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FARM SHOP PRACTICE

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BY

MACK M. JONES, M.S.

Professor of Agricultural Engineering, University of Missouri; Member, American Society of Agricultural Engineers

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PREFACE

This book has been prepared to meet an increasing need for a text in farm shopwork that deals simply and directly, yet comprehensively, with tools and basic tool processes. It is recognized more and more that for satisfactory achievement in shopwork the student must study the subject systematically, much as he would study any other school subject, as well as work with his hands on practical jobs or projects in the shop. Because of the wide variety of mechanical work done on the farm and the multiplicity of jobs or projects available for practice work in the school shop, a well-organized series of lessons on tools and tool processes is needed to serve as a nucleus around which the course can be centered and to serve as a guide to keep the work definitely related to fundamental principles and to the most important phases of the work.

This book is planned to permit all possible flexibility in its use. It treats tools and tool processes separately and apart from any particular set of jobs or projects, for it is hardly possible to use any one set under different local school conditions. The book can be used, therefore, in connection with any jobs that meet particular local needs.

The material is not arranged in any definite teaching sequence, for there probably is no one absolutely correct arrangement, except for one particular set of conditions, and then for one time only. Probably the best way to use the book is to assign certain topics on tools and tool processes, giving as reference certain sections of the book. The topics may then be discussed much as topics in any other school subject. It will usually be profitable to give demonstrations also.

In most schools it is possible for only a few students immediately to put into practice in the shop the principles covered in a discussion or demonstration, mainly because of a lack of tools and equipment to accommodate the whole class on the same kind of work at the same time. It is very desirable, therefore, that the student review in the text or a suitable reference the main points or principles of a new subject just before he starts laboratory work on it. Also, as he proceeds and difficulties or doubts arise, he should refer to the text or reference for help. Self-help thus rendered develops resourcefulness in the student and is better than too much reliance upon the instructor. Furthermore, it is not possible for the instructor to give individual instruction to all students of a large class at just the time needed.

It is generally not possible to cover a subject completely and thoroughly in a discussion or demonstration in the time available. Nor can a student retain all that is brought out in discussions and demonstrations. Frequently students are absent from class. Therefore, a textbook which can be used to supplement discussions and demonstrations and which can be referred to later by the student, either in the shop or in the library, as he pursues a subject, is an invaluable teaching aid. It is to provide such an aid that this book has been prepared.

MACK M. JONES.

COLUMBIA, MO.;
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TO THE STUDENT

It is often said that practice makes perfect, and many believe that to attain success in mechanical work one has but to practice, and that little or no study is required. However, without a certain amount of diligent study, only very meager and unsatisfactory results may be expected. This book is intended to provide a convenient text and ready reference for such study. Much more rapid progress will be made and higher achievements attained when work with the hands is supplemented by systematic study.

Practice, to be profitable, must be practice of right methods, for, once a wrong method is learned, it is difficult to learn the right. It is most important, therefore, when a tool is to be used for the first time, or a process performed for the first time, that the student really know how to use the tool or perform the process correctly. In case of doubt, he should consult his text or a suitable reference. Careful, thoughtful practice of correct methods, combined with diligent study and reading, is the best way to acquire accuracy and speed.

It is true that the student need not become a skilled craftsman in the various phases of farm shopwork, yet he should acquire a certain minimum proficiency in whatever he undertakes. He should be able to recognize good work, and he should have enough practice to give him confidence in his own ability. Unless a student progresses far enough to acquire self-confidence, his time and effort will be largely wasted. It is far better, therefore, to learn a few things thoroughly than to learn many in a slipshod manner and to be unable to use them later when they are needed.

Furthermore, thoroughness and a mastery of fundamental principles of one phase of shopwork make for easier and more rapid progress in other phases. A student who has acquired proficiency in woodwork, for example, can learn blacksmithing or cold-iron work or sheet-metal work much more easily and rapidly than a student without previous shop training. One of the main objectives in shopwork, therefore, might well be thoroughness and the development of a reasonably high degree of skill in whatever phases of the work are undertaken.

PART I

FARM WOODWORK AND CARPENTRY

CHAPTER I

MEASURING AND MARKING

Although there is an increase in the amount of steel and other metals used in farm machinery and equipment, there will always be a need for the farmer to make repairs and construct appliances involving the use of wood. It is a simple matter to become reasonably proficient in the use of woodworking tools, because woodworking, like most other kinds of mechanical work, is based upon a comparatively few fundamental tool processes or operations, like sawing and planing. Once these are mastered, one is well on his way toward becoming a proficient woodworker.

1. Measuring with the Rule.—Accurate measuring and marking is the first requirement for good work in the shop. In making accurate meas-

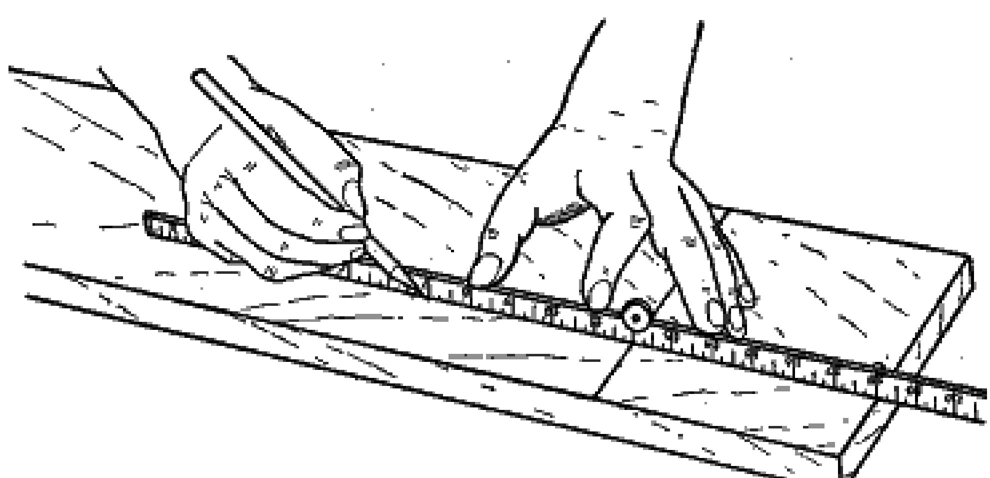

FIG. 1.—Accurate measurements can best be made with a rule laid on edge. When making several measurements in a straight line, do not raise the rule until all are marked.

urements with a rule, the measurer should lay the rule on edge so that the graduations touch the work being marked.

In making several measurements in a straight line, it is best to mark off all measurements without raising the rule, for if the rule is raised and each measurement made separately, then there is much more possibility of errors.

An easy method of locating the middle of a board is to place the rule across the board at an angle so that major divisions, as even inch marks, coincide with the edges of the board. The middle of the board is then midway between these two major divisions of the rule. A similar method may be used for dividing a board into several equal widths.

In reading a fractional measurement on a rule, it is best to think of the measurement as a major fraction plus or minus a small fraction. For example, $^{11}/_{16}$ in. is $^{3}/_{4}$ in. minus $^{1}/_{16}$; $^{5}/_{16}$ in. is $^{1}/_{4}$ in. plus $^{1}/_{16}$; etc.

2. The carpenter's steel square is also used for measuring and dividing distances. In addition, it is used for marking off lines at right angles to an edge of a board or to another line, and for laying out other angles (see Art. 17, page 12).

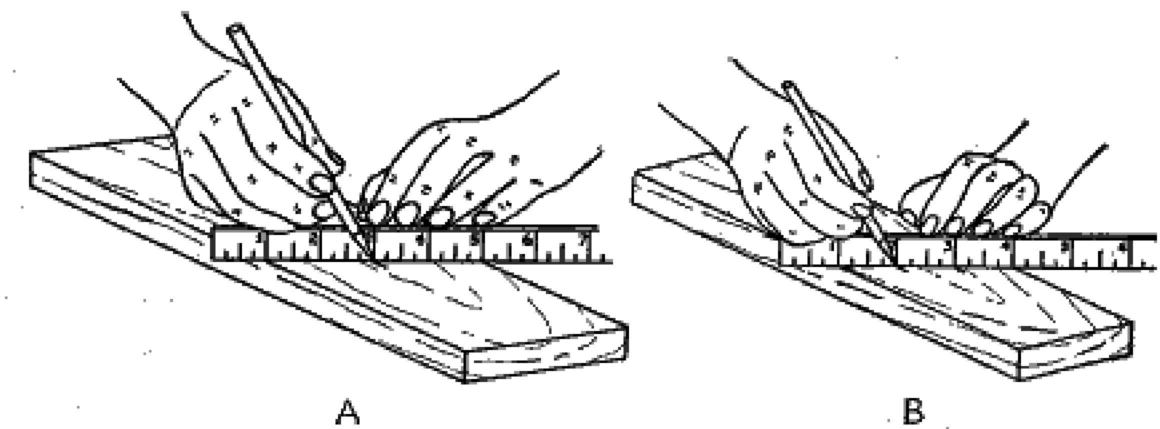

Fig. 2.—*A*. An easy method of marking the middle of a board. The rule is laid across the board at an angle with two even inch marks coinciding with the edges, and then the mid-point is marked.
B. In a similar manner, a board is easily divided into a number of equal widths.

3. The try square is used mostly at the workbench for (1) measuring short distances, (2) laying out lines perpendicular to an edge or side of a board, (3) checking edges and ends of boards to see if they are square with adjoining surfaces, and (4) checking the width or thickness of narrow boards. In order to keep the try square accurate, care should be taken not to drop it. The try square should never be used for hammering or prying.

In squaring with a try square, the handle should always be held firmly against either the working surface or the working edge of the board. (See Art. 37, page 30, for definitions of working surface and working edge.)

4. Testing a Square.—If a square is suspected of not being true, it may be tested easily. Use a board that has a perfectly straight edge. Place the blade of the square along the straight edge and mark a line across the board (presumably at right angles to the edge). Turn the square around (Fig. 5) and see if the line still checks square. If not, the square is not true.

If a steel square is found not true, it may be adjusted by placing the corner of the square flat on an anvil and hammering carefully to stretch the outer part or the inner part of the corner, as may be required.

5. The bevel is used for laying out and checking angles and bevels. The blade is adjustable and is held in place by a thumbscrew. After it is

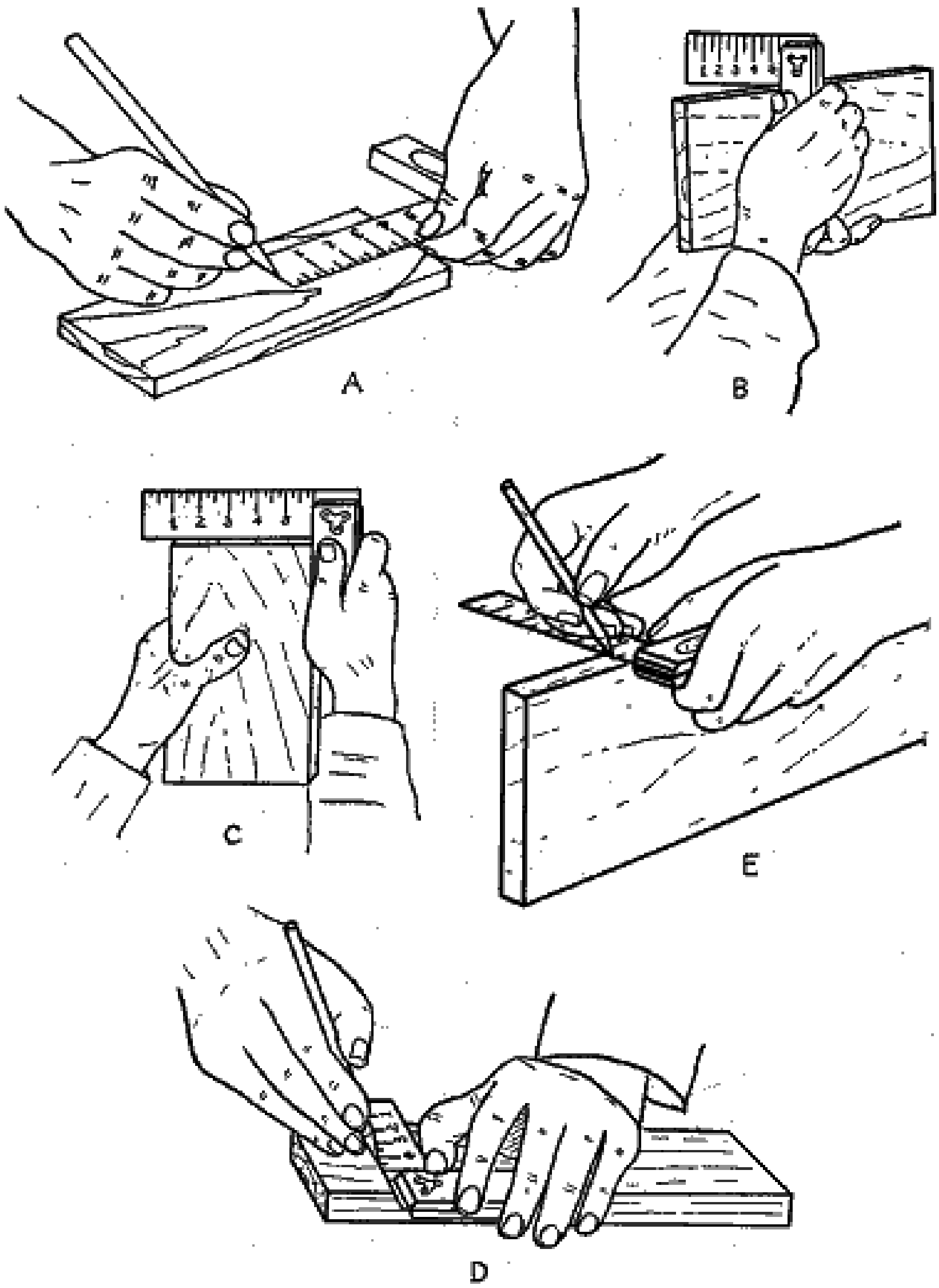

FIG. 3.—Examples of use of the try square.
A. Marking off short measurements.
B. Checking an edge for squareness with a surface.
C. Checking an end for squareness with an edge.
D. Squaring across a surface.
E. Squaring across an edge.

set to the desired angle it is used in a manner similar to the try square. For setting the bevel at angles of 30, 45, or 60 deg., the methods illustrated in Fig. 7 may be used.

6. Marking with a pencil or knife should be done carefully. The square or rule should first be very carefully placed, and then a sharp pencil or knife should be drawn along the straight edge of the rule or square so as

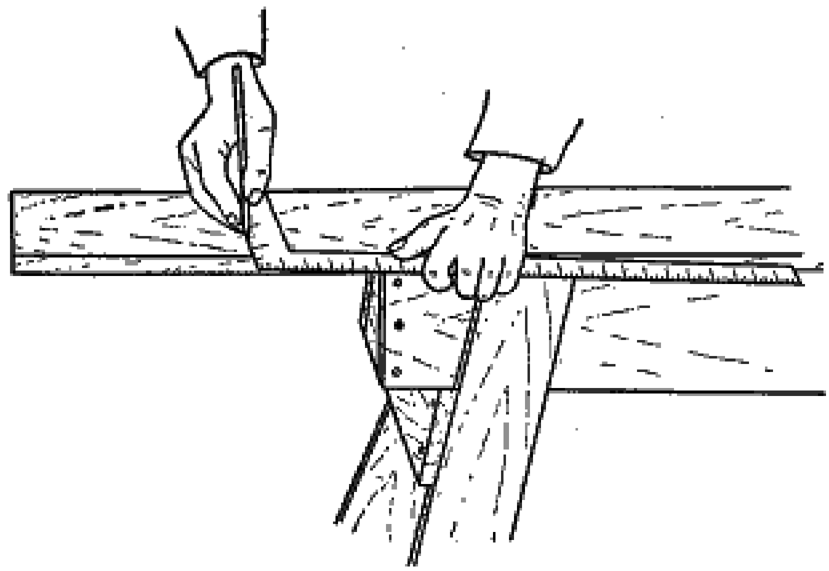

Fig. 4.—When squaring across from the edge of a board, hold the body of the square firmly against the edge and mark close to the tongue of the square.

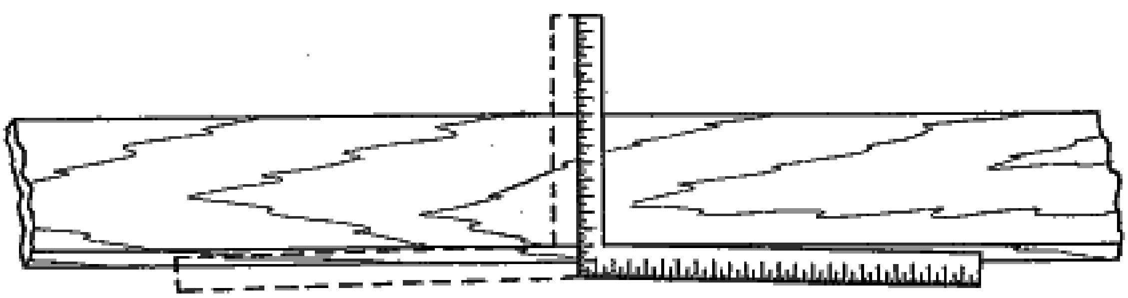

Fig. 5.—To test a square, square a line across a board that has a straight edge. Then turn the square over and see if the line checks square.

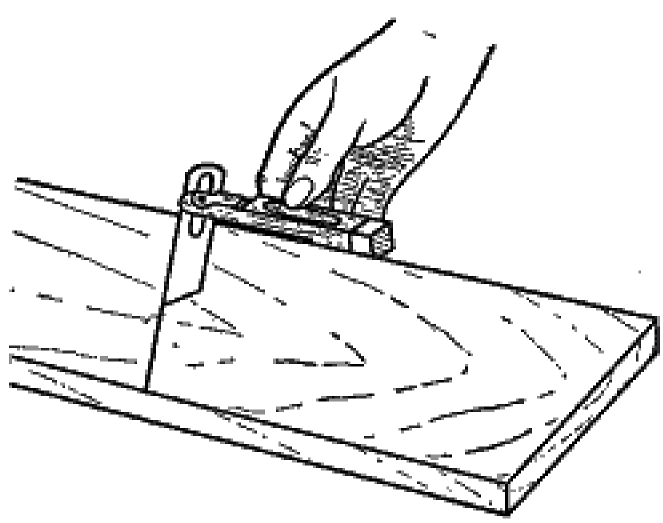

Fig. 6.—The bevel is used for marking out angles.

to make a fine narrow line *very close* to the edge. A knife makes a finer line than a pencil and is recommended for very accurate work. For most farm shopwork, however, a sharp-pointed pencil is accurate enough. A hard pencil stays sharp longer and makes a finer mark than a soft one.

7. The marking gage is used to mark lines parallel to the sides, edges, or ends of a board. The spur in the gage should be filed to a sharp point so as to make a very fine line, and it should be set to protrude through the

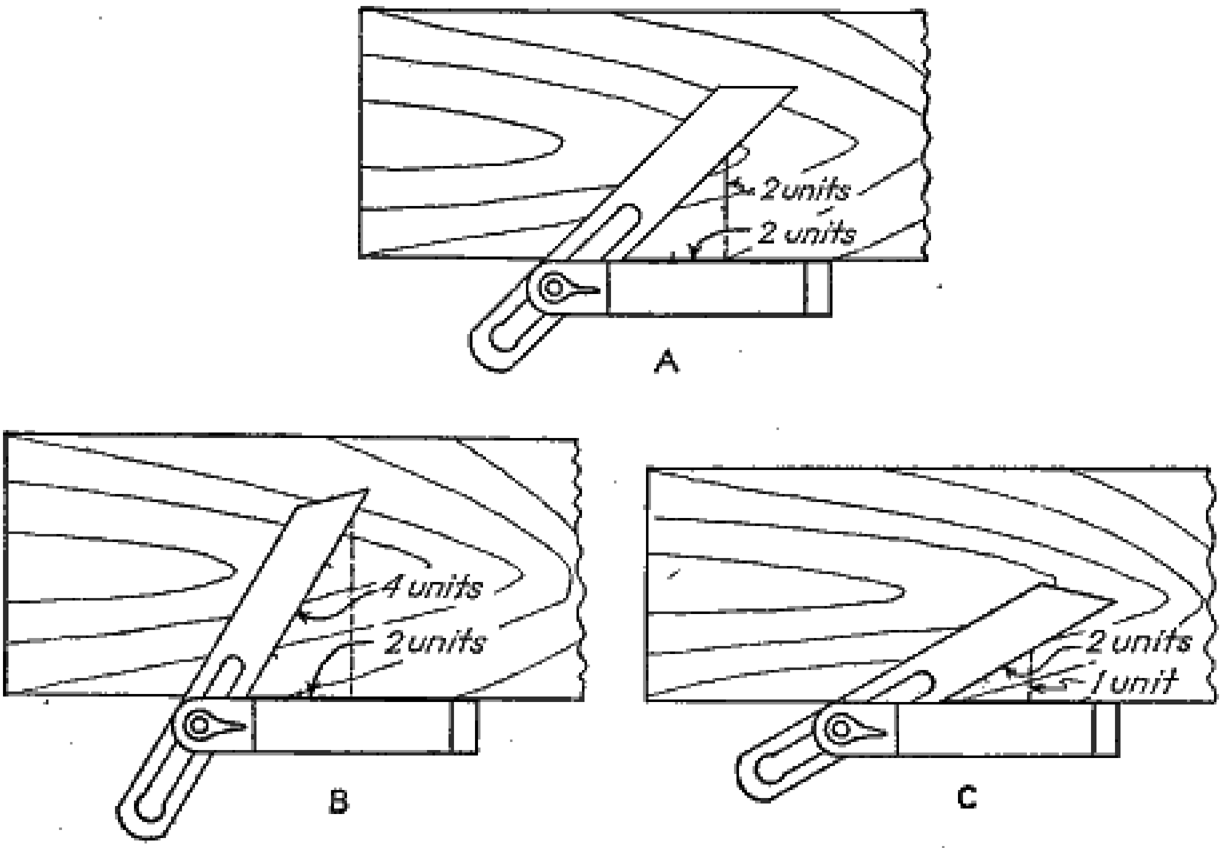

FIG. 7.—Methods for setting the bevel at common angles. *A*, 45 deg.; *B*, 60 deg.; *C*, 30 deg.

beam about ⅛ in. After setting the gage it is best to check the setting with a rule. In using the gage, the head should be held firmly against the surface from which the line is being gaged, normally against the working surface or the working edge. Also the gage should be rolled forward slightly to allow the spur to drag at a slight angle and thus prevent gouging (see Fig. 10).

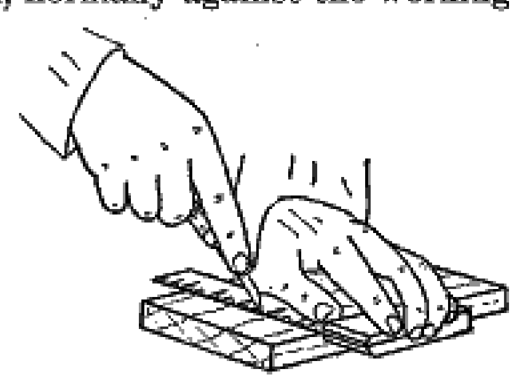

FIG. 8.—For accurate work, marking with a knife is better than with a pencil.

8. Gaging with a Pencil.—Gaging may be done with an ordinary rule and a pencil. The rule is grasped in one hand with the thumbnail firmly placed against the edge of the rule and at the desired distance from the end. The rule is then drawn along with the thumbnail against the edge of the board and with a pencil held in the other hand at the end of the rule (see Fig. 11*A*).

For gaging narrow widths where extreme accuracy is not required, a pencil may be held between the thumb and first two fingers and drawn along the edge of the board with the second, third, and fourth fingers against the edge of the board (see Fig. 11*B*).

Another simple method of pencil gaging is illustrated in Fig. 11*C*. The pencil is grasped in the closed fist with the point protruding out the

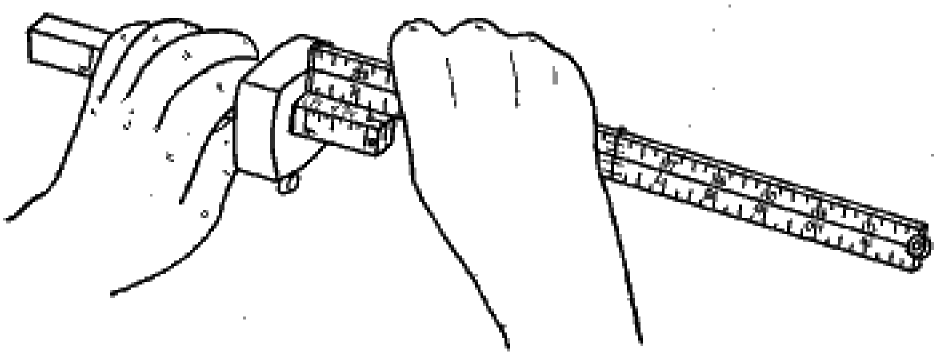

FIG. 9.—The setting of the marking gage should be checked with a rule.

distance the line is to be marked from the edge. The pencil is then drawn along with the thumb and first finger firmly against the edge.

9. Dividers are used for (1) marking out circles and part circles, (2) transferring or duplicating short measurements, and (3) dividing distances

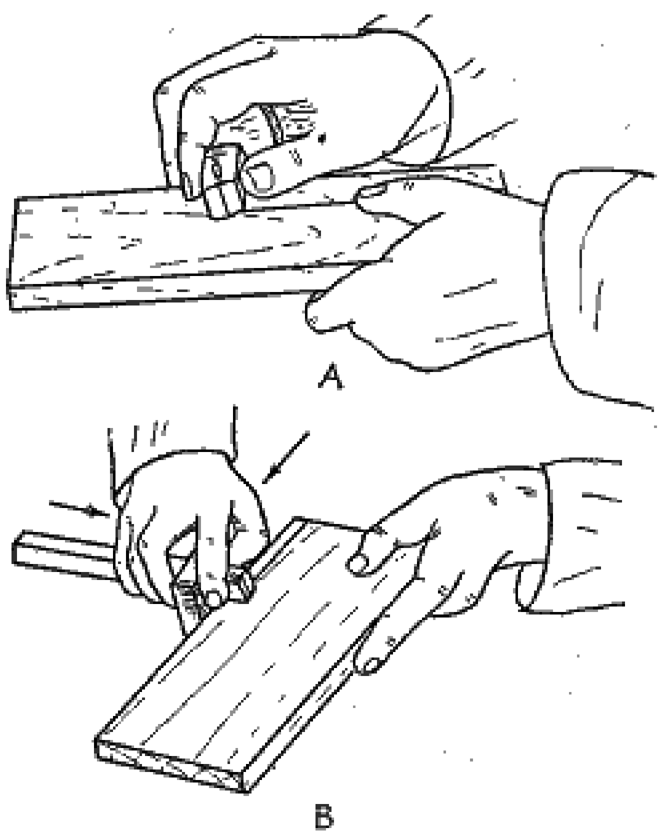

FIG. 10.—In using the marking gage, hold the head firmly against the edge of the board and roll the beam slightly forward so that the spur drags at a slight angle.

into a number of equal parts. In setting a pair of dividers, the thumbscrew is loosened until the legs are approximately set, and then it is tightened. A fine or close adjustment is then made with the thumb nut at the end of the arc (see Fig. 12).

To divide a line into a number of equal parts, say three, the dividers are set by guess to one-third the total length. The setting is then checked by stepping off three steps and seeing if the three steps equal the total length. If the setting is too large, then the dividers are set closer, by guess, by one-third (why one-third?) the distance overstepped on the last step. (If the setting is too small, the dividers are set wider.) The new setting is then checked by stepping off the line again.

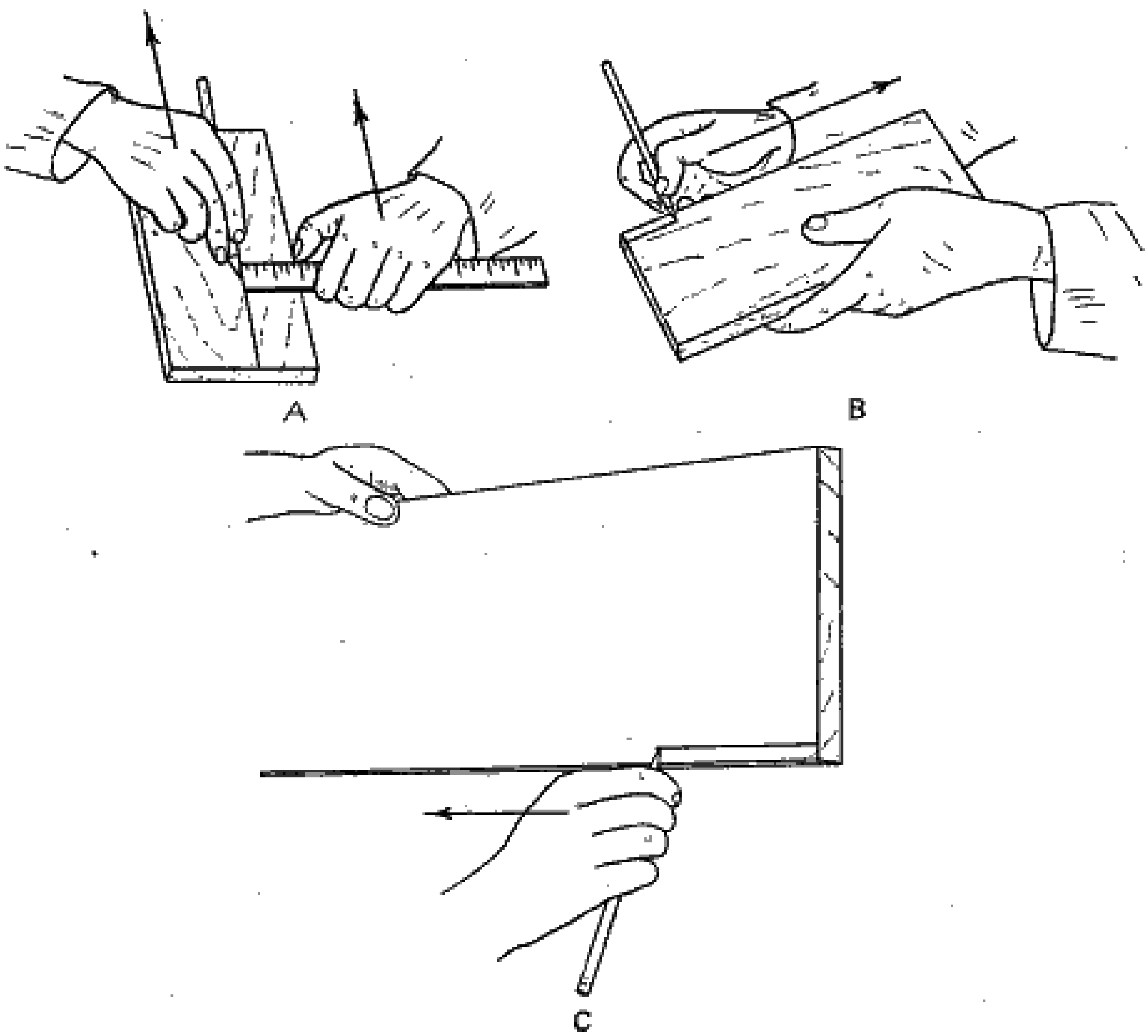

FIG. 11.—Easy methods of gaging with a pencil. With a little practice a workman can easily become proficient at pencil gaging.

