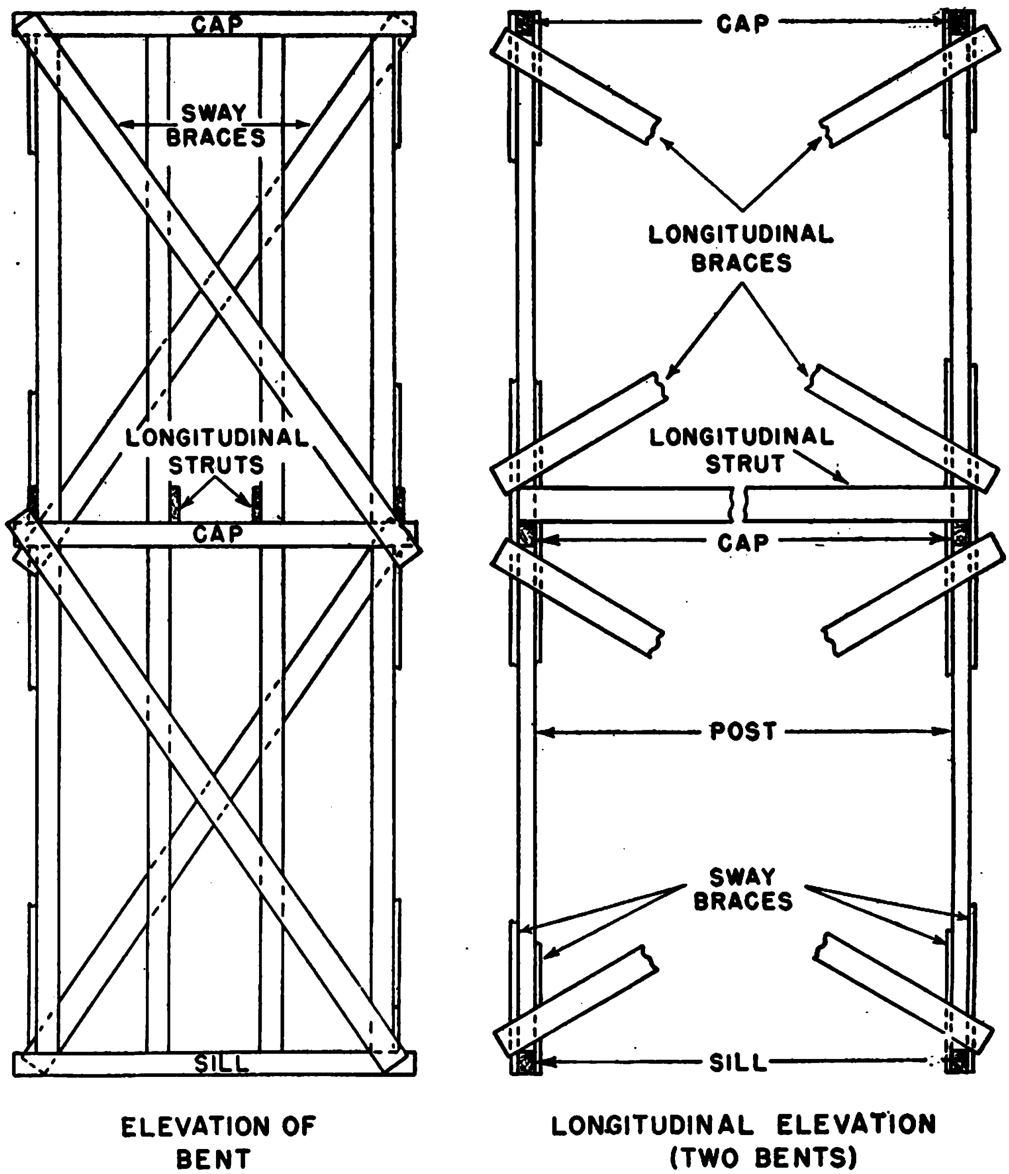


FIGURE 194.—Double-story bent.

in half and nailed together, may be used. There are numerous combinations of small timber that can be used when large timber is not available.

(4) Timber from nearby buildings that have been partially demolished may be used.

(5) Often corrugated pipes filled with concrete can be used as posts;

however, time is required for the concrete to harden. When available, reinforced steel should be used in the pipe.

g. Double-story bents.—Because of the bending or buckling effect of timber posts over 16 feet long, multiple-story bents are built. An intermediate sill is used to form the sill of the upper story and the cap of the lower, each story being sway-braced (fig. 194). When there is more than one double-story bent, longitudinal strut-bracing is used between the intermediate sills as this timber is large enough to afford compression between the intermediate sills. The struts are bolted to the sills. To stiffen the struts they are braced laterally and diagonally between bents (fig. 194). Longitudinal cross-bracing is used for each story of a trestle bent at each end between trestles (fig. 194). In spans of 20 feet or over, longitudinal cross-bracing is used on every post. When sawed timber is not available for braces, small round poles may be used for bracing on trestles.

165. Piers.—*a. General.*—Piers may be of masonry, reinforced concrete, cribwork, or of several bents so constructed as to form an integral unit which needs no additional bracing for stability. This type of support is used where the trestle bent is not advisable. Because of their size, more time and material is required to construct them. In regions where timber is limited and rock prevalent, masonry piers are used extensively.

b. Construction.—There is no set method for constructing piers.

(1) *Masonry.*—The construction of masonry piers is simple; it is merely a process of laying bricks, stones, or rocks on top of each other with mortar between as a binder. Care should be taken to stagger the joints. In building these piers, the excavation should be deep enough, if possible, to secure firm soil, clay, or rock as a base, as the weight of the pier, in all probability, will be more than the load which it is to carry. If lime or cement is not available for mortar, swamp mud or red or yellow clay can be used. Although the binding power is not as great as that of regular mortar, it will hold if the rock or brick is carefully laid.

(2) *Concrete.*—Concrete piers are discussed in paragraph 151.

(3) *Crib piers.*—Crib piers are boxlike structures constructed of sawed timber or logs (fig. 195). They are seldom used because of the great amount of material and labor required. Crib piers are used where trestle bents and other types of pier cannot be used, with the exception of the pile bent. The crib pier is filled with stone, gravel, and earth, well tamped to give good bearing pressure for the footings. In some cases the crib pier is built high enough for the sill to be placed on top to hold the stringers, as shown in figure 195. The excavation for a crib pier is merely that of leveling the ground.

(4) *Trestle piers.*—Two or more trestle bents may be constructed close together and braced to act as a single unit for a pier. These bents are simple to construct. They are simple trestle bents joined with braces and self-supporting. These are used where extra-heavy loads are to be carried or where the bridge is exceptionally high. The amount of timber used in this type of bent is much more than in a regular trestle bent. The foundation is similar to that of the standard trestle bent.

166. Stringers.—*a. General.*—Stringers are the longitudinal members that rest on the abutments and piers and support the flooring.

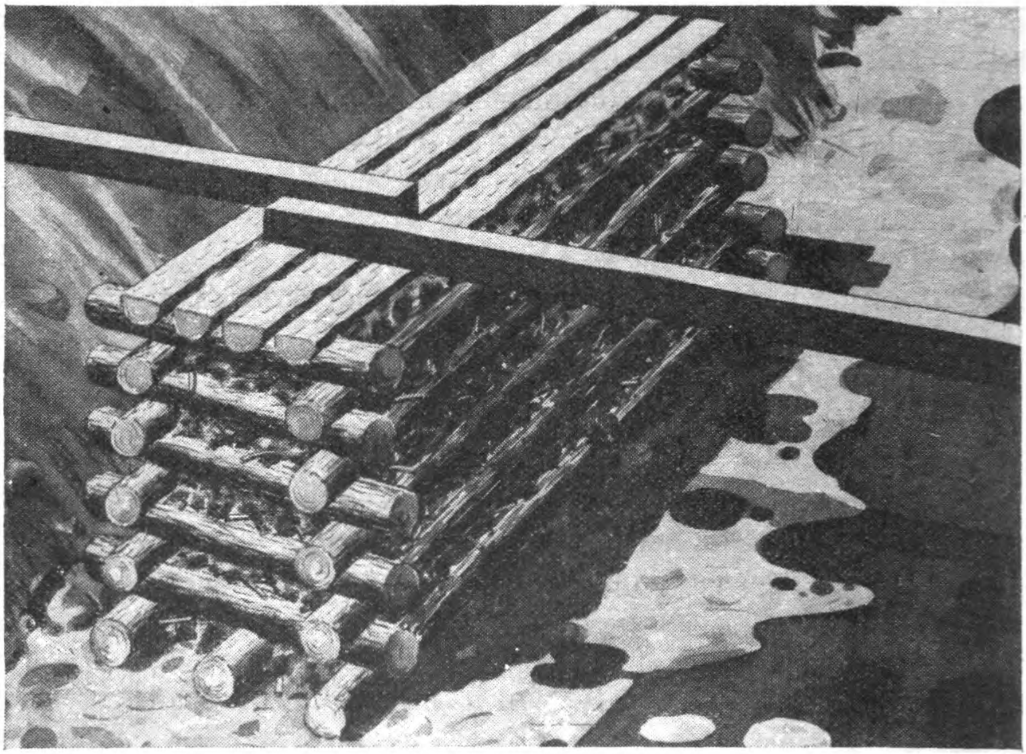


FIGURE 195.—Crib pier.

The stringers carry the load to the bridge supports and are made of steel or wood.

b. Arrangement of stringers.—The proper arrangement of stringers is of vital importance. They should be placed as nearly under the wheel load as possible so that the maximum efficiency may be obtained. Stringers placed in the middle of a single-track military bridge are of little value. The outside edge of the outside stringer should be set 5 feet from the center line of the bridge. The remaining stringers on that side are then spaced equally under the plank treadway. When four standard-size wood stringers are used, they are spaced so that the four stringers for the next span barely fill the spaces left by the first four, with the last stringer on the inside of the last stringer of the first span. For timber of sizes that are not standard, the spacing is varied in accordance with the size. When the span is over 15 feet and steel stringers are used, the spacing varies according to the size of the steel stringer. The first stringer on the outside is placed in the same position as the first wood stringer; the remaining stringers are equally spaced under the treadway (fig. 196). The distance between steel stringers is greater than between those of wood, only six steel stringers are used per span.

c. Placing stringers.—Wood and steel stringers vary in weight according to their size and length. Several methods may be used to install them.

(1) *By hand.*—The wood stringers and small steel stringers may be carried and placed on the abutments and piers by hand. This is hard, manual labor, but it is the quickest method. To make the work easier, peavy hooks or hand sticks are used.

(2) *By rollers.*—Short round poles may be placed crosswise under the stringers to roll them near the final position.

(*a*) When the stringer is near the final position it may be moved into position by hand, one end at a time.

(*b*) A triangular frame may be used to ease the work of placing the stringer in its final position (fig. 197).

(*c*) A gin pole may be used to lift the stringer into place.

(*d*) Where the stringer cannot be managed by hand or by rollers, a rope and block may be used to pull it to a position where it can be handled by a gin pole.

(3) *Power crane.*—If a power crane is available at the bridge site, it is useful in placing stringers.

d. Methods of fastening stringers.—Bridge stringers may be secured to the trestle, pier, or abutment in several different ways.

(1) *Wood stringers* (fig. 198①).—Wood stringers are fastened by—

(*a*) *Toenailing.*—Nails are driven diagonally through the side of the stringer into the sill or cap.

(*b*) *Driftpins.*—A hole a little smaller than the driftpin is bored through the stringer and into the sill or cap. The driftpin then is driven through the stringer into the sill or cap.

(*c*) A combination of (*a*) and (*b*) above.

(*d*) Triangular blocks on the outside of the joint to prevent overturning.

(2) *Steel stringers* (fig. 198②).—Steel stringers are fastened by—

(*a*) Driving railroad spikes into the sill, or cap, beside the flange, with the lip of the spike resting on top of the bottom flange.

(*b*) Driving boat nails into the cap or sill through holes drilled in the flange.

(*c*) Driving two or more 60-penny nails beside the flange partially into sill or cap, and then bending them over onto the bottom flange.

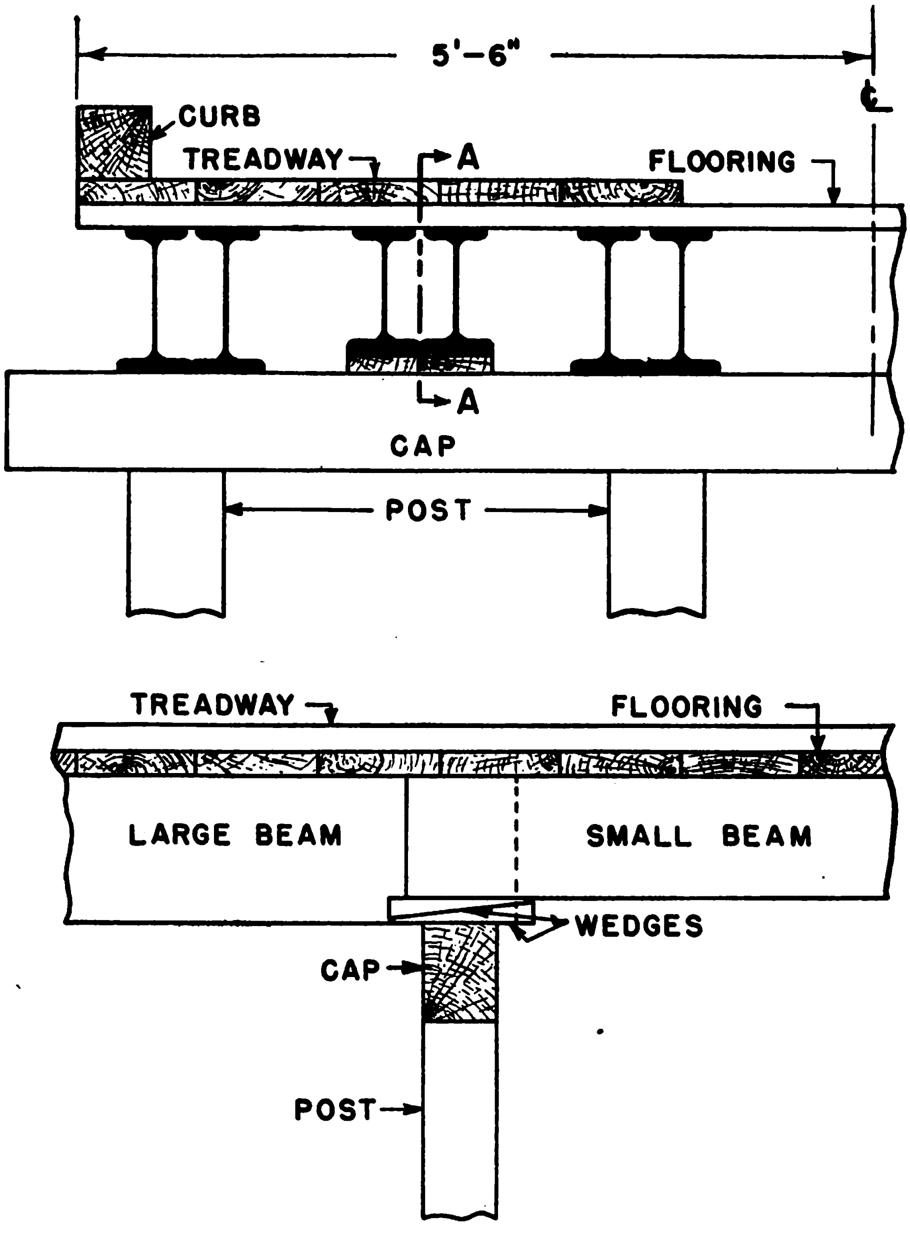


FIGURE 196.—Stringer spacing and method of blocking up extra stringers.

(*d*) Nailing a 2 by 4 or 2 by 6 block to the cap or sill so that it rests on the flange tends to prevent the stringer from overturning.

(3) *Steel stringers resting on wood filler strips.*—Where this situation occurs, the wood filler should be wider than the flange in order to provide a nailing surface to anchor the stringer. The wood filler

strip should be nailed securely to the sill or cap before the stringer is placed.

(4) *Nailing strip for steel stringers.*—In order to fasten wood flooring to steel stringers, a wood nailing strip is fastened to the top flange. There are several ways by which this may be accomplished (see fig. 198②).

(*a*) By driving nails partially into the side of the nailing strip and bending them around the flange of the stringer.

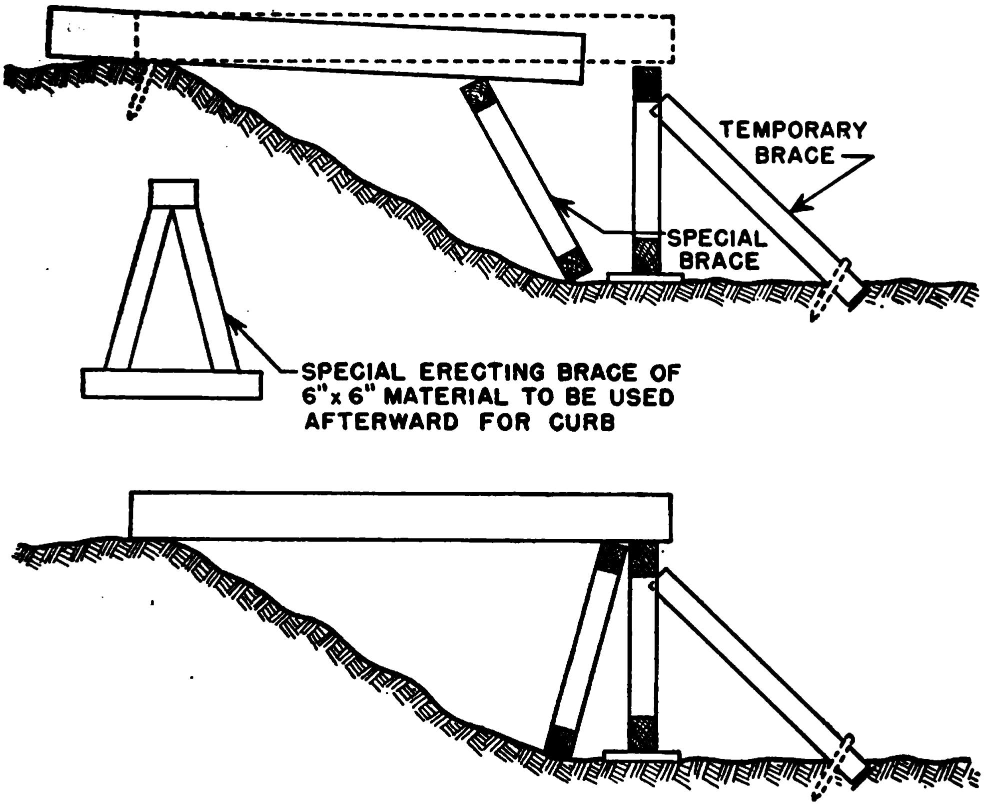


FIGURE 197.—Method of placing stringers.