10. Laying Out Duplicate Parts; Superposition.—In marking out two or more pieces that are to be alike in all or part of their dimensions, much time may be saved and more accurate work insured by marking all pieces at the same time, or from a pattern.

Frequently in shopwork a piece can be marked for the required sawing, cutting, or boring by superposition—that is, by properly placing the parts together and marking them.

In marking out a number of pieces that are to be alike, rafters for example, the same piece should always be used as the pattern to insure uniformity.

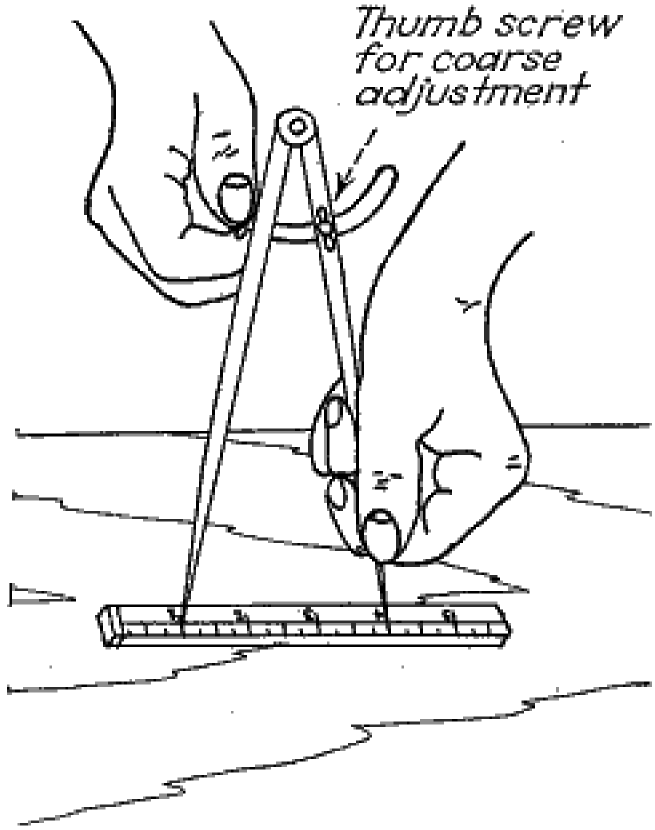

Fig. 12.—To set a pair of dividers, make an approximate adjustment with the thumb-screw and then make the fine adjustment with the nut at the end of the arc. Steadying the knuckle against the bench top helps to hold the points accurately.

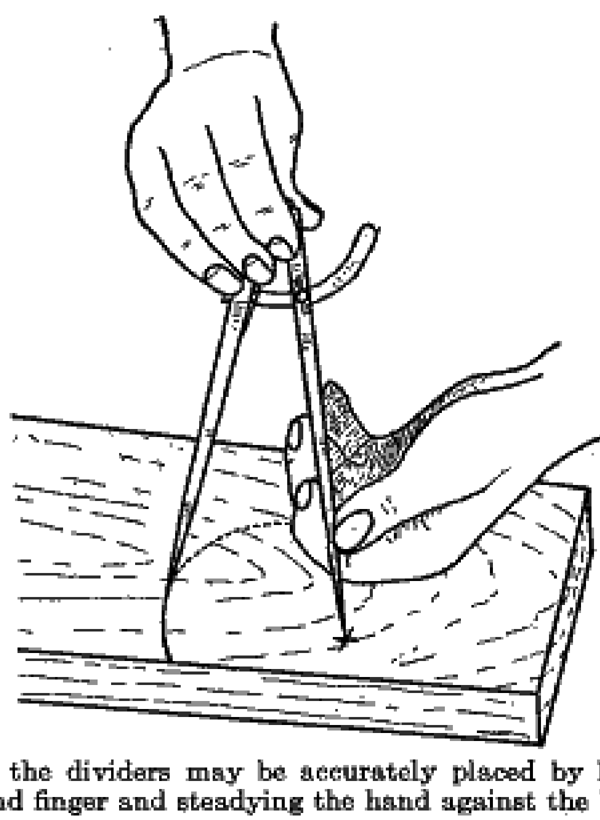

Fig. 13.—One leg of the dividers may be accurately placed by holding it between the thumb and finger and steadying the hand against the bench top.

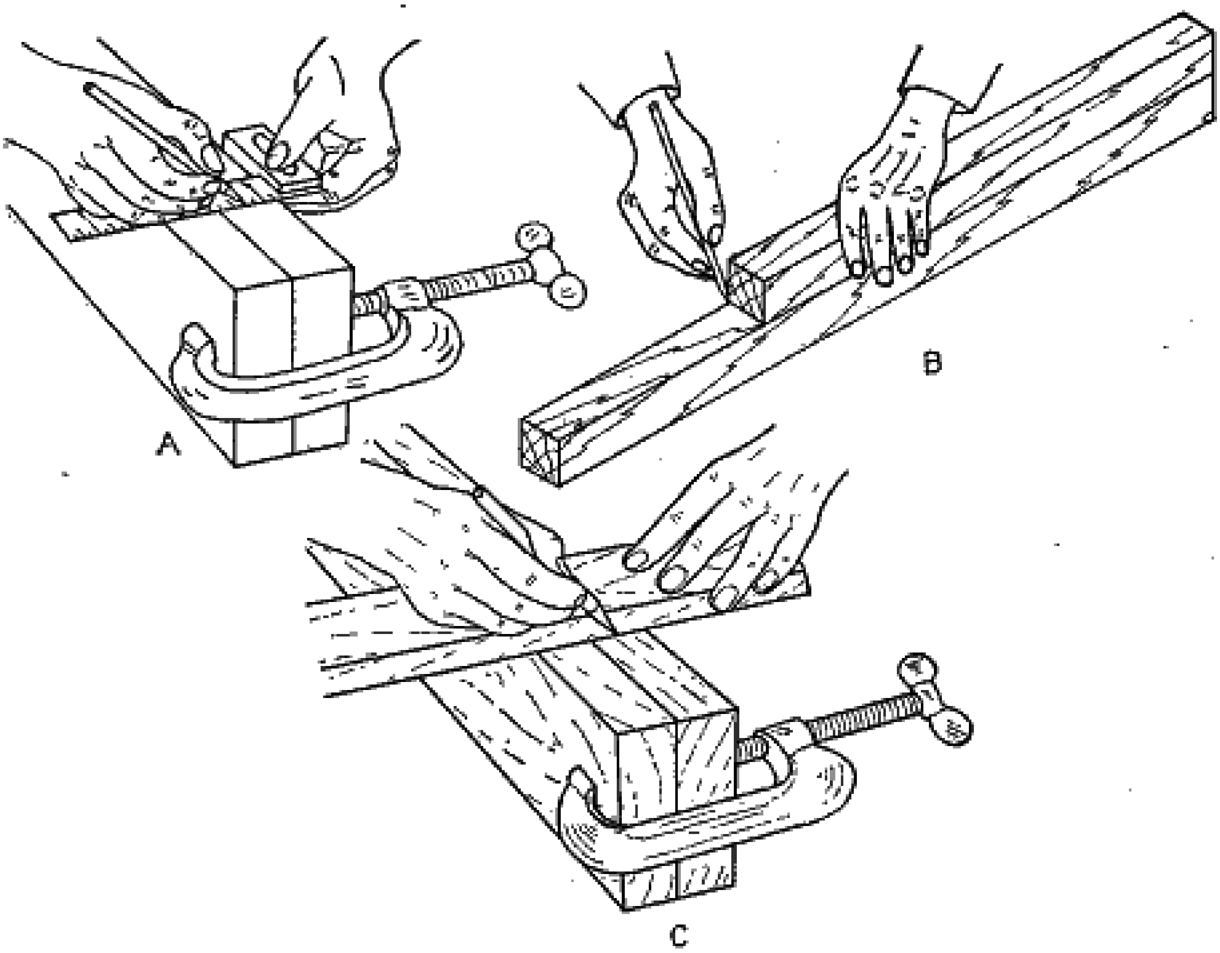

FIG. 14.—Forethought and planning in laying out and marking duplicate parts saves time and helps to insure accuracy.

A. Marking duplicate parts at the same time.

B. Marking duplicate parts with a pattern. (Always use the same piece for the pattern).

C. Marking the width of a notch by superposition.

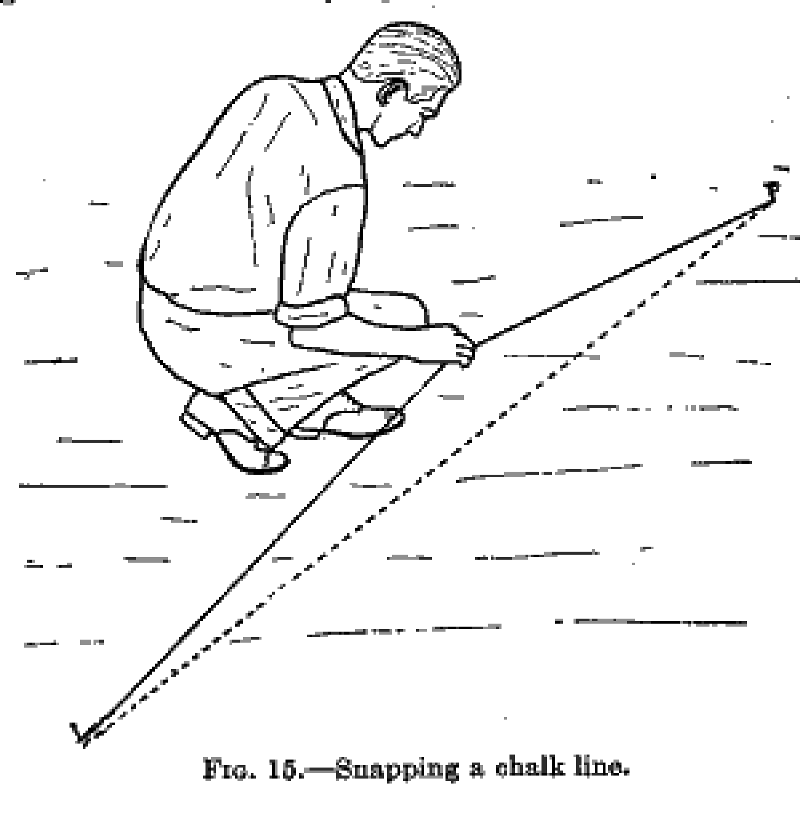

FIG. 15.—Snapping a chalk line.

LAYING OFF LINES IN BUILDING CONSTRUCTION

11. Making a Chalk Line.—A quick and simple method of marking off a straight line on a floor, wall, ceiling, or piece of lumber is to use a chalk line, that is, a string or cord that has been rubbed with chalk and coated with chalk dust. The line is stretched tightly between the two points on the surface that are to be joined by a straight line and held in place by a helper or fastened, as by wrapping or tying around nails. The line is then raised off the surface at a point between the two ends and allowed to snap back into place. A straight chalked line is the result.

12. Laying Off Long Lines at Right Angles.—A method, known as the 6-8-10 method, is very good for laying off long lines at right angles to each other, as in laying out the sides of a foundation for a building. The carpenter's square is too small for accuracy on such work. This method is based upon the fact that, if one side of a triangle is 6 ft. long, the second side 8 ft. long, and the third side 10 ft. long, then the triangle is a right triangle. Instead of 6, 8, and 10 ft., multiples or sub-multiples of these figures, as 30, 40, and 50, or 3, 4, and 5, may be used. The larger the numbers, the more accurate the work is likely to be. A practical way of using this method is to measure a distance of 6 ft. along one line (see Fig. 16). From one end of this 6-ft. line swing an arc with a radius of 8 ft., and from the other end an arc with a radius of 10 ft. A line from the point of intersection of these arcs to the center of the 8-foot arc, that is, to that end of the 6-ft. line from which the 8-ft. arc was swung, will be perpendicular to the first line.

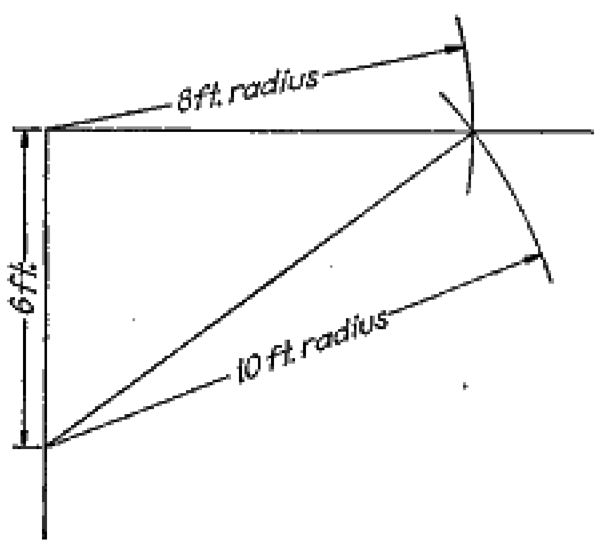

Fig. 16.—The 6-8-10 method of laying off lines at right angles.

13. Laying Off a Line Parallel to Another.—One method of laying off a line parallel to another is to erect a perpendicular to the first line and measure out on it a distance equal to the distance the two parallel lines are to be separated. At this point on the perpendicular erect a second perpendicular, using the 6-8-10 method. The third line will then be parallel to the first.

Another method is to erect perpendiculars to the first line at two widely separated points on the line. Measure out on each perpendicular the same distance. A line passed through these two points will be parallel to the first line.

14. Use of the Plumb Bob.—The easiest method of locating a point directly beneath another is to suspend a plumb bob from the first point, being careful to allow the bob to come to rest before marking beneath it, and being careful not to let the wind blow it. In case a plumb bob is not available, a symmetrical weight like a nut may be carefully suspended from a string and used for rough work.

Figure 18 illustrates a method of establishing a level line by means of a plumb bob and square.

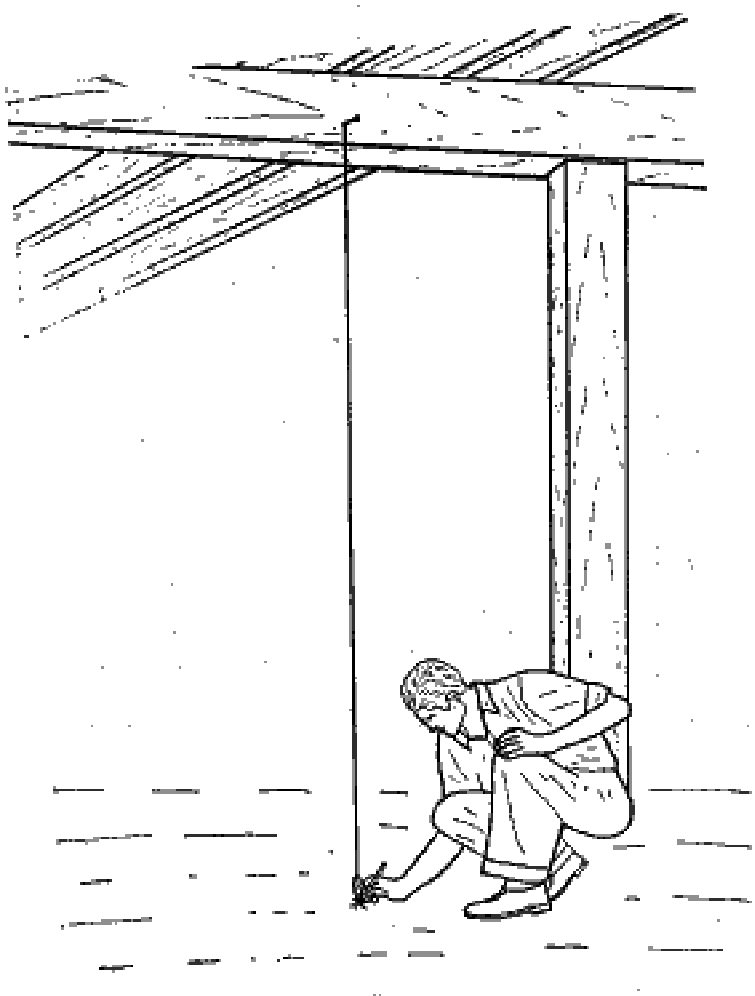

FIG. 17.—Using the plumb bob.

15. The Level.—The level is used to indicate when a surface is horizontal. The bubble vial or tube has a very gentle curvature and is almost filled with a nonfreezing liquid. The tube is mounted so that when the base of the level is horizontal, the bubble will be in the middle.

Levels are commonly equipped with a second bubble tube located near one end. This second tube is mounted perpendicular to the base of the level, and is used in checking vertical pieces for plumb.

16. Testing a Level for Accuracy.—To test a level, place it on a bench or some other convenient surface, and wedge up under one end until the bubble comes to center. Then turn the level end for end. The bubble should return to center; if it does not, the level is not in adjustment. Most good levels can be adjusted by turning a screw in the bubble-tube mounting.

17. Laying Off Angles with the Square.—The carpenter's steel square is commonly used for marking off angles in carpentry and in measuring

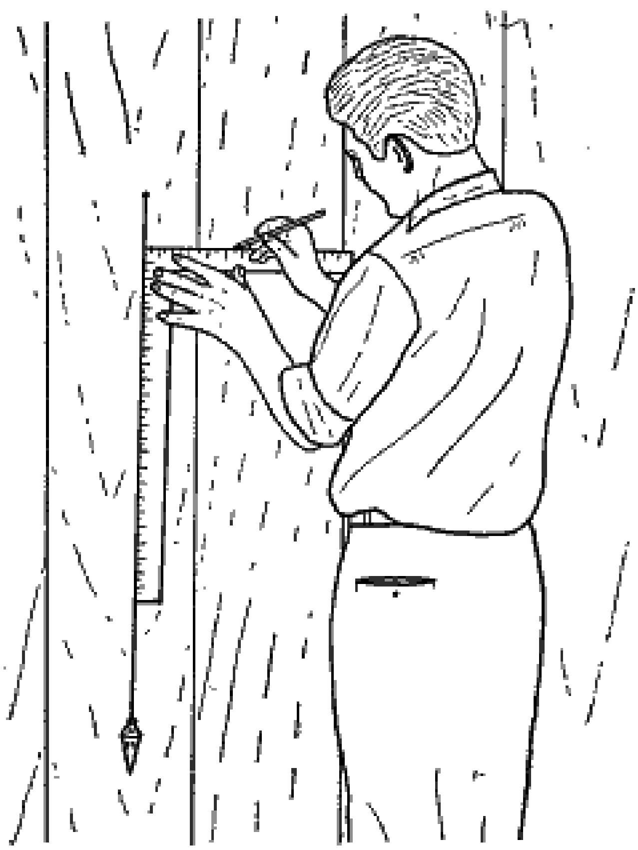

FIG. 18.—Establishing a level line by means of a plumb bob and square.

angles and describing them so they may be duplicated. Suppose that the end of a board is cut off at an angle and it is desired to cut another board just like it. The square is placed with the tongue along the end of the board (see Fig. 20) and then the readings are noted where both the body

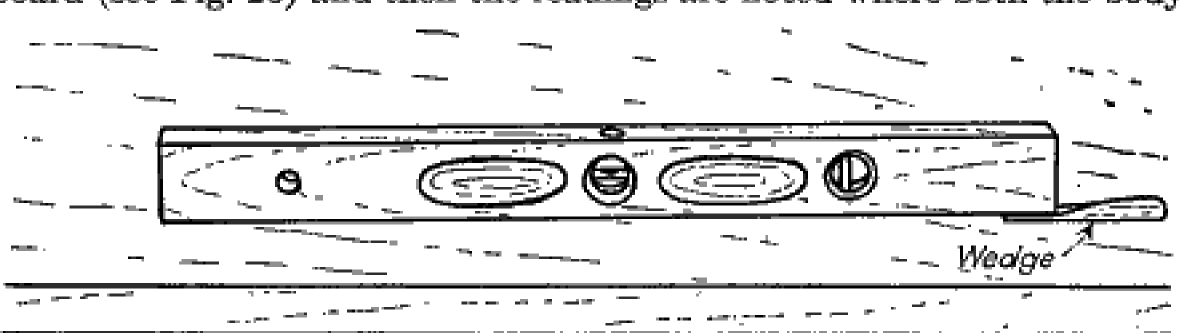

FIG. 19.—Testing a level for accuracy. The bubble should return to center when the level is turned end for end on a level surface.

of the square and the tongue touch the edge of the board. If the square is placed on the second board with these same two readings along one edge of the board, a mark along the tongue will give exactly the same angle as on the first board.

The readings on the square should be taken as large as convenient in order to insure accuracy. For instance, a setting of 12 and 4 would be preferable to 6 and 2 or 3 and 1.

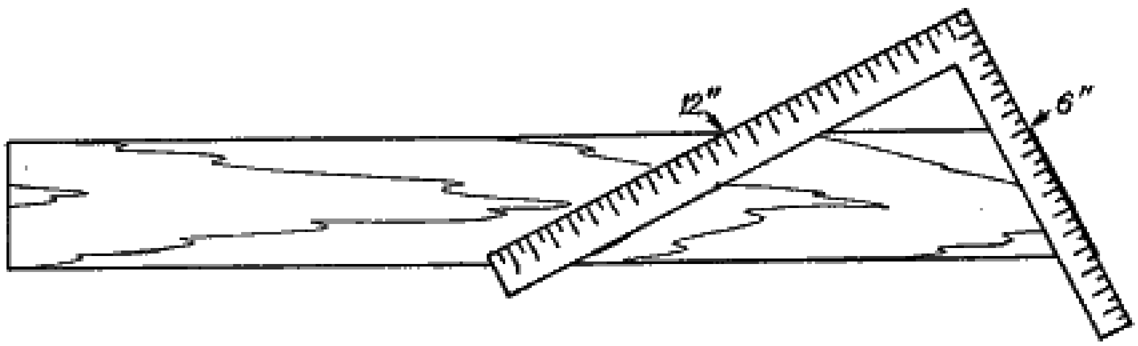

FIG. 20.—The square is a valuable tool for marking off various angles.

18. Measuring the Width of Openings.—A convenient method of measuring the width of a door opening, or similar opening, is to extend two yardsticks or pieces of scrap lumber until they span the opening. The measurement may then be transferred to a single board or piece and the exact measurement determined in feet and inches if desired.

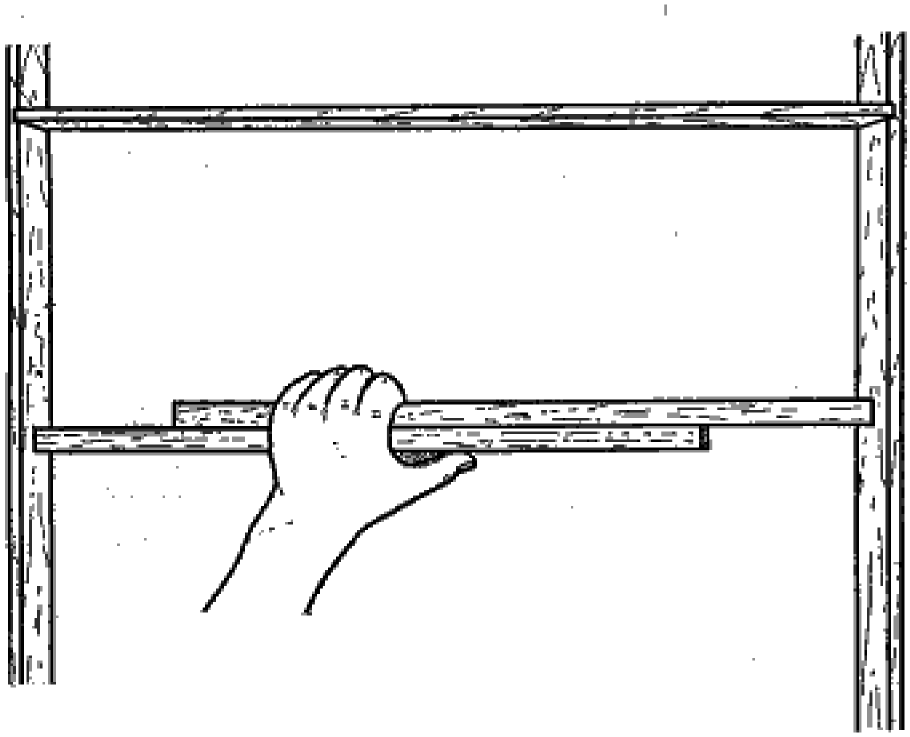

FIG. 21.—Measuring the width of an opening.

19. Board Measure.—Lumber is sold by the *board foot*, or *foot, board measure*, which is the amount of lumber in a piece 1 in. thick, 1 ft. wide, and 1 ft. long. Since a foot, board measure, is one-twelfth of a cubic foot, the number of feet, board measure, in one or more pieces of lumber may be determined by first finding the cubic feet contained in the piece or pieces and multiplying by twelve. This method at first may seem to be very tedious, but in practice it is a very simple and easy one. To use it, simply apply the following simplified formula:

$$\text{Feet, board measure} = \frac{\text{number of pieces} \times \text{inches thick} \times \text{inches wide} \times \text{feet long}}{12}$$

For example, to find the feet, board measure, in three two by fours, 10 ft. long:

$$\text{Feet, board measure} = \frac{\cancel{3} \times 2 \times \cancel{4} \times 10}{\underset{\cancel{4}}{\cancel{12}}} = 20$$

Cancellation will nearly always simplify the figuring so that it may be done without tedious multiplication and division.

Lumber that is less than 1 in. thick is commonly figured in square feet instead of board feet.

Mill-surfaced lumber is never full width nor full thickness, owing to waste removed when the boards are surfaced or planed. In figuring the board measure, however, it is always figured as if it were full width and thickness. For example, a two by four actually measures only about $1\frac{5}{8}$ by $3\frac{5}{8}$ in. but is always figured as full 2 by 4 in.

When ordering or buying lumber to cover a given surface, the area of the surface is first determined, which will be theoretically the number of board feet of lumber required, assuming that the lumber is 1 in. thick. In practice, however, it is always necessary to add a certain amount to this figure, the amount depending upon how much the board lacks of covering its nominal width. About one-twelfth will need to be added when one by twelve sheathing or barn boards are used; about one-tenth for one by tens; and about one-eighth for one by eights. For tongue-and-grooved or matched lumber like shiplap, flooring, siding, and ceiling, an amount varying from one-eighth to one-third or more must be added, depending upon the width of the boards and the amount of lapping in the grooves.

Questions

1. (*a*) Why should the rule be laid on edge when making measurements? (*b*) In making several measurements in a straight line, why should all measurements be marked without raising the rule? (*c*) Describe an easy method of locating the middle of a board. (*d*) How may a board be divided into several equal widths? (*e*) How can such measurements as $1\frac{3}{16}$ be easily located on the rule?

2. Give three or four uses of the carpenter's steel square.

3. (*a*) Give four uses of the try square. (*b*) How should the try square be held in squaring lines on a board?

4. (*a*) How may a square be tested? (*b*) How may a steel square be adjusted if not true?

5. (*a*) What is the bevel and for what work is it used? (*b*) How may a bevel be set for angles of 30, 45, and 60 deg.?

6. (*a*) What precautions should be used in marking with a pencil or knife? (*b*) For what kind of work is marking with a knife preferred to marking with a pencil?

7. (*a*) For what is the marking gage used? (*b*) How far should the spur protrude through the beam? (*c*) How may the setting of a marking gage be checked? (*d*) What precautions should be observed to prevent gouging and to insure good work with the marking gage?

8. Describe and be able to demonstrate two methods of pencil gaging.

9. (*a*) Give three uses for dividers. (*b*) How are dividers set? (*c*) How may the dividers be used to divide a line into a number of equal parts?

10. Describe two good methods of marking duplicate parts.

11. Explain how to make a straight line by using a chalk line.

12. (*a*) Explain how a right angle may be laid off with the 6-8-10 method. (*b*) In what respects is this method superior to using a carpenter's square?

13. Describe two methods of laying off parallel lines.

14. For what is the plumb bob used?

15. (*a*) How is a level constructed so that it can be used to indicate when a surface is level? (*b*) Why do some levels have more than one bubble tube?

16. How may a level be tested for accuracy?

17. (*a*) Explain how the steel square may be used to lay off, or to duplicate, angles. (*b*) Why is it better to use large readings than small ones on the square when laying off angles?

18. Explain an easy way of measuring the exact width of an opening like a door opening.

19. (*a*) What is a foot, board measure? (*b*) State a rule for figuring the board measure of a piece of lumber and give an example of its use. (*c*) When is lumber figured in square feet instead of feet, board measure? (*d*) Why will 100 ft.b.m. of lumber not cover a full 100 sq. ft. of surface?

References

HJORTH: "Basic Woodworking Processes."
BROWN and TUSTISON: "Instructional Units in Hand Woodwork."
GRIFFITH: "Essentials of Woodworking."
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Educational charts and pamphlets, Stanley Tool Works, New Britain, Conn.

CHAPTER II

SAWING

Probably the most common and most useful woodworking tool on the farm is the handsaw. The proper method of using the saw is not difficult to learn, and everyone studying farm shopwork should early master the art of sawing.

The first requirement for satisfactory work with the saw is that it be in good condition. Creditable work cannot be done with a saw that is

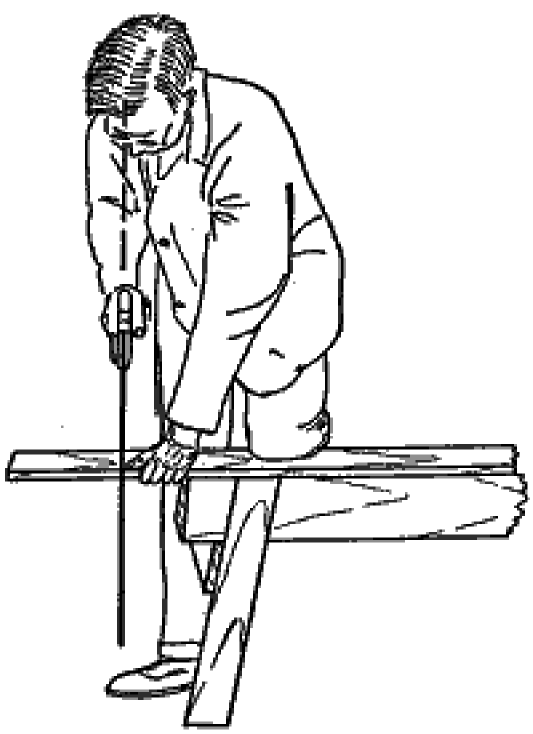

FIG. 22.—The saw, arm, elbow, shoulder, and right eye should all be in the same vertical plane.

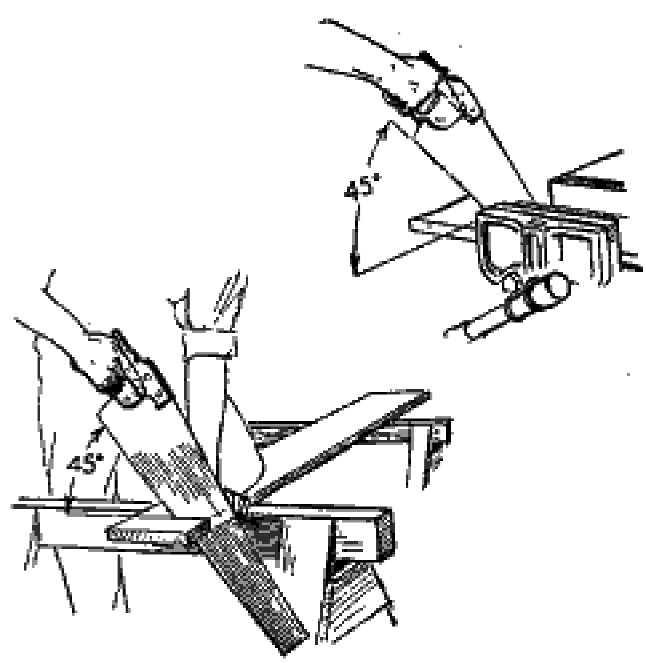

FIG. 23.—About 45 deg. is the correct angle between the saw and the work for crosscut sawing. *(Courtesy, Stanley Tools, New Britain, Conn.)*

dull or poorly filed or set (see pages 117 to 125 on saw sharpening). If the workman cannot or does not wish to sharpen his own saw, he should have it done by a competent mechanic.

20. Holding the Saw.—The saw should be grasped with the forefinger extending along the side of the handle, and not through the handle with the other fingers. This enables the workman better to guide the saw. The handle should be grasped firmly, yet not too tightly. The workman should not stand too close to the saw and the work, but should stand back a little and in a position so that a line across his chest and shoulders will make an angle of about 45 to 60 deg. with the line of sawing. The saw, the arm, elbow, shoulder, and right eye (for a right-handed workman) should all be in the same vertical plane. In this position, the saw can be

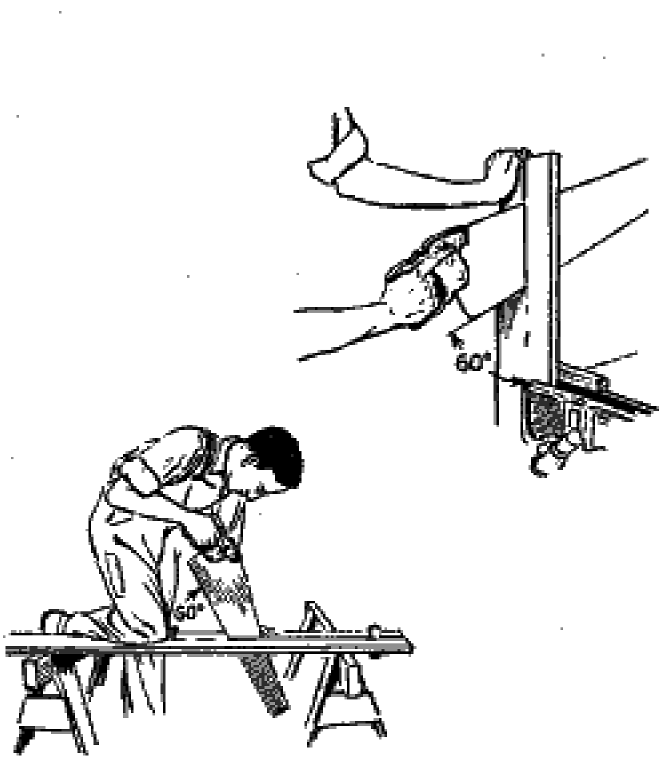

FIG. 24.—About 60 deg. is the correct angle between the saw and the work for ripsawing. (*Courtesy, Stanley Tools, New Britain, Conn.*)

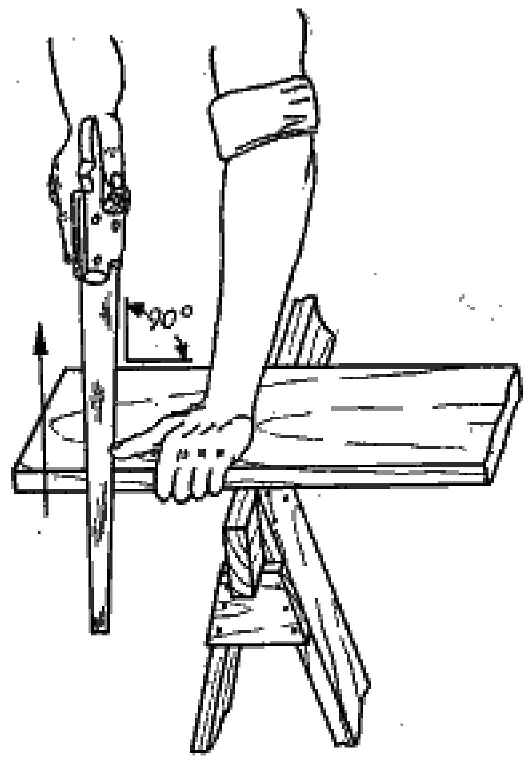

FIG. 25.—Start the saw cut by drawing the saw backward. Hold the blade square to the stock. Steady it at the line with the thumb.

more easily controlled and made to follow a straight line and cut perpendicular to the surface of the board.

21. Starting the Saw.—To saw a board off, it should be clamped in a vise, or held firmly on a box or sawhorse with the left knee and hand (in the case of a right-handed workman). The left hand should grasp the board on the far edge, with the thumb serving as a guide for the saw while

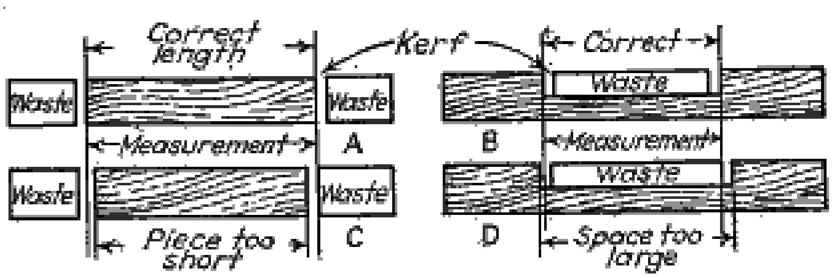

FIG. 26.—Be sure to saw carefully on the *waste side* of the line, as at *A* and *B*. Sawing on the line or on the wrong side of the line makes the stock too short, as at *C*, or the opening too large, as at *D*.

two to three backstrokes are made to start the cut. The saw is lifted on the forward strokes. The saw should be drawn back very slowly and carefully and just exactly where the saw is to start.

It should be remembered that the saw cut or kerf has appreciable width, and therefore the saw should not be started on the line itself, *but beside the line in the waste material*, the line itself normally being left (see Fig. 26). In case the piece is to be finished to the line with a plane or other tool, it is customary to saw a little farther from the line.

22. Sawing to the Line.—After the saw is started, push it forward firmly and pull it back, using long, easy, fairly rapid strokes, and a light pressure. The cutting edge of the saw, in case of a crosscut saw, should make an angle of about 45 deg. with the board. If the saw tends to go to one side of the line, twist the handle slightly and gently to make it come gradually back to the line as the sawing proceeds (see Fig. 27). If it cannot be made to follow a straight line, the set may not be enough, or it

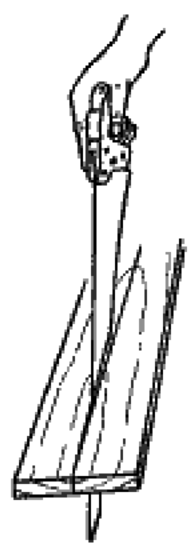

FIG. 27.—If the saw leaves the line, twist the handle slightly and gradually draw it back to the line.

may be uneven, the teeth on one side being bent out more than those on the other side. Watch the saw to keep the blade square with the surface of the board. Testing occasionally with the square may be advisable. If the saw is not square with the surface, bend it a little to gradually straighten it as the sawing proceeds (see Fig. 28).

If heavy pressure is used, or if short, quick strokes are made, there is danger of catching the saw and bending or kinking the blade. It will also be much more difficult to saw a straight line. If heavy pressure is required, the saw needs sharpening.

23. Finishing the Cut.—In order to prevent splintering just as the saw is about to finish the cut, the outer end of the board should be supported, and somewhat slower and steadier strokes should be made.

24. Using the Ripsaw.—The ripsaw is used for cutting lengthwise of the grain. It is handled in practically the same manner as described above for the hand crosscut saw, except that the cutting edge of the

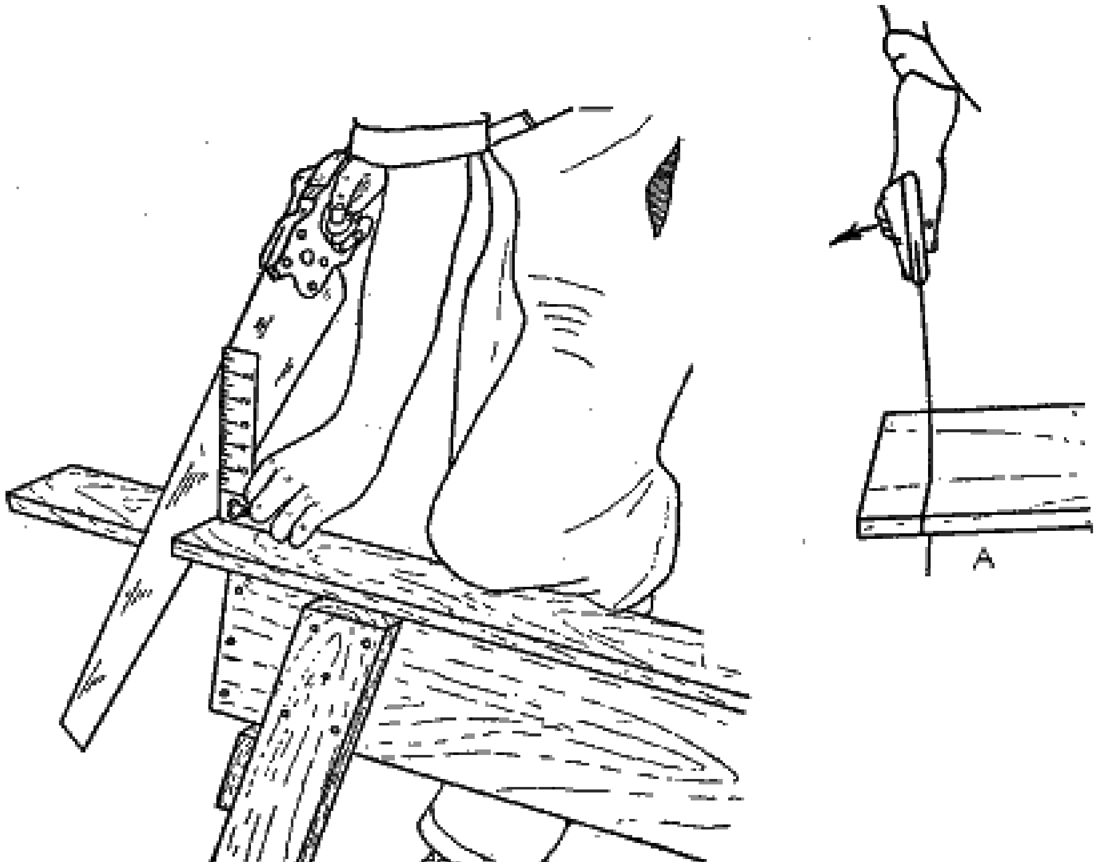

FIG. 28.—It is best for the beginner to check his work occasionally to see that he is making a square cut. If he is not, he should bend the saw a little, as shown at *A*, to straighten it as the sawing proceeds.

FIG. 29.—Support the outer end of the board as the saw finishes the cut. Splintering is thus avoided.

ripsaw should make a little steeper angle with the surface of the board—about 60 deg. instead of 45.

A good method of holding a board for ripping is to place it lengthwise on a sawhorse and hold it in place with the right knee. If the blade binds in the board, a small wedge or a chisel may be used to spread the sides of the kerf.

If a ripsaw is not available, a crosscut saw may be used for an occasional job of ripping, but it will be slower and require more work than if a ripsaw were used.

Questions

20. Explain exactly how the workman should stand at work when sawing and just how the saw should be grasped in the hand.

21. (*a*) How should a saw cut be started? (*b*) What is a kerf? (*c*) Should the saw cut out the line, or should it cut just inside or just outside the line? Explain.

22. (*a*) What kind of strokes and how much pressure should be exerted on the saw in sawing off a board? (*b*) What angle should the saw make with the board? (*c*) How may the saw be brought back to the line if it tends to work away from the line? (*d*) How may the saw be straightened if it is found not to be sawing square with the surface?

23. What precaution should be taken to prevent splintering just as the saw finishes a cut?

24. (*a*) What angle should a ripsaw make with the board? (*b*) How does this angle compare with that of the crosscut saw? (*c*) What remedy can be used in case the saw cut tends to close and pinch the saw blade? (*d*) Can a crosscut saw be used for ripping?

References

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CHAPTER III

PLANING AND SMOOTHING

In order to do good work with a plane it should be sharp, properly assembled, and properly adjusted. (See pages 87 to 93 for information on sharpening.)

25. Assembling the Standard Plane.—The cap iron or chip breaker should be fastened to the flat side of the plane iron or bit—not to the

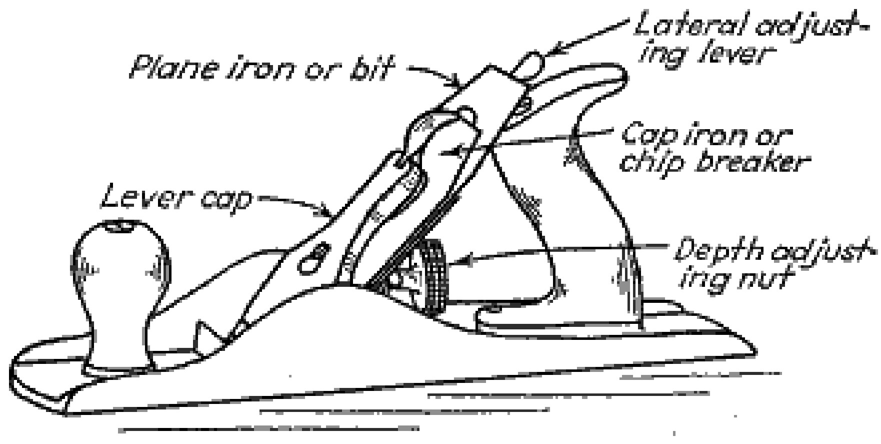

FIG. 30.—The jack plane is one used most in the farm shop.

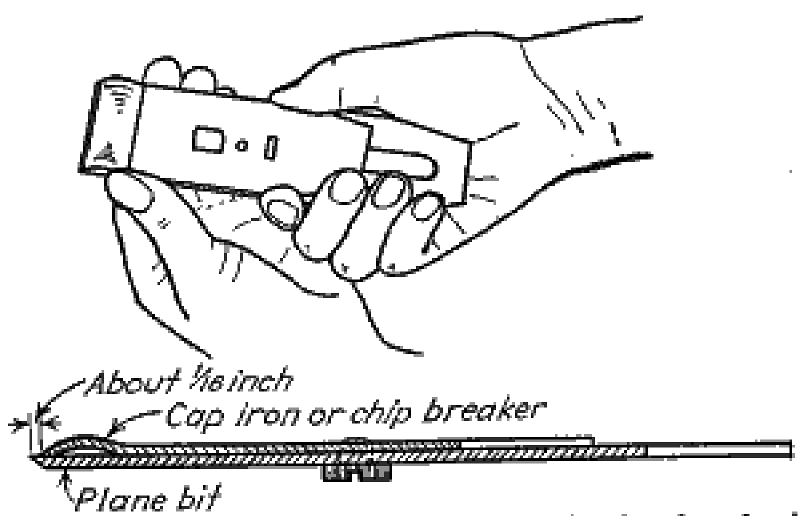

FIG. 31.—For average work the edge of the cap iron or chip breaker should be set about 1/16 in. back from the cutting edge of the bit.

beveled side. For average work the bit should project beyond the end of the cap iron about 1/16 in., or about the thickness of a dime.

The cap iron and the bit should fit together very tightly so that shavings will not wedge in between them and cause choking. The lever cap should clamp the cap iron and bit into the body of the plane very securely to prevent chattering and to prevent adjustments from changing while the plane is in use. The cap iron should be on top and the bit on the bottom.

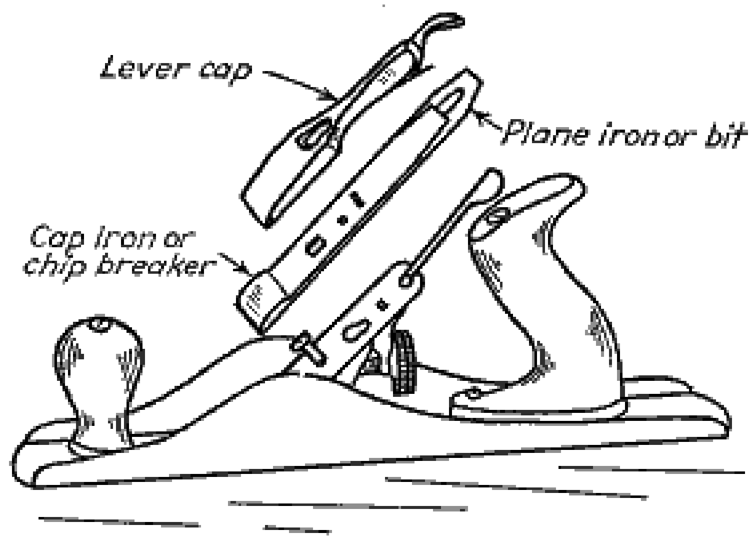

FIG. 32.—The plane should be assembled with the beveled edge of the bit down.

26. Adjusting the Plane.—There are two main adjustments on the standard plane. The knurled nut just in front of the handle is to regulate the depth of cut; and the small lever just under the back end of the blade is to straighten the blade in the plane so that it will not cut deeper on one side than on the other.

To make a trial adjustment, turn the plane upside down, holding the front end toward you, and sight along the bottom. Move the lateral adjusting level until the blade projects through the throat evenly on both

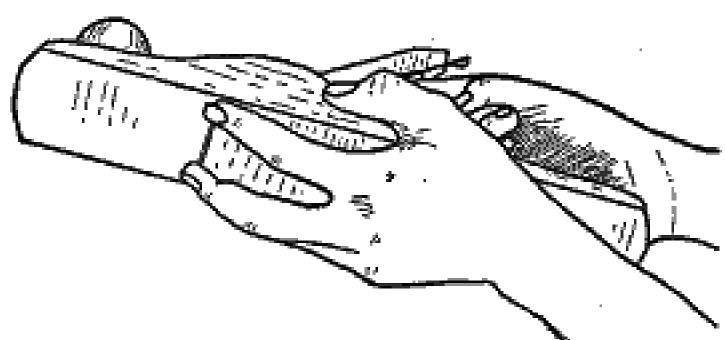

FIG. 33.—The plane bit should project through the throat of the plane very little, and the same amount at both edges. This may be checked by sighting along the bottom of the plane or by feeling with the fingers.

edges. Then turn the depth-adjusting nut until the blade projects through about the thickness of a sheet of writing paper. It is well also to check the adjustment by feeling the corners of the bit with the first two fingers of one hand. If one corner projects through the throat farther than the other, it can be readily detected by this method.

27. Holding and Using the Plane.—The workman should grasp the handle of the plane with his right hand, assuming that he is right-handed, and the knob of the plane with his left hand, keeping the palm on top of the knob. He should stand with his right side to the bench, with feet apart and the left foot slightly ahead. As the plane is gradually pushed forward, the weight is shifted to the left foot. In such a position the

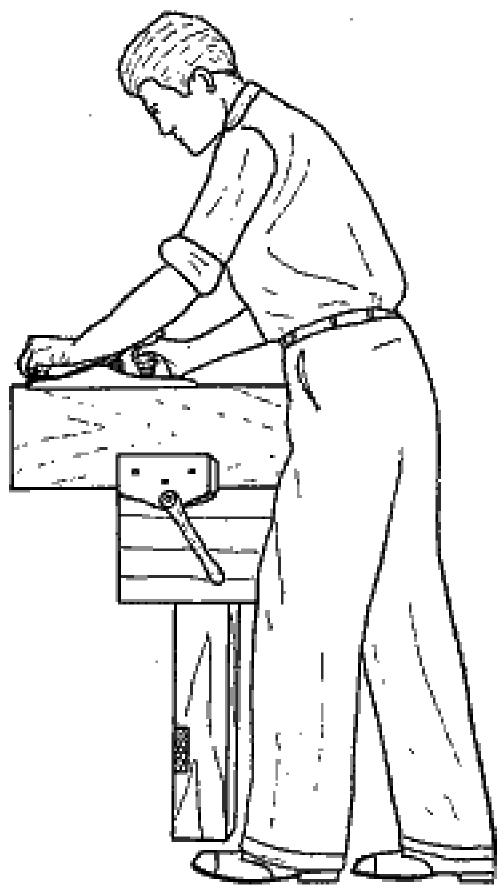

FIG. 34.—The workman should stand with his right side to the bench, feet apart with the left foot slightly ahead. As the plane is pushed forward the weight is gradually shifted to the left foot.

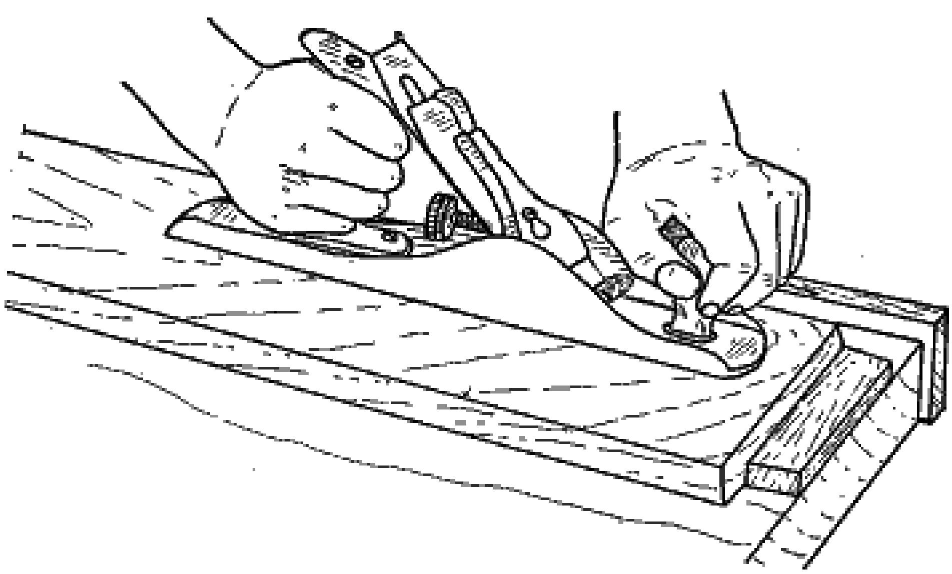

FIG. 35.—The plane should be held with the left palm on top of the knob and with the right forearm pushing straight in line behind the plane.

workman can better control his plane and work with less fatigue. The forearm should be kept straight in line behind the plane. In this way the workman can push the plane with less effort.

In starting the plane, pressure should be exerted on the knob on the front end of the plane, and a forward push exerted with the right hand. As the plane advances over the work (which is held in a vise or against stops on top of the bench), pressure should be exerted downward at the back of the plane. As the plane goes out over the end of the work, completing the stroke, the pressure on the knob should be gradually released and the back of the plane held down firmly. Thus the board will be planed straight to the very end.

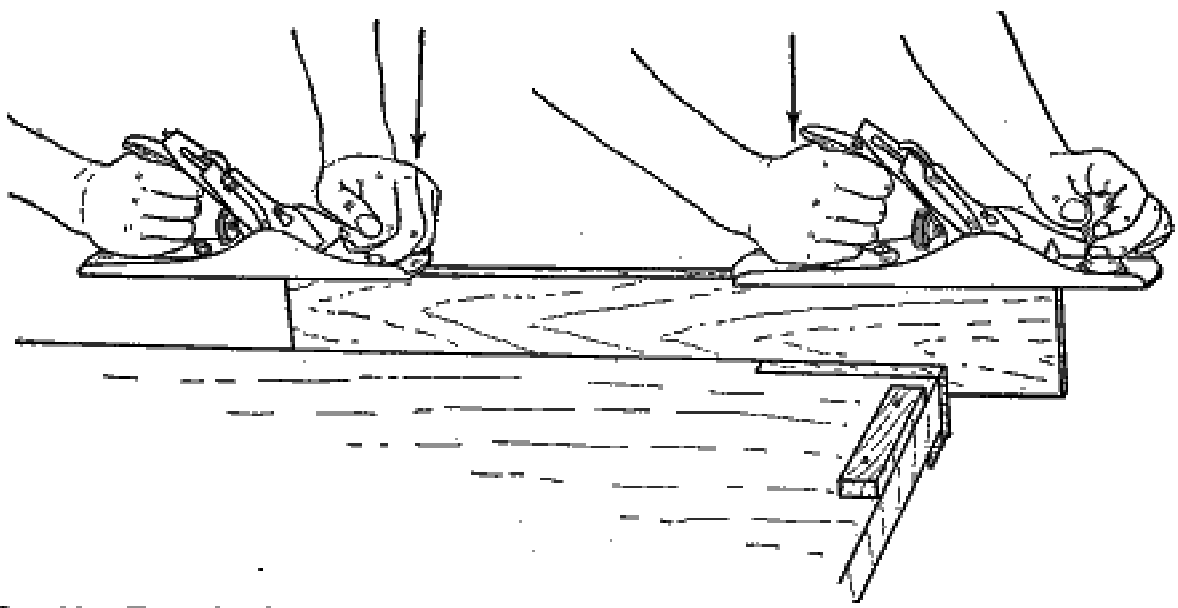

FIG. 36.—To make the plane cut a uniform depth all the way across, bear heavily on the knob at the beginning of the stroke and on the back of the plane at the end of the stroke.

28. Keep the Plane Set Shallow.—The plane should be set to cut a very thin shaving, except in smoothing up rough lumber or in removing considerable excess stock, and even in these cases the finishing strokes are made with the plane set to take a very shallow cut. A common mistake is to set the plane too deep.

29. Plane with the Grain.—Before starting to plane, one should always examine the board to see which way the grain runs and then plane with the grain. If there is doubt as to which way the grain runs, a stroke with the plane will indicate the direction. An attempt to plane against the grain will result in rough work, and possibly in choking the plane. Sometimes, due to irregular grain, it may be necessary to plane part of the board in one direction, and the remainder in another.

30. Planing Less than Full Length of the Stock.—Where it is desired to plane one part of a board and not the whole length, the front end of the plane is allowed to ride along on the surface and the back end gradually lowered down onto the work to start the cut. If the cut is to be stopped before reaching the end of the board, the back end is gradually raised to end the cut and thus feather the shaving.

31. Lift the Heel on the Backstroke.—The back end of the plane should be raised slightly on the back or return stroke so as not to dull the cutting edge by dragging it over the surface of the board.

32. Preventing Dulling.—The plane should always be laid on its side on the bench when not in use to prevent the keen edge from being dulled by coming into contact with the gritty bench top. When the plane is put away, it should have a thin strip of wood under the front end to keep the cutting edge off the bottom of the tool chest or case; or else the depth-adjusting screw should be turned to draw the cutting edge well up into the throat of the plane and thus protect it.

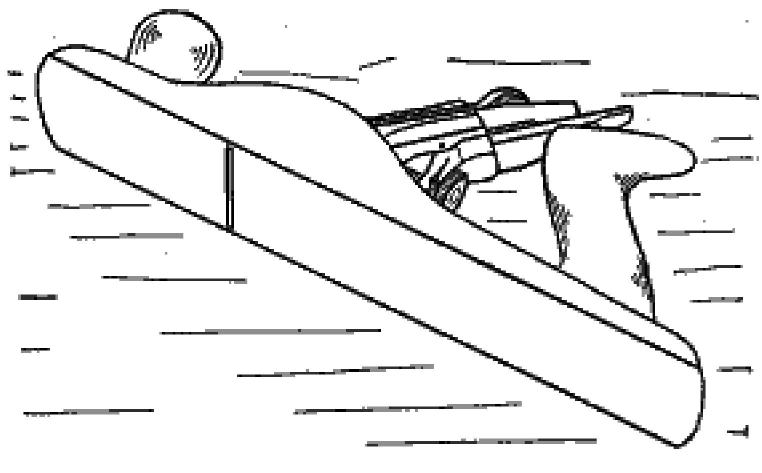

FIG. 37.—When not in use a plane should be laid on its side or otherwise placed to prevent dulling the cutting edge.

33. Planing and Testing a True Surface.—After the whole surface of a board has been smoothed and the plane cuts a thin shaving the full length of the stroke, the surface should be tested to see if it is a true plane.

If the piece is not too long, a straightedge, such as the edge of a steel square, may be placed on one diagonal of the surface, then on the other, and then moved along crosswise, and then lengthwise of the piece. If the same amount of light can be seen under the straightedge in the various different positions, the surface may be considered a true plane.

Another test for a true plane is first to hold the piece up to the light and sight across it and see if the top of the back edge is in line with the top of the front edge; and then to place the try square or other straightedge across the surface and move it from end to end and see if the same amount of light can be seen under it in various positions.

By such tests any high and low spots can be located, and then the high ones can be planed down.

34. Planing an Edge Straight and Square with Adjoining Surface.—It is frequently necessary in woodworking to plane the edge of a board to make it (1) straight and (2) square with an adjoining surface. It would be well, therefore, for the beginner in woodwork to early master this simple but important operation.