(*b*) By using short, narrow strips of metal (drilled with holes) nailed to the sides of the nailing strip and bent around the top flange.

(*c*) By bending thin metal strips around the nailing strip and around the top flange.

167. Flooring, curb, and handrail.—*a. Flooring.*—Plank flooring for military use should have two layers and should be 3 inches thick. It should be laid where the loads are heavy and the traffic heavy. In order to give a clearance of 10 feet between the 6 by 6 curbs at each end of the flooring, the flooring should be at least 11 feet long. In most cases the flooring is 12 feet long, since 11-foot material is not standard length. When nonstandard material is used, care should be taken to maintain the proper thickness and length of the flooring.

This is accomplished by using one or more layers of material for thickness, and by making joints in the floor to maintain the correct length.

(1) *Method of laying.*—Flooring should be laid perpendicular to the stringers, with approximately ¼-inch clearance between planks to allow for expansion. The center of the flooring should be the center of the bridge in order to distribute the load equally to the stringers. Where a plank tread is laid over the first floor, it should be laid parallel with the stringers, as shown in figure 196, with the outside edge of the outside tread planks 5 feet 6 inches from the center of the bridge. The over-all width of the treadway on one side of the bridge should be

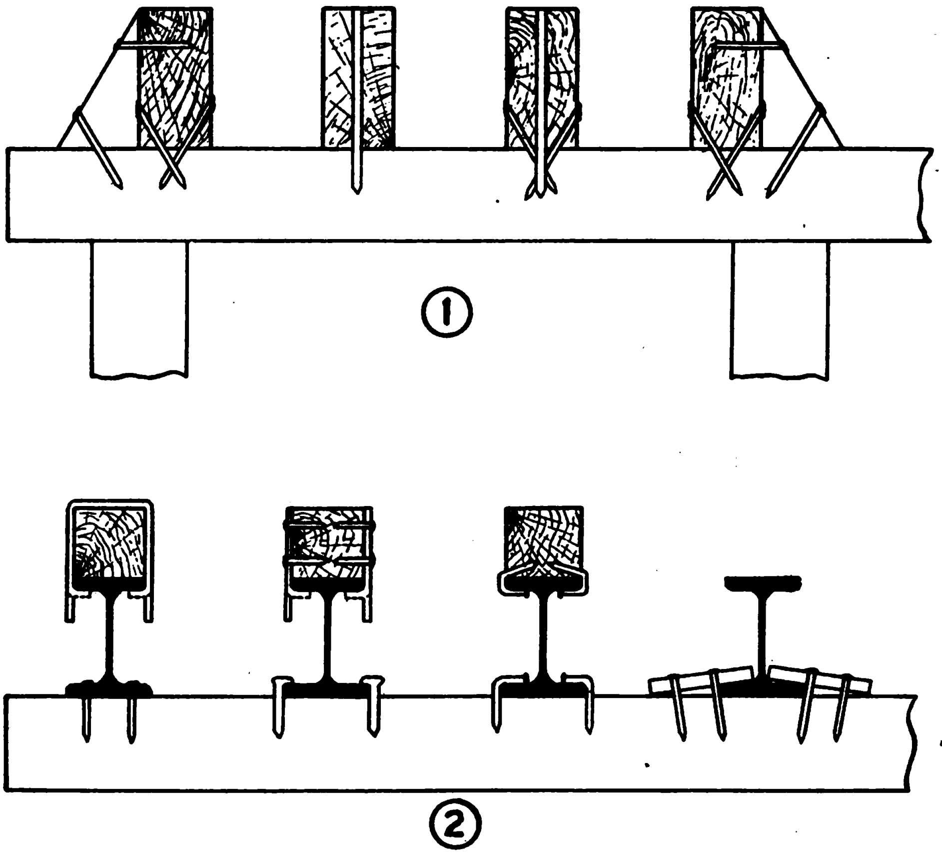


FIGURE 198.—Methods of fastening wood and steel stringers.

approximately 4 feet. The joints in the treadway should be staggered to give more strength.

(2) *Method of fastening.*—The flooring should be nailed with at least one 60-penny nail per stringer; two is preferable. Each plank of the treadway should be secured with at least two nails at each end, and one for every plank crossed; the nails should be placed alternately on either side.

b. Curb.—(1) *General.*—Every bridge subjected to motor traffic should have a curb. The curbs should be at least 6 by 6 inches. When this size is not available three 2 by 6's nailed together will serve the purpose. A 3 by 12 ripped in half and then nailed together forms a good curb. A 6 by 8 with the 6-inch side up can be used also. The curb should be run continuously from one end of the bridge to the other on both sides. The distance between the curbs should be 10 feet (fig. 199).

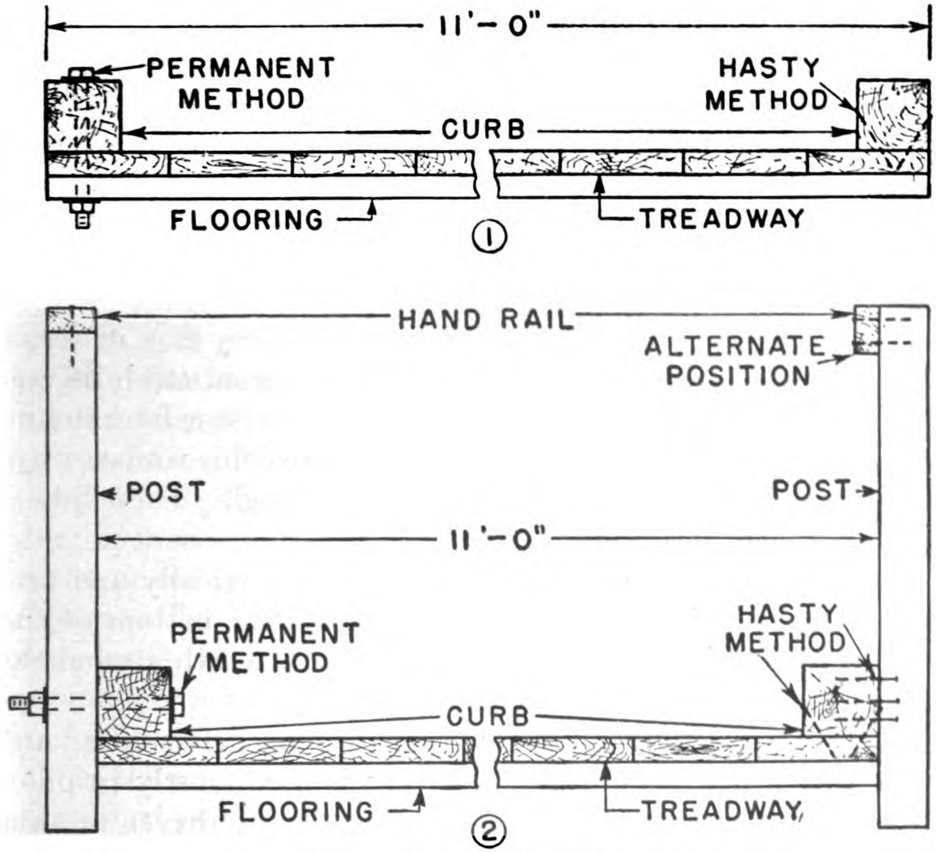


FIGURE 199.—Guard and hand-rail detail.

(2) *Methods of fastening.*—The curb may be fastened to the flooring by several methods (fig. 199①).

(*a*) By boring holes through the curb and flooring, and using bolts with nuts and washers.

(*b*) By toenailing it to the flooring with 60-penny nails.

(*c*) By lashing the curb to the flooring with rope or wire.

c. Handrails.—(1) *General.*—If time permits the installation, all military bridges should have handrails. The handrail serves as a guide for foot troops or truck drivers. It is composed of posts spaced from 6 to 8 feet apart with a rail either on top or on the inside at the top (fig. 199②). The posts are of 4 by 4's or any other suitable material that is available. Round poles may be used. The rails are of 2 by 4's, round poles, or any other suitable material.

(2) *Methods of fastening.*—The posts that support the handrail may be fastened as follows (fig. 199②):

(*a*) By toenailing the post to the curb and floor with 60-penny nails.

(*b*) By boring holes through the post and curb and using ½-inch by 12-inch bolts with washers.

(*c*) By fastening the handrail to the post with nails or bolts.

Section II

PILES AND PILE DRIVING

168. Piles.—Piles are columns of timber, iron, steel, or concrete driven into the ground to support a load, to resist a lateral force, or to consolidate the ground. For work in the field, timber, either of round or square cross section, is normally used. These piles may be classified as follows:

a. Bearing piles.—Bearing piles are driven vertically and are used to support a load. They may be driven until the bottom of the pile reaches firm stratum or until the friction of the earth around the pile is sufficient to permit the pile to carry a load.

b. Batter piles.—Batter piles are bearing piles driven at an angle in order to give a bracing effect. This type is used mostly in pile bents and pile trestles, the outside post of the bent being driven at an angle.

c. Anchor piles.—Anchor piles are driven into the ground and are used for anchorage. They are used extensively at piers and wharves to anchor ships while loading or unloading. They may be used also as underwater anchorage for cables.

d. Fender piles.—Fender piles are driven around a pier, trestle, or wharf to give protection against blows from boats or floating debris.

e. Sheet piles.—Sheet piles are planks driven into the ground around an excavation to prevent cave-in or leakage while work is being carried on in the hole. Bracing is placed on the inside to prevent the outside pressure from pushing the piles inward. The piles are driven down as the hole is excavated.

f. Shoes.—A pile driven into soft ground should not be sharpened to a point, but should be cut off square. The corners of square piles should be given a slight chamfer for protection. No shoes or metal strips are required where the ground is soft, but where the ground is hard, or contains large boulders, the point of the pile should be covered with a metal shoe or strap iron to prevent the pile from splitting or becoming battered at the point. Since the shoe is not intended to increase the penetrating power, it should be blunt, not pointed.

g. Rings.—Rings are used to prevent the head of the pile from splitting while being driven. The rings are fitted tightly over the end of the pile and fastened with nails. Several turns of wire may be used instead of iron rings. The head of the pile must be sawed off square, whether a ring is to be used or not.

h. Bolsters.—Where piles are driven into soft ground and are not long enough to reach firm stratum, more bearing is secured by bolting bolsters to the sides of the piles. Brush, logs, etc., may be placed under the bolsters to give extra bearing surface. Bolsters should be used under exceptional circumstances only. Lagging of piles by spiking or bolting available timber to them on the sides increases the functional resistance in soft ground.

169. Pile bents and pile piers.—*a. Use.*—Pile bents and pile piers should be used only when it is impossible to obtain satisfactory footing for framed trestles. They are used in rivers which are subjected to freshets, deep water, or scouring action due to high velocity of water; in marshy ground; or in river bottoms that are too uneven for trestles or sea-landing piers.

b. Design.—The general principles of design are similar to those of the trestle bents. The piles should be arranged directly under the load, but the number and arrangement depends upon the type of ground and length of pile. The spacing center to center should not be closer than three times the diameter of a pile. The two outside piles in bents and piers should, if possible, be driven at an angle to give a bracing effect. This pile is known as batter pile. Where work is to be permanent, or semipermanent, piles should be cut below the low-water mark, if possible, to avoid decay. Trestles can be replaced more easily than piles. A pier consists of two pile bents spaced about 4 feet apart and well braced. The piles must be driven deep enough to permit each to support safely its proportionate share of the load.

c. Bracing.—Pile trestles less than 8 feet above the earth do not require diagonal bracing if the piles have good penetration and bearing. Pile trestles, or pile bents, over 8 feet high require diagonal bracing. Where the pile trestle or bent is over 12 feet, it is advisable to use a framed trestle on the pile with a cap sill. It should be braced as a double-story bent. Since it is difficult to fasten bracing below the water level, this practice is not advisable unless it is essential to the rigidity of the pier.

d. Cap sill.—The cap sill is fastened to the top of the piles either by driftpins or by scabs and nails. It is essential that the heads of the piles be cut off at exactly the same level so that the cap sill may have an even bearing on all piles. The method of cutting piles to the same height is simple. Mark the correct height on the two outside piles of the pier, then nail, on each side of the piles, battens which have straight upper edges and are long enough to reach across the pier. With the battens acting as a guide a crosscut or chain saw may be used to cut the piles. Piles should not be cut off below water unless the bridge is to be of the semipermanent or permanent type.

e. Splicing piles.—When it is necessary to lengthen a pile by joining it with another piece of timber, a plain butt joint is used. The timber or iron fishplates are fastened with lag screws or bolts.

170. Pile drivers.—*a. General.*—Piles may be driven, according to their size and the nature of the ground, by blows with a maul, by dropping weights suspended from a pile-driving frame, or by blows with a steam- or air-driven hammer. Sheet pile may be driven by blows of a maul or by the use of a pavement breaker with a sheet-pile attachment, the power being furnished by an air compressor. For heavy work in base areas, or on the lines of communication, a steam hammer supported at the end of a jib is the most suitable form of pile driver. In forward areas, because of the difficulties of transporting, light pile-driving frames must be used. Rigs may be constructed from local material, but must be unusually well constructed to be satisfactory.

b. Pile-driving frame and hammer.—(1) The frame for field use can be similar to that shown in figure 200. It consists of a framework of timber or steel supporting two vertical pieces called "leads." The hammer is guided by these leads; either the hammer has slots in which the guides work, or it is fitted with a bolt with a plate on the back which overlaps the leads to hold the hammer in place (fig. 200). At the top of the leads a pulley is placed, to be used with a rope or cable to raise the hammer. In order to drive piles of 16 feet in length, the lead should be 20 feet or more high.

(2) The hammer may be made of steel or of a hardwood block; steel is preferable. It is raised by a rope or cable and is worked by hand or by a power winch. The rope is attached to the hammer by a trip hook which is used to trip the hammer after it is raised. The weight of the hammer should, if possible, be from 1½ to 2 times the weight of the pile. For work in the field it should be light, not more than 1,000 pounds, so that it can be manhandled. It is possible to make frame and leads from a variety of material, such as pipe, railroad rails, channels beams, timber, logs, or a combination of these.

171. Pile driving.—*a. General.*—When a weight is allowed to drop on the head of a pile, the work done by the fall of the weight is

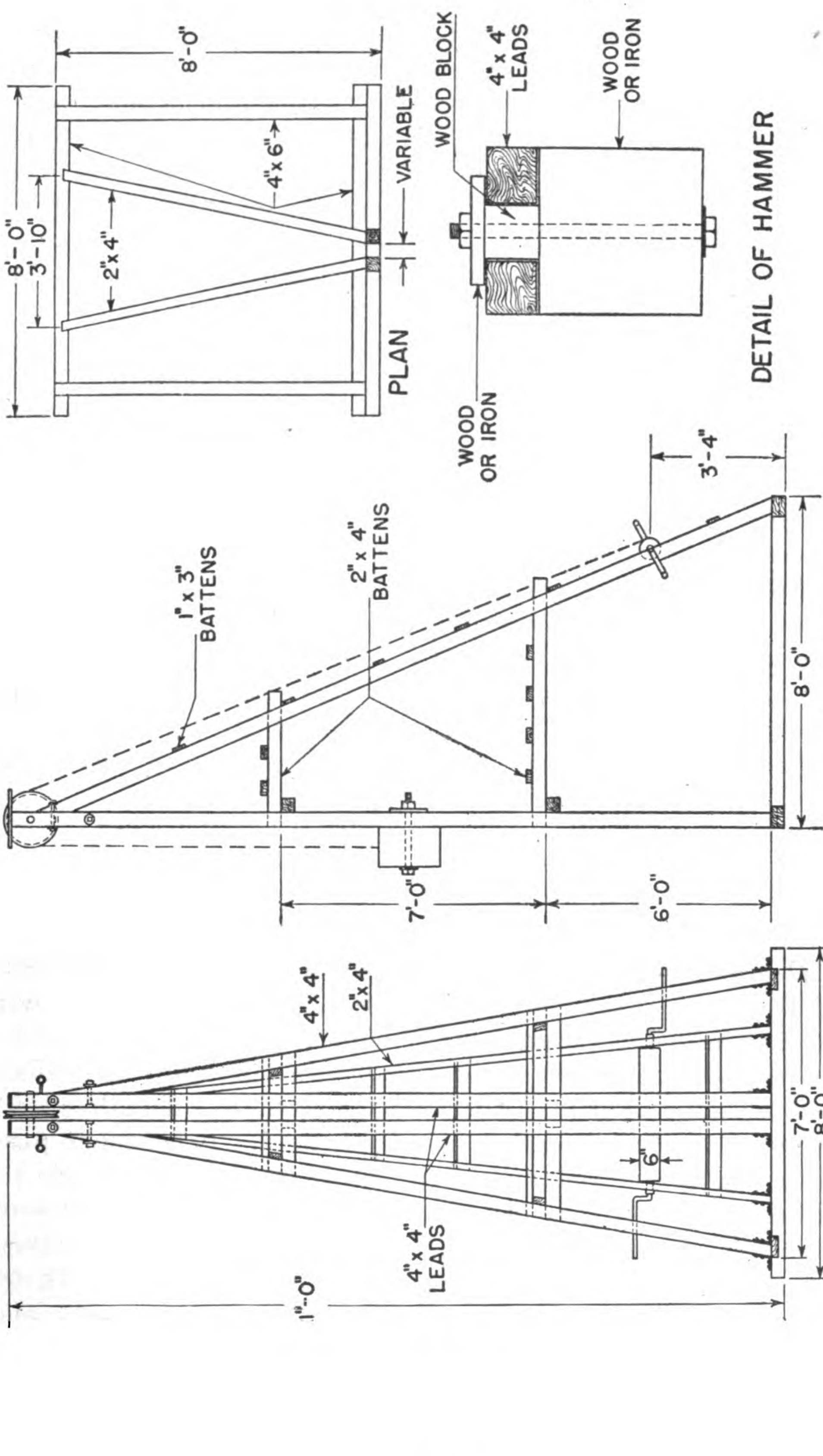


FIGURE 200.—Pile-driving frame.

approximately equal to work done by the penetration of the pile against the resistance of the earth. When a pile is driven into the ground, a cone of earth is formed on the end of the pile and forced down, while the earth on the sides is being compressed as it is pushed outward. The supporting power of the ground penetrated is one of the elements which determine the load capacity of the pile. Therefore, the deeper the pile the more load it will carry. The pile is also supported by the friction of the earth against the pile. Usually the two forces stated above act in conjunction to support a pile. Where a pile is driven deep enough to reach a firm stratum, its acts as a pillar or post, and is no longer considered as a pile.

b. Terms.—(1) *Brooming.*—As a result of the constant blows from the hammer, the fibers in the head of the pile become crushed. This is called brooming. The rings around the head prevent the pile from splitting so that the pile is not damaged by brooming, but the cushion thus formed reduces the driving effect of the hammer.