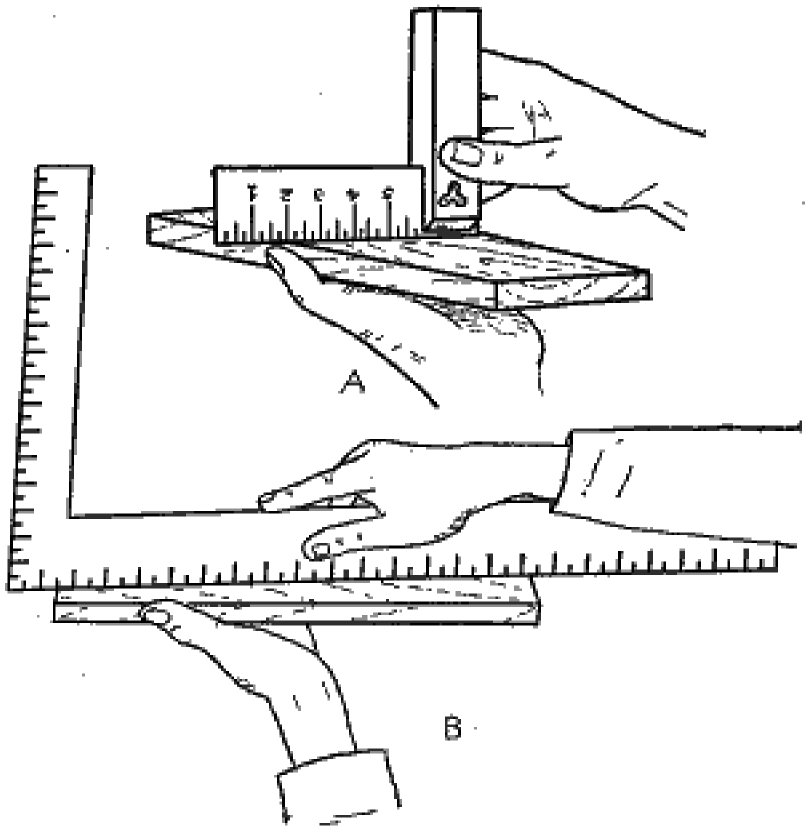

Fig. 38.—Testing to see if the surface is a true plane. Always test crosswise, lengthwise, and diagonally. The large square is better for large surfaces.

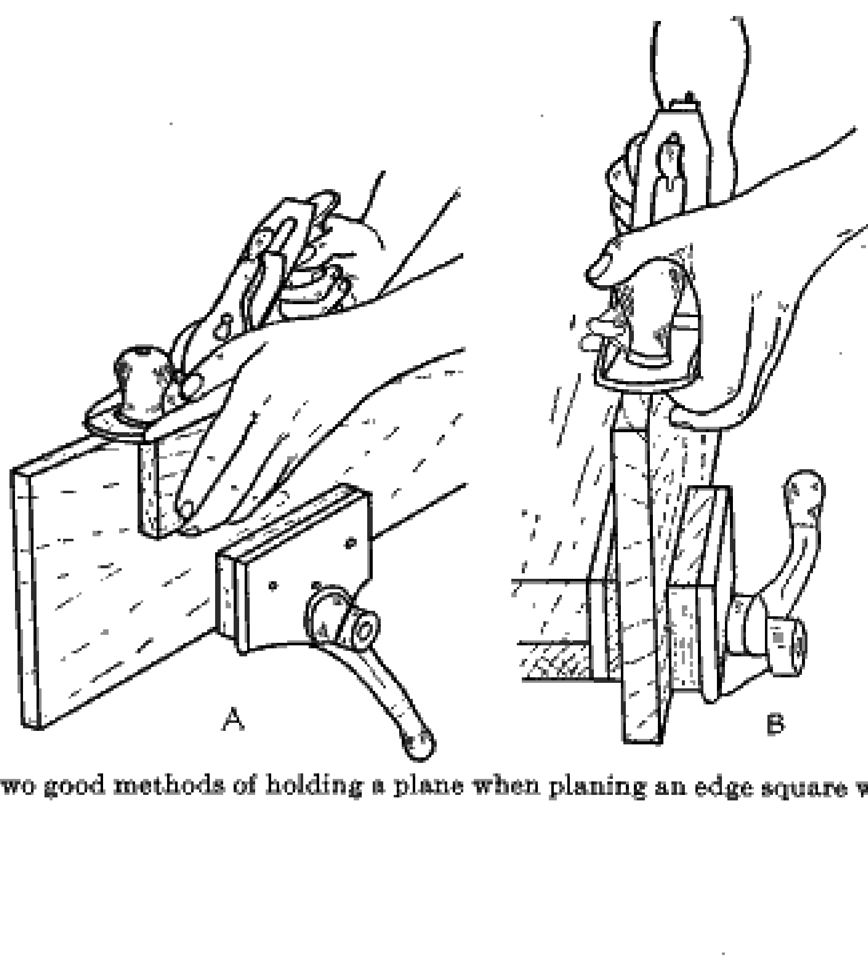

Fig. 39.—Two good methods of holding a plane when planing an edge square with a surface.

Before starting to plane an edge to straighten it, sight along it to note the location of the high spots. After the high places have been planed down, it is well to take long strokes extending the full length of the piece, if possible. Care should be taken to keep the front end of the plane firmly down against the work as the plane starts onto the edge, and to keep the back end down firmly as the plane goes out over the other end at the finish of the stroke.

Care must also be exercised to *keep the bottom or sole of the plane perpendicular to the side of the board.* Many workmen prefer to hold the front end of the plane down with the thumb of the left hand, allowing the fingers to project down and under the plane and rub along the side of the board to steady the plane and keep it square with the side.

Another simple method of keeping the bottom of the plane square with the adjacent surface is to hold a small square-edged block under the front of the plane and against the side of the piece being planed.

As the planing proceeds, the edge should be checked frequently for straightness and squareness, by sighting or using a straightedge, and by using the try square.

35. Planing End Grain.—This is an operation seldom used in farm woodworking. By careful marking and sawing very little smoothing of

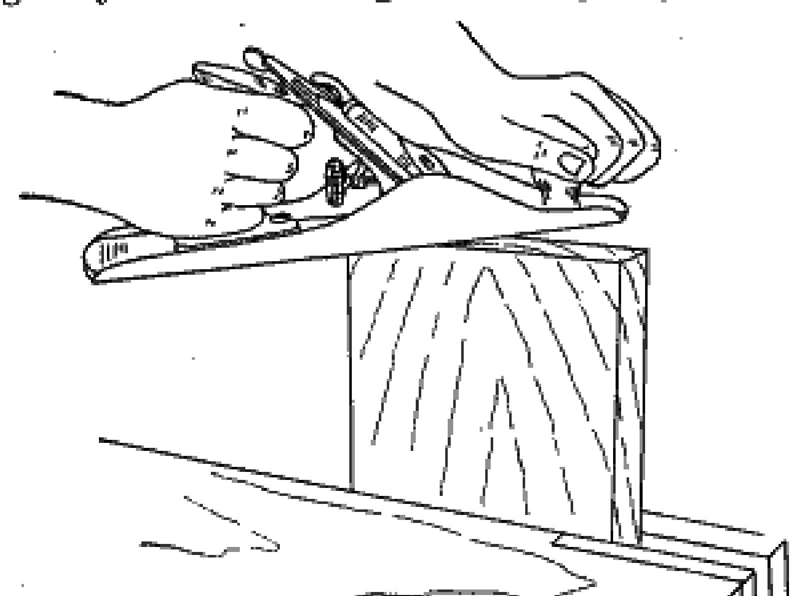

FIG. 40.—Planing end grain. Pushing the plane at an angle gives an oblique cutting action and makes it cut better. The plane should be very sharp and set very shallow.

the ends will be required, and such as is required can frequently be better done with a file. For planing across the end of a board, the plane should be very sharp, and it should be set extremely shallow. If it is dull, or if it is set too deep, it will gouge and jump, resulting in rough, uneven work.

Instead of pushing the plane straight along the end of the board, it may be pushed along at an angle. This makes the plane cut better and gives the workman better control of it. The plane must not be pushed entirely across the end of a board, unless the far edge is firmly supported or backed up to prevent splintering or splitting of the edge. Clamping a piece of scrap material to the far edge as shown in Fig. 41 is a very good

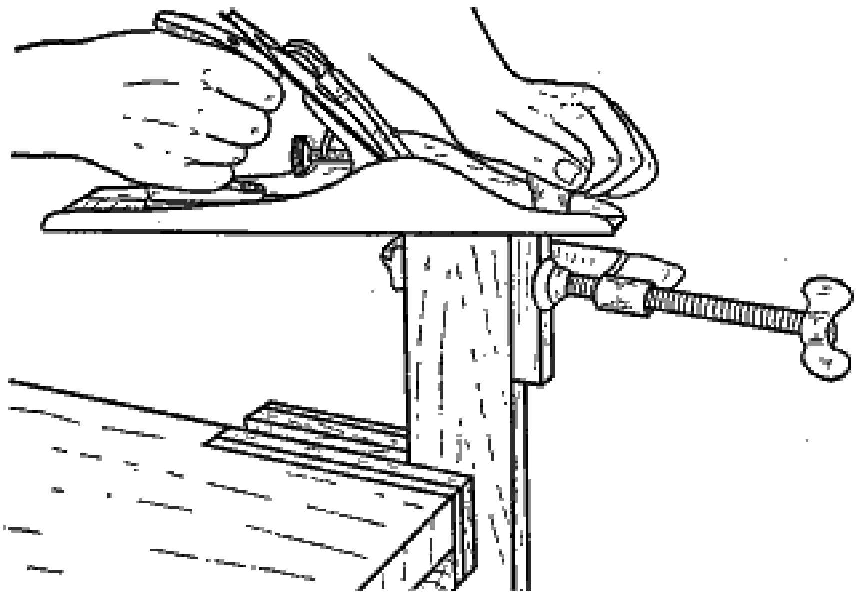

FIG. 41.—Clamping a small block of scrap material on the far edge prevents splintering in planing end grain.

method to avoid splintering. If some such method cannot be used, the end of the board should be planed partly from one edge, and then reversed for planing the remainder.

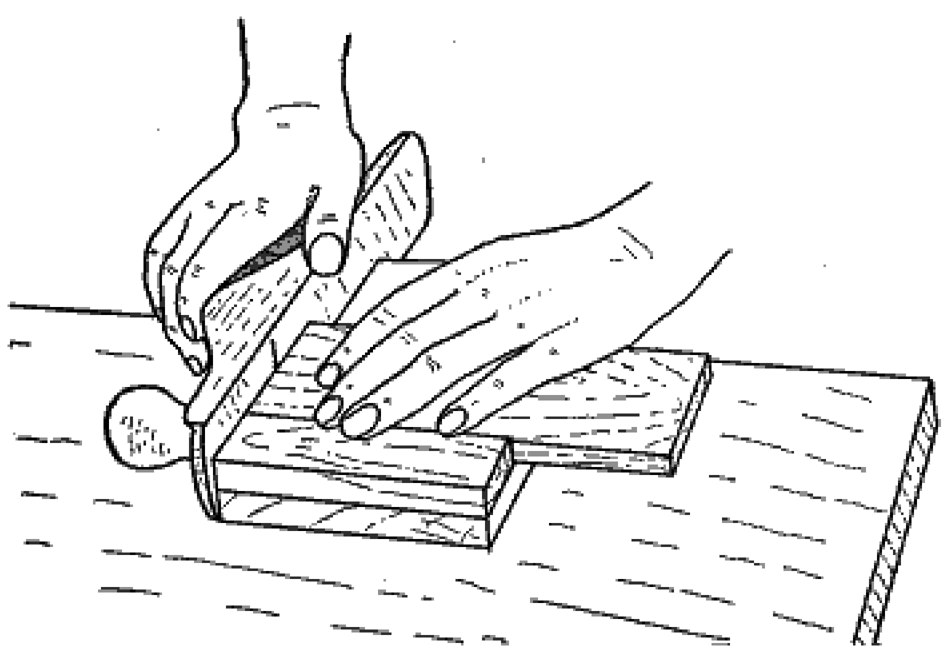

FIG. 42.—The ends of small pieces may be planed with the aid of a bench hook.

Care should be taken, of course, to work down the high points and to check the work frequently with the try square as the planing proceeds. It is the mark of a good workman to remove as little material as possible in straightening and squaring his work.

The bench hook or a homemade miter box may be used to aid in square planing the ends of small pieces. The left hand holds the piece firmly against the backstop with the end to be planed projecting very little—almost not at all—beyond the edge of the bench hook. The plane is then pushed entirely across the end of the piece with the right hand.

The block plane is better for end planing than other planes.

36. Smoothing End Grain with the File.—Frequently the end of a board may be smoothed and made straight and square with a file much

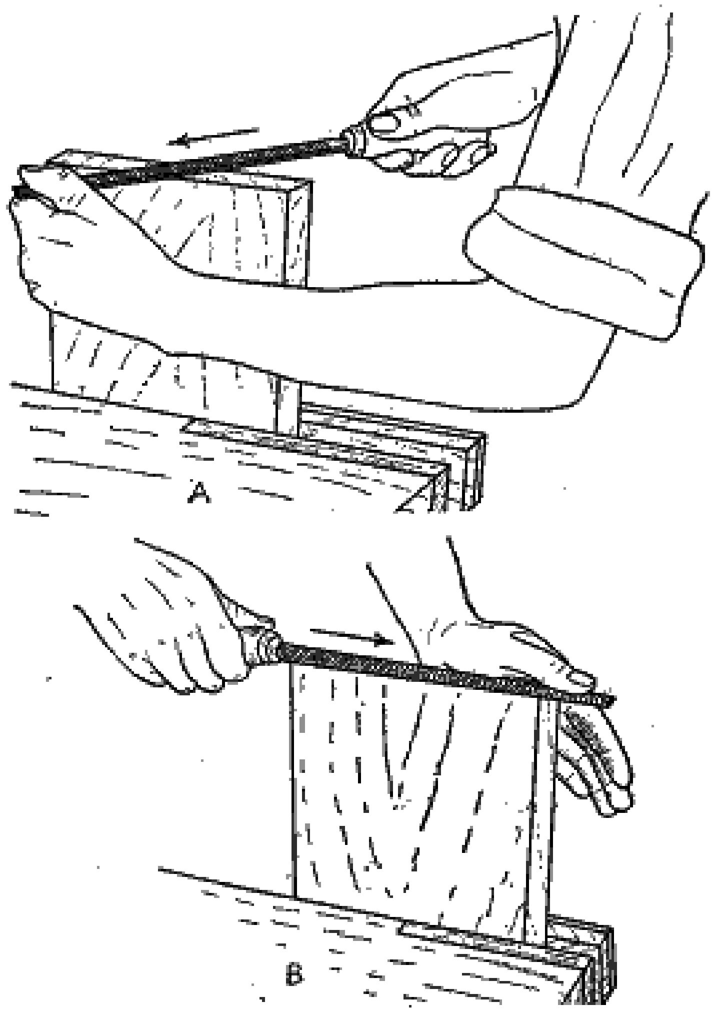

FIG. 43.—Smoothing and squaring ends frequently may be done more easily by filing than by planing, particularly if care has been used in sawing, and only little waste is to be removed.

A. Removing considerable material.
B. Making a light finishing cut.

more easily than with a plane. In using a file, *long, steady strokes should be made*—not short, quick, jerky ones—and the file should be lifted slightly on the back or return stroke. In this manner it is much easier to control the file and to work the end down straight and square. As in planing, more pressure should be put on the front end of the file as it starts a stroke, and the pressure gradually shifted until more is on the rear or handle end at the finish of the stroke. A moderately coarse file, such as a flat bastard file, or a woodworker's file, is recommended for filing wood.

Where very much material is to be removed, the file should be used at an angle as shown in Fig. 43*A*. For light finishing cuts the file may be used in line with the edge as shown in Fig. 43*B*.

37. Squaring Up a Board.—By squaring up a board is meant making all surfaces (sides, ends, and edges) smooth, true planes at right angles to each adjoining surface. (A true plane is one that has all points in the same plane. A surface may be smooth, yet not true. See Art. 33, page 25, for methods of testing a surface for trueness.) For many farm woodwork jobs, mill-planed lumber as it comes from the lumber yard will be smooth enough, the surfaces will be near enough to true planes, and the surfaces will be near enough square with each other. Other jobs, however, will require greater accuracy and smoother work than can be done with the lumber at hand, and the pieces will need to be partly if not completely squared up.

To do creditable work where accuracy is required, the workman should perform at least the first two steps of the squaring up process as outlined below:

1. *Plane one broad surface smooth and true* (*make it a true plane*). This surface is then known as *the working surface* and is marked with a short line extending to the edge that is to be selected for the working edge. The first step should not be considered complete until the marking is done. If a test shows the board to be true and smooth enough for its purpose without planing, then the working surface is simply marked.

2. *Select the best edge for the working edge and plane it* (*a*) *straight, and* (*b*) *square with the working surface.* Straightness is tested by sighting or with a straightedge; and squareness is tested with a try square. This edge is called *the working edge.* It should be marked with two short lines extending to the working surface. If the edge is already straight and square with the working surface, it is simply marked and need not be planed. (With the marking done as indicated one can tell which is the working surface and which is the working edge by seeing *either.*)

3. *Make the second edge parallel to the working edge.* It will then be (*a*) straight and (*b*) square with the working surface. Probably the easiest way of performing this third step is to gage (or otherwise mark) for the desired width, marking on both the working surface and the opposite side; and then to plane to the gage lines or marks.

4. *Mark and cut one end* (*a*) *straight,* (*b*) *square with the working surface, and* (*c*) *square with the working edge.* The handle of the try square should always be held against either the working edge or the working surface in marking around a board. Sawing should be done carefully and very close to the line.

5. *Mark the piece for desired length and cut the second end like the first one,* making it (*a*) straight, (*b*) square with the working surface, and (*c*) square with the working edge.

6. *Gage for thickness and plane to the gage lines,* making the second surface parallel to the working surface. This step is usually omitted when working with mill-planed lumber.

Order of Steps in Squaring-up Process.—Many workmen prefer to perform the operations of squaring up a board in the order given above. After the working surface and the working edge are established, however, the remaining steps may be performed in any order.

38. Planing a Chamfer.—If a piece is to be chamfered all the way around, lines should be gaged down from the working surface all the way

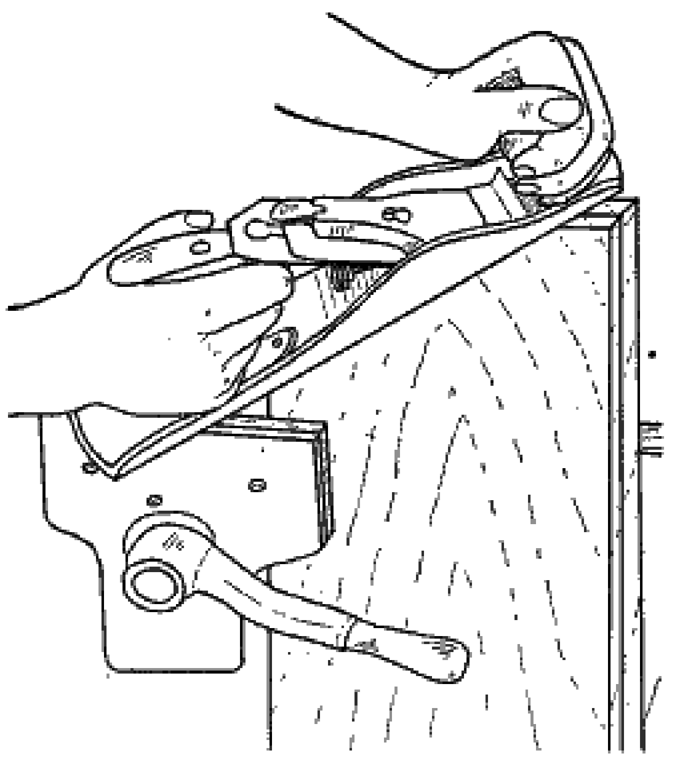

FIG. 44.—In planing a chamfer around a board, plane the edges first and the ends last. Push the plane at an angle when planing the ends, so as to give an oblique cutting action.

around the piece; and lines should be made on the working surface all the way around, back the same distance from the edges and ends as the lines on the edges and ends are down from the working surface. Gaging with a pencil and rule (as explained in Art. 8, page 5) is a good method of marking out a chamfer. The marking gage is a very convenient tool for this work, but it has the disadvantage of leaving marks in the surface that are difficult to remove. In case the marking gage is used, very light marks should be made.

The chamfers on the edges or sides should be planed first. The direction of planing is parallel to the edges. The chamfers across the ends are planed last in order to avoid splintering. The plane should not be held parallel to the ends in planing the end chamfers, but at an angle of about 45 deg. with the ends. The movement of the plane, however, should be parallel with the ends, that is, the plane should be moved with a semisidewise motion.

39. The Block Plane.—The block plane is a small plane about 6 in. long. It is used mostly for planing across end grain and for planing small pieces where it is not convenient to hold them in a vise. The plane, being small, can be used with one hand while the other hand holds the stock. The plane bit is mounted in the body of the plane at a much lower angle than in the jack plane. This makes it better adapted for cutting across end grain.

There are three adjustments on the block plane. In addition to the depth adjustment and the lateral adjustment of the blade as in the jack plane and other standard planes, there is a small lever at the front of the plane for adjusting the width of the throat opening. The block plane

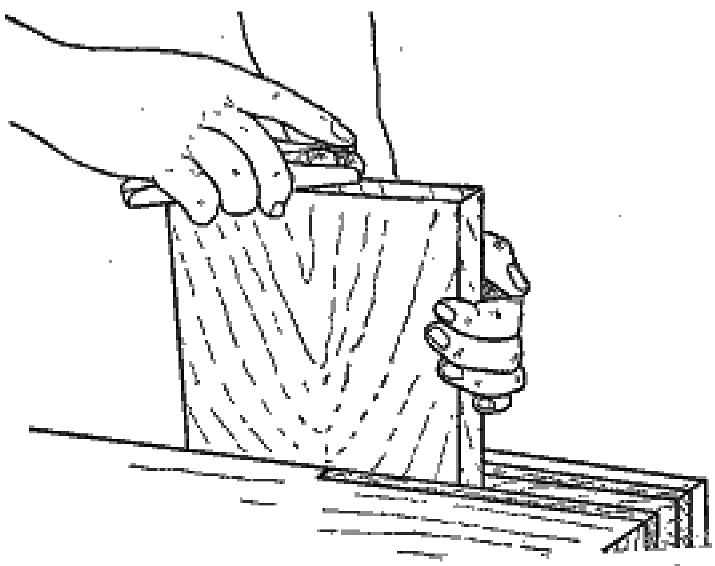

FIG. 45.—The block plane is a very good tool for planing end grain.

should be kept very sharp, and, for end planing, it should be set very shallow.

Although a block plane is convenient, especially for end planing, it is not at all necessary for the farm shop.

40. Other Planes.—The jack plane, which is about 14 in. long, is a general-purpose plane and is all that is needed for the average farm shop. There are other kinds of planes especially adapted to certain kinds of work. The smooth plane is from about 6 to 10 in. long, and, as its name implies, it is for smoothing boards. Being short, it can follow into slight depressions in a board better than the longer planes. The smooth plane is used after the main straightening of the surface has been done with the jack plane.

The jointer plane is from 22 to 24 in. long, and is used primarily for straightening the edges of long pieces.

SMOOTHING WOOD SURFACES

41. Scraping.—The scraper is a thin, flat piece of steel used for putting a fine-smooth surface on a piece of wood. It is used after planing and before sandpapering. When properly sharpened, the scraper will take off a very fine, silky shaving, leaving a much smoother surface than would be possible with a plane. It is also valuable in smoothing wood that is difficult to plane on account of irregular grain. Scraping with a dull scraper is exceedingly slow and tedious work. Only an inexperienced or poor workman would use a dull scraper. (See page 99 for instructions on sharpening scrapers.)

The scraper is held at an angle of about 75 deg. to the surface of the wood and is usually pushed or pulled along with one end slightly ahead of the other.

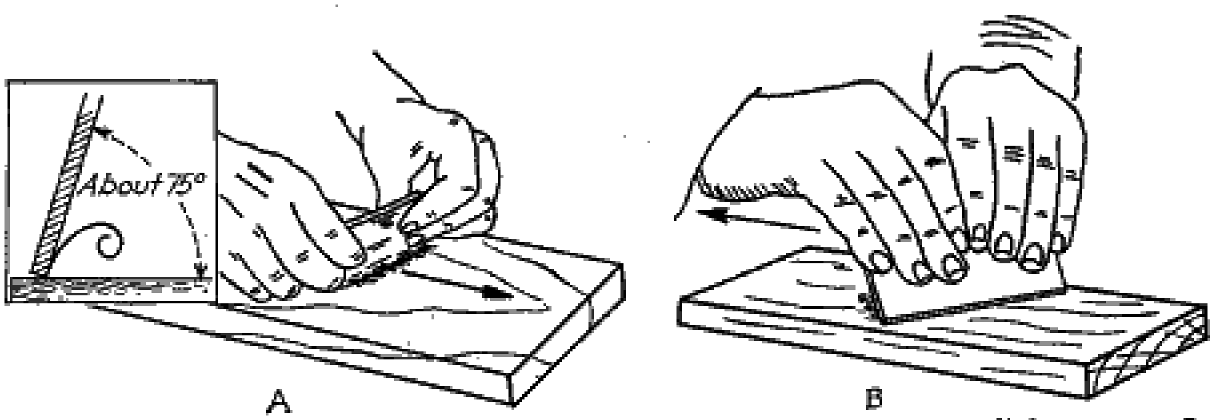

FIG. 46.—The wood scraper should be held firmly and sprung to a slight curve. It should be held at an angle of about 75 deg. with the surface and pushed, as at *A*, or pulled, as at *B*, with one end slightly ahead of the other. The scraper should be kept sharp. Dust instead of shavings indicates a dull scraper.

42. Sandpaper and Its Use.—The beginner usually wants to use sandpaper before he should. Sandpapering should not be done until all work with the cutting tools and scrapers is finished. There is no advantage in using sandpaper on wood that has not been previously planed or scraped. With sandpaper it is practically impossible to remove the "hollows and ridges" left on a piece by the mill planer; in fact, sandpapering such mill-surfaced lumber generally magnifies the hollows and ridges and actually detracts from the appearance, rather than improving it.

The sheets of sandpaper are usually torn into four pieces, by creasing firmly and then tearing over the sharp edge of a rule or over the edge of the bench. The small pieces are then wrapped part way around a flat block for use. For economy the block should be of such a size that the paper will come only part way up on each edge and not around on top.

Sandpaper with the Grain.—Sandpaper should always be rubbed back and forth *with the grain* and never with a circular motion or across the grain, as this would roughen and scratch the work instead of smoothing it. Care must be exercised to hold the block flat against the surfaces and not to round the edges. A good workman does not round the corners and edges except where there would be danger of splintering. In such cases the sharpness may be removed by running a plane along each corner before sandpapering, or by running the sandpaper over the edges once or twice very carefully after the other sanding is finished. For sandpapering curved surfaces no block is needed, the paper being held in the hand.

Sandpaper is available in several grades or degrees of coarseness. The commonly used grades range from No. 00 (fine) to No. 2 (coarse).

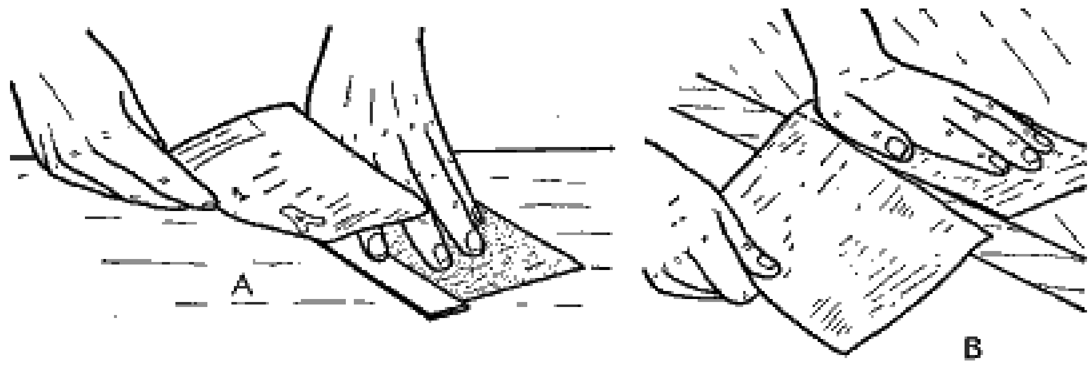

FIG. 47.—Sheets of sandpaper are easily torn by creasing and then tearing along the sharp edge of a rule as at *A*, or over the edge of the bench as at *B*.

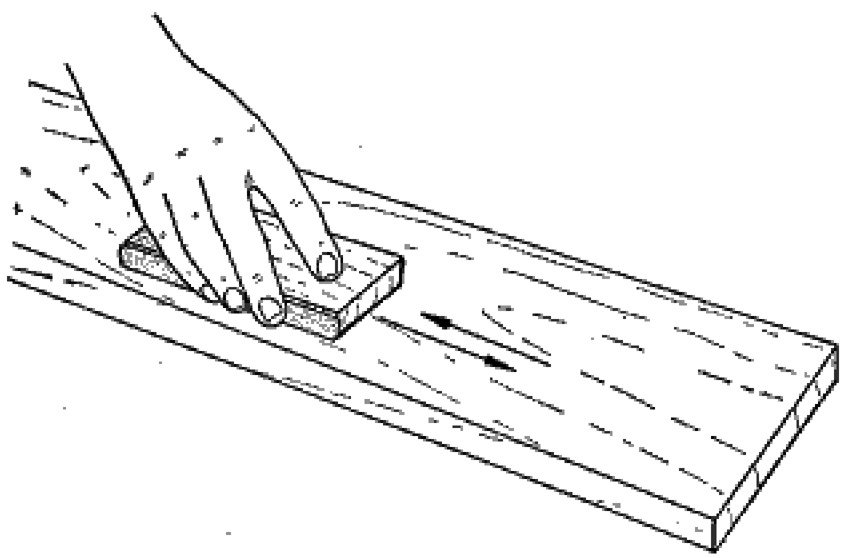

FIG. 48.—Flat pieces are best sandpapered with paper wrapped part way around a flat block. Sanding should always be done with the grain—never across it.

43. Other Smoothing Materials.—*Steel wool* may be used also for smoothing the surface of wood, but, like *emery cloth* or *emery paper*, it is used more on metal than on wood.

Pumice stone is sometimes used in cabinetmaking to produce a very fine finish on wood.