(2) *Springing.*—Springing is the lateral vibration of the head of the pile caused by blows of the hammer and occurs if the—

(*a*) Pile is crooked.

(*b*) Head of the pile is not square, so that the hammer strikes on one side only.

(*c*) Pile and direction of the fall of the weight are out of line, excessive springing resulting in a waste of energy.

(3) *Bounce.*—A bounce of the hammer occurs at every blow, under good conditions, but decided bouncing may occur—

(*a*) When penetration ceases.

(*b*) If the hammer is too light.

(*c*) If the fall is too great.

(*d*) If the head of the pile is crushed.

(4) *Overdriving.*—Overdriving is a frequent cause of injury to piles. The result is that the pile is broken, crushed, or split. Overdriving is indicated by excessive springing or bouncing of the hammer.

(5) *Dolly.*—When it is necessary to drive a pile below the leads, a follower or dolly is used. The simplest form is a length of pile ringed at both ends and resting on the pile head. It is kept in place at the bottom by a dowel, and at the top by gage bolts between the leads of the pile-driving frame.

c. Methods of supporting pile drivers.—In all pile-driving operations some type of support is required for the pile driver. In the field the support in all cases is temporary. These supports may take the form either of temporary staging or of a raft. The raft is used where the water is deep enough to float it and where a large number of piles are to be driven. Each job of pile driving is confronted with a different problem of support. The method used should be the simplest and fastest in all cases.

d. Practical details for rapid pile driving in the field.—(1) *Planning.*—(*a*) The combined weight of the pile driver, hammer, and crew must not exceed the safe load of a standard trestle bridge.

(*b*) The pile-driver frame must be capable of being manhandled and should not weigh over 1,000 pounds.

(*c*) The hammer must be capable of being manhandled and should not weigh more than 1,000 pounds.

(*d*) There must be a sufficient number of pile drivers.

(*e*) There must be a platform, such as a temporary stage or a ponton, from which the piles can be driven.

(*f*) The organization must be planned in advance and all changes of position of pile driver must be carefully coordinated.

(2) *Operations.*—(*a*) Two pulleys should be at the tip of the leads, one for the hammer and one for raising the piling into position.

(*b*) A round pile is driven normally with the tip, or small end, down. In quicksand, the tip is up.

(*c*) If the winding gear is not fixed to the frame, guy ropes or wire should be placed on the frame to prevent tilting.

(*d*) The blows of the hammer should be light until the pile is firmly fixed, then they should be increased until a full blow is delivered.

(*e*) Drive the pile as rapidly as possible and without stopping. Keep it moving.

(*f*) If the pile suddenly stops, reduce the blows and drive quickly. If this does not start the pile, leave it and proceed to the next. If it starts again, drive until it reaches a firm stratum. Generally, piles in the same area penetrate to approximately the same depth.

(*g*) The behavior of a pile varies greatly with the nature of the soil. Sometimes the pile even rises between blows.

(*h*) Water usually acts as a lubricant, particularly in clay, and reduces the friction of the ground. Infiltration of water may cause a decrease in the bearing power of the pile.

(*i*) Never use a damaged pile. If a pile is damaged during the driving, alter the design of the pier or trestle and drive a new pile.

e. Penetration.—It is not possible to lay down any rule as to the minimum penetration necessary. The ability to penetrate depends upon the type of ground. The pile should be driven until an average set of from ½ to 1 inch is obtained with a hammer weighing 1,500 to 3,000 pounds for a drop of 15 to 18 feet. With a hammer of approximately 800 pounds, the average set should be from ¼ to ¾ inch for a drop of 15 to 18 feet.

f. Pile capacity.—Loads of 20 tons per pile should not be exceeded in normal theater of operation construction. The most widely used pile driving formula for the capacity of wood piles is the following:

$$P=\frac{2Wh}{S+1}$$

Where P=Safe load in tons.
W=Weight of drop hammer in tons.
h=Height of fall of hammer in feet.
S=Penetration of pile per blow in inches.

Section III

METHODS OF REINFORCING AND REPAIRING FIXED BRIDGES

172. General.—The repair, maintenance, and reinforcing of bridges is one of the most important duties of the engineer officer and carpenter. Partially demolished or weak structures must be repaired and strengthened to carry heavy loads and traffic. Narrow bridges must be widened or new bridges built alongside to handle an increased volume of traffic. This type of engineering demands great skill in devising expedients by combining different materials, ingenuity in designing so as to use the available material, and in addition, common sense. Results in military engineering must be attained with the maximum economy of time, labor, and material. A new bridge should never be built when an old one can be repaired and made to serve the purpose. Bridges should be inspected regularly so as to be kept in a state of repair at all times. Before repairs are begun, a careful check should be made to determine which portions need repair and the extent of the repair. This is very important in requisitioning material or using material that is available nearby.

173. Trestle, pile, and crib-pier bridges.—*a. Trestle-bent bridge.*—A trestle-bent bridge may be strengthened in several ways, the amount of repair depending upon the portion of the bridge that is weak or damaged.

(1) *Flooring.*—(*a*) *New or additional flooring.*—Where a bridge has but one layer of floor, it may be strengthened by a new floor, by replacing individual planks, or by a treadway of flooring laid upon the old flooring. The treadway consists of planks laid parallel to the

length of the bridge and under the wheel loads. The joints are staggered to prevent weak spots. The treadways should be approximately 3 inches thick and 4 feet wide.

(*b*) *Extra stringers.*—The flooring may be strengthened by additional stringers. The flooring may be removed to place the new stringers, or small depth stringers may be inserted under the floor and wedged up tight against the floor as shown in figure 196. New stringers and new flooring may be laid over an existing floor.

(2) *Stringers, wood or steel.*—The span of the stringer may be cut in half by using a trestle, pile, bent, crib bent, A-frames, or individual supports such as shores (fig. 201). These supports are placed under

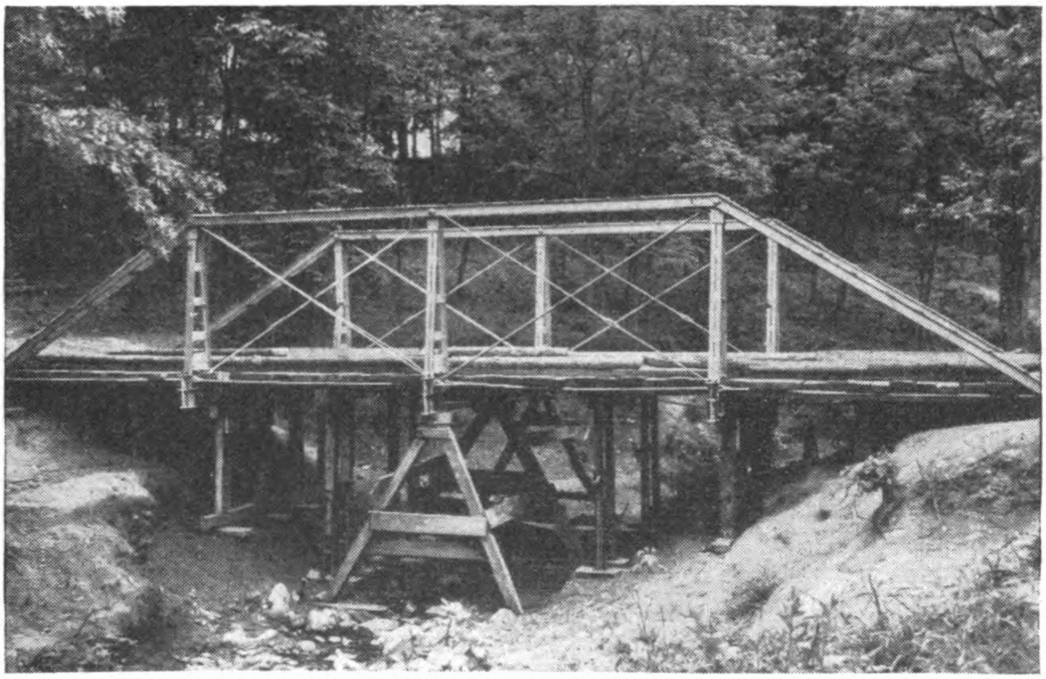


FIGURE 201.—Bridge reinforced with A-frame and additional trestles.

the stringers and high enough to require little wedging, but not so high as to interfere with ready installation. When it is impossible to use these types of reinforcing, the knee-brace or truss method may be used (fig. 202). These latter methods are not as strong as the former but they work well in an emergency. The braces are fastened with large nails or bolts and should be placed under each stringer. If crib bents are used, they should be filled with earth and rock to give better bearing strength. Where piles are used, they are cut off even and level, and a cap is placed on top. Wedges are then placed between the cap and the stringer to hold the latter tight against the floor, and nailed to prevent slipping. To give support to the stringers, three A-frames and cap can be used, with sills at the lower ends of the A-frame and footings underneath. Lateral bracing is necessary.

(3) *Trestle bents.*—There are times when trestle bents must be reinforced. For this purpose 2 by 6's or 2 by 8's are fastened with large nails to both sides of the cap and sill, and 2 by 6's or 2 by 8's are nailed to the post between them. The scabs and braces must be removed from the original bent and replaced after the reinforcing is applied (fig. 203). Extra posts may be inserted in the bent. This is accomplished by cutting the post approximately 2 inches shorter and filling the remaining distance by long, tapered wedges (fig. 204). These wedges should be nailed after they have been tightened. The post may be several small pieces of sawed timber nailed together, a single large piece of sawed timber, or a log. In some cases a small

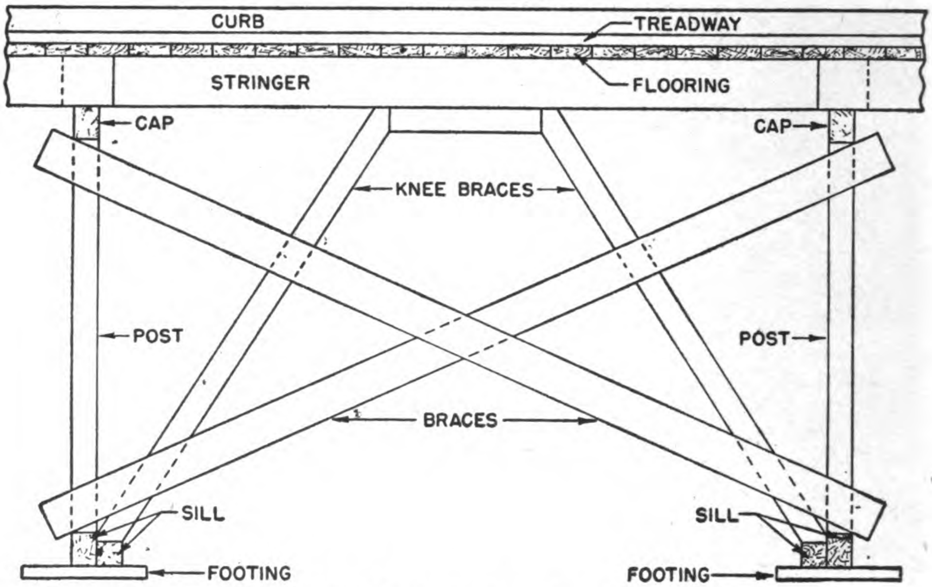


FIGURE 202.—Method of reinforcing bridge.

bent is required on each side of the original trestle to give the required support. These small, new trestle bents require new footings since the old footings were designed for the old trestle.

(4) *Abutments.*—When abutments need repair, the type of soil and the conformation of the ground largely determine the method of reinforcement. If the bank is sloughing or settling, a retaining wall should be built, filled with soil and stone, and tamped well. Extra footings should be placed under the abutment sill. If the sill needs extra bearing surface an additional sill may be placed beside the old one.

(5) *Footings.*—If trestle bents require additional footing it is advisable to use additional trestle bents or crib bents rather than to try to put more footing planks under the support. It is difficult to place new footings under the trestle without weakening the bearing power of the soil.

b. Pile-bent bridge.—The flooring and abutments of a pile-bent bridge are reinforced in the same manner as a trestle-bent bridge.

(1) In most cases when stringers have to be reinforced, new piling must be driven. The pile can be driven easily as the old bridge may be used as a support for the pile driver. Two or three pieces of flooring may be removed to make an opening so that the pile can be driven.

(2) Where the piling has decayed above the water, it may be cut off level, and capped with a trestle bent. If this cannot be done, new piling must be driven or a crib bent built.

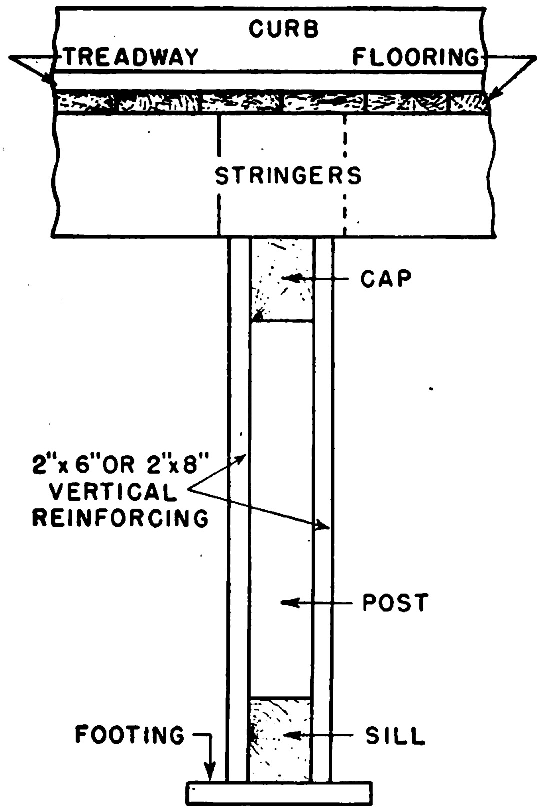


FIGURE 203.—Method of reinforcing trestle post.

(3) If the old piling will not carry the load, new piling may be driven near the old piling for the construction of a pier.

c. Crib-pier bridge.—The crib bents of this type of bridge are not easy to repair. The flooring and abutments are reinforced as described in *a* above. The stringers can be reinforced by trestle bents if the soil permits. If the ground is too soft, piling must be driven or additional cribs built. The cribs themselves cannot be reinforced. New ones must be built.

174. Truss bridges.—To reinforce truss bridges a knowledge of trusses is required. If a truss bridge is to be reinforced by placing additional material on the members, the officer in charge must know which members are in tension and which are in compression. This is very important as the strength of the bridge depends upon these members. A tension member usually will not work as a compression member. In most cases the simplest way to reinforce a truss bridge is to add trestle bents, pile bents, or crib bents underneath. These are constructed in the same manner as for the trestle bridge. Once a truss bridge is supported underneath, except at the abutments, it loses the

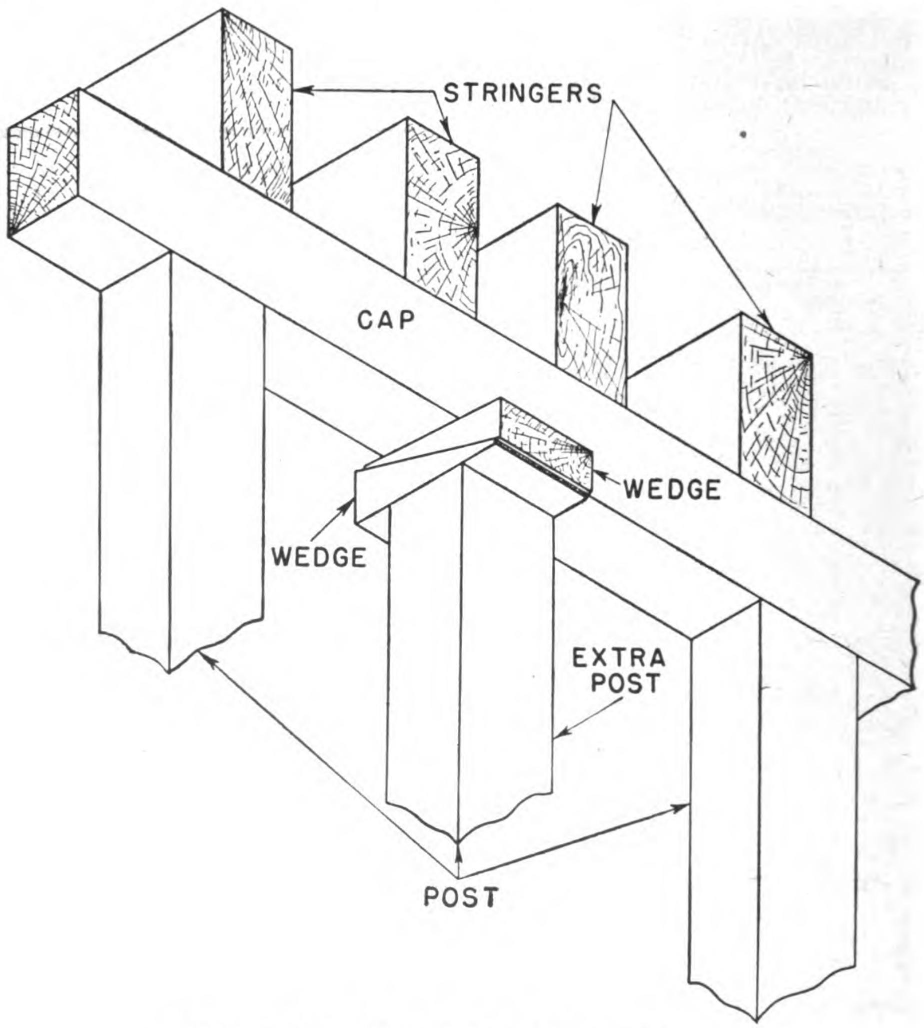


FIGURE 204.—Method of installing extra post.

qualities of a truss. The supports must be large enough to hold the weight of the bridge, plus the live load and the impact. Figure 201 shows a truss bridge reinforced.