Questions

25. (*a*) Should the cap iron or chip breaker be fastened to the flat or to the beveled side of the plane bit? (*b*) How far should the plane bit extend beyond the cap iron? (*c*) Why should the bit and cap iron fit together tightly? (*d*) What may happen if the lever cap does not clamp the bit and cap iron tightly into the body of the plane?

26. (*a*) What are the two main adjustments of the standard plane? (*b*) Explain just how to make a trial adjustment on a plane.

27. (*a*) Describe the body position for planing. (*b*) How should the plane be held in the hands? (*c*) Why should the pressure be shifted from the front to the back of the plane as it advances over the work?

28. Under what conditions should the plane be set for a deep cut?

29. (*a*) Why should a board be planed with the grain? (*b*) How may a board with irregular grain be planed?

30. How should the plane be handled when the stock is to be planed less than full length?

31. Why should the heel of the plane be lifted slightly on the back or return stroke?

32. (*a*) How should the plane be laid on the bench when not in use? (*b*) Give two ways of protecting the sharp cutting edge of a plane when it is put away in the tool case.

33. Give two tests to indicate whether or not the surface of a board is a true plane.

34. (*a*) What precautions should be observed in planing an edge straight? (*b*) Describe two methods of holding the front end of a plane so that it will plane the edge of a board square with a side.

35. (*a*) How may the amount of planing of end grain be kept at a minimum? (*b*) How should a plane be set for planing end grain? (*c*) Why should the plane be pushed at an angle? (*d*) How may splintering of the edges be prevented when planing the end of a board? (*e*) How may a miter box or a bench hook be used to advantage in planing end grain?

36. (*a*) How should the file be held and manipulated in filing end grain? (*b*) When is filing preferred over planing end grain? (*c*) What kind of a file is best for filing wood?

37. (*a*) What is meant by the expression *squaring up a board?* (*b*) What is a true plane? (*c*) What is the difference between a smooth surface and a true surface? (*d*) Name the steps of the squaring-up process. (*e*) What is a working surface? A working edge? (*f*) How are the working surface and the working edge marked?

38. (*a*) Why is a pencil better than a marking gage for marking out a chamfer? (*b*) What precautions should be observed in case a marking gage is used? (*c*) Should the chamfers on the sides or the chamfers on the ends of a piece be planed first? Why? (*d*) How should the plane be held and pushed in planing chamfers across the end of a board?

39. (*a*) For what kinds of work is the block plane particularly good? (*b*) In what ways is the block plane different from the jack plane? (*c*) What feature of construction enables the block plane to be used to advantage for planing end grain?

40. (*a*) How is the smooth plane different from the jack plane? (*b*) For what kind of work is the jointer plane used? Why is it better than the jack plane for this work?

41. (*a*) Should a scraper be used before or after planing? Before or after sandpapering? (*b*) Just how should the scraper be held and manipulated in use?

42. (*a*) At what stage in smoothing and finishing a board should it be sandpapered? (*b*) How may sheets of sandpaper be torn straight and easily? (*c*) State precautions to be observed in the use of sandpaper.

43. What materials other than sandpaper are sometimes used for smoothing wood surfaces?

References

HJORTH: "Basic Woodworking Processes."
BROWN and TUSTISON: "Instructional Units in Hand Woodwork."
GRIFFITH: "Essentials of Woodworking."
CRAWSHAW and LEHMANN: "Farm Mechanics."
Educational charts and pamphlets, Stanley Tool Works, New Britain, Conn.

CHAPTER IV

WOOD CHISELS AND THEIR USE

44. Types of Chisels.—Wood chisels may be classified as socket type or tang type, according to the method of attaching the handle. On the socket type, the wooden handle fits into a steel socket on the driving end of the chisel. The tang type has a steel tang, much like the tang on the end of a file, which fits into the wooden handle. Tang chisels are preferred by some workmen for paring, because of their light weight and better balance, but they are not adapted to heavy chiseling with a mallet. For the farm shop, a medium-weight socket chisel is usually preferred.

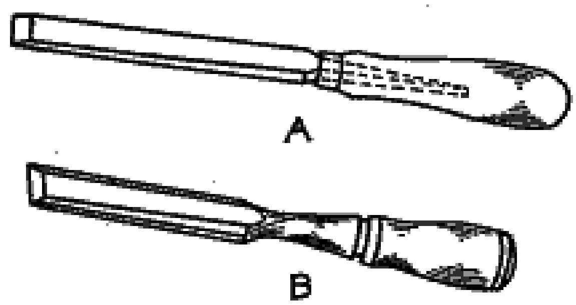

FIG. 49.—Types of wood chisels: *A*, tang type; *B*, socket type. The socket type is usually preferred for the farm shop.

Such a chisel can be handled easily for light paring, and it can also be used for the heavier work where a mallet is needed.

Chisels are made in various sizes, ranging from ⅛ to 2 in. wide.

45. Keep the Chisel Sharp.—The first requirement for good work with a chisel is that it be kept very sharp. Working with a dull chisel not only requires considerable extra effort to force it through the wood, but, what is more serious, it cannot be easily guided and controlled. Consequently, rough, inaccurate work is almost certain to result.

The chisel is very easily sharpened (see page 87). Whenever it becomes dull, stop and sharpen it. The time required will soon be gained back in faster and better work with the sharpened tool.

46. Chiseling with the Grain.—In chiseling with the grain, as on the edge or surface of a board, the following points should be observed:

1. Always cut with the grain, as in planing, to avoid splitting or splintering.
2. Fasten the work in a vise whenever possible, so as to leave both hands free to use the chisel.
3. Always push the chisel from you, keeping both hands behind the cutting edge.
4. Use the left hand to guide the chisel, and the right to push the handle forward.

5. Use the chisel with the bevel down for roughing cuts, and with the bevel up for fine paring, or finishing cuts.

6. Hold the handle slightly to one side, or move it back and forth slightly, as the chisel is pushed forward. This gives a sliding or oblique cutting action, which makes the chisel cut better and easier.

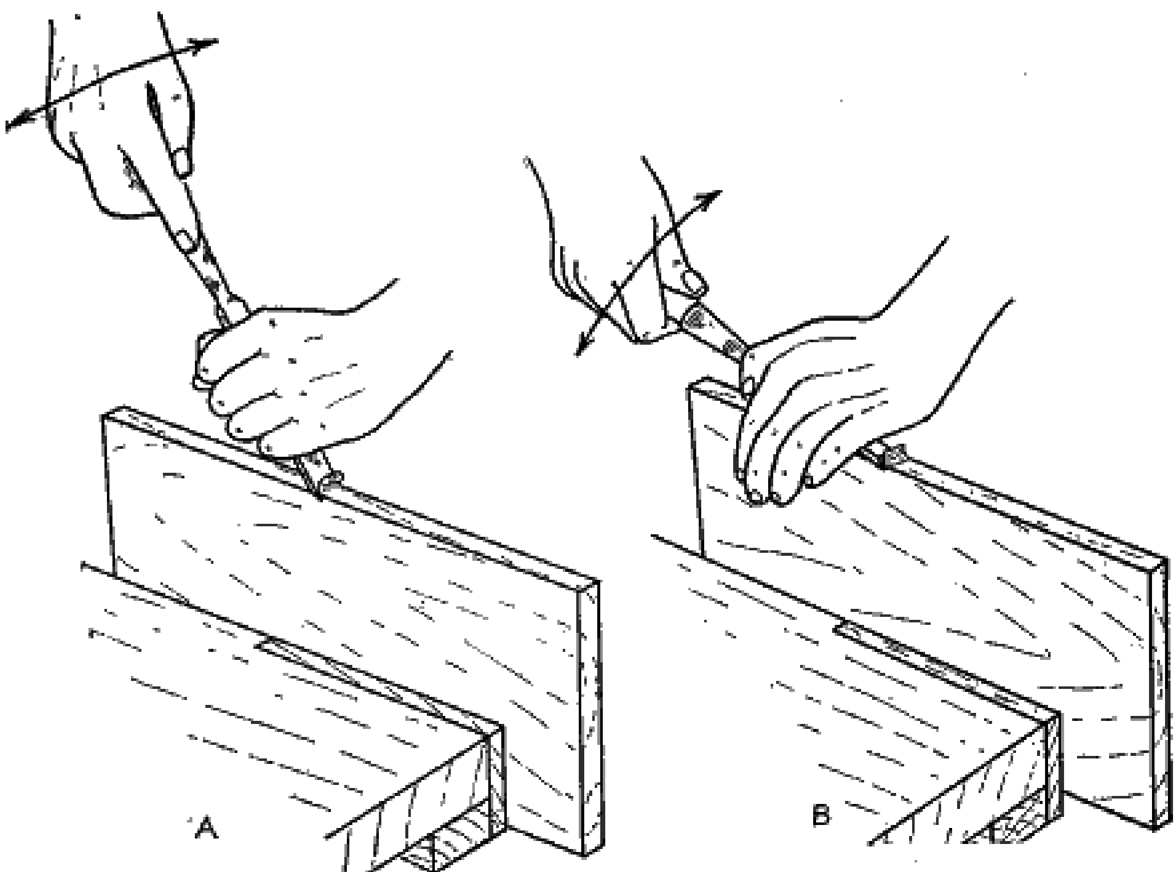

FIG. 50.—Chiseling with the grain. Use the chisel with the bevel down, as at *A*, for deep roughing cuts, and bevel up, as at *B*, for light finishing cuts. Move the handle from side to side slowly as the chisel is pushed forward in order to give an oblique cutting action.

47. Chiseling Across a Board.—This kind of work is done mostly in making dadoes, gains (see Arts. 51 and 52), or notches. The following points should be observed in chiseling across the grain:

1. Grasp the blade of the chisel between the thumb and first two fingers of the left hand, to act as a brake while the pushing is done with the right hand.

2. Cut from both edges of the board to avoid splintering.

3. Move the handle from side to side slightly as the chisel is pushed forward in order to give a sliding or oblique cutting action.

4. Cut with the beveled side up, raising the handle just enough to make the chisel cut. In working across wide boards, however, where the chisel cannot reach the center of the board, the beveled side should be kept down.

48. Chiseling End Grain.—This kind of chiseling is seldom required in farm shopwork. Many mechanics prefer to pare or trim end grain in cutting dadoes and gains to exact width, but by sawing carefully, as illustrated in Fig. 56, finishing with the chisel is seldom required. When paring of end grain is done, the following points should be observed:

1. If much waste is to be removed, take a roughing cut first, leaving about $\frac{1}{16}$ in. to be removed with a finishing cut. Taking too large a cut causes the chisel to wedge sidewise, making it difficult to work to a line.

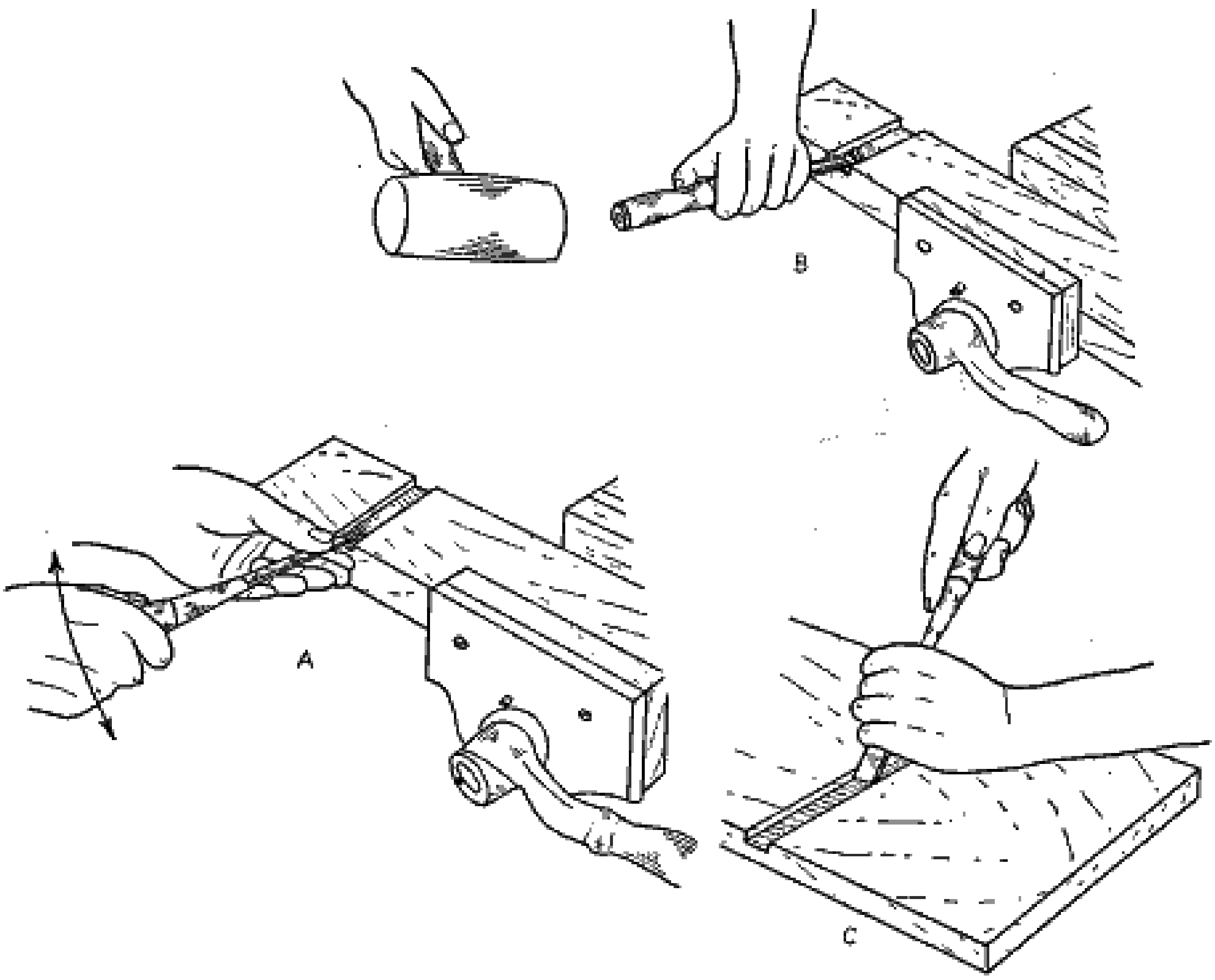

Fig. 51.—Chiseling across a board.

A. Work with the bevel up (except for wide boards). Raise the handle just enough to make the chisel cut and move the handle from side to side slowly. Guide the front of the chisel with thumb and fingers of left hand.

B. For heavier chiseling or roughing cuts, the mallet may be used. Do not use a hammer.

C. For chiseling across wide boards where the chisel will not reach to the center, work with the bevel down.

2. Start on the near edge of the board and push forward at an angle and downward. As the stroke proceeds, the handle is straightened up until it is about vertical at the end of the stroke (see Fig. 52).

3. Guide the chisel with the left hand, and apply force with the right.

4. Use about half the width of the chisel for cutting on each new stroke. Keep the back half of the blade flat against the surface left by the previous stroke. Thus the work of cutting is made easier, and the line of cutting is more easily kept straight.

5. If the chisel is to cut entirely through or across a piece, place the work on a cutting board or piece of scrap lumber, to keep the chisel from cutting into the bench, thus marring its surface and possibly dulling the chisel.

49. Use of the Mallet.—Where considerable force is required, particularly in making deep roughing cuts, a wooden mallet may be used to drive the chisel. A steel hammer should never be used, because the chisel handle would soon be ruined. A series of light taps with the mallet is

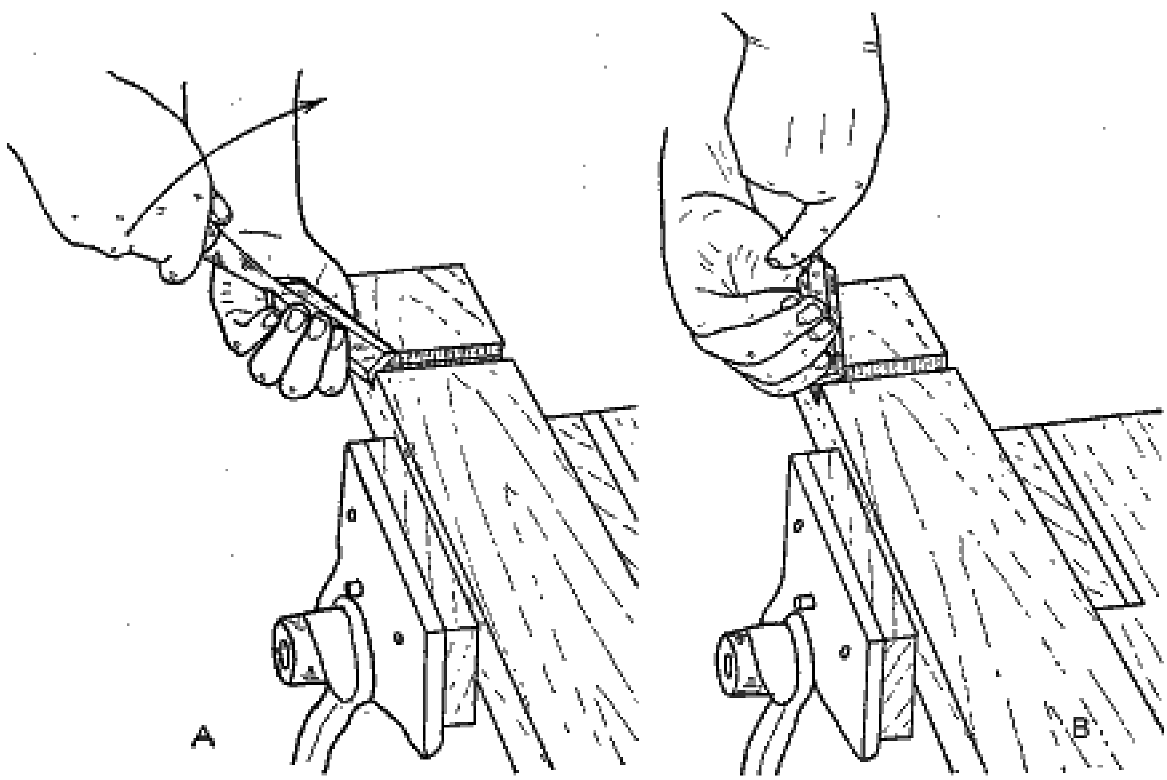

FIG. 52.—Chiseling down across end grain. Guide the chisel with the left hand, pushing forward and downward at the start, and gradually raise the handle. *A*, beginning a stroke. *B*, finishing a stroke.

usually better than heavy blows, because the chisel can be better controlled.

50. Paring Chamfers.—The chisel may be used quite satisfactorily in paring chamfers, either with the grain or across end grain. In chamfering, the beveled side of the chisel is kept up and the flat side down. As in most other chiseling, the handle should be held slightly to one side, or moved from side to side, as it is pushed forward in order to give the oblique or sliding cutting action. To prevent splintering when cutting a chamfer on end grain, part of the cutting should be done from one edge of the piece and part from the other.

51. Making a Dado.—A dado is a groove that runs across one board and is to receive the end or edge of a second board. Dadoes are commonly made in shelving and in cabinet work.

The first step in making a dado is to mark it out very accurately to exact width—the same as the thickness of the piece that is to fit into the dado. The piece itself may be used to mark the width of dado by superposition. A square should be used, of course, to insure marking the sides of the dado square with the edge of the board. A knife is best for mark-

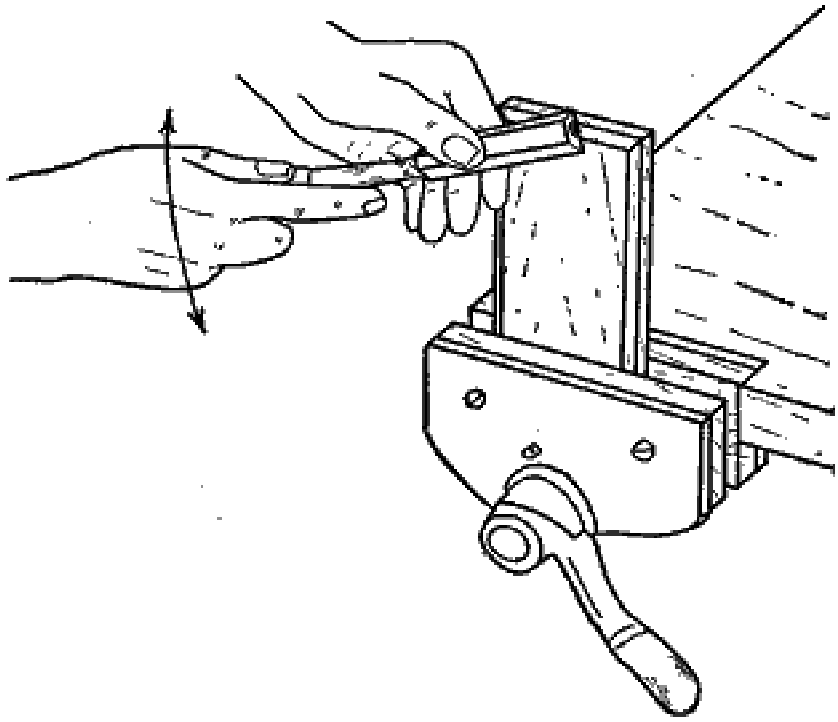

FIG. 53.—Chamfers are easily made by paring with a chisel.

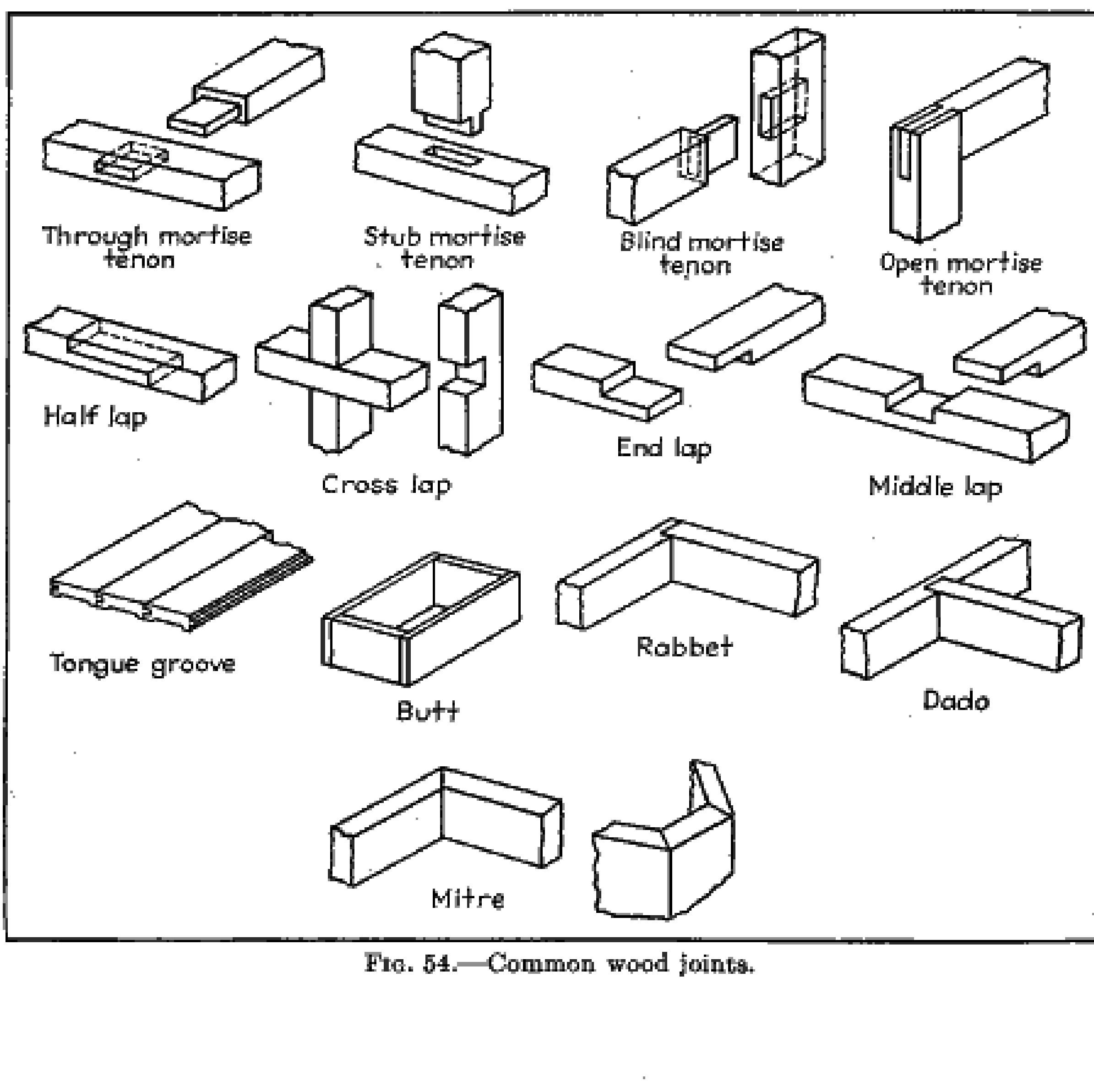

FIG. 54.—Common wood joints.

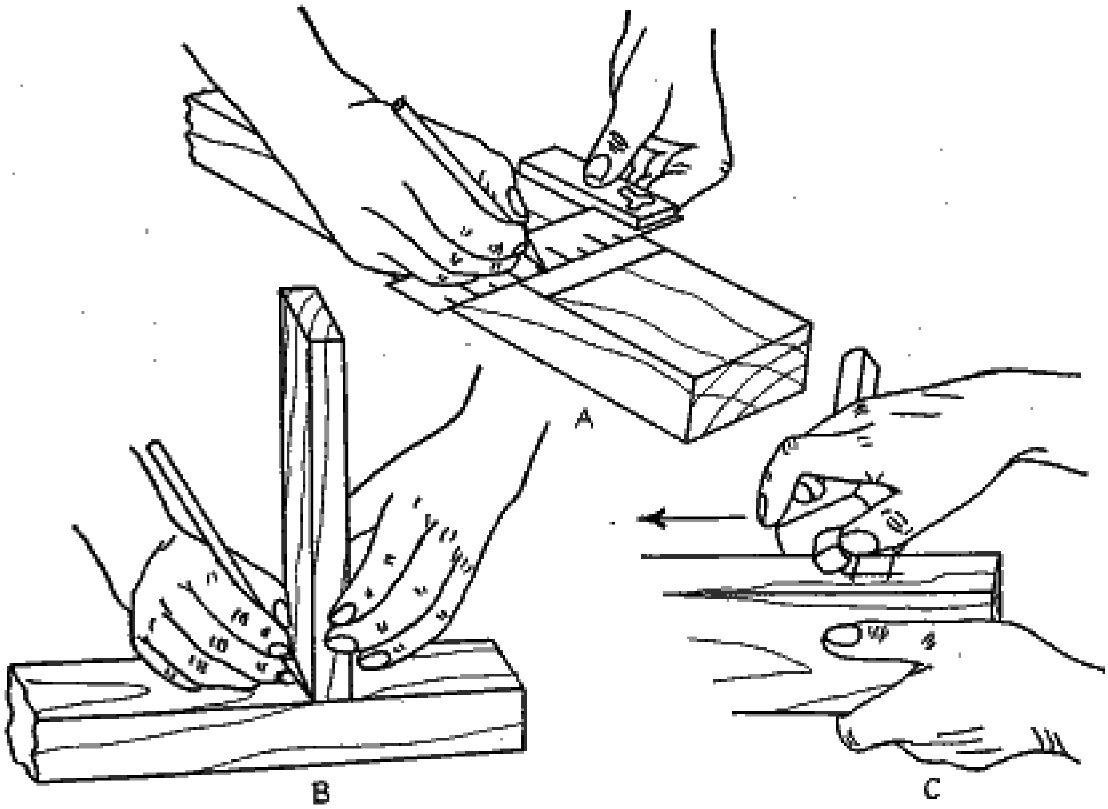

FIG. 55.—The first step in making a dado is to mark it out accurately.
A. Marking the width with the try square.
B. Marking the width by superposition.
C. Marking the depth with the marking gage.

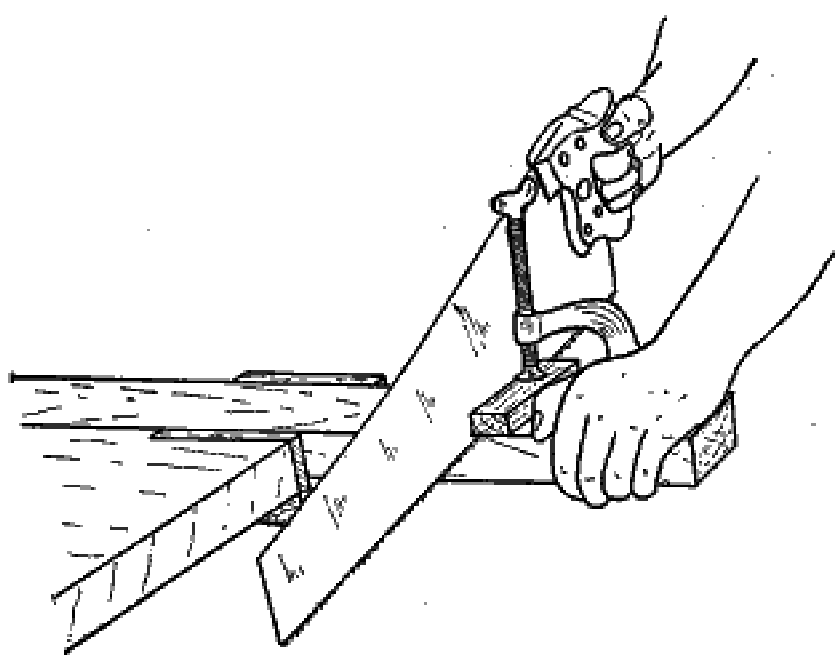

FIG. 56.—A good way to saw accurately the sides of a dado is to clamp a straight-edged block in place to guide the saw. Thus little or no chiseling of end grain will be required. An extra saw cut or two between the sides of the dado will facilitate chiseling out the waste.

ing, although a sharp pencil can be used. The depth of the dado should also be marked on the edges of the board. A marking gage is a good tool for this.

After the dado is accurately marked out, the piece should be sawed just inside the lines in the waste material, care being taken not to saw too deep. To do a good job of sawing, a straight square-edged piece may be clamped temporarily in place to guide the saw. If the dado is wide, an extra saw kerf or two may be cut in the waste material to make it more easily removed with a chisel. The chiseling across the board should be done in accordance with suggestions in Art. 47.

If the sawing has been carefully done, no paring of end grain will be required with the chisel to finish the sides of the dado. If the sawing has not been done accurately to the lines, however, the sides of the dado may be finished by vertical paring with a chisel (see Art. 48) or by filing or sandpapering.