175. Repair of demolished bridges.—*a.* A demolished bridge often may be repaired by raising it back into position and blocking it up underneath with bents or piers. Where the abutment has been demolished, it can be remade by cribbing or by a retaining wall filled with earth and stone.

b. If large steel beams have been used as stringers and the masonry supports have been damaged, either the supports can be leveled off and used again at a lower level, or trestle bents or crib piers can be built on top to raise the bridge to the original level. By using the material of the demolished structure, a new bridge may be constructed on the old supports or foundations. There is no set rule for repairing a demolished structure as every bridge presents a different problem, and the engineer must use skill in determining the most speedy repair with the available material and labor.

SECTION IV

CULVERT CONSTRUCTION

176. Culverts.—*a. Type.*—A transverse drain under a road may be defined as a culvert. It may be constructed of concrete, metal pipe, wood, logs, rock or other material. The size in most cases is small. Culverts are used in small gullies, drains, or ravines where the watershed is small and the construction of a bridge is not required. They may be constructed from plank timber in the form of boxes. If the soil at the bottom is fairly firm, a bottom is not required; a few planks nailed across the bottom of the box are sufficient (fig. 205). If plank timber is not available, logs may be used as shown in figure 206. If the culvert must be made large it can be covered with heavy timber stringers or a bearing wall made through its center (fig. 208). Culverts should be covered with at least 18 inches of earth. When the span is 8 feet or more, the depth of the earth should be considerably more.

b. Protection against scour.—If time permits, head walls and wing walls should be constructed at the mouth end and the discharge end of culverts to prevent the scouring of the bank (figs. 207 and 208). The head walls are placed perpendicular to the culvert and the wing walls are placed at an angle. The head walls should extend at least 2 feet above the top of the culvert and should extend on each side at least the width of the culvert. They may be constructed of planks, logs, stones, or concrete.

c. Construction.—In building a culvert for a new road, the bottom and the banks of the stream are leveled and shaped so that a box or framework may be placed. If a small box is to be used, it can be assembled as shown in figure 207, and placed in the stream bed with earth filled over it to the desired depth. The length of the culvert should be the width of the road plus twice the depth of the fill. The center of the culvert should be under the center of the road. Where

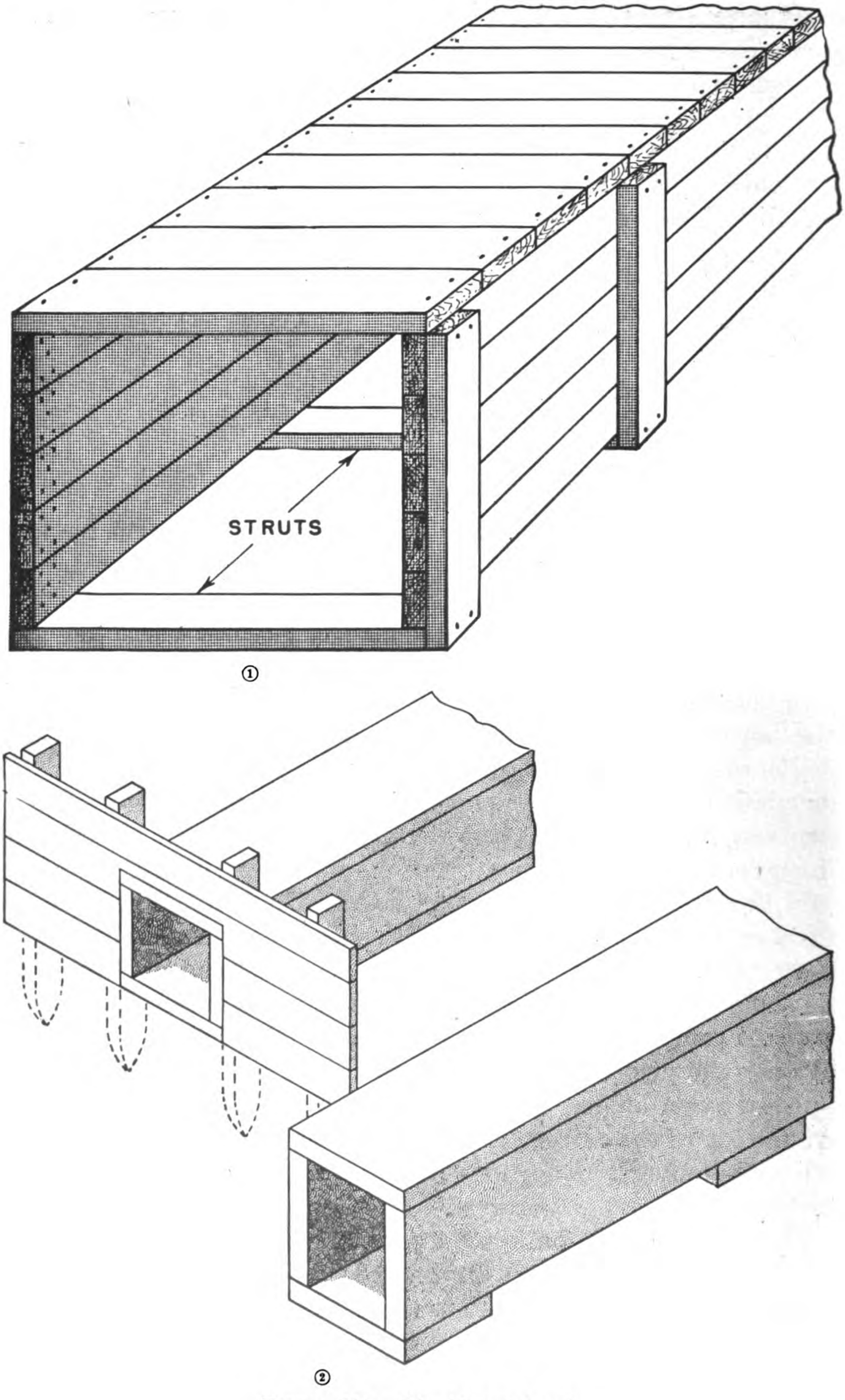


Figure 205.—Wood box culvert.

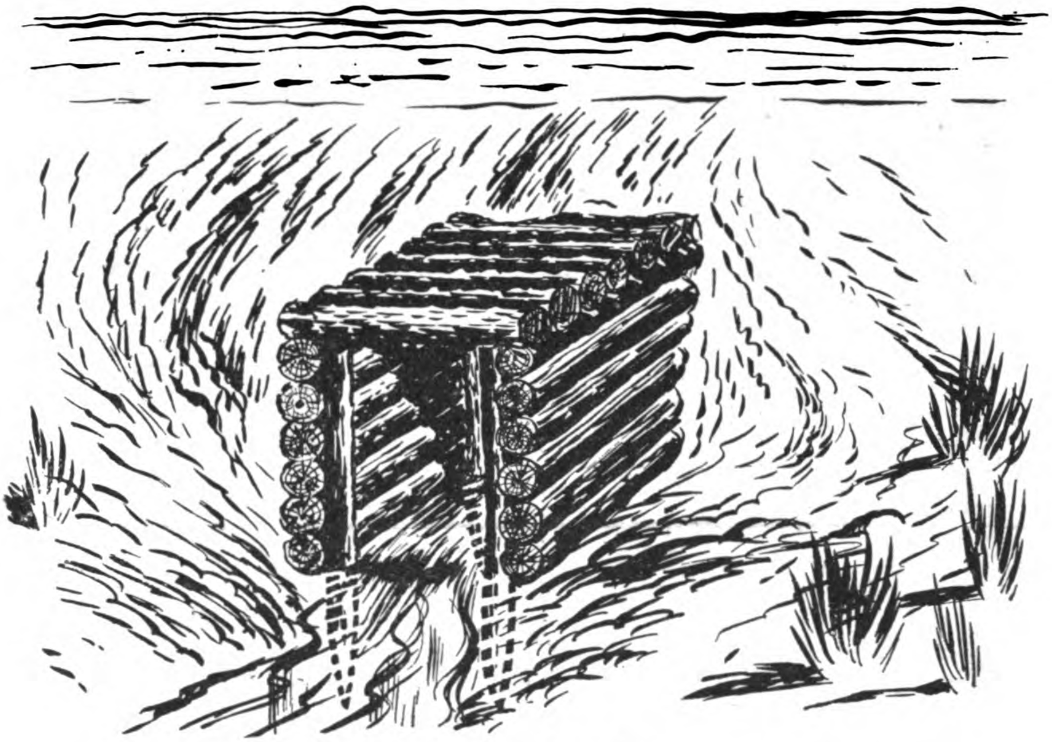


FIGURE 206.—Log culvert.

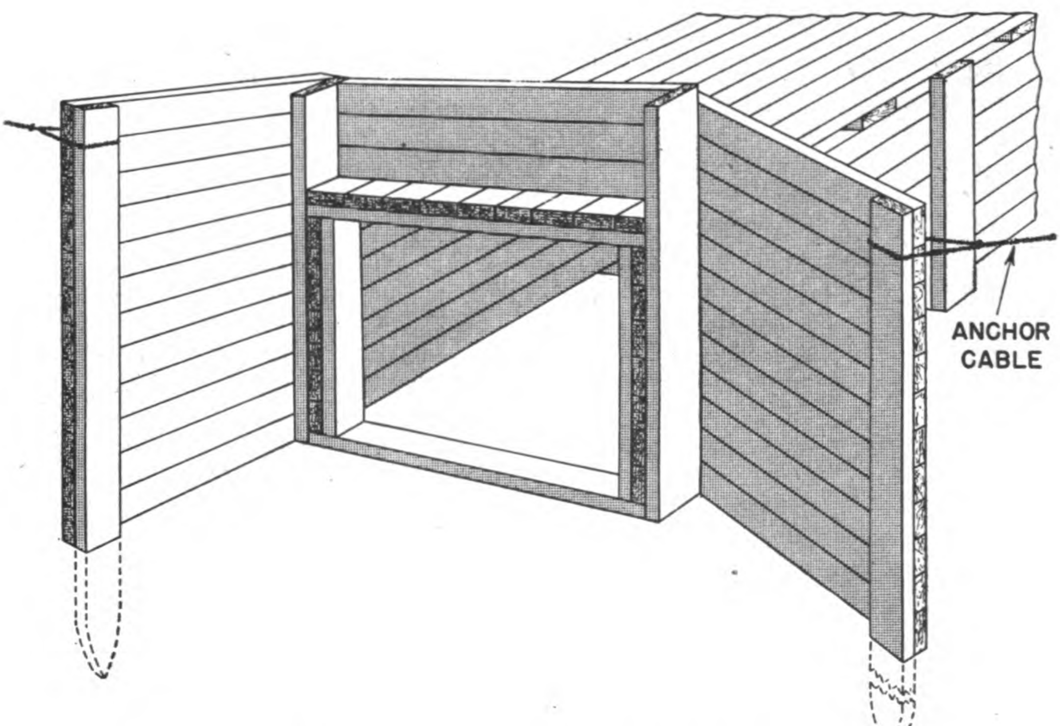


FIGURE 207.—Culvert with wing walls.

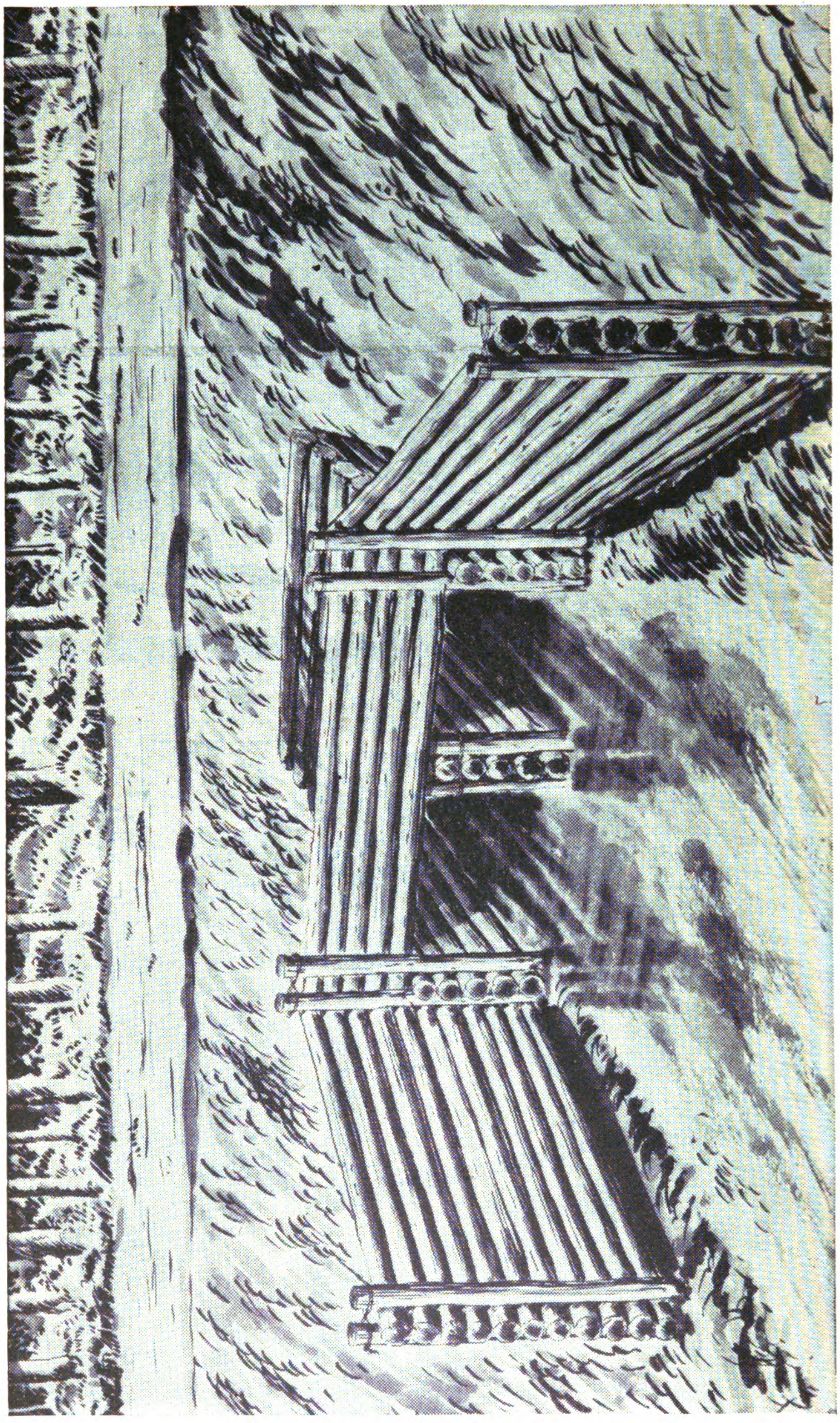


FIGURE 208.—Culvert with long wing walls.

culverts are too large for a prefabricated box to be used, the section can be made and assembled in the stream bed. This type is shown in figure 208. Sometimes the culvert is large enough to require stringers over the top to hold the flooring and the earth load. In that case the sidewalls are set in place, the stringers laid on top, and the flooring laid over the stringers lengthwise of the culvert (fig. 207). A large culvert of this type should have a plank bottom or footing under the sidewalls. The head walls are held in place by posts driven into the ground and anchored there with wire cable. The wing walls are held secure in the same way (fig. 207) and are set at an angle of approximately 45° with the center line of the culvert.

CHAPTER 11

WHARVES, DOCKS, AND PIERS

SECTION I

GENERAL

177. Definitions.—*a. Wharves.*—A wharf is a structure at which vessels may land and load or unload their cargoes and passengers. It is sometimes called a quay, when marginal (parallel to the shore line). It may be marginal or it may project at an angle to the shore line.

b. Docks.—A dock or slip is an artificial basin between piers or wharves, used by vessels in loading or unloading their cargoes. A group of several piers and wharves at a port is sometimes called a dock.

c. Piers.—A pier is a wharf projecting from the shore line.

178. Material.—Wharves, docks, and piers may be constructed of timber, concrete, masonry, or steel, or a combination of these. Only timber structures are covered in this section. Timber, in most cases, is the most economical material for this type of construction. It is easy to install, much lighter than the other types of material, and it is usually easy to obtain. However, timber has disadvantages; it is subject to decay by rot, destruction by marine animals, and fire. The life of timber is short in this type of construction unless it is treated against decay and marine animals. In regions subject to bombing or shelling, wood normally lasts until it is destroyed or rendered unserviceable.

SECTION II

CONSTRUCTION

179. General detail of timber construction.—*a. Piles.*—(1) *Bearing piles.*—Bearing piles for the support of wharves or piers should be straight, measure not less than 6 inches at the tip and not more than 18 inches at the butt. If crooked, the crook should not exceed 6 inches for the entire length. The length of the piles should be from 60 to 80 feet, depending upon the depth of the water and the condition of the stream bottom. The pile should be driven straight and should be braced. Figures 5 and 6, appendix III, show the plans for a section of a wharf and a pier. The piles for a wharf are driven 6 feet center-to-center, while the piles for a pier are driven 10 feet center-to-center in one direction and 5 feet in the other. For heavier loads, the piles may be driven closer together. All timber and piling should be creosoted to prevent decay and destruction by marine animals. It should be of structural grade and of good bearing qualities.

(2) *Fender piles.*—Fender piles for wharves and piers protect the pier or wharf by absorbing the shock from ships. They should be driven about 2¼ feet outside the center line of the outside bearing pile. The fender pile is connected to the pier or wharf by long bolts with a block between the fender pile and the bearing pile. These piles should be driven about 18 feet apart, along the sides of the pier or wharf where the vessels land.

(3) *Mooring piles.*—Mooring piles are driven in line with the outside line of the bearing piles of piers and wharves. They are braced with the outside row of bearing piles. The piles should rise about 4 feet above the floor of the pier or wharf and be spaced approximately 30 feet center-to-center.

b. Bracing.—Bracing of piles is of great importance since the piles are subjected to abuse from waves, debris, and blows by moving vessels. Figures 5 and 6, appendix III, show how wharves and piers should be braced. Note that the timber is large. The piles are braced to each other horizontally, both parallel and perpendicular to the shore line. This type of bracing may be in one or more tiers depending upon the height of the pile above low-water level. The size of the horizontal bracing should be 6 by 10 or 6 by 12. The vertical, diagonal, or sway bracing, which tends to counteract the swaying of the pier, should be 6 by 12 and bolted to each pile. The pile is notched to give a flat surface against which the brace can rest. Two flat grid connectors should be used between the pile and brace as shown in the drawings. The 6 by 12's are used on wharves; 4 by 10's are heavy enough for piers where double-story cross bracing is used. The wharf has a truss brace under each girder. The web members of the truss are 8 by 14's. All bracing is connected with bolts and grid connectors. The girders of wharves are braced diagonally underneath the girder with bolts and grid connectors.

c. Caps and girders.—Caps are used on top of piles in piers. They are 12 by 12 inches by 18 feet, and are fastened to the piles with driftpins. On top of these caps rest the girders. The girders under the track section of the pile are 6 by 14's and are double under the rails. The girders on the wharf are 14 by 16's. They rest on the piles and are fastened to them with driftpins.

d Joists.—The joists in wharves and piers in most cases are 8 by 12's. These joists rest on the caps or girders and are fastened to them

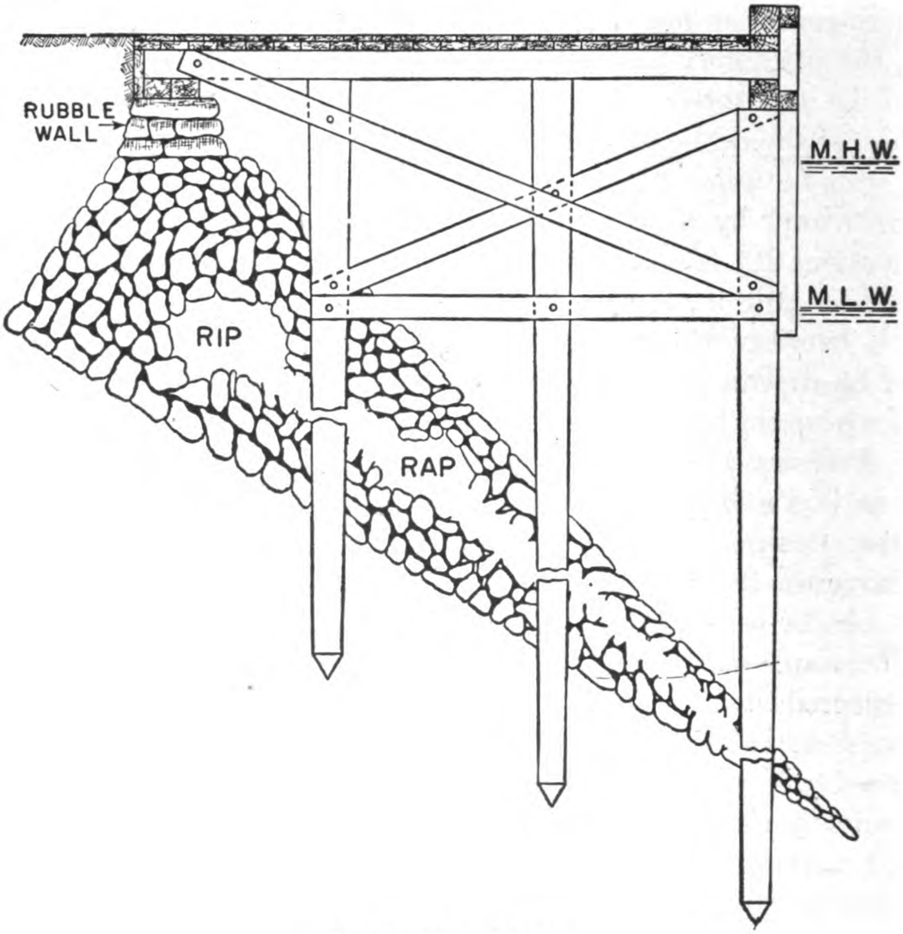


FIGURE 209.—Riprap.

by driftpins. Under the track section of the pier the joists are 6 by 8's. These joists act as cross ties for the railroad track in conjunction with the ties.

e. Flooring.—The flooring for wharves and piers should be at least 4 inches thick. It is laid perpendicular to the joists and should be fastened with two 60-penny nails or two driftpins countersunk at each joist. The joints in the flooring should be staggered and made over the joists.

180. Retaining walls.—Retaining walls prevent earth, loose stones, or any type of fill from sloughing. There are several ways in which these walls may be built.

a. Riprap.—The base of a riprap retaining wall is made by piling stones on top of one another at an angle; the top course is hand-placed. The hand-placing is above low-water level (fig. 209). This type of wall, if not too steep, will not slough, nor will it overturn as a masonry wall. If the stone is available, this type of wall is suitable for piers and wharves and is easy to construct. The slope of the riprap should be approximately 1 to 1. The riprap should not extend beyond the

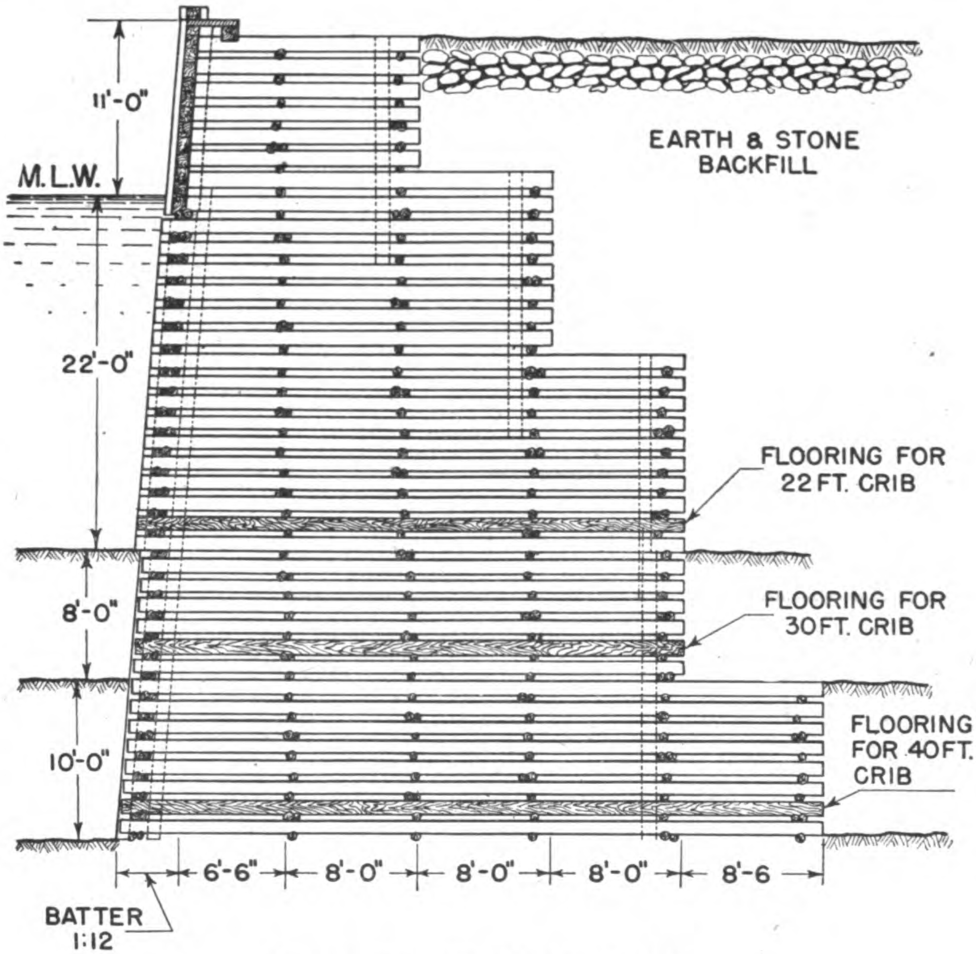


FIGURE 210.—Wharf with crib wall.

last line of pile unless it is low enough in the water to permit the passage of vessels.

b. Cribwork.—When rock is not available and timber is abundant, cribwork may be used for retaining walls. The cribwork should be filled with earth, stone, or gravel. Figure 210 shows a good example of cribwork. The flooring has been placed at intervals where cribwork has an offset in the back. This gives the structure stability. This type of wall requires more time and material to construct, and should not be used when another type can be built with less time and material.

Appendix I

ABBREVIATIONS AND SYMBOLS

1. **Abbreviations.**—The following abbreviations in connection with lumber are used by the carpenter:

A D—air-dried
a. l.—all length
av.—average
av. w.—average width
av. l.—average length
bd.—board
bd. ft.—board foot; that is, an area of 1 square foot by 1 inch thick
bdl.—bundle
bev.—beveled
b.m.—board (foot) measure
btr.—batter
clg.—ceiling
clr.—clear
CM—center matched; that is, tongue-and-groove joints are made along the center of the edge of the piece
Com.—common
Csg.—casing
Ctg.—crating
cu. ft.—cubic foot
D & CM—dressed (one or two sides) and center matched
D & M—dressed and matched; that is, dressed one or two sides and tongued and grooved on the edges. The match may be center or standard
D & SM—dressed (one or two sides) and standard matched
D 2S & CM—dressed two sides and center matched
D 2S & M—dressed two sides and (center or standard) matched
D 2S & SM—dressed two sides and standard matched
Dim.—Dimension
D. S.—drop siding
E.—edge
FAS—firsts and seconds, a combined grade of the two upper grades of hardwoods
f. bk.—flat back

fcty.—factory (lumber)
F. G.—flat grain
Flg.—flooring
f. o. k.—free of knots
Frm.—framing
ft.—foot or feet. One accent mark (′) is also used
Hdl.—handle (stock)
Hdwd.—hardwood
Hrt.—heart
Hrtwd.—heartwood
in.—inch or inches. A pair of accent marks (″) is also used
KD.—kiln-dried
k. d.—knocked down
lbr.—lumber
lgr.—longer
lgth.—length
lin. ft.—linear foot, that is, 12 inches
L. R.—log run
Lr. MCO—log run, mill culls out
M.—thousand
M. b. m.—thousand (feet) board measure
MCO—mill culls out
Merch.—merchantable
M. R.—mill run
M. s. m.—thousand (feet) surface measure
m. w.—mixed width
No.—number
1s & 2s—ones and twos, a combined grade of the hardwood grades of firsts and seconds
Ord.—order
P.—planed
Pat.—pattern
Pky.—picky
Pln.—plain, as in plain sawed
Pn.—partition
Qtd.—quartered (with reference to hardwoods)
rd.—round
rdm.—random
res.—resawed
rfg.—roofing
Rfrs.—roofers
rip.—ripped
r. l.—random length

r. w.—random width
S & E—surfaced one side and one edge
S1E—surfaced one edge
S1S1E—surfaced one side and one edge
S1S2E—surfaced one side and two edges
S2E—surfaced two edges
S4S—surfaced four sides
S & CM—surfaced one or two sides and center matched
S & M—surfaced and matched; that is surfaced one or two sides and tongued and grooved on the edges. The match may be center or standard
S & SM—surfaced one or two sides and standard matched
S2S & CM—surfaced two sides and center matched
S2S & M—surfaced two sides and standard or center matched
S2S & SM—surfaced two sides and standard matched
Sap.—sapwood
SB—standard bead
Sd.—seasoned
Sdg.—siding
Sel.—select
S. E. Sd.—square-edge siding
s. f.—surface foot; that is, an area of 1 square foot
Sftwd.—softwood
Sh. D.—shipping dry
Ship.—shiplap
Sm.—standard matched
s.m.—surface measure
s.n.d.—sap no defect
snd.—sound
sq.—square
sq. E.—square edge
sq. E & S—square edge and sound
sqrs.—squares
Std.—standard
stk.—stock
S.W.—sound wormy
T & G—tongued and grooved
TB & S—top, bottom, and sides
Tbrs.—timbers
V.G.—vertical grain
w.a.l.—wider, all length
wdr.—wider
wt.—weight
wth.—width

2. Architectural symbols.

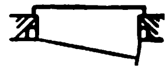
Tile 

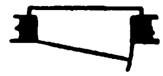
Earth 

Plaster 

Sheet metal 

Built-in cabinet 

Outside door: Brick wall 

Frame wall 

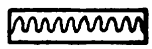
Inside door: Frame wall 

Brick 

Firebrick 

Concrete 

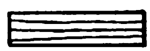
Cast concrete block 

Insulation: Loose fill 

Board or quilts 

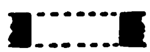
Cut stone 

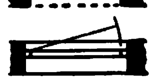
Ashlar 

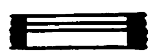
Shingles (siding) 

Wood, rough 

Wood, finished 

Cased or arched openings 

Single casement window 

Double-hung windows 

Double casement window 

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3. Plumbing symbols.

Bath tubs:

Corner 

Free standing 

Floor drain 

Shower drain 

Hot-water tank  H.W.T.

Grease trap 

Hose bibb or sill cock 

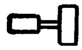
Lavatories:

Pedestal 

Wall-hung 

Corner 

Toilets:

Tank 

Flush valve 

Urinals:

Stall-type 

Wall-hung 

Laundry trays 

Built-in shower 

Shower 

Sinks:

Single drain board 

Double drain board 

4. Electrical symbols.

Pull switch  P.S.

Single-pole switch S_1

Double-pole switch S_2

Triple-pole switch S_3

Buzzer 

Floor outlet 

Bell 

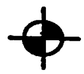
Drop cord 

Ceiling outlet 

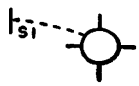
Wall bracket 

Single convenience outlet 

Double convenience outlet 

Ceiling outlet, gas & electric 

Motor 

Light outlet with wiring and switches indicated 

Appendix II

TRADE TERMS AND DEFINITIONS

Anchor.—Irons of special form used to fasten together timbers or masonry.

Backing.—The bevel on the top edge of a hip rafter that allows the roofing boards to fit the top of the rafter without leaving a triangular space between it and the lower side of the roof covering.

Balloon frame.—The lightest and most economical form of construction, in which the studding and corner posts are set up in continuous lengths from first-floor line or sill to the roof plate.

Baluster.—A small column used to support a rail.

Balustrade.—A row of balusters with the rails, generally used for porches, balconies, etc.

Band.—A low, flat molding.

Base.—The bottom of a column; the finish of a room at the junction of the walls and floor.

Batten (*cleat*).—A narrow strip of board used to fasten several pieces together.

Batter board.—A temporary framework used to assist in locating the corners when laying out a foundation.

Beam.—An inclusive term for joists, girders, rafters, and purlins.

Bedding.—A filling of mortar, putty, or other substance in order to secure a firm bearing.

Belt course.—A horizontal board across or around a building, usually made of a flat member and a molding.

Bevel board (*pitch board*).—A board used in framing a roof or stairway to lay out bevels.

Board.—Lumber less than 2 inches thick.

Board foot.—The equivalent of a board 1 foot square and 1 inch thick.

Boarding in.—The process of nailing boards on the outside studding of a house.

Braces.—Pieces fitted and firmly fastened to two others at any angle in order to strengthen the angle thus treated.

Bracket.—A projecting support for a shelf or other structure.

Break joints.—To arrange joints so that they do not come directly under or over the joints of adjoining pieces, as in shingling, siding, etc.

Bridging.—Pieces fitted in pairs from the bottom of one floor joist to the top of adjacent joists, and crossed to distribute the floor load; sometimes pieces of width equal to the joist and fitted neatly between them.

Building paper.—Cheap, thick paper, used to insulate a building before the siding or roofing is put on; sometimes placed between double floors.

Built-up timber.—A timber made of several pieces fastened together and forming one of larger dimension.

Carriages.—The supports of the steps and risers of a flight of stairs.

Casement.—A window in which the sash opens upon hinges.

Casing.—The trimming around a door or window opening, either outside or inside, or the finished lumber around a post or beam, etc.

Ceiling.—Narrow, matched boards; sheathing of the surfaces that inclose the upper side of a room.

Center-hung sash.—A sash hung on its centers so that it swings on a horizontal axis.

Chamfer.—A beveled surface cut upon the corner of a piece of wood.

Checks.—Splits or cracks in a board, ordinarily caused by seasoning.

Clamp.—A mechanical device used to hold two or more pieces together.

Clapboards.—A special form of outside covering of a house; siding.

Columns.—A support, square, rectangular, or cylindrical in section, for roofs, ceilings, etc., composed of base, shaft, and capital.

Combination frame.—A combination of the principal features of the full and balloon frames.

Concrete.—A combination of sand, broken stone, or gravel, and cement used in foundations, building construction for walks, etc.

Conductors.—Pipes for conducting water from a roof to the ground or to a receptacle or drain; downspout.

Cornice.—The molded projection which finishes the top of the wall of a building.

Counterflashings.—Strips of metal used to prevent water from entering the top edge of the vertical side of a roof flashing; they also allow expansion and contraction without danger of breaking the flashing.

Deadening.—Construction intended to prevent the passage of sound.

Drip.—The projection of a window sill or water table to allow the water to drain clear of the side of the house below it.

Fascia.—A flat member of a cornice or other finish, generally the board of the cornice to which the gutter is fastened.

Flashing.—The material used and the process of making watertight the roof intersections and other exposed places on the outside of the house.

Flue.—The opening in a chimney through which smoke passes.

Flush.—Adjacent surfaces even, or in same plane (with reference to two structural pieces).

Footing courses.—The bottom and heaviest courses of a piece of masonry.

Foundation.—That part of a building or wall which supports the superstructure.

Frame.—The surrounding or inclosing woodwork of windows, doors, etc., and the timber skeleton of a building.

Framing.—The rough timber structure of a building, including interior and exterior walls, floor, roof, and ceilings.

Full frame.—The old-fashioned mortised-and-tenoned frame, in which every joint was mortised and tenoned. Rarely used at the present time.

Furring.—Narrow strips of board nailed upon the walls and ceilings to form a straight surface upon which to lay the laths or other finish.

Gable.—The vertical triangular end of a building from the eaves to the apex of the roof.

Gage (gauge).—A tool used by carpenters; to strike a line parallel to the edge of the board.

Gambrel.—A symmetrical roof with two different pitches or slopes on each side.

Girder.—A timber used to support wall beams or joists.

Girt (ribband).—The horizontal member of the walls of a full or combination frame house which supports the floor joists or is flush with the top of the joists.