52. Gaining In.—It is frequently desirable to gain into, or notch into, a piece in order to securely fasten a second piece. Typical examples are fastening the lower crosspieces to the legs of a bench or table, and fastening the steps to the side rails of a ladder.

The first step in making the gain or notch is to mark it out accurately to exact width and depth, using square and knife or sharp pencil and possibly also the marking gage. The gain is then sawed and chiseled out in a manner similar to that described for dadoes in the preceding article.

Marking for a gain may frequently be greatly simplified by using the second piece and marking the width of the notch by superposition. A square, of course, should be used to square the lines across for the notch.

Chiseling out the waste will be much easier if, before chiseling begins, several saw kerfs are cut about ¾ in. apart in the waste.

53. Attaching Butt Hinges.—The hinge is put in place on the edge of the door, and a knife used to mark around it. The hinge is then removed and a line gaged on the side of the door to indicate the depth the hinge is to be set in. The gain is then carefully cut out with a chisel, trying the hinge in place for fit as the work nears completion.

After the gain is finished the hinge is fastened in place with screws, first using an awl or drill to make holes for the screws.

54. Mortise-and-tenon Joints.—A mortise is a hole cut into or through one piece, and into which, or through which, another piece fits. A tenon is an end of a piece specially shaped (usually with a shoulder) to fit into a mortise. Figure 54 illustrates several mortise-and-tenon joints as well as other joints commonly used in fastening pieces of wood together.

The first step in making a mortise is to mark out accurately the location, using a square and a knife or a sharp pencil. The waste wood may be removed altogether with a chisel of appropriate width or by boring first with an auger bit to remove most of the waste and then finishing with a chisel (see Fig. 58).

If the mortise is to go entirely through a piece, its location should be accurately marked on both sides and the mortise cut partly through from each side.

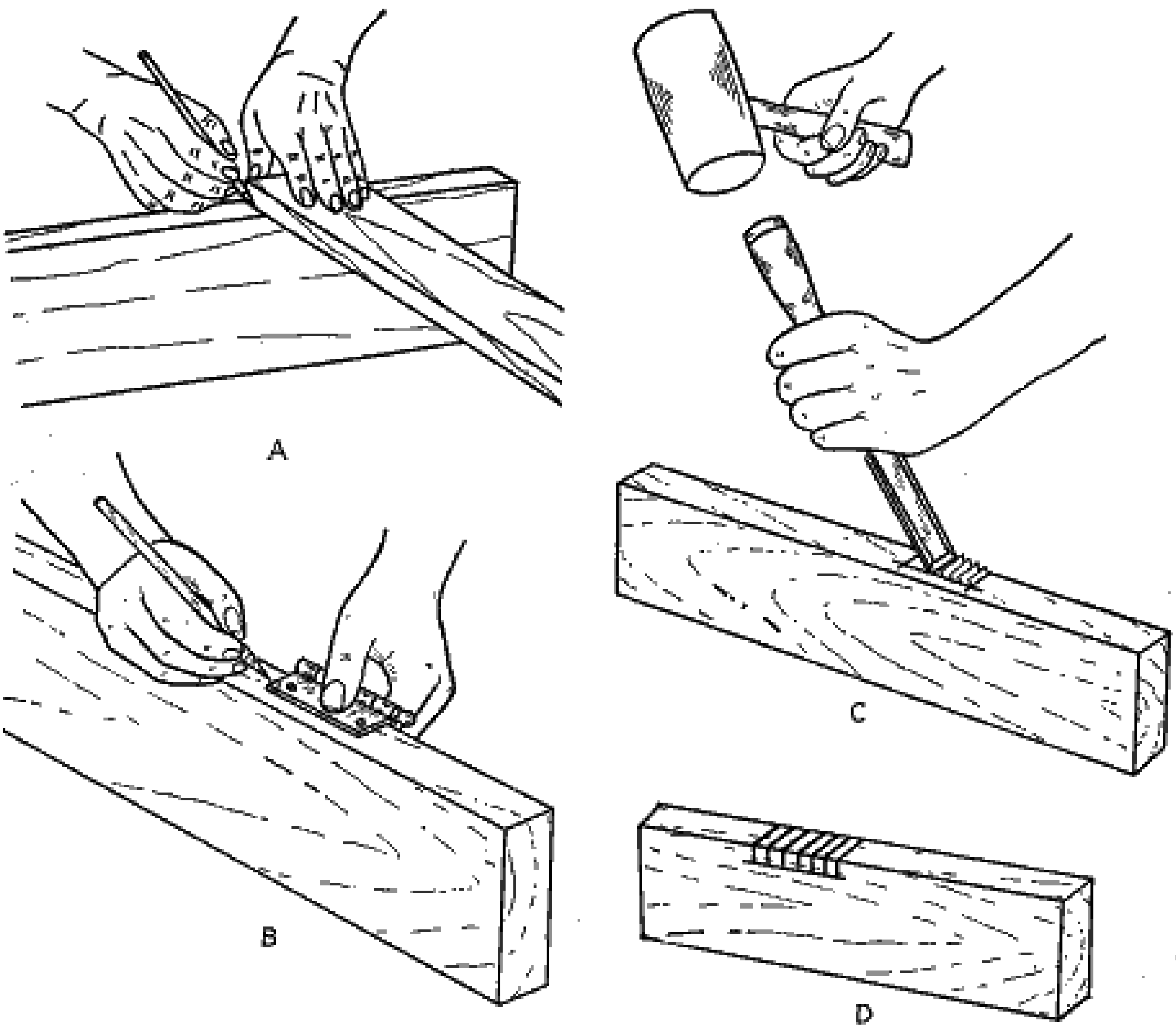

FIG. 57.—Gaining in.

A. Marking for a gain by superposition.

B. Marking with a sharp pencil preparatory to gaining-in a butt hinge. Some prefer a sharp knife instead of a pencil.

C. Cutting a shallow gain for a butt hinge.

D. Making several saw cuts lessens the work of chiseling out the waste.

The tenon is easily made, although it requires careful work. The tenon is first accurately marked out and then worked to size with the saw and chisel.

55. Rabbeting.—A rabbet is a groove cut in the edge or end of a piece to receive a second piece like a panel. Rabbeting is commonly done in making frames to hold glass, and frequently, also, in constructing drawers and other cabinet work. The rabbet may be cut with a chisel, if the work is first accurately marked out and the workman is careful. It

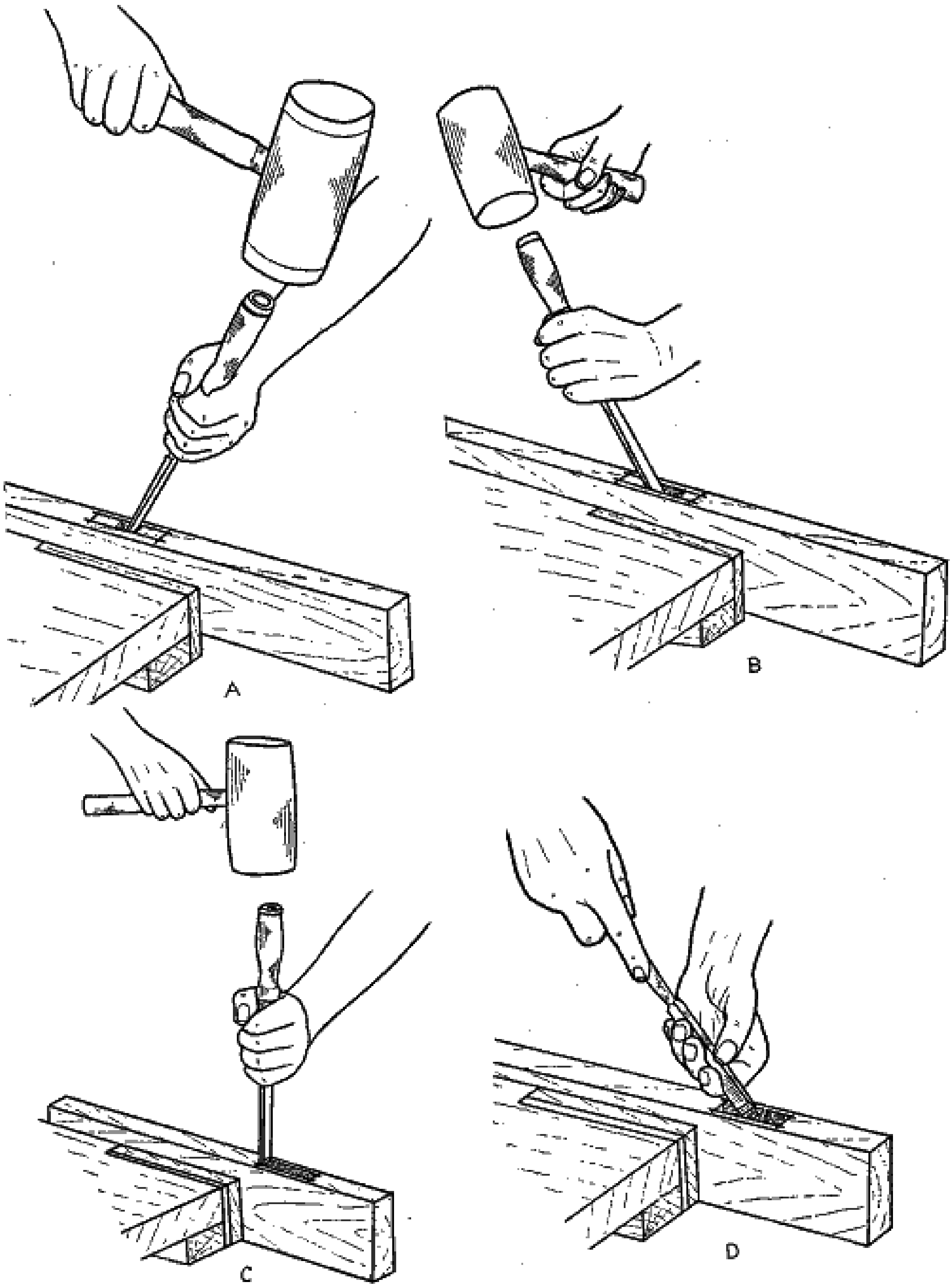

FIG. 58.—A mortise for a mortise-and-tenon joint is easily made with a wood chisel. It should first be accurately marked out.

A. Mortise started.
B. Mortise partly done.
C. Finishing the mortise.
D. If desired, most of the waste may be removed with a wood auger and the mortise finished with a chisel.

is, of course, easier to cut a rabbet with a power saw or with a special grooving or rabbeting plane, but the amount of this work done in the farm shop usually will not justify such equipment.

Questions

44. (*a*) What are the common types of wood chisels? (*b*) Which is preferred for the farm shop? Why? (*c*) How is the size of a chisel designated?

45. Why is it possible to do better work, as well as faster work, with a sharp chisel than with a dull one?

46. (*a*) Name several important points to be observed in chiseling with the grain. (*b*) Under what conditions should the chisel be used with the bevel up, and under what conditions with the bevel down? (*c*) Why should the chisel be used with sliding or oblique cutting action?

47. (*a*) In what kind of work is chiseling across the grain most commonly done? (*b*) How can splintering of the edge of the board best be avoided?

48. (*a*) How may chiseling of end grain be kept at a minimum in shop work? (*b*) Why should a roughing cut be taken first, followed by a finishing cut, when much waste is to be removed in chiseling end grain? (*c*) Describe the proper method of using the chisel on end grain to insure good straight work.

49. (*a*) Why should a mallet, rather than a hammer, be used to drive the chisel in heavy work? (*b*) Is it better to use a series of light blows with the mallet, or a few heavy ones?

50. (*a*) What points should be observed in paring chamfers with a chisel? (*b*) How may splintering of edges best be prevented in chiseling chamfers on end grain?

51. (*a*) What is a dado? (*b*) What is the first step in making a dado? (*c*) Describe a method for sawing the sides of a dado very accurately, so that little or no chiseling will be required.

52. Describe the process of making a gain.

53. How may a gain to receive a butt hinge be easily marked out?

54. (*a*) Describe the process of making a mortise. (*b*) What tools are commonly used to remove the waste in making a mortise? (*c*) What is a tenon, and how is it made?

55. (*a*) What is a rabbet? (*b*) Give examples of the use of rabbets. (*c*) What tools are required for making a rabbet?

References

HJORTH: "Basic Woodworking Processes."
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BROWN and TUSTISON: "Instructional Units in Hand Woodwork."
Educational charts and pamphlets, Stanley Tool Works, New Britain, Conn.

CHAPTER V

BORING AND DRILLING HOLES IN WOOD

56. The carpenter's brace is used for turning such tools as wood auger bits, twist drills, screw-driver bits, countersinks, and reamers. Braces are made either with or without the ratchet device. A ratchet brace makes it possible to bore holes where the handle cannot be turned a complete revolution. This type is also more convenient in boring in hardwood and in driving screws with a screw-driver bit. For such work it is frequently easier and better to advance the brace by part turns rather than to make full continuous revolutions.

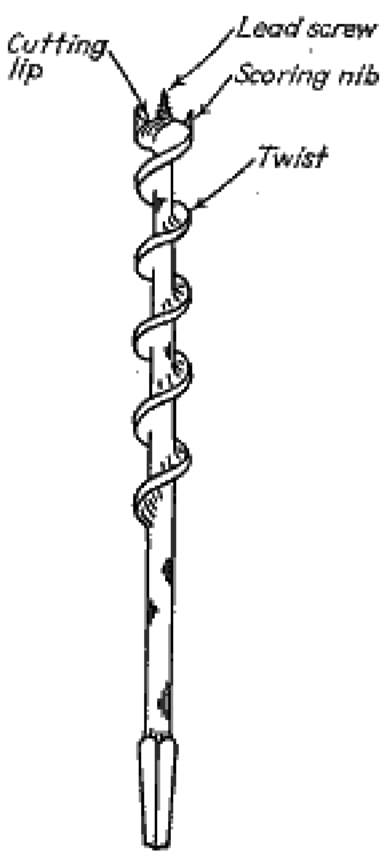

FIG. 59.—Auger bit.

The size of a brace is designated by its sweep or the diameter of the circle through which the handle swings. A brace with a 10-in. sweep is best for average work in the farm shop.

57. The auger bit is the most common tool for boring holes in wood. The size of an auger bit is designated by a number stamped on the shank, the number being the size of the bit in sixteenths of an inch. Thus a bit marked "7" bores a hole $7/16$ in. in diameter, a bit marked "11" bores a hole $11/16$ in., etc.

As an auger bit is turned, the feed screw guides the bit and draws the cutting parts into the wood, so that only moderate pressure is required on the brace. The spurs or scoring nibs cut off the wood fibers, and the cutting lips cut out the waste inside the circle scored by the spurs, the waste being carried to the surface by the twists on the bit. To bore a clean, straight hole, the bit must be in good condition. See page 98 on how to sharpen an auger bit.

58. Starting the Auger Bit.—Before starting to bore a hole, its center should be accurately located, generally by the intersection of two cross lines, or a small hole made with an awl.

With the thumb and fingers of one hand, the bit is guided so that the point of the feed screw is placed very carefully at the intersection of the cross lines, or in the awl hole, while a slight pressure is exerted on the head of the brace with the other hand.

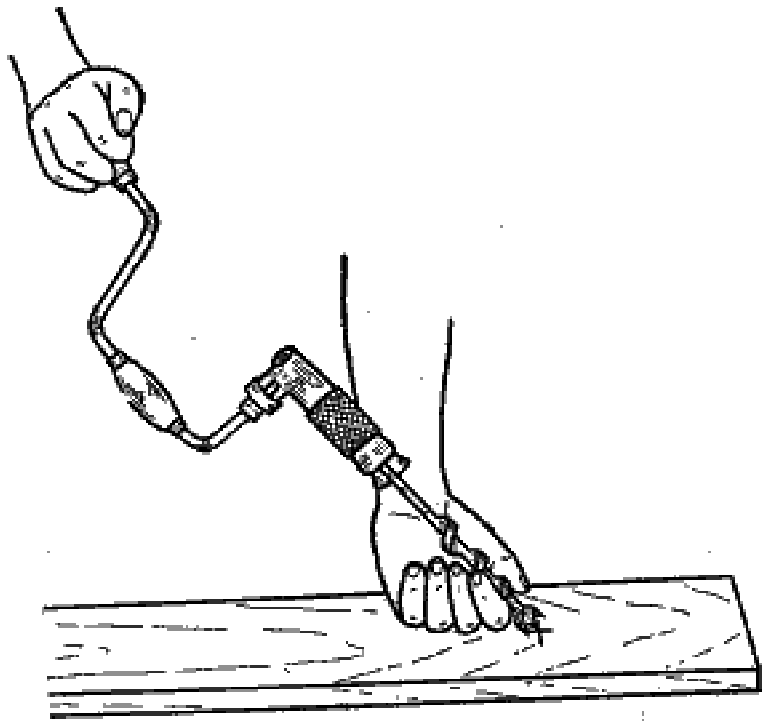

FIG. 60.—The bit may be accurately placed by steadying the hand, knuckles down, against the board.

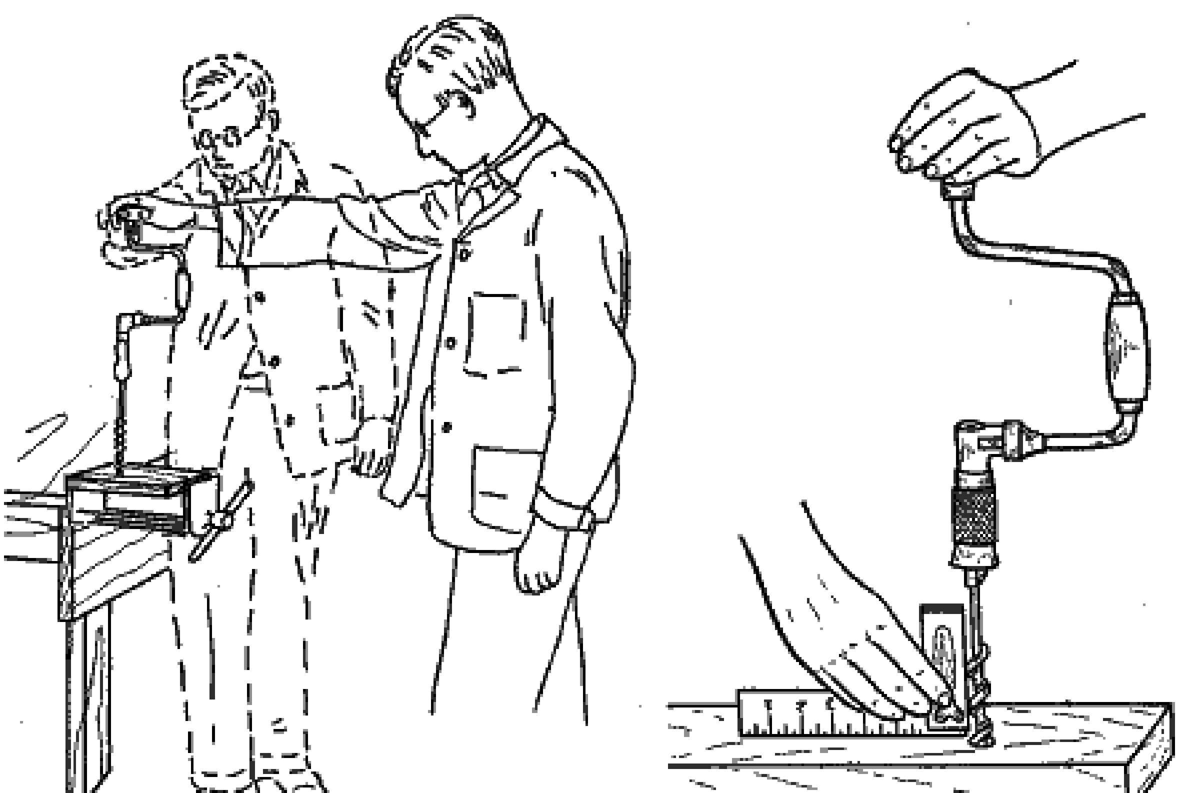

FIG. 61.—To insure boring straight, sight from two directions, as at *A*; or check with a square, as at *B*.

As the auger is started, care should be taken to keep it perpendicular to the surface (unless it is desired to bore a hole at an angle). To insure that the hole is being bored square with the surface, step back a little, steadying the brace with one hand, and sight; then in a similar manner, step around and sight in another direction at about right angles to the first direction of sighting. If at any time it is found that the bit is not perpendicular, the top of the brace should be leaned accordingly. The try square may also be used to see if the bit is going straight. The student should not depend altogether on the square, however, but should develop his ability in sighting.

59. Boring Through.—In boring a hole entirely through a board, the boring should proceed until the point of the feed screw can be felt on the

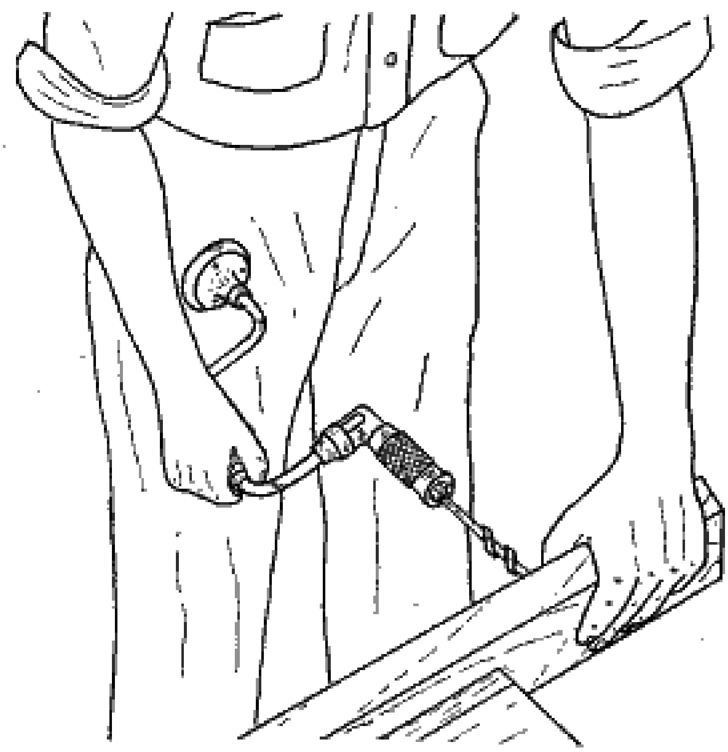

FIG. 62.—To prevent splintering when boring a hole, stop when the point of the bit can be felt and finish by boring back through from the other side.

back side. The board is then turned over and the hole finished by boring from the other side. This prevents splintering of the wood around the edge of the hole.

Another method that may be used, especially on pieces that can be held in a vise, is to clamp a block of scrap wood behind the piece through which the hole is to be bored. The boring may then be done all from one side without danger of splintering.

60. Boring to Depth.—If it is desired to bore a hole to a definite depth, the turning is stopped as soon as the cutting lips touch the wood and the distance from the end of the chuck to the surface of the piece is measured with a rule. The boring then proceeds until the measurement on the rule is decreased by an amount equal to the desired depth of hole.

If a number of holes are to be bored to the same depth, considerable time can be saved by cutting a block to the correct length and using it as a gage, as shown in Fig. 63*C*, or by using a homemade gage similar to the one shown in Fig. 67.

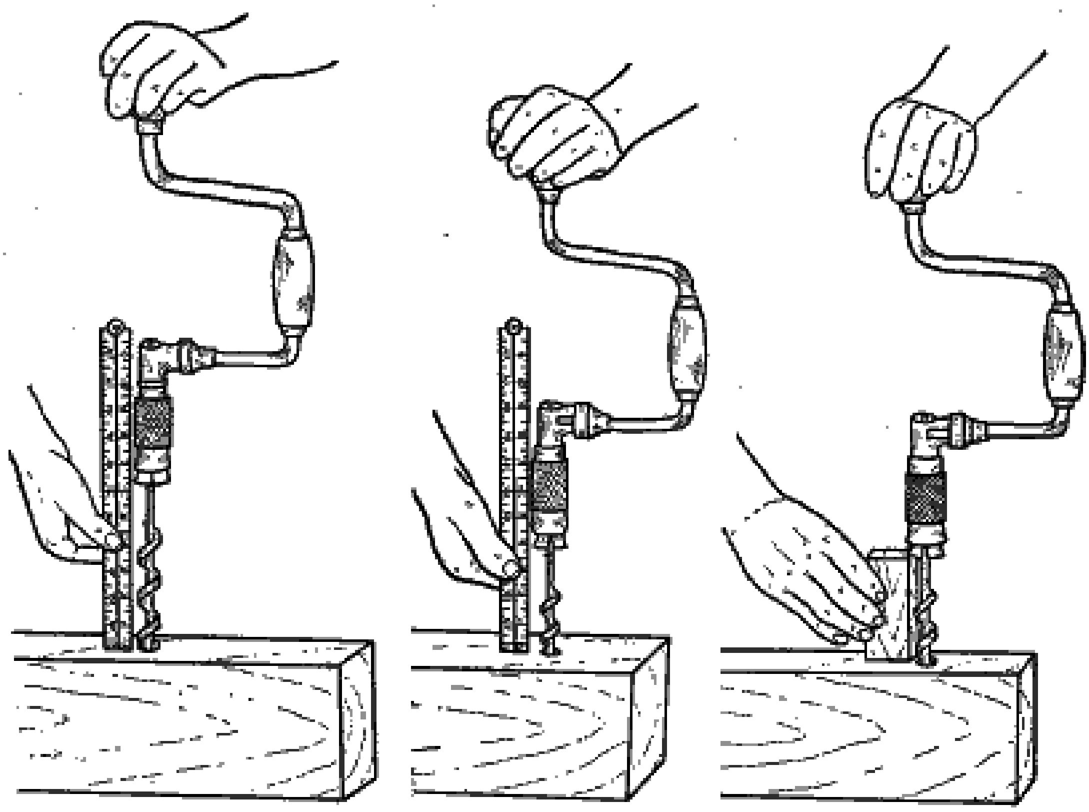

FIG. 63.—In order to bore to exact depth, measure the distance from the surface to the chuck just as the lips start cutting, as at *A*; then bore until the measurement is decreased an amount equal to the desired depth, as at *B*. When several holes are to be bored the same depth, a block may be cut to fit under the chuck and used as a gage, as at *C*.

61. Counterboring.—Counterboring is making a hole larger in diameter at its mouth than deeper down. Where pieces of wood are fastened together with bolts, counterboring is frequently done to sink the bolt heads or nuts below the surface.

In making a counterbored hole, a bit of the diameter of the counterbore is used first; and after the desired depth of counterboring is reached, the hole is finished with a smaller bit. (Why not bore with the small bit first and then counterbore with the large bit?)

62. Prevention of Splitting while Boring.—Boring large holes in narrow pieces of hardwood sometimes tends to split the pieces, owing to the wedging action of the feed screw. Such splitting can be avoided by clamping the piece flatwise in a vise (with the jaws of the vise against the edges of the piece) while boring.

63. Twist drills can be used for drilling holes in either wood or metal, and their use is recommended where there is danger of striking a nail or other metal that would dull an auger bit. The smaller sizes of twist drills are very good for drilling holes to receive wood screws.

In drilling holes in wood with a twist drill or other blunt-pointed drill, the drill point should be started in a mark or depression made with an awl or nail. Otherwise the point may "drift" from the proper location when the drill starts turning, and the hole will not be drilled exactly where it is wanted.

When making holes in wood with a twist drill, the drill should be withdrawn frequently to clean the cuttings from the twists or flutes. This prevents heating the drill and also speeds up the work of drilling. See pages 104 to 109 for suggestions on sharpening twist drills.

64. Wood-boring drills are similar to twist drills but are usually longer and have sharper points.

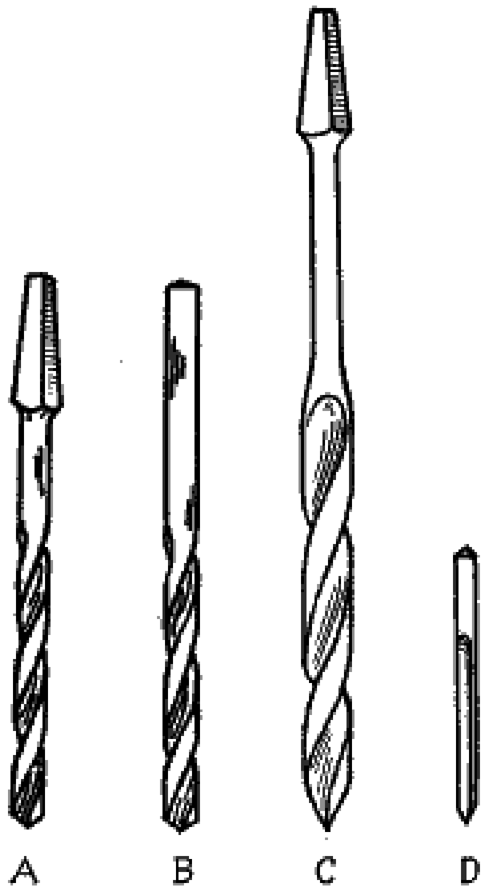

FIG. 64.—Wood-drilling bits. *A*, bit-stock twist drill; *B*, straight round-shank twist drill; *C*, wood-boring drill; *D*, wood-drill point.

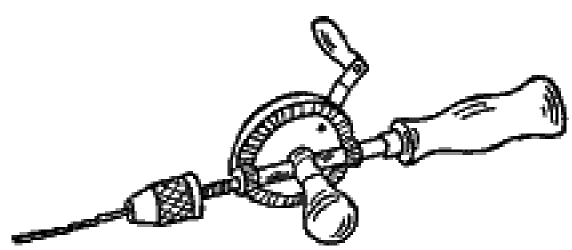

FIG. 65.—The hand drill is a very useful tool for drilling small holes, either in wood or metal.

65. Wood-drill points are used for drilling small holes in wood. They are very much like small twist drills except that they are made of softer steel and have straight instead of spiral grooves or flutes. They are commonly sold in sets ranging in size from $\frac{1}{16}$ to $\frac{11}{64}$ in. They are used in hand drills or automatic push-type drills.