Groove.—A long hollow channel cut by a tool, into which a piece fits or in which it works. Carpenters have given special names to certain forms of grooves, such as dadoes and housings. A *dado* is a rectangular groove cut across the grain the full width of the piece. Dadoes are used in sliding doors, window frames, etc. A *housing* is a groove cut at any angle with the grain and partway across the piece. Housings are used for framing stair risers and treads into a string (not stringer). Grooving is used largely in the fastening of boards together or in the prevention of warping and twisting of wide boards or boards glued together. In doing this it is necessary to prevent the warping but to permit the free swelling and shrinking due to changes in the humidity. Various simple devices are used, such as hardwood batten, tapering key, or iron rod. Grooving is required in the first two.

Ground.—A strip of wood assisting the plasterer in making a straight wall and in giving a place to which the finish of the room may be nailed.

Ground floor.—The floor of a building on a level with the ground or nearly so.

Header.—A short joist supporting tail beams and framed between trimmer joists; the piece of stud or finish over an opening; a lintel.

Headroom.—The clear space between floor line and ceiling, as in a stairway.

Heel of a rafter.—The end or foot that rests on the wall plate.

Hip roof.—A roof which slopes up toward the center from all sides, necessitating a hip rafter at each corner.

Jack rafter.—A short rafter framing between the wall plate and a hip rafter.

Jamb.—The side piece or post of an opening; sometimes applied to the doorframe.

Joint-butt.—Squared ends or ends and edges adjoining each other.

> *Dovetail.*—Joint made by cutting pins the shape of dovetails in which fit between dovetails upon another piece.
>
> *Drawboard.*—A mortise-and-tenon joint with holes so bored that when a pin is driven through, the joint becomes tighter.
>
> *Fished.*—An end butt splice strengthened by pieces nailed on the sides.
>
> *Halved.*—A joint made by cutting half of the wood away from each piece so as to bring the sides flush.
>
> *Housed.*—A joint in which a piece is grooved to receive the piece which is to form the other part of the joint.
>
> *Glue.*—A joint held together with glue.
>
> *Lap.*—A joint of two pieces lapping over each other.
>
> *Mortised.*—A joint made by cutting a hole or mortise, in one piece, and a tenon, or piece to fit the hole, upon the other.
>
> *Rub.*—A flue joint made by carefully fitting the edges together, spreading glue between them, and rubbing the pieces back and forth until the pieces are well rubbed together.
>
> *Scarfed.*—A timber spliced by cutting various shapes of shoulders, or jogs, which fit each other.

Joists.—Timbers supporting the floor boards.

Kerf.—The cut made by a saw.

Laths.—Narrow strips to support plastering.

Lattice.—Crossed wood, iron plate, or bars.

Ledgerboard.—The support for the second-floor joists of a baloon-frame house, or for similar uses; ribband.

Level.—A term describing the position of a line or plane when parallel to the surface of still water, an instrument or tool used in testing for horizontal and vertical surfaces, and in determining differences of elevation.

Lintel (*header*).—The piece of construction or finish, stone, wood, or metal, which is over an opening; a header.

Lookout.—The end of a rafter, or the construction which projects beyond the sides of a house to support the eaves; also the projecting timbers at the gables which support the verge boards.

Louver.—A kind of window, generally in the peaks of gables and the tops of towers, provided with horizontal slots which exclude rain and snow and allow ventilation.

Lumber.—Sawed parts of a log such as boards, planks, scantling, and timber.

Matching, or tonguing and grooving.—The method used in cutting the edges of a board to make a tongue on one edge and a groove on the other.

Meeting rail.—The bottom rail of the upper sash, and the top rail of the lower sash of a double-hung window. Sometimes called the check rail.

Miter.—The joint formed by two abutting pieces meeting at an angle.

Molding—Base.—The molding on the top of a base board.

Bed.—A molding used to cover the joint between the plancier and frieze; also used as a base molding upon heavy work, and sometimes as a member of a cornice.

Lip.—A molding with a lip which overlaps the piece against which the back of the molding rests.

Rake.—The cornice upon the gable edge of a pitch roof, the members of which are made to fit those of the molding of the horizontal eaves.

Picture.—A molding shaped to form a support for picture hooks, often placed at some distance from the ceiling upon the wall to form the lower edge of the frieze.

Mortise.—The hole which is to receive a tenon, or any hole cut into or through a piece by a chisel; generally of rectangular shape.

Mullion.—The construction between the openings of a window frame to accommodate two or more windows.

Muntin.—The vertical member between two panels of the same piece of panel work. The vertical sash-bars separating the different panes of glass.

Newel.—The principal post at the foot of a staircase; also the central support of a winding flight of stairs.

Nosing.—The part of a stair tread which projects over the riser, or any similar projection; a term applied to the rounded edge of a board.

Piers.—Masonry supports, set independently of the main foundation.

Pilaster.—A portion of a square column, usually set within or against a wall.

Piles.—Long posts driven into the soil in swampy locations or whenever it is difficult to secure a firm foundation, upon which the footing course of masonry or other timbers are laid.

Pitch.—Inclination or slope, as of roofs or stairs, or the rise divided by the span.

Pitch board.—A board sawed to the exact shape formed by the stair tread, riser, and slope of the stairs and used to lay out the carriage and stringers.

Plan.—A horizontal geometrical section of a building, showing the walls, doors, windows, stairs, chimneys, columns, etc.

Planks or lumber.—Material 2 or 3 inches thick and more than 4 inches wide, such as joists, flooring, etc.

Plaster.—A mixture of lime, hair, and sand, or of lime, cement, and sand, used to cover outside and inside wall surfaces.

Plate.—The top horizontal piece of the walls of a frame building upon which the roof rests.

Plate cut.—The cut in a rafter which rests upon the plate; sometimes called the seat cut.

Plumb cut.—Any cut made in a vertical plane; the vertical cut at the top end of a rafter.

Ply.—A term used to denote a layer or thickness of building or roofing paper as two-ply, three-ply, etc.

Porch.—An ornamental entrance way.

Post.—A timber set on end to support a wall, girder, or other member of the structure.

Plow.—To cut a groove running in the same direction as the grain of the wood.

Pulley stile.—The member of a window frame which contains the pulleys, and between which the edges of the sash slide.

Purlin.—A timber supporting several rafters at one or more points, or the roof sheeting directly.

Rabbet or rebate.—A corner cut out of an edge of a piece of wood.

Rafters, common.—Those which run square with the plate and extend to the ridge.

Cripple.—Those which cut between valley and hip rafters.

Hip.—Those extending from the outside angle of the plates toward the apex of the roof.

Jacks.—Those square with the plate and intersecting the hip rafter.

Valley.—Those extending from an inside angle of the plates toward the ridge or center line of the house.

Rail.—The horizontal members of a balustrade or panel work.

Rake.—The trim of a building extending in an oblique line, as rake dado or molding.

Return.—The continuation of a molding or finish of any kind in a different direction.

Ribband.—(See *Ledger board*.)

Ridge.—The top edge or corner formed by the intersection of two roof surfaces.

Ridge cut.—(See *Plum cut*.)

Rise.—The vertical distance through which anything rises, as the rise of a roof or stair.

Riser.—The vertical board between two treads of a flight of stairs.

Roof.—The covering or upper part of a building.

Roofing.—The material put on a roof to make it wind and waterproof.

Run.—The length of the horizontal projection of a piece such as a rafter when in position.

Saddle board.—The finish of the ridge of a pitch-roof house. Sometimes called comb board.

Sash.—The framework which holds the glass in a window.

Sawing, plain.—Lumber sawed regardless of the grain, the log simply squared and sawed to the desired thickness; sometimes called slash or bastard sawed.

Scaffold or staging.—A temporary structure or platform enabling workmen to reach high places.

Scale.—A short measurement used as a proportionate part of a larger dimension. The scale of a drawing is expressed as 1/4 inch=1 foot.

Scantling.—Lumber with a cross section ranging from 2″ x 4″ to 4″ x 4″.

Scarfing.—A joint between two pieces of wood which allows them to be spliced lengthwise.

Scotia.—A hollow molding used as a part of a cornice, and often under the nosing of a stair tread.

Scribing.—The marking of a piece of wood to provide for the fitting of one of its surfaces to the irregular surface of another.

Seat cut or plate cut.—The cut at the bottom end of a rafter to allow it to fit upon the plate.

Seat of a rafter.—The horizontal cut upon the bottom end of a rafter which rests upon the top of the plate.

Section.—A drawing showing the kind, arrangement, and proportions of the various parts of a structure. It is assumed that the structure is cut by a plane, and the section is the view gained by looking in one direction.

Shakes.—Imperfections in timber caused during the growth of the tree by high winds or imperfect conditions of growth.

Sheathing.—Wall boards, roofing boards; generally applied to narrow boards laid with a space between them, according to the length of a shingle exposed to weather.

Sheathing paper.—The paper used under siding or shingles to insulate the house; building papers.

Siding.—The outside finish between the casings.

Sills.—The horizontal timbers of a house which either rest upon the masonry foundations or, in the absence of such, form the foundations.

Sizing.—Working material to the desired size; a coating of glue, shellac, or other substance applied to a surface to prepare it for painting or other method of finish.

Sleeper.—A timber laid on the ground to support a floor joist.

Span.—The distance between the bearings of a timber or arch.

Specifications.—The written or printed directions regarding the details of a building or other construction.

Square.—A tool used by mechanics to obtain accuracy; a term applied to a surface including 100 square feet.

Stairs, box.—Those built between walls, and usually with no support except the wall strings.

Standing finish.—Term applied to the finish of the openings and the base, and all other finish necessary for the inside of the house.

Stucco.—A fine plaster used for interior decoration and fine work, also for rough outside wall coverings.

Studding.—The framework of a partition or the wall of a house; usually referred to as 2 x 4's.

Threshold.—The beveled piece over which the door swings; sometimes called a carpet strip.

Timber.—Lumber with cross section over 4″ x 6″, such as posts, sills, and girders.

Tie beam (collar beam).—A beam so situated that it ties the principal rafters of a roof together and prevents them from thrusting the plate out of line.

Tin shingle.—A small piece of tin used in flashing and repairing a shingle roof.

To the weather.—A term applied to the projecting of shingles or siding beyond the course above.

Tread.—The horizontal part of a step.

Trim.—A term sometimes applied to outside or interior finished woodwork and the finish around openings.

Trimmer.—The beam or floor joist into which a header is framed.

Trimming.—Putting the inside and outside finish and hardware upon a building.

Valley.—The internal angle formed by the two slopes of a roof.

Verge boards.—The boards which serve as the eaves finish on the gable end of a building.

Vestibule.—An entrance to a house; usually inclosed.

Wainscoting.—Matched boarding or panel work covering the lower portion of a wall.

Wash.—The slant upon a sill, capping, etc., to allow the water to run off easily.

Water table.—The finish at the bottom of a house which carries the water away from the foundation.

Wind (*"i" pronounced as in kind*).—A term used to describe the surface of a board when twisted (winding) or when resting upon two diagonally opposite corners, if laid upon a perfectly flat surface.

Wooden brick.—Piece of seasoned wood, made the size of a brick, and laid where it is necessary to provide a nailing space in masonry walls.

Appendix III
SUPPLEMENTARY ILLUSTRATIONS

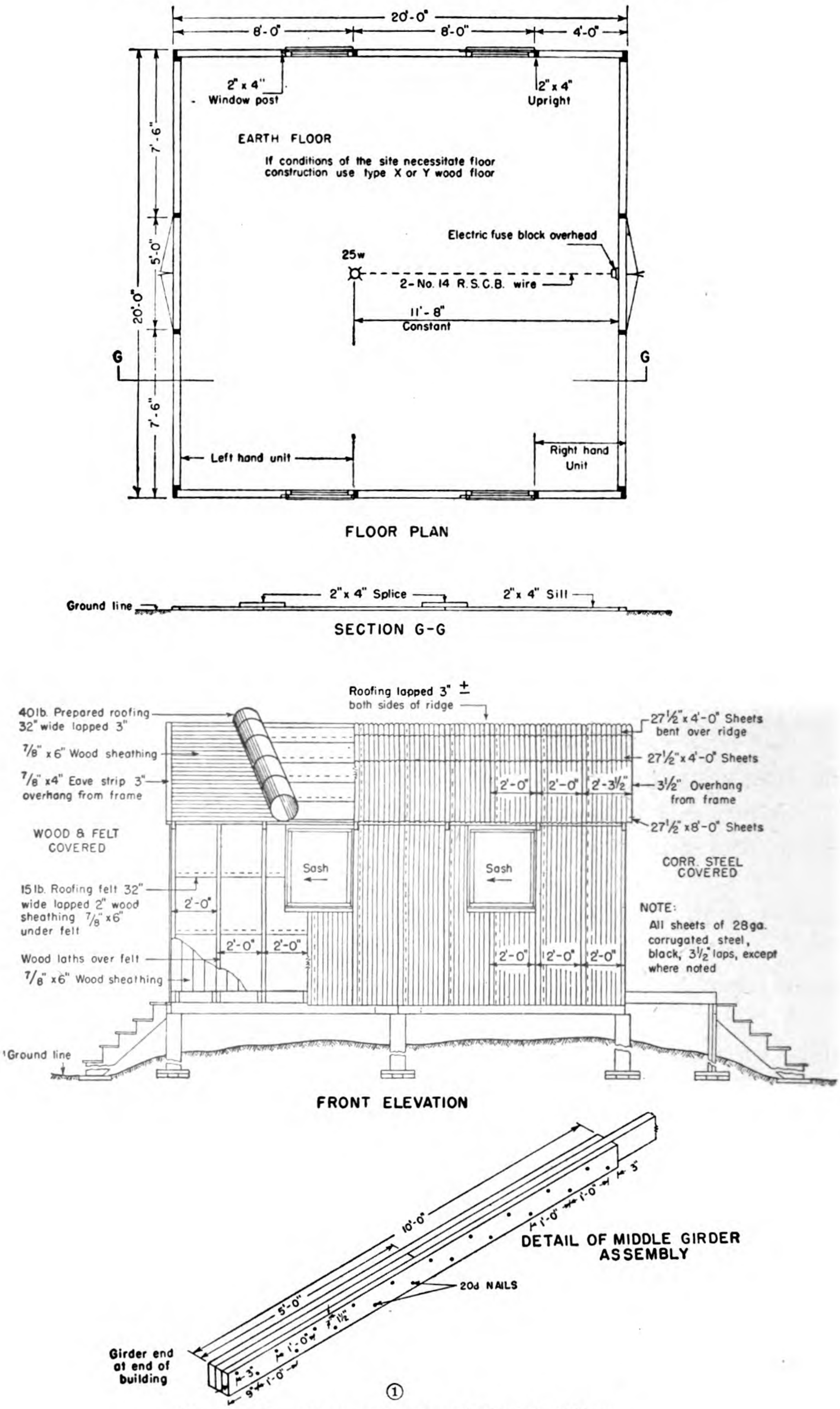


FIGURE 1.—Plan of 20- by 20-foot building.

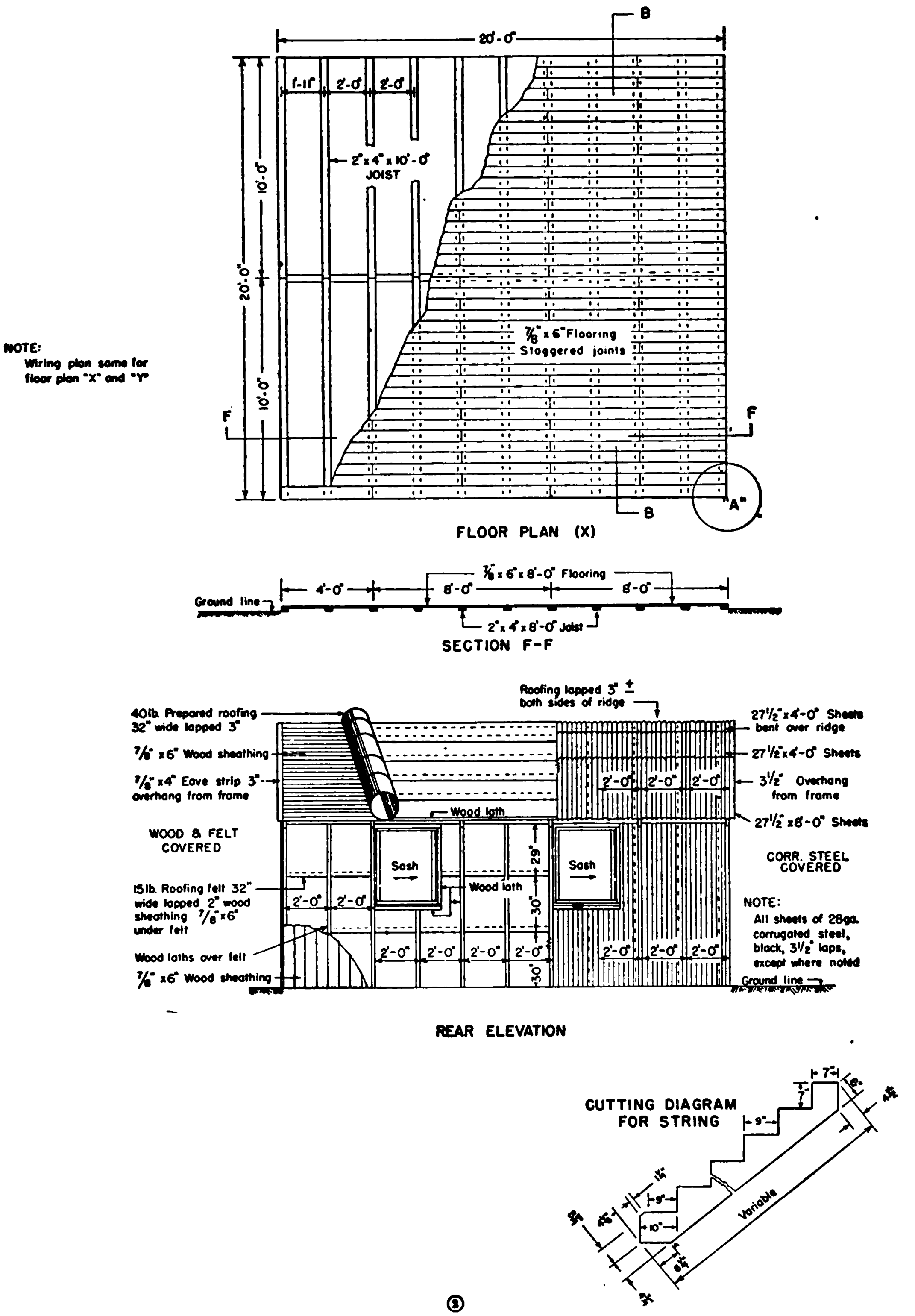


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FIGURE 1.—Plan of 20- by 20-foot building—Continued.