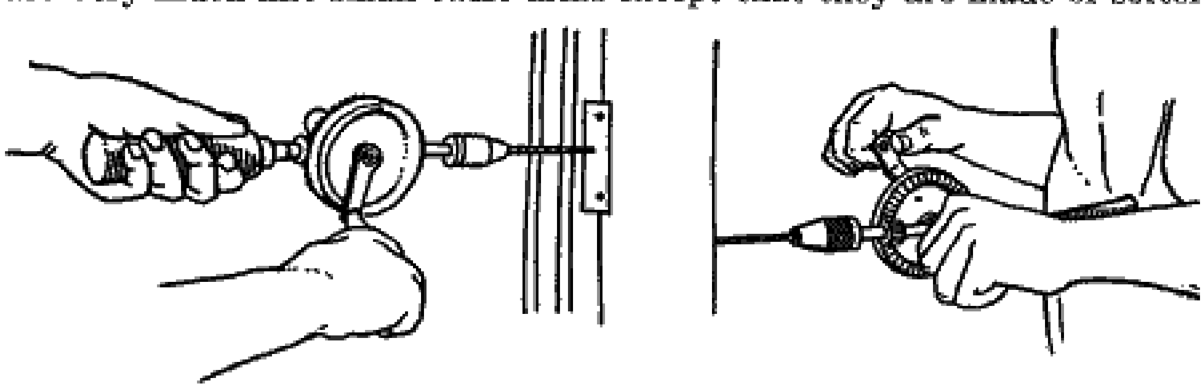

FIG. 66.—The hand drill should be held straight and steady, and turned with a moderate uniform speed. It is sometimes more convenient to hold the drill by the side handle and lean against the end handle. *(Courtesy, Stanley Tools, New Britain, Conn.)*

66. The hand drill is one of the most useful tools for drilling small holes either in wood or in metal. It is small and light and is much faster and more convenient than the carpenter's brace. Also, there is less danger of breaking small drill bits when using them in the hand drill.

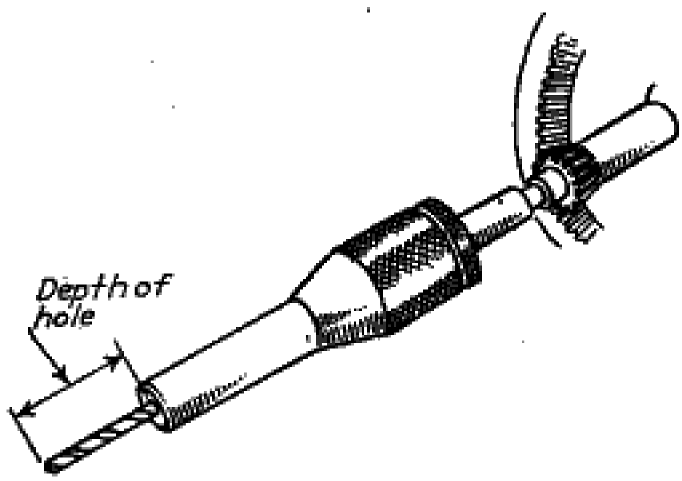

FIG. 67.—A convenient depth gage can be made by cutting a piece of wood to correct length, drilling a hole through it, and slipping it over the bit. (*Courtesy, Stanley Tools, New Britain, Conn.*)

The hand drill should be held straight and steady, and an even pressure exerted. It is important also to turn the crank with a steady, moderate speed.

67. The automatic push drill is sometimes used for drilling small holes in wood. By pushing the handle down and letting it come back up, a

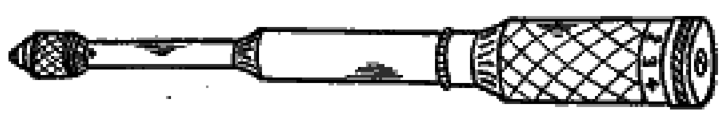

FIG. 68.—The automatic push drill.

forward-and-backward rotary motion is imparted to the drill point. Drilling with the push drill is a little slower than with the hand drill. The push drill can be operated with only one hand, however, leaving the other free to hold the work.

Questions

56. (*a*) What tools besides wood auger bits are commonly used in the carpenter s brace? (*b*) Of what particular advantage is the ratchet brace? (*c*) How is the size of a brace designated? (*d*) What size is best for the farm shop?

57. (*a*) How is the size of an auger bit designated? (*b*) Name the parts of the auger bit and give the purpose of each.

58. (*a*) Explain and be able to demonstrate how to start an auger bit at exactly the point desired. (*b*) How may the workman check his work to make sure a hole is being bored straight or square with the surface?

59. Explain two methods of boring a hole entirely through a board without danger of splintering.

60. Explain two or three methods of boring holes to a definite depth.

61. (*a*) What is counterboring? (*b*) Just how would you proceed to make a counterbored hole?

62. How may large holes be bored in narrow boards without danger of splitting them?

63. Give two or three suggestions on how to drill holes in wood with twist drills.

64. What is the difference between wood-boring drills and twist drills?

65. In what ways are wood-drill points different from twist drills?

66. (*a*) Why is the hand drill better than the carpenter's brace for drilling small holes in wood? (*b*) What points should be observed in using the hand drill?

67. (*a*) What is an automatic push drill? (*b*) What are its advantages and disadvantages when compared with a hand drill?

References

HJORTH: "Basic Woodworking Processes."
BROWN and TUSTISON: "Instructional Units in Hand Woodwork."
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Educational charts and pamphlets, Stanley Tool Works, New Britain, Conn.

CHAPTER VI

WOOD FASTENINGS

NAILS AND NAILING

68. Nail Hammers.—There are two general kinds of nail hammers: bell-faced hammers and flat or plain-faced hammers. Bell-faced hammers have striking surfaces that are slightly rounded or convex, and by careful use nails can be driven up tight with their heads flush with the surface of a board, or even slightly below, without leaving hammer marks. Plain-faced hammers, however, are a little easier to learn to use.

Hammers with straight claws instead of curved ones are called *ripping hammers* and are especially good for ripping off old boards.

The size of the hammer is designated by the weight of the hammer head exclusive of the handle, the most common sizes ranging from 12 to 16 oz.

69. Nails are made from steel wire by special machines that receive the wire from large rolls, cut it into the desired lengths, and form the points and heads automatically. For ordinary rough work where strength is required, common nails are used. For inside finishing work, or for cabinet work, finishing nails are used. Casing nails are similar to finishing nails but are somewhat larger and have slightly larger heads. Finishing nails and casing nails can be set with their heads slightly below the surface, and then the nail holes can be filled with putty.

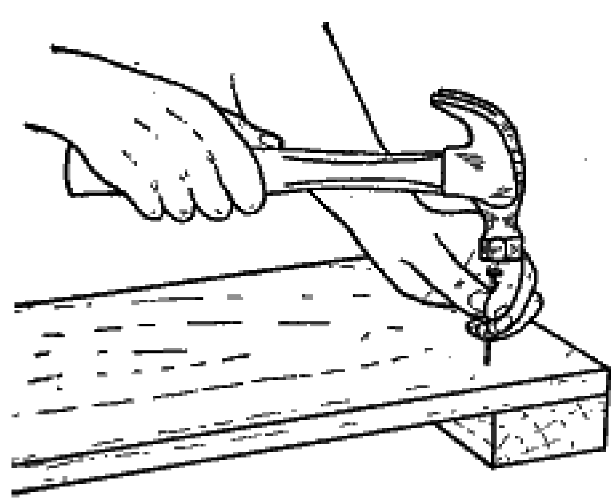

Fig. 69.—Steady the nail with one hand while starting it with one or two light taps of the hammer. Then follow with firm, well-directed blows. Grasp the hammer handle near the end.

The size of nails is determined by the gage or size of wire from which they are made. The size of nails is commonly designated, however, by the term *penny*, twopenny nails being small, and four-, six-, or eightpenny nails being larger.

70. Driving Nails.—To start a nail it is held steady with one hand while one or two light blows are struck with the hammer. After the nail is started straight, it is then driven up tight with firm, well-directed blows.

The hammer should be held firmly near the end of the handle, and the blows struck squarely on top of the nailhead. For light driving, the blows should be made mostly with motion from the wrist; for heavier hammering, from the wrist and the elbow; and for very heavy hammering, from the wrist, the elbow, and the shoulder.

The striking face of the hammer should be kept clean to keep it from slipping off the nail head.

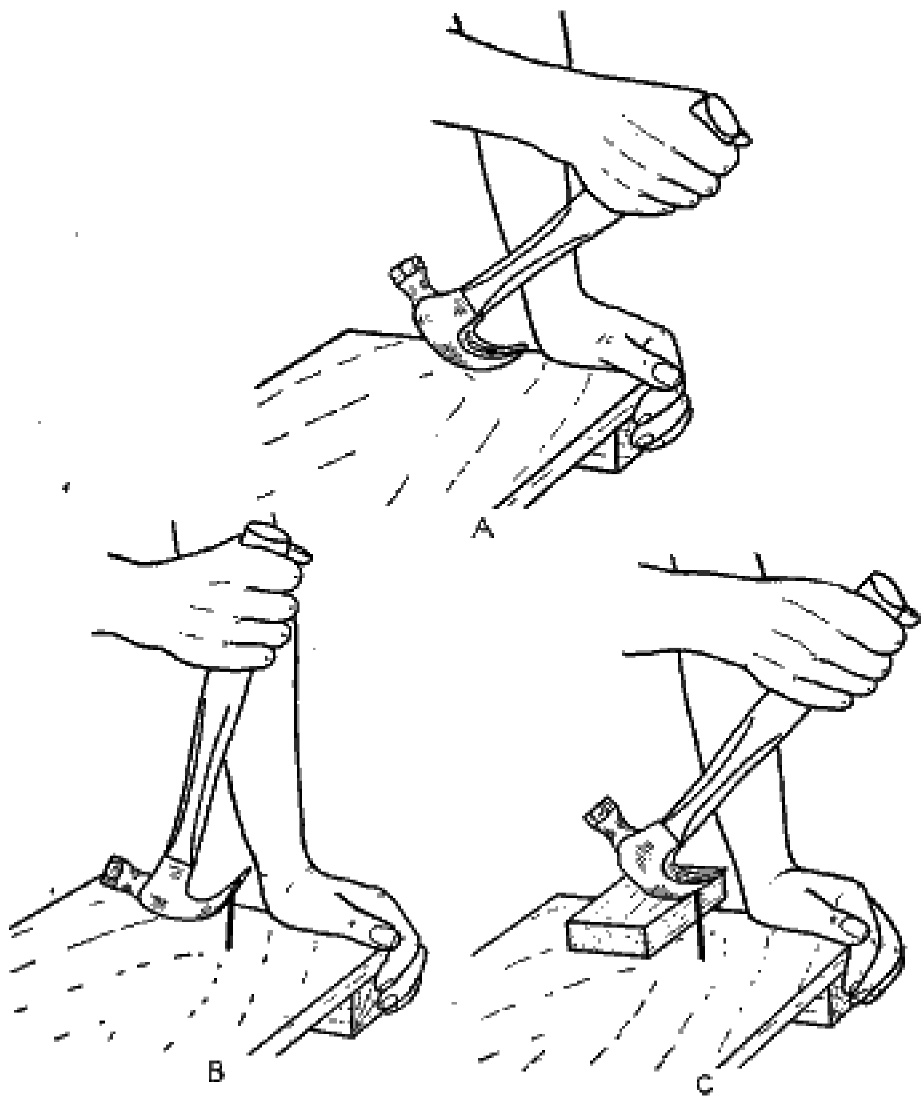

FIG. 70.—Steps in pulling a nail. Slip the claws under the nailhead and pull until the hammer handle is nearly vertical; then put a block under the hammer head to increase the leverage and relieve the strain on the handle.

In ordinary work the nail is driven flush with the surface of the board, with the final blow being carefully made so as not to leave a hammer mark on the surface.

71. Preventing Splitting.—If there is danger of splitting when the nail is driven, a smaller nail should be used, as a smaller nail will have greater holding power than a larger one that splits the board. Some nails have chisel-shaped points, due to the method of manufacture. With such nails the long way of the point should be across the grain, so that it cuts the fibers of the wood instead of wedging them apart and causing splitting. Splitting may be prevented in thin boards and where short nails are used by cutting the ends of the nails off square or chisel-shaped with nippers or pliers.

72. Pulling Nails.—To pull a nail, the claws of the hammer should be caught under the head of the nail, and the handle pulled up and backward. Usually the handle should not be pulled back any further than enough to make it perpendicular to the surface. Pulling it further increases the leverage and may overstrain the handle and possibly break it. When the pulling has progressed this far, a block of wood should be placed under the head of the hammer and the process repeated. In drawing long nails more blocks may need to be added at intervals. The blocks increase the leverage and reduce the strain on the handle.

If the nailhead is down in the wood and the claws cannot be slipped under it, a pair of pincers or nippers may be used to start pulling the nail.

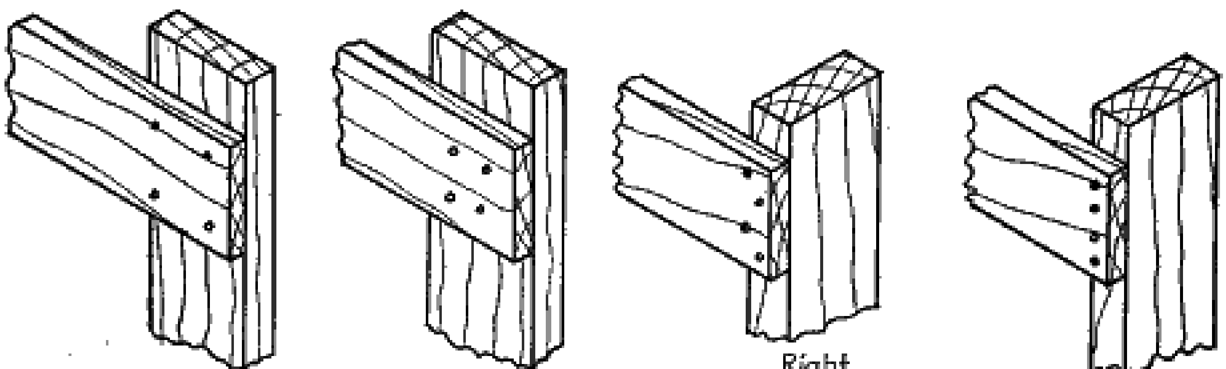

Fig. 71.—Right and wrong methods of nailing.

73. Locating the Nails.—The strength of a nailed joint depends largely on the distribution and location of the nails. Where possible, the nails should be staggered and not driven too close together nor in line with the grain. It is always good practice to nail through a thin piece into a thick one, and not through a thick piece into a thin one. A nail will hold much more if driven across the grain than if driven into end grain. Figure 72 illustrates a good method of making a crate corner.

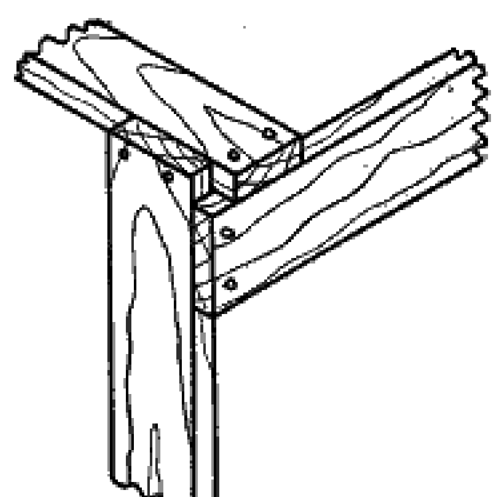

Fig. 72.—A strong nailed corner used in crating.

74. Clinching.—Clinching nails makes them hold better. For greatest holding power, the end of the nail should be bent in a direction opposite to the direction the head will tend to move in case it draws under load. For example, if the strain on the nailed parts tends to pull the head down, then the point of the nail should be bent up; if the strain tends to bend the head to the right, then the point should be bent to the left.

75. Toenailing is done to fasten a piece that butts against another. Good judgment must be used in selecting the point to start the nail and

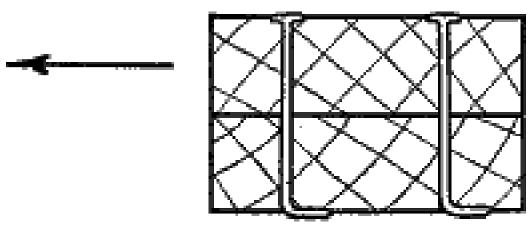

FIG. 73.—Clinched nails. If forces tend to move the top board to the left, then the points of the nails should be bent over to the right.

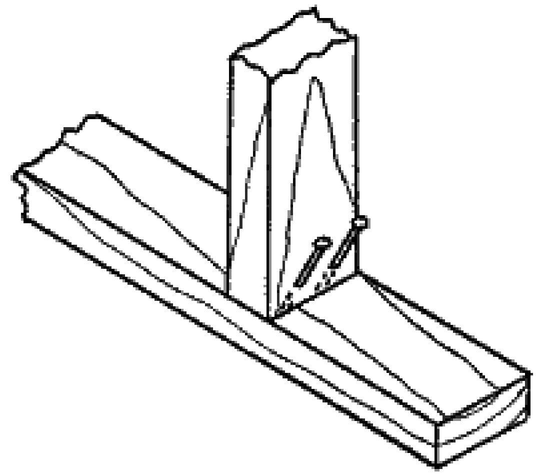

FIG. 74.—A toenailed joint. The nail should be started high enough to prevent splitting, and yet it should go deep enough into the second piece to hold securely.

the angle at which it is to be driven. The nail should get a good hold in the first piece without danger of splitting, and yet it should go deep enough into the second piece to insure good holding.

76. Setting Nails.—If the head of a finishing nail or a casing nail is to be set slightly below the surface, it is driven in the usual manner until the head is almost, but not quite, flush. The work is then finished with a nail

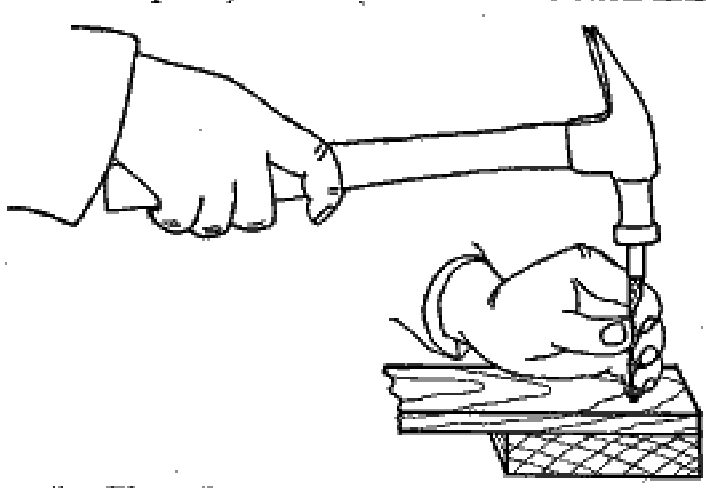

FIG. 75.—Setting a nail. The nail set can be kept in place on the nail head by steadying the hand on the board and by holding the tip of the little finger against the set.

set. A nail set resembles a small punch and has a cup-shaped point. Care must be exercised to keep the nail set from slipping off the nail. The set is held in the left hand, the top part being supported by the thumb and first fingers and the point being held on the nail head with the tip of the little finger. Nails are usually set about $\frac{1}{16}$ in. below the surface.

77. Draw Nailing.—Where it is desired to make a tight joint between two boards, as between two pieces of tongue-and-grooved flooring, the nail may be driven at an angle with the surface, as shown in Fig. 76. The nail then has a drawing effect as it is driven up, making a tight joint.

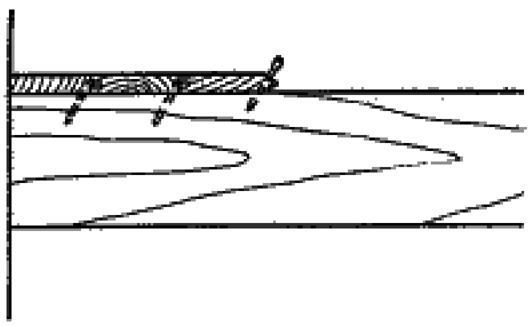

FIG. 76.—Draw nailing. Driving the nails at an angle helps to draw the boards tightly together.

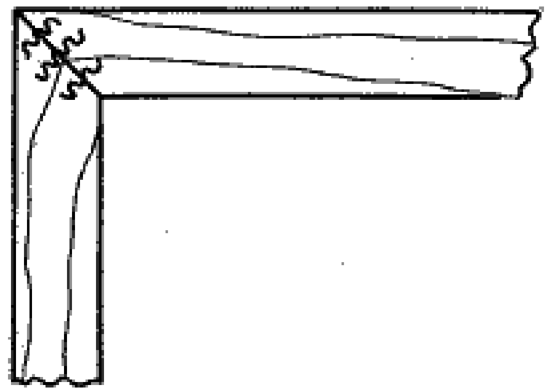

FIG. 77.—Corrugated fasteners used to strengthen a miter joint.

78. Corrugated Fasteners.—Corrugated fasteners can frequently be used to advantage in reinforcing joints such as miter joints and butt joints. They are especially good when used in end grain. In driving them, care must be exercised to drive them evenly and not to drive one end faster than the other.

FASTENING WITH SCREWS

Pieces of wood can be more securely and more permanently fastened together with screws than with nails. Yet pieces fastened with screws can be taken apart more easily and with less damage than if they had been fastened with nails. Fastening with screws, if done in a systematic and thorough fashion, can be done quickly and with excellent results. On the other hand, if slovenly, careless methods are used, much time will be wasted, and the work will likely be disappointing.

79. Sizes and Kinds of Wood Screws. *Shape of Head.*—The flat-headed screw is most commonly used in woodwork, although oval-headed

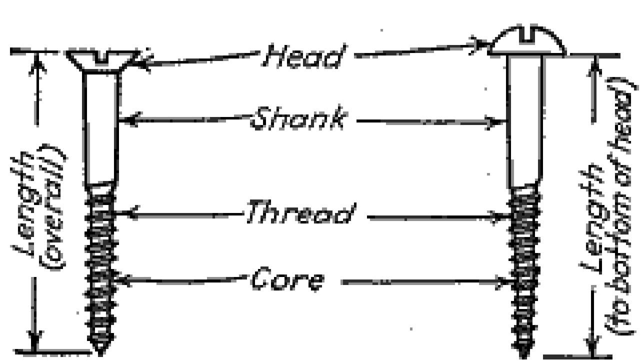

FIG. 78.—Parts of a wood screw

and round-headed screws are sometimes used, mainly for their ornamental effect.

The size of wood screws is designated by (1) the gage or size of wire from which they are made and (2) their length, measured as shown in Fig. 78.

Finish.—Steel screws without any special finish, designated simply as *bright*, were once commonly used in woodwork. Cadmium-plated, rust-proof screws are much better and are now more commonly used. Other common finishes are nickel plated and blued. Screws made of brass are also sometimes used. Brass screws are not so strong as steel screws, however, and more care must be exercised in driving them to prevent twisting them off.

In ordering screws, the size, kind, and finish should be completely specified, as 1½-in., No. 8, flat-headed, cadmium-plated wood screws. Screws are commonly sold in packages of 12 doz. (1 gross).

The names of the various parts of wood screws are shown in Fig. 78.

80. Lag Screws.—A lag screw might be described as a square-headed bolt, but pointed and with coarse threads to screw into wood instead of fine threads to receive a nut. Lag screws are used where ordinary wood screws would not be strong enough. The size of lag screws is designated by the diameter of the unthreaded portion near the head and by the length.

81. Sizes of Holes to Drill for Screws.—Whenever pieces of wood are to be fastened together with screws, holes should always be drilled as shown in Fig. 79. The holes through the first piece should be the same size as the shank of the screw, or a little larger; and the pilot holes in the second piece should be the same size as the core or body of the screw under the threads, or slightly smaller. The pilot holes should go nearly as deep as the screws will go if the wood is hard, or if the screws are large, or if they are made of soft metal like brass. If the wood is soft and if medium to small screws are used, the pilot holes should be drilled about half as deep into the second piece as the screws will go. Sometimes when very short screws are used and the wood is soft, the holes in the second piece may be made with an awl. If there is doubt as to the size of drills to use, it is a good plan to drill holes in scrap material and try the screws in them before drilling holes in the work. Table I will serve as a guide in selecting the proper sizes of drills for different sizes of screws.

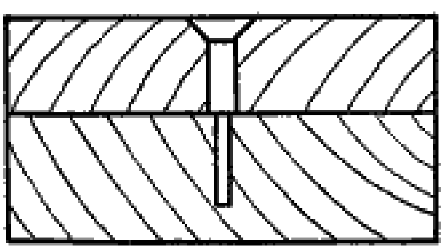

FIG. 79.—The hole through the top piece should be the size of the screw shank. The pilot hole in the lower piece should be the size of the core of the screw and in general should go nearly as deep as the screw will go.

82. Locating and Drilling the Holes.—The locations for the holes in the first piece should be accurately marked, usually first by the intersection of cross lines, and then by a deep *mark* or depression made with an

TABLE I.—SIZES OF HOLES TO DRILL FOR WOOD SCREWS

Screw size	Size of first hole (shank), 32ds in.	Size second hole (thread), 32ds in.
2	3	2
3	4	2
4	4	2
5	4	3
6	5	3
7	5	4
8	6	4
9	6	4
10	6	4
11	7	5
12	7	5
13	8	6
14	8	6
15	9	7
16	9	7

awl. The mark should be large to keep the drill from *wandering* when it starts to turn. The holes should be drilled through the first piece before

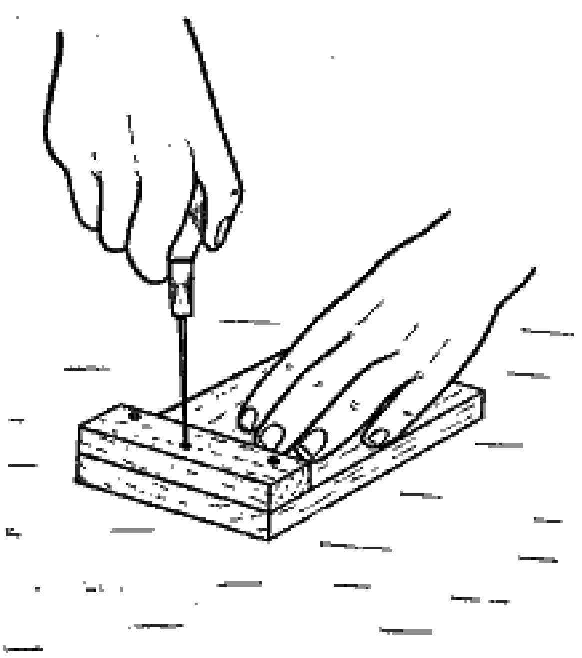

FIG. 80.—Marking the locations for pilot holes in the bottom piece, using the top piece as a template for guiding the awl.

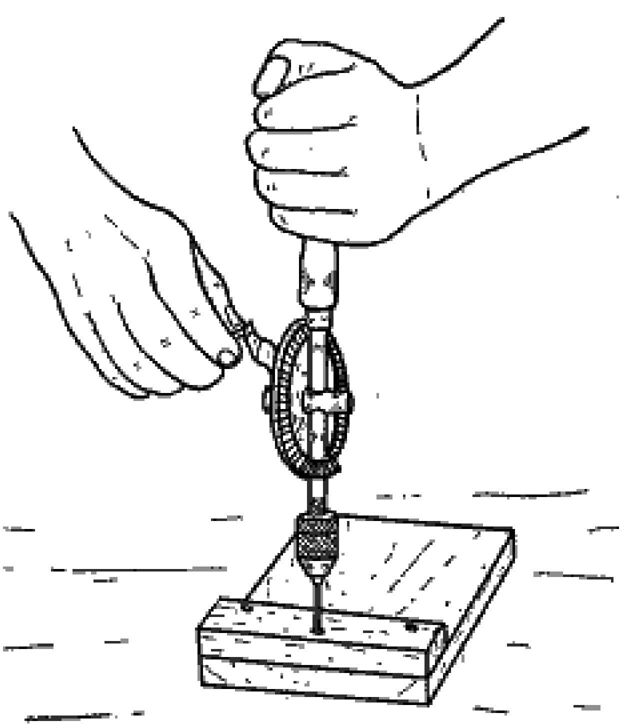

FIG. 81.—After one or two screws are driven, then the remaining pilot holes in the bottom piece are easily drilled by using the holes in the top piece to guide the drill.

marking the locations for the holes in the second piece. The first piece may then be used as a guide or template and the holes in the second piece marked through the holes in the first piece, with a pencil, a nail, or an awl; or if the two pieces can be held in alignment in a vise or clamp, the locations for the pilot holes need not be marked but simply drilled, using the holes in the first piece to guide the drill.

Where several screws are used to hold two pieces together, it is sometimes possible to drill one or two pilot holes and set the screws in these holes up tight before drilling the pilot holes for the remaining screws. The other pilot holes can then be drilled with ease by using the holes in the first board as guides.

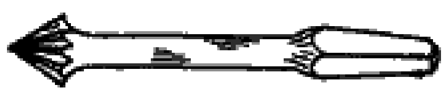

FIG. 82.—A common type of countersink used for countersinking flat-headed screws.

83. Countersinking.—When flat-headed screws are used, the holes should be countersunk to allow the heads to come down flush or slightly below the surface. A common mistake is to countersink too deep. Holes for oval-headed screws are also countersunk. Countersinks are commonly made with square tapered shanks and are used in bit braces.

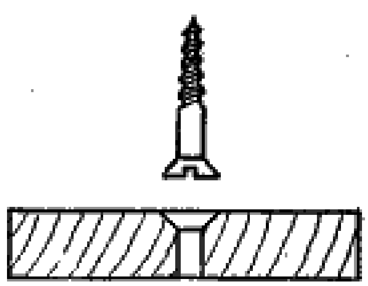

FIG. 83.—Trying the screw upside down in the countersunk hole will indicate whether the countersunk portion is deep enough.

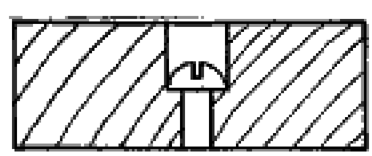

FIG. 84.—Counterbored holes may be used to sink round-headed screws below the surface.

Sometimes when round-headed screws are used, the holes are counterbored to sink the heads below the surface.

84. Using the Screw Driver.—The screw driver should be properly dressed and of a size that fits the screws. (See page 104 for methods of dressing screw drivers.) A screw-driver tip that is rounded or beveled may slip from the slot and mar the work and the screw head. A screw driver that has a blade that is too wide will roughen or tear the wood around the screw head. In using the screw driver, the handle should be grasped firmly in the right hand with the palm resting on the end of the handle and the thumb and first finger extending along the handle. While the right hand gets a new grip on the handle for the next turn, the screw driver should be held steady with the left hand and kept in the slot in the screw head.