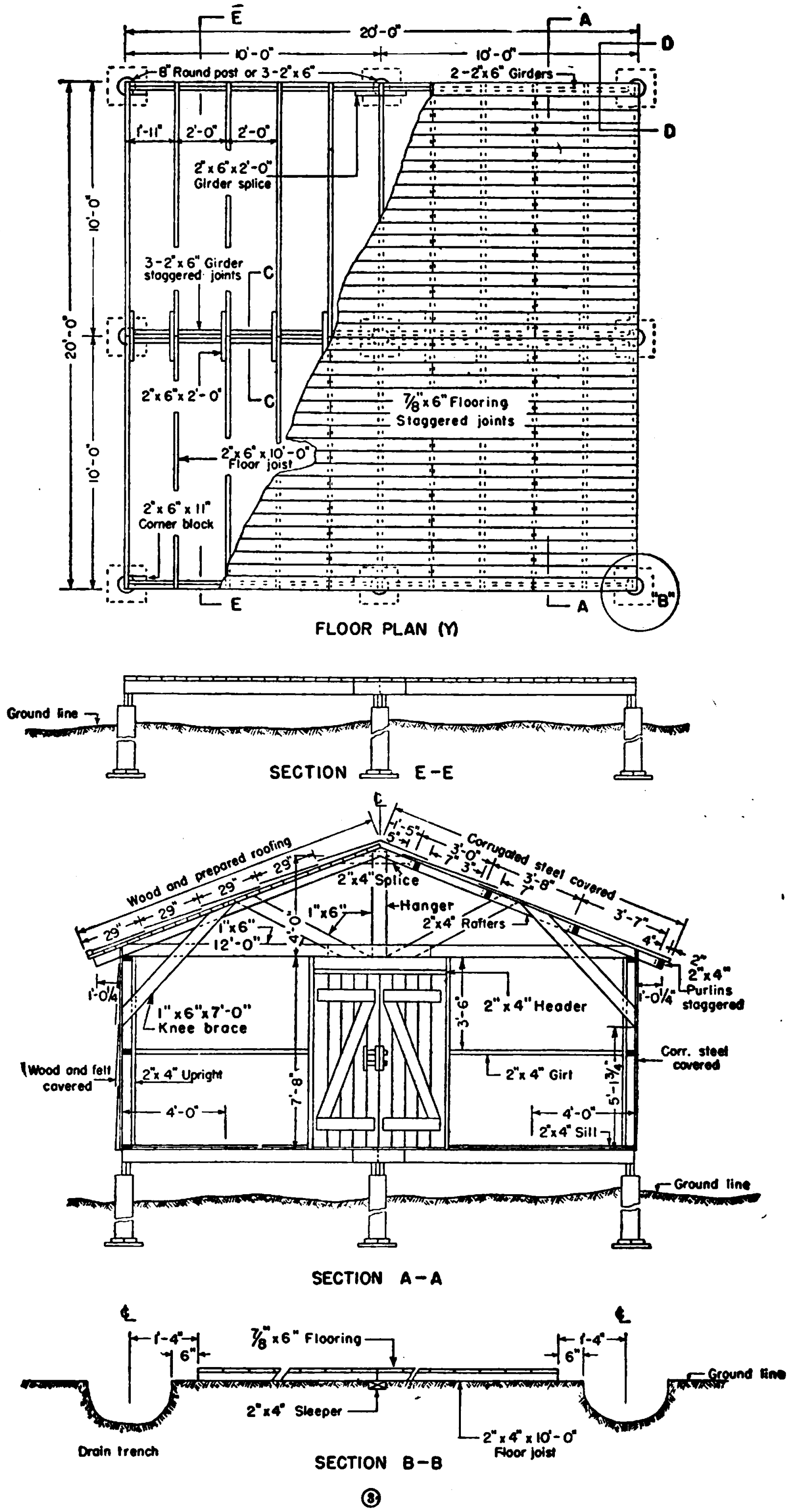
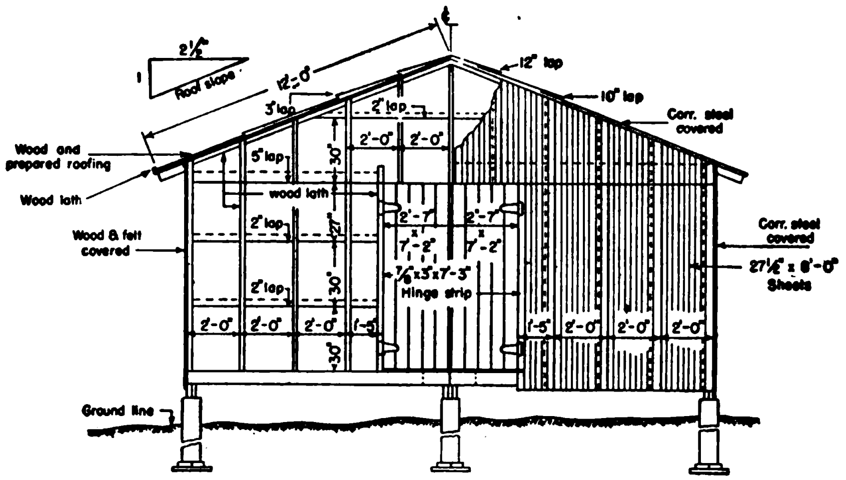
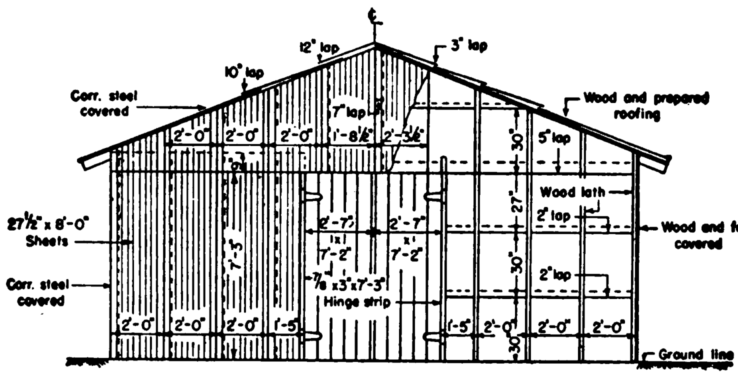


FIGURE 1.—Plan of 20- by 20-foot building—Continued.



LEFT END ELEVATION



RIGHT END ELEVATION

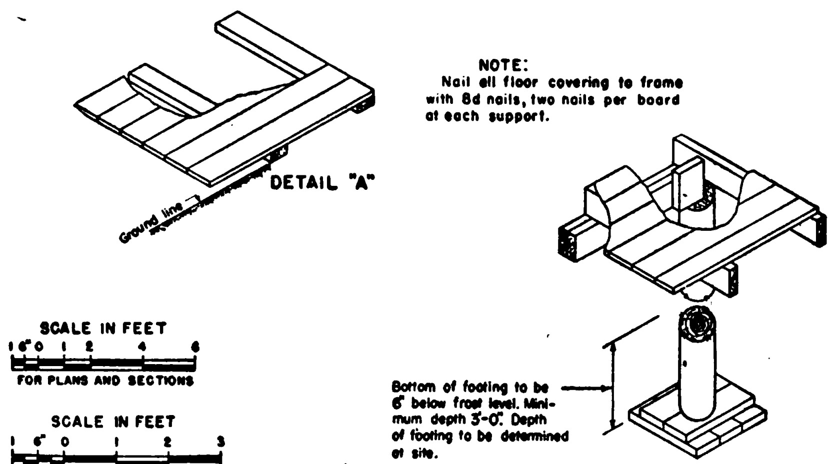


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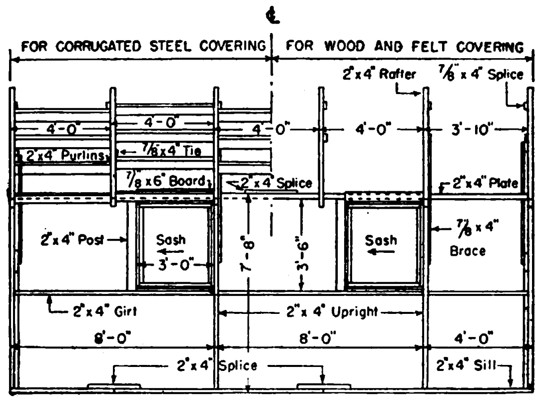
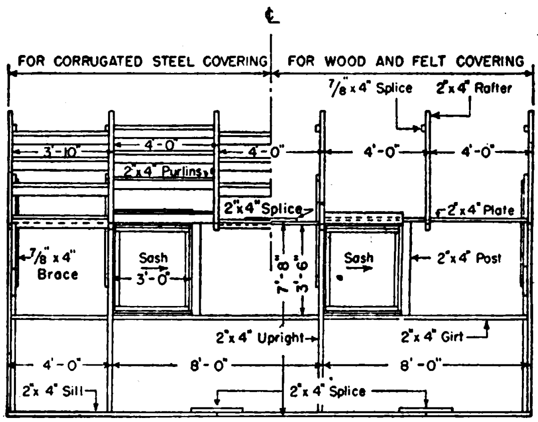
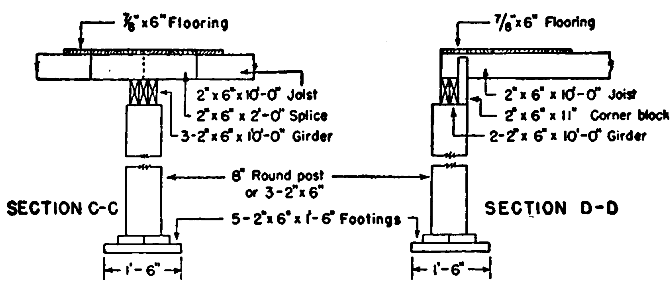
FIGURE 1.—Plan of 20- by 20-foot building—Continued.



FRONT FRAME ELEVATION



REAR FRAME ELEVATION



DETAILS OF WOOD FLOOR TYPE "Y"

STRUCTURE 20 FT. x 20 FT. WOOD
PLANS, ELEVATIONS, SECTIONS, ERECTION DIAGRAMS & DETAILS
WOOD FLOORS TYPE X & Y & SECTIONS
DRAWN....... CHECKED..... DATE.........

⑤

FIGURE 1.—Plan of 20- by 20-foot building—Continued.

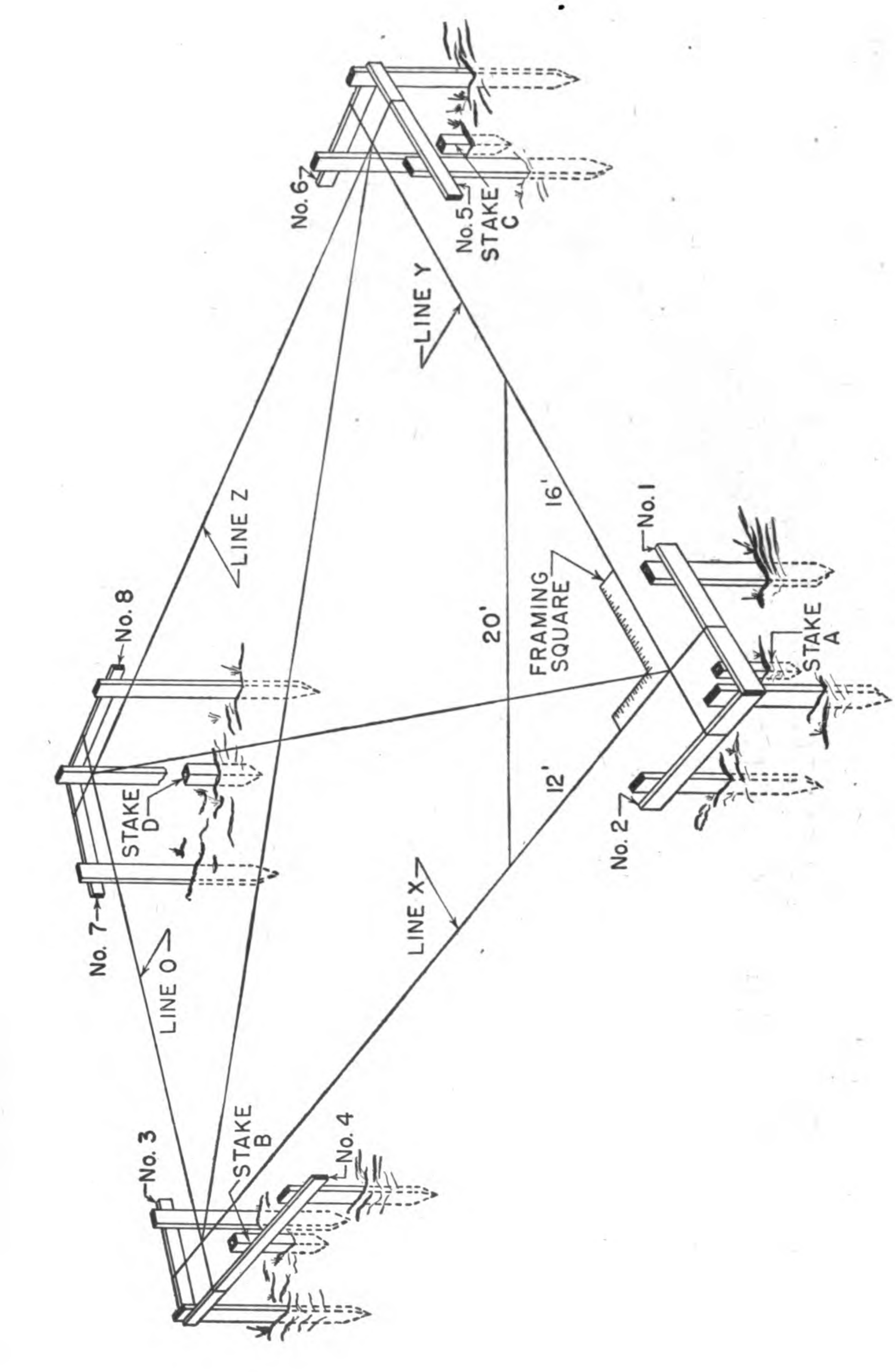


FIGURE 2.—Foundation lay-out.

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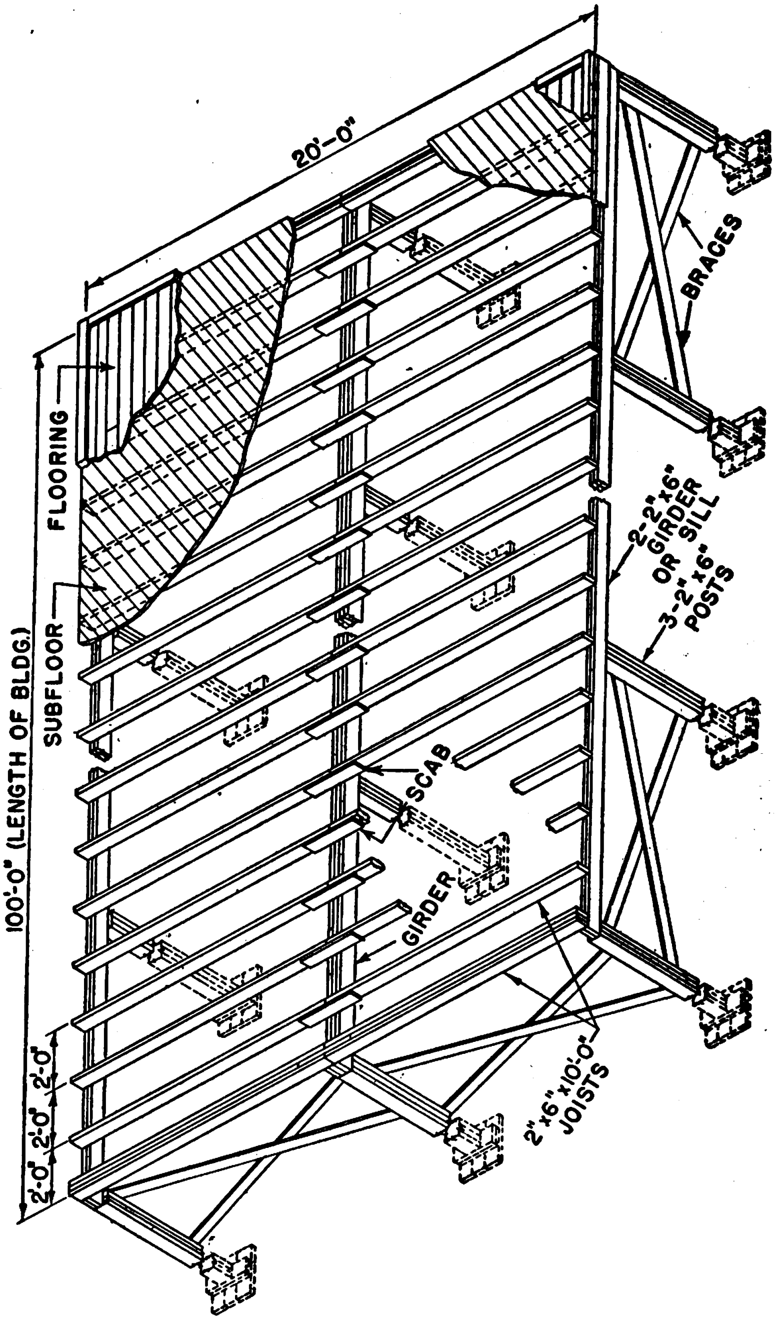

FIGURE 3.—Pier, sill, girder, and joist construction.

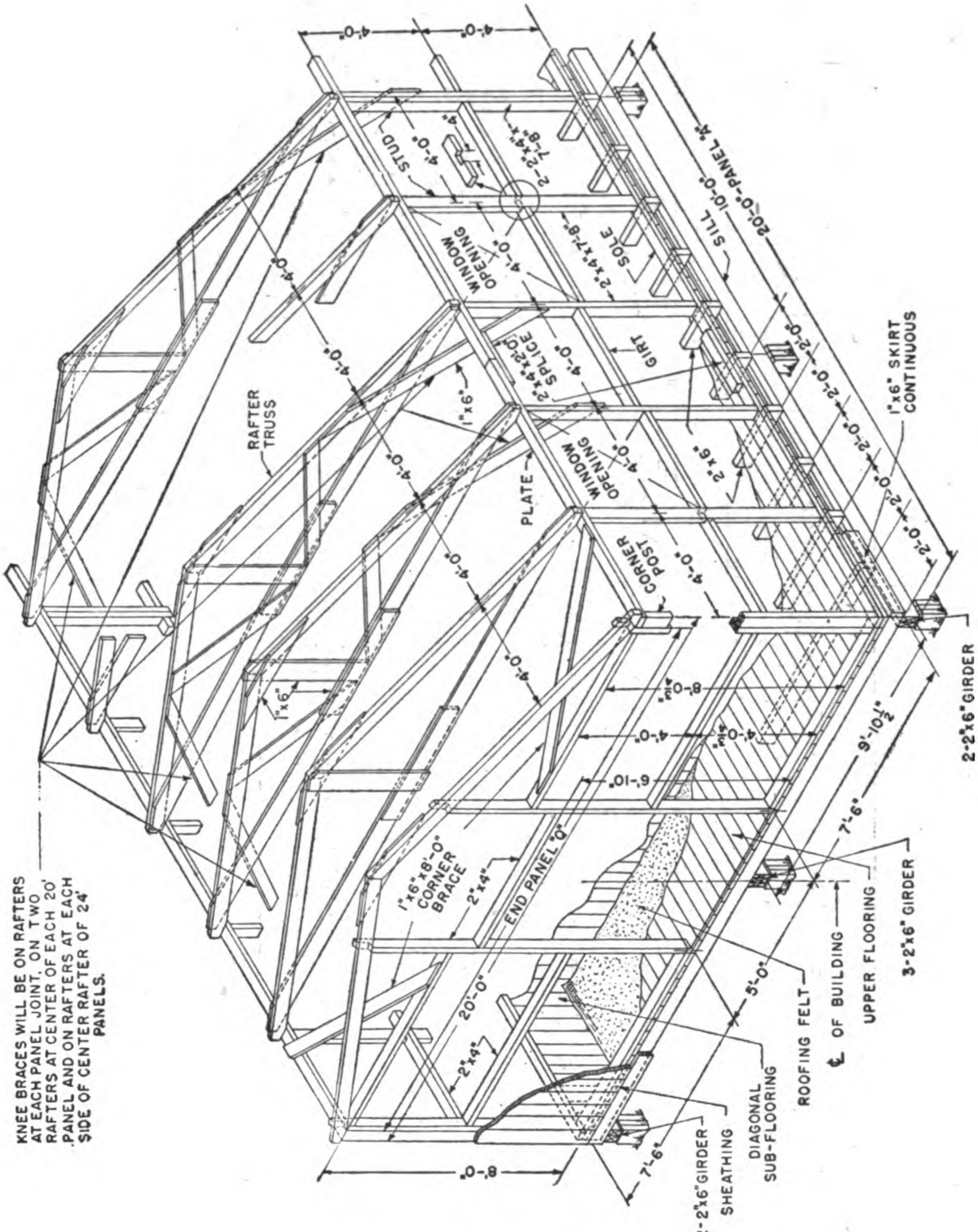

FIGURE 4.—Structural framing.

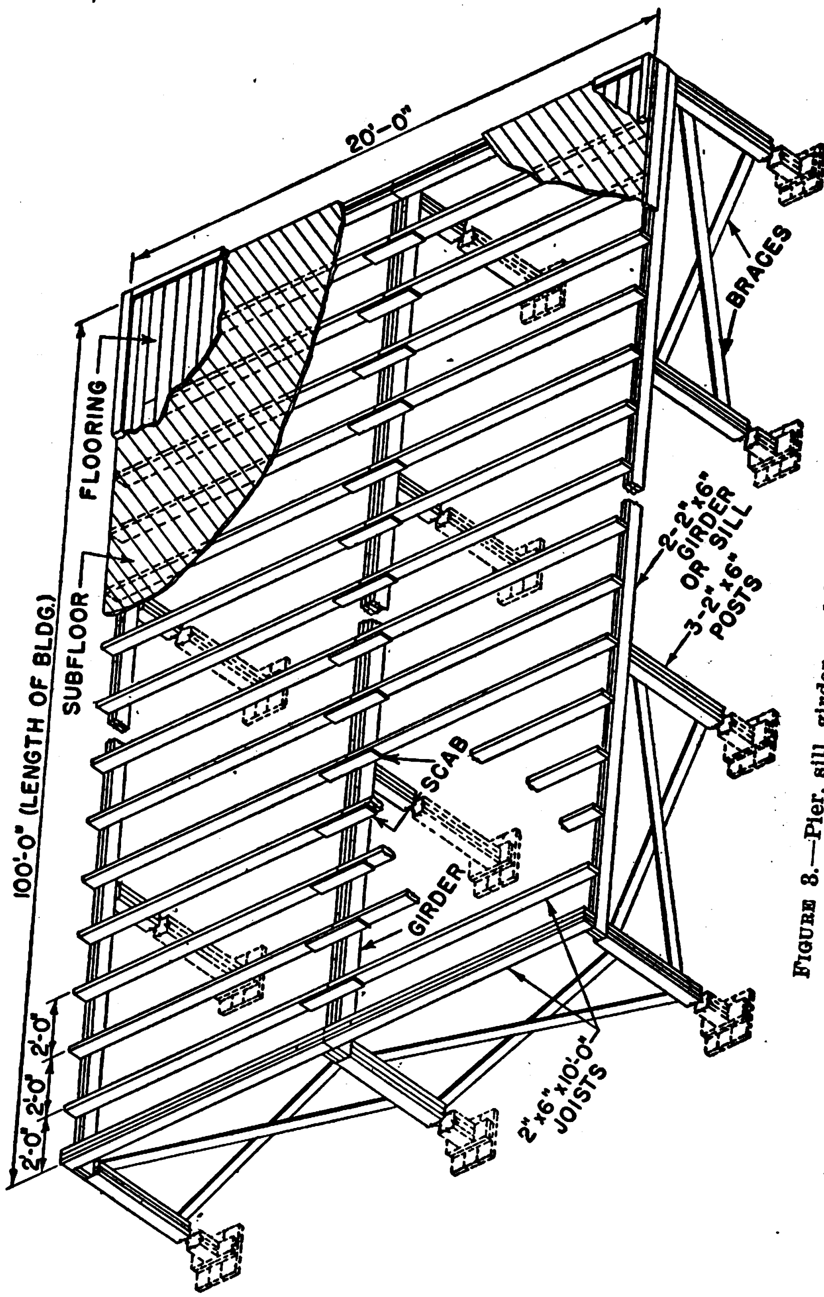

Figure 8.—Pier, sill, girder, and joist construction.

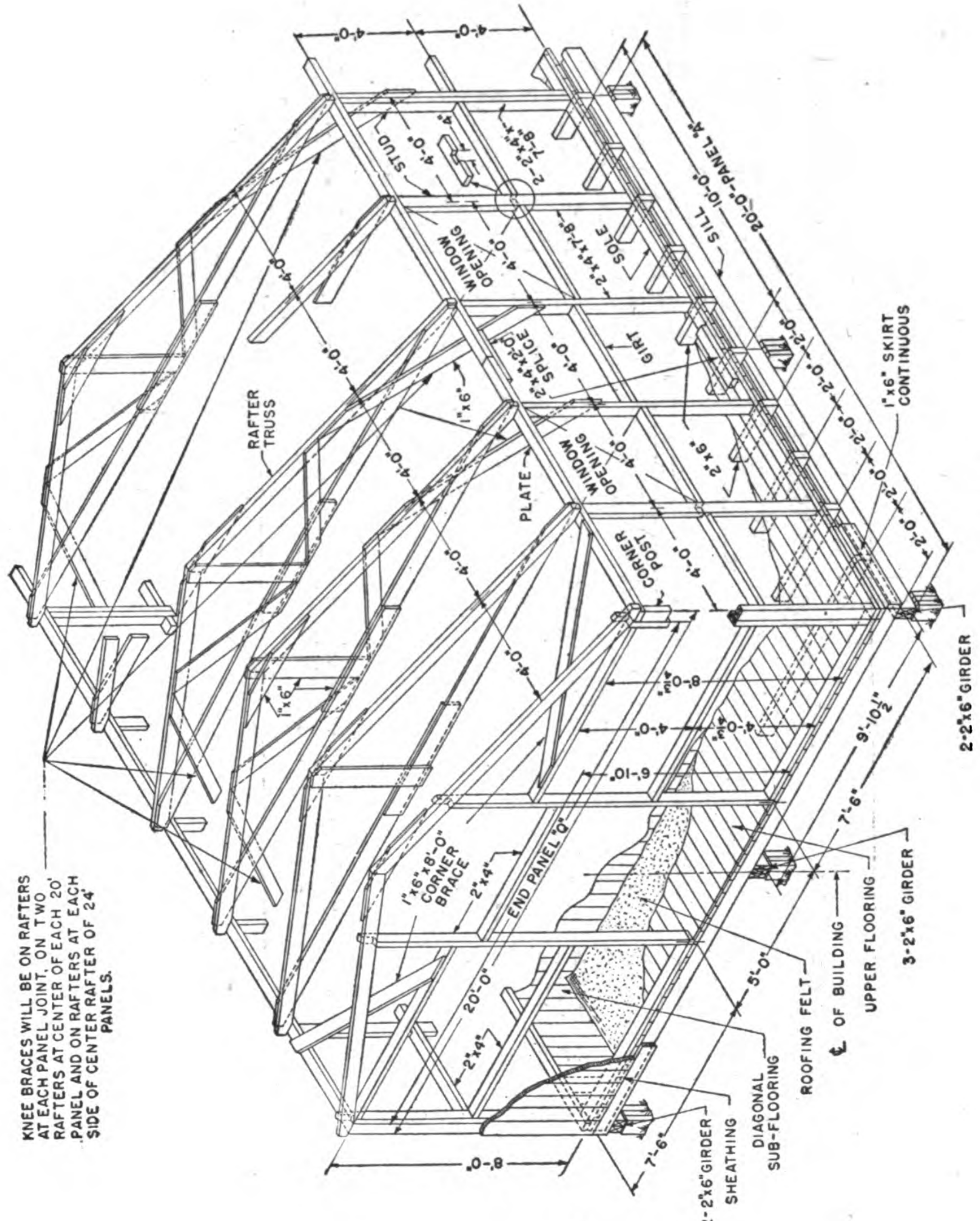

FIGURE 4.—Structural framing.

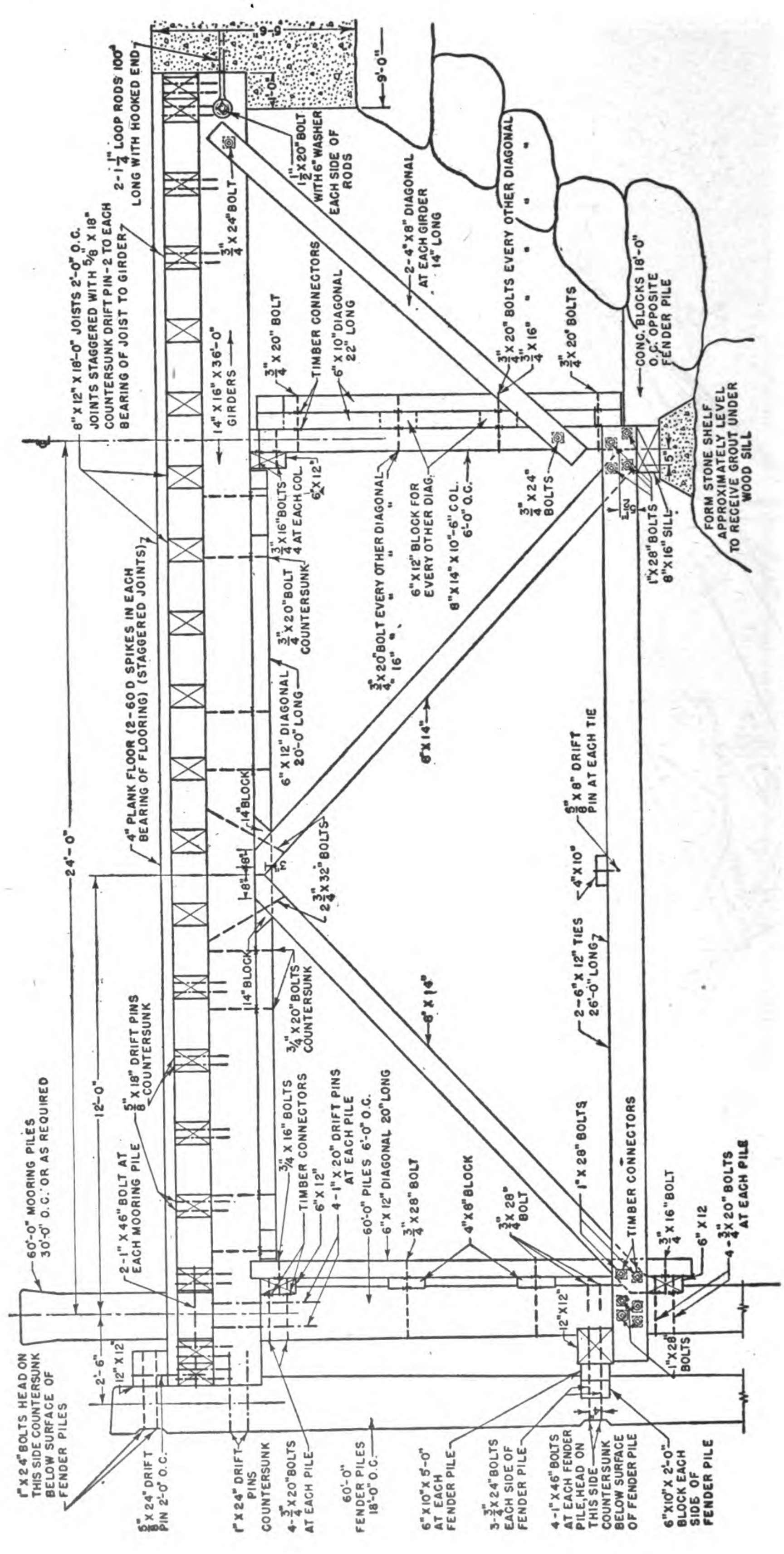

FIGURE 5.—Wharf plan.

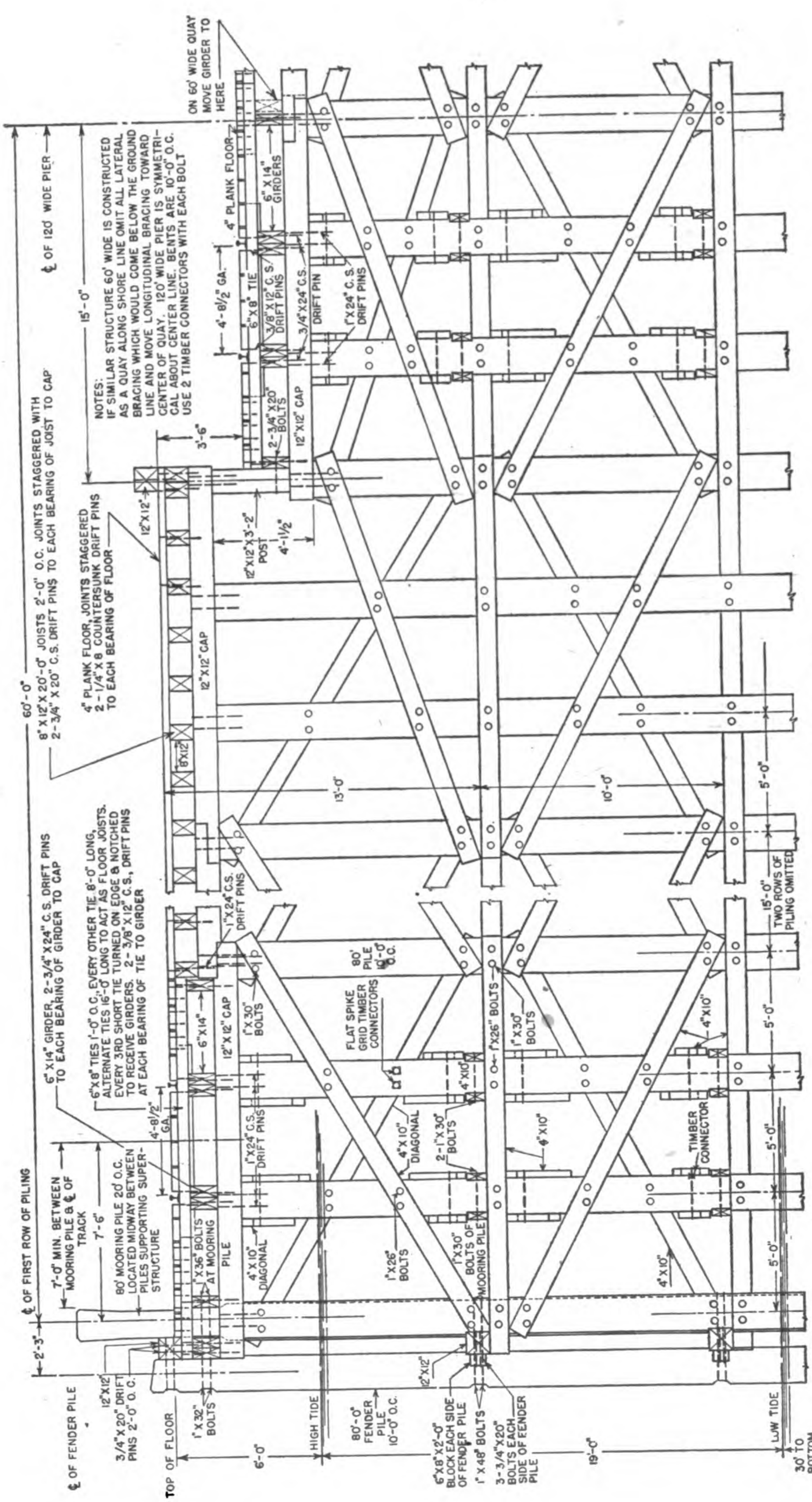

FIGURE 6.—Pier plan.

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[A. G. 062.11 (3–5–43).]

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(For explanation of symbols see FM 21–6.)

U. S. GOVERNMENT PRINTING OFFICE: 1943