If the screw turns too hard, it indicates that the pilot hole is too small or not deep enough, or that possibly the shank hole is too small. The screw should be removed and the trouble remedied. If this is not done, the screw may twist off, or split the board, or the screw driver may slip from the slot and mar the work or the screw head. A little soap, oil, or

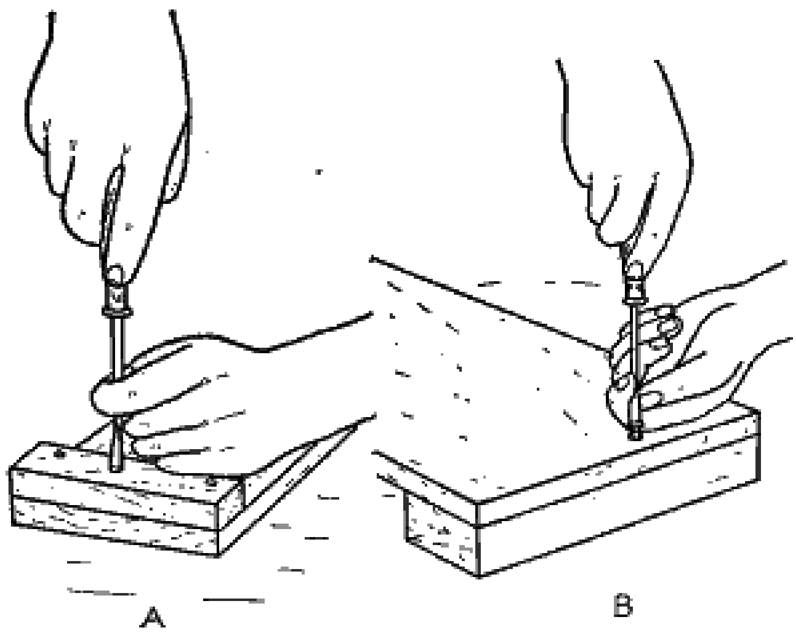

FIG. 85.—Two good methods of using the screw driver. While the right hand gets a new grip on the handle for the next turn, the left hand holds the bit steady and keeps it in the screw slot.

wax applied to the threads of the screw will make it go into the hole more easily.

85. Using the Screw-driver Bit.—Where several screws are to be driven, particularly large screws, a screw-driver bit in a brace makes for faster and easier work. Such a bit is simply a screw driver that, instead of having a handle, has a square tapered end that fits into a brace. Care should be exercised when using the screw-driver bit to keep it from slipping out of the slot and marring the wood and possibly the screw head also. The bit is more easily kept in the slot if the ratchet on the brace is used or if the crank is backed up slightly every quarter or half turn.

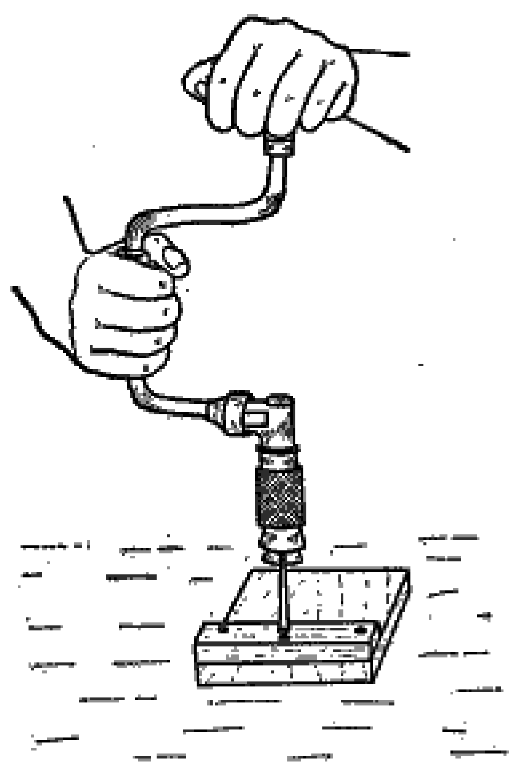

FIG. 86.—Driving screws with the screw-driver bit. Backing the crank a little every quarter or half turn helps keep the bit in the screw slot.

GLUE AND GLUING

86. Kinds of Glue.—There are two general kinds of glue: hot glue and cold glue. The hot kind must be heated carefully and applied hot, while cold glue may be bought in cans ready to apply. Ready prepared cold glue is probably better for the farm shop because of the greater convenience.

Glue should be used in accordance with directions on the container. In cold weather it is generally best to warm the glue by placing it in hot water for a while before using. If the glue is too thick, owing to evaporation from a can that was not tightly sealed, it should be thinned with alcohol or other thinning material that may be recommended in the directions on the can.

87. Applying Glue.—Be sure that the parts to be glued fit properly, and that all clamps, material, and equipment are in readiness before applying the glue. The glue should be applied thoroughly to all parts and brushed or otherwise worked well into the pores and grain of the wood. It is a common tendency of beginners to apply too much glue. If the joint is a movable one, rub one piece back and forth over the other to thoroughly distribute the glue and work it into the pores.

88. Clamping Pieces Together.—Once the glue is applied, the pieces should be securely clamped together and allowed to stand until the glue has hardened. If regular cabinetmaker's clamps are not available, clamps may be improvised by using the vise, or the bench top and wedges, or by twisting wire or rope.

If two or more boards are to be glued edge to edge to form a wider piece, the edges must be very carefully jointed, that is, made straight and square with the working surfaces of the boards. If the boards are to be planed after gluing, they must be so placed that the grain will run the same way in all of them. If the grain should run one way in one board, and the opposite in the adjoining one, it would be impossible to plane one smooth without roughing up the other.

Glued joints are generally reinforced by the use of dowels or corrugated fasteners, or both.

89. Doweling.—A doweled joint is one in which the pieces are held together by round wooden pins called *dowels*. Figure 87 illustrates a

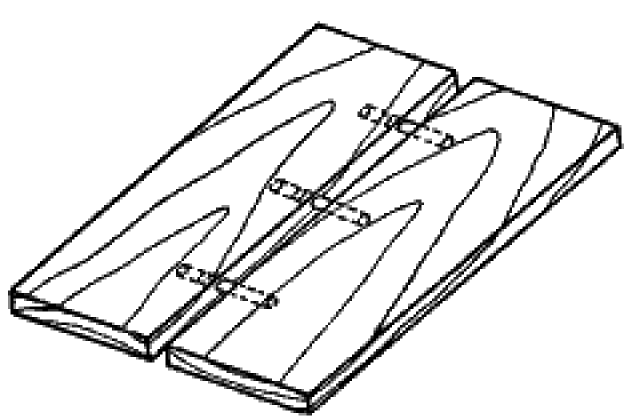

Fig. 87.—A doweled joint ready to be glued and assembled.

typical doweled joint. Dowels may be bought, or they may be made by splitting some straight-grained wood and planing or whittling roughly to size, after which the pieces are driven through a round hole in a piece of steel called a *dowel plate*. The holes in a dowel plate are tapered slightly, and the wooden pieces are driven through the small end of the hole first to prevent binding. It is a good practice to drive the piece of wood first through an oversize hole in the dowel plate and finally through a hole of the required size.

A dowel plate can be easily made by drilling holes of the desired size, usually 5/16 to 1/2 in., in a piece of steel and reaming them slightly with a tapered reamer or with a round file if the work is done carefully. Care must be taken in reaming not to enlarge the hole on one side of the plate.

90. Locating and Boring Dowel Holes.—In using dowels it is very important that the holes be accurately located and bored so as to match, and that the holes be bored perpendicular to the surface. If two boards are to be fastened edge to edge by doweling, they should be clamped together in the vise with the edges to be joined even and with the working surfaces out. The dowel holes are then located by squaring across the edges with a try square and a knife, and by gaging about half the thickness of the pieces from the working surfaces.

Dowel holes are then bored the same size as the dowels. They generally need not be over 1 in. deep. The mouth of the holes should be countersunk slightly. The dowels should have their ends trimmed or pointed very slightly, and each one should have a small groove cut lengthwise in it with a knife or saw, to allow the air and excess glue to escape when it is forced into place.

Questions

68. (*a*) Name two different kinds of nail hammers. (*b*) What are the advantages of the two kinds? (*c*) How is the size of a hammer designated?

69. (*a*) How are nails made? (*b*) Name and describe a few of the more common kinds of nails. (*c*) How is the size of nails designated?

70. (*a*) Explain and be able to demonstrate just how to start a nail and drive it properly. (*b*) What trouble is likely to be encountered if dirt is allowed to get on the striking face of the hammer?

71. (*a*) What are some of the common causes of splitting when nails are driven? (*b*) How may nails be treated to prevent splitting thin boards?

72. (*a*) Explain and be able to demonstrate just how to pull nails with a hammer. (*b*) What is the purpose of using blocks under the hammer head when pulling nails? (*c*) How may a nail be pulled when the hammer claws cannot be slipped under the nail head?

73. What points should be observed in locating nails in a nailed joint?

74. State a principle to be observed in clinching nails to give increased holding power.

75. (*a*) What is toenailing? (*b*) What difficulties are likely to be encountered in toenailing if the workman is not careful, and how may these difficulties be prevented?

76. (*a*) What is meant by "setting" nails? (*b*) Describe and be able to demonstrate the method of holding a nail set on a nail.

77. (*a*) What is draw nailing? (*b*) Give an example of its use.

78. (*a*) Give examples of the use of corrugated fasteners. (*b*) What precaution should be observed in driving them?

79. (*a*) Name common kinds of wood screws, classified according to shape of head and finish. (*b*) How is the size of wood screws designated?

80. (*a*) What is a lag screw? (*b*) How is the size of lag screws designated?

81. (*a*) How large a hole should be drilled through the top or first piece when fastening two pieces of wood together? (*b*) How large a hole should be drilled into the second piece, and how deep should it be drilled?

82. (*a*) Why is it important to start a drill in an awl hole? (*b*) Describe and be able to demonstrate different ways of easily locating and drilling the pilot holes in the second board to receive screws.

83. (*a*) What kind of screws require countersinking? (*b*) What is a common mistake in countersinking, and how may it be prevented? (*c*) What is the difference between countersinking and counterboring?

84. (*a*) What troubles are likely to be encountered in using a screw driver that is poorly fitted or of wrong size? (*b*) Explain and be able to demonstrate a good method of holding and using a screw driver. (*c*) What should be done in case a screw turns too hard?

85. (*a*) What advantages has a screw-driver bit used in a brace over an ordinary screw driver? (*b*) Why is it better to use the ratchet device on the brace and advance the screw by part turns rather than complete continuous turns?

86. (*a*) What kind of glue is generally best for the farm shop? (*b*) What material may be used for thinning glue?

87. (*a*) What preparations should be made before applying glue? (*b*) How may glue be worked well into the pores of wood?

88. (*a*) In the absence of cabinetmaker's clamps, how may boards be held together after glue is applied? (*b*) What precautions should be taken in assembling boards so they may be planed after gluing?

89. (*a*) What is a dowel? (*b*) How may dowels be made? (*c*) How may a dowel plate be made in the farm shop?

90. (*a*) Describe and be able to demonstrate the process of locating and boring holes for dowels. (*b*) What treatment should dowels receive before glue is applied and before they are inserted in the holes? Why?

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CHAPTER VII

USE OF MODELING OR FORMING TOOLS; SHAPING CURVED AND IRREGULAR SURFACES

Although many appliances, like hammer handles, sledge handles, single trees, and neckyokes can generally be purchased as cheaply as they can be made in the farm shop, if the time required to make them is considered, it frequently happens that valuable time in a rush season may be saved and the inconvenience of delay avoided by being able to quickly renew such broken parts. Also, at certain seasons of the year when the farmer's time cannot be put to other profitable use, he would enjoy making his own tool handles and other similar appliances, even though their cost if bought would be small. It would, therefore, seem advisable for the student of farm shopwork to acquire reasonable proficiency in the use of modeling and forming tools in making curved and irregular-shaped appliances of wood.

91. Using the Drawknife.—The drawknife is very useful in shaping curved surfaces, especially where considerable waste stock is to be

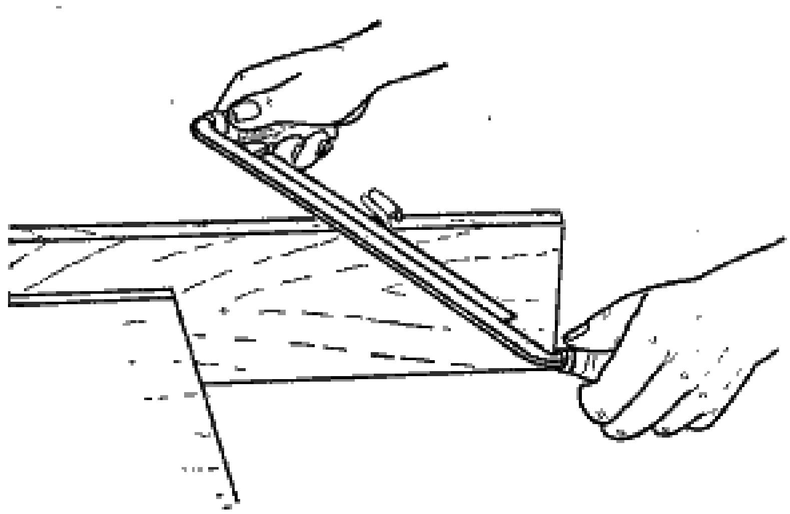

Fig. 88.—Trimming with a drawknife. Moving the blade with one handle slightly ahead gives an oblique cutting action that enables the workman to control the tool better.

removed, as in tapering a piece to make an implement tongue, or in making teeth for a sweep rake.

To use a drawknife the work should be clamped in the vise or otherwise securely held. Both hands are used to pull the knife, care being taken not to trim or cut against the grain. The beveled side of the knife is usually kept up, as in this position it can be better controlled and guided. Moving the blade with one end slightly ahead of the other gives an oblique or sliding cut and enables the workman to more easily cut to a line.

92. Hewing.—Hewing with a hand ax or hatchet, or even with a chopping ax, is often the fastest way of removing a large amount of excess stock. A higher degree of skill is required to do good work with an ax, however, than with a drawknife. In hewing, the surface is first deeply cut or hacked every inch or two with the ax, striking the surface at an angle of 45 to 60 deg. Then the roughened waste is removed with the

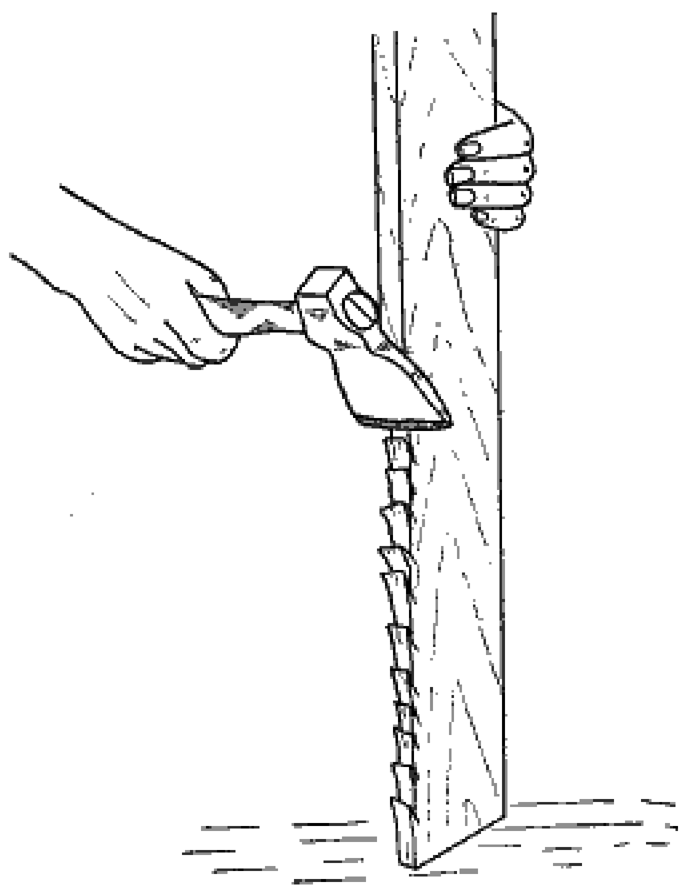

Fig. 89.—In hewing, the surface is first deeply hacked and then the roughened waste is removed with light, well-directed strokes.

blade striking the surface at a very small angle. A hand ax with a single bevel, being flat on one side, is best for hewing. As in all other cutting operations on wood, hewing should be done with the grain and not against it.

93. Using the Spokeshave.—The spokeshave is used for planing curved and irregular surfaces. Its action is very much like a plane, and the blade is sharpened and set in much the same manner. Best work can be done with the blade set to give a thin shaving. Being very short, the spoke shave can follow rather abrupt turns or curves. It may be operated either by pushing or by pulling. Keeping one handle slightly ahead of the other gives an oblique or sliding cut and thus gives better control of the tool.

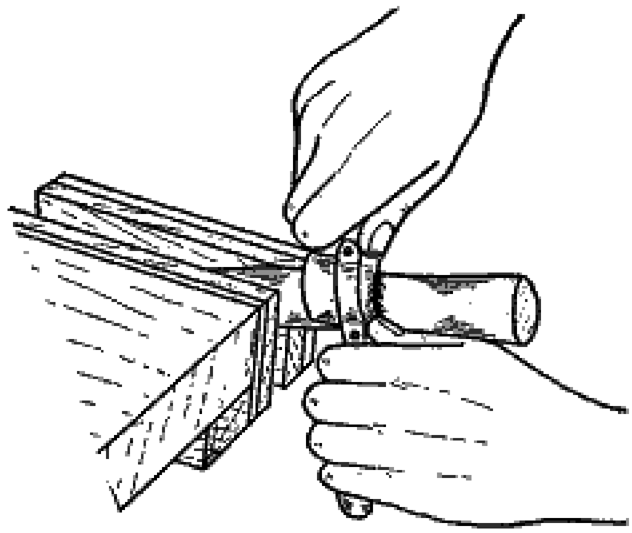

FIG. 90.—The spokeshave acts like a very short plane and is used for planing curved surfaces.

94. Use of Files and Rasps.—The wood rasp is valuable for removing waste in forming curved and irregular surfaces. The "half-round" rasp, or one having a flat surface on one side and a curved surface on the other, is usually preferred. The rasp cuts faster than a wood file but leaves a rougher surface. After using a rasp the surface may be smoothed with a file or a spokeshave. The rasp should be used much like a file, that is, with long, steady strokes, so that it may be better controlled. A reasonably coarse file, such as a flat bastard file or a woodworker's file is usually preferred for filing wood.

95. Sawing Curves.—*The compass saw* is useful in sawing curves, especially inside curves where the cut must be started in a hole bored with an auger bit. In making abrupt turns with the compass saw, it is best to use short strokes and do the sawing near the point of the blade where it is narrow. Care should be exercised to prevent catching the blade and bending it. The sawing should be done with the cutting edge perpendicular to the surface and not at an angle as in sawing with other saws. In sawing curves it is best to leave about $\frac{1}{16}$ in. to be removed with other tools, such as the spokeshave or file, as it is difficult to saw exactly to the line and leave a smooth cut.

The coping saw has a light, thin, short blade held in a frame and is used for sawing curves in light work. The blade may be inserted so as to cut on the pull or on the push stroke. Cutting on the pull stroke is less apt to kink or break the blade. Long strokes should be used to prevent overheating the blade.

Sawing with a coping saw can best be done by holding the work level, allowing it to project over the bench top or supporting it in a "saddle" or V-shaped bracket held in the vise as shown in Fig. 92*B*. The sawing is then done with the handle below the work, the blade being inserted to cut on the pull or down strokes.

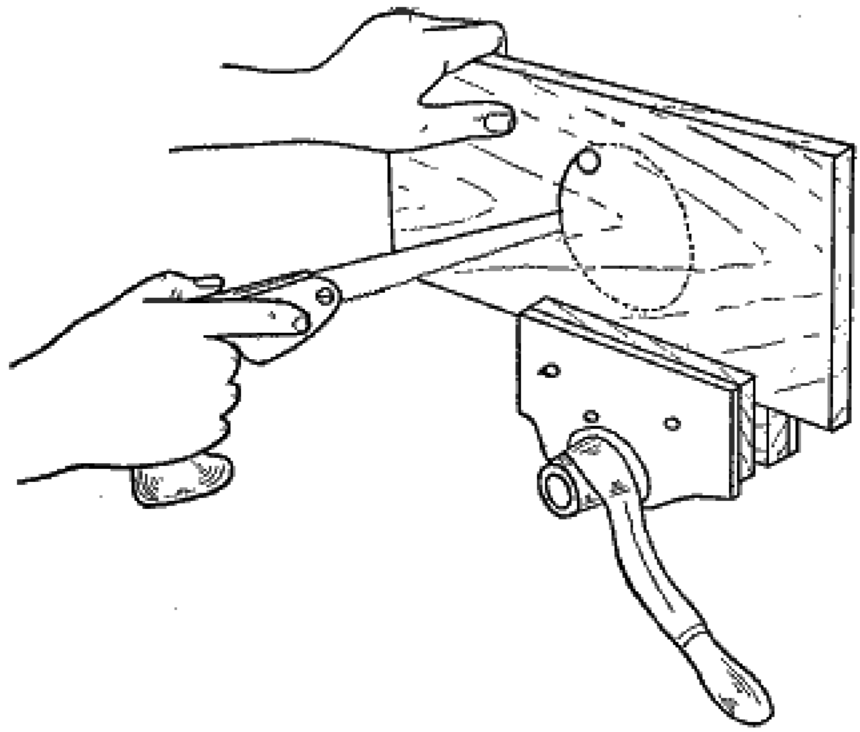

FIG. 91.—The compass saw is used for sawing curves.

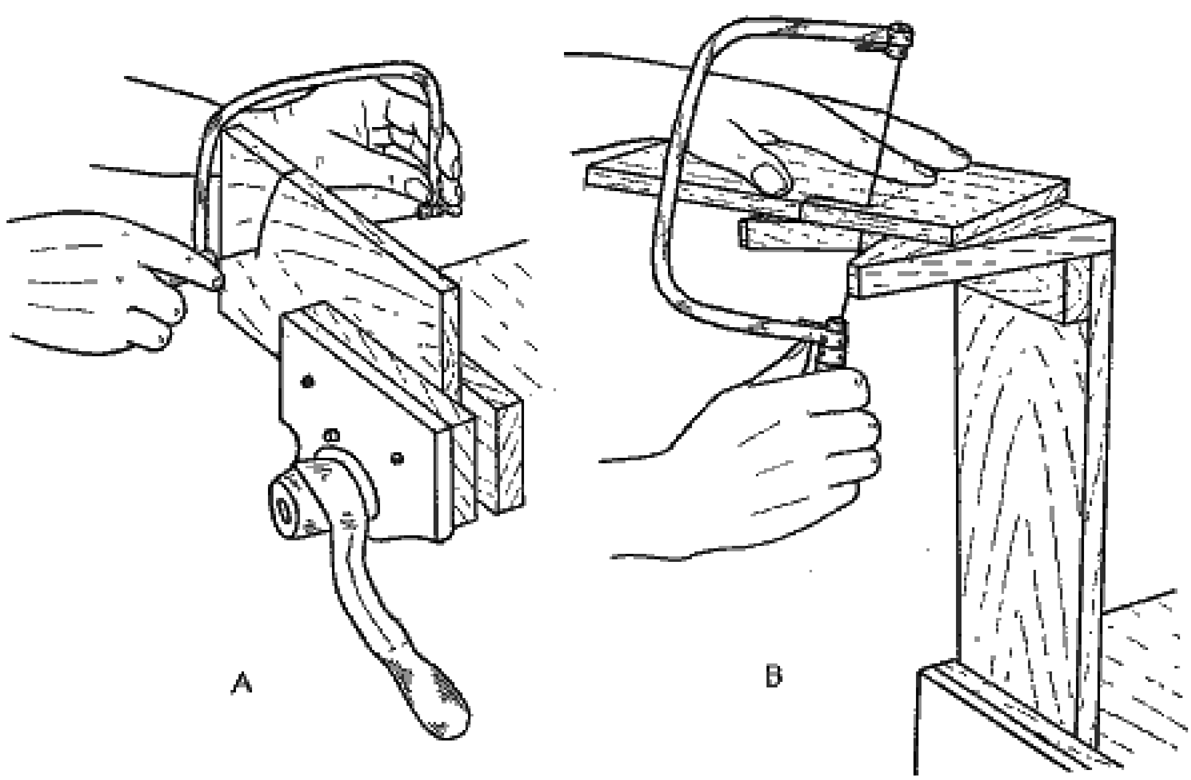

FIG. 92.—The coping saw is useful for sawing curves in light work. Although the work may be held in a vise, as at *A*, it is usually better to use a bracket or saddle, as at *B*, with the blade inserted in the saw frame to cut on the down stroke.

When the sawing has progressed as far as the frame of the saw will permit, it is frequently possible to turn the blade a quarter turn in the frame and saw farther.

96. Planing a Piece Round.—To make a cylinder, such as a round handle for a vise, or a round peg, the first step is to square up a piece of wood of the desired length, making it square in cross section. An octagon is then marked out on the end of the piece, by marking from each corner a distance equal to one-half the diagonal (see Fig. 93*B*). The lines are extended along the sides of the piece the full length with a marking gage or with a straightedge and pencil. The corners are then planed off, making the piece eight-sided. Each one of the eight corners is then planed off about the same amount, making the piece 16-sided, and the process is continued until the piece is practically round. Final smoothing may be done with sandpaper, rubbing the paper lengthwise of the piece.

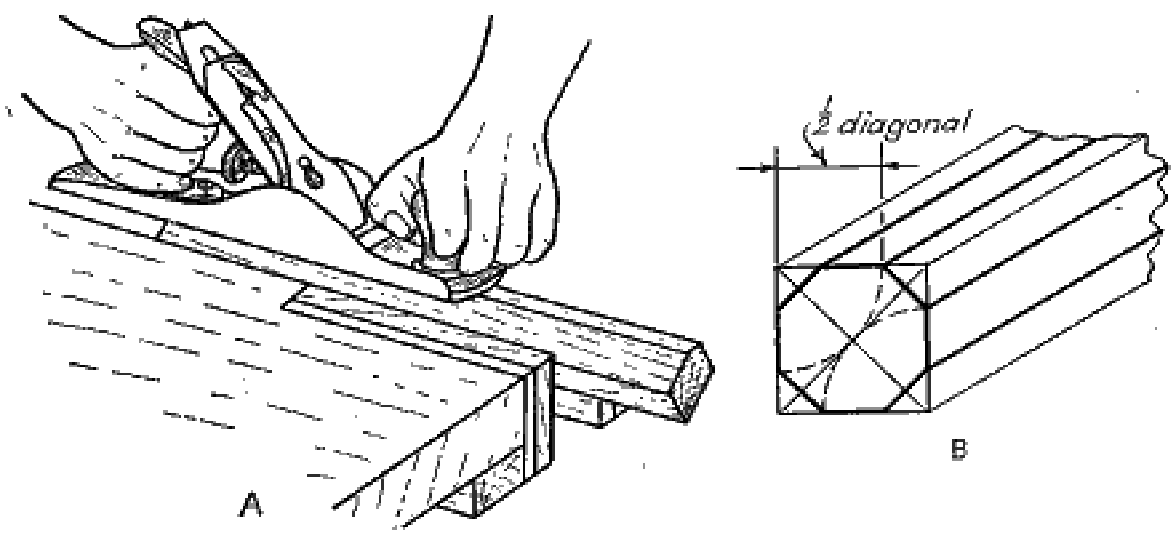

FIG. 93.—*A*. By careful work a cylinder may be easily made with a plane. First make it square, then eight-sided, sixteen-sided, and finally round.
B. Method of marking an octagon on the end of a square stock preparatory to planing it eight-sided.

The pocketknife is an invaluable tool for light cutting or whittling on curved or irregular surfaces. It can frequently be used in places where it would not be possible to use other cutting tools. For best work it should, of course, be kept sharp (see page 93 for method of sharpening). The same principles apply to the use of the pocketknife as to other cutting tools, the main one being to cut with the grain wherever possible and not against it. Moving the blade obliquely, that is, with one end slightly ahead of the other, makes the work easier and enables the workman to cut better to a line.

97. Shaping Curved Surfaces.—In making curved objects as a hammer handle, the workman will need to rely upon his judgment much more than in making objects with flat surfaces. With curved surfaces it is difficult or impossible to always work to lines. Most articles with curved and irregular surfaces can best be made, however, by squaring up a piece of stock just large enough to make the article. Curves and tapers on two edges, say top and bottom, are laid out and made, using such tools as the drawknife, spokeshave, rasp, or file (see Fig. 94). These curved surfaces should be made square with the sides.

Curves and tapers on the other two sides are then laid out and made. The corners are then rounded and the piece finished with such tools as

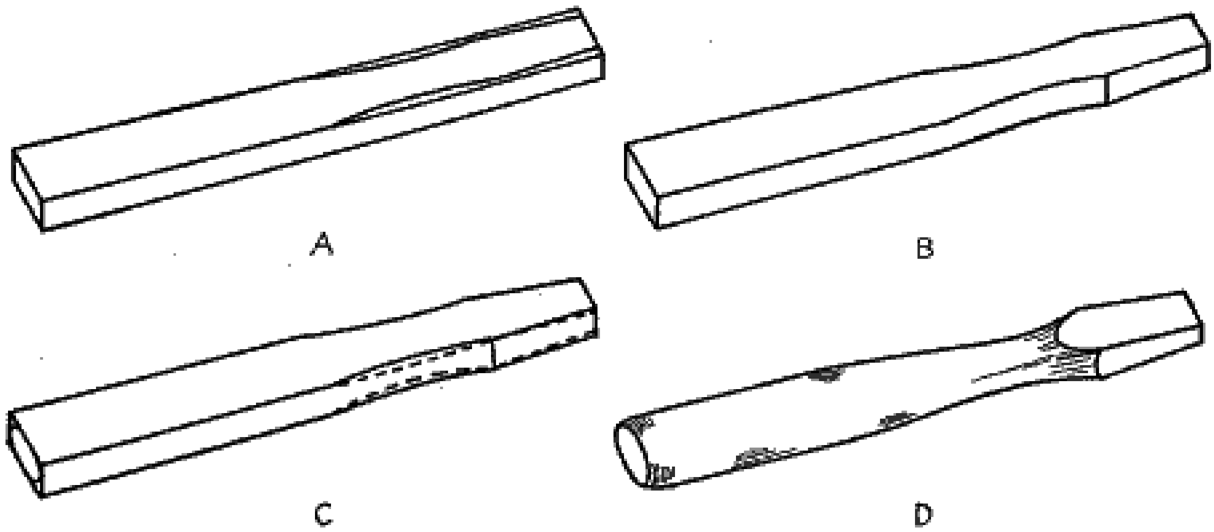

FIG. 94.—Steps in making a hammer handle.

the spokeshave, scraper, and sandpaper. If a steel scraper is not available, the sharp edge of a piece of broken glass may be used as a very acceptable scraping tool on irregular surfaces. In sandpapering a curved surface the paper is held in contact with the wood with the hand or fingers, no block being needed as in sandpapering a flat surface.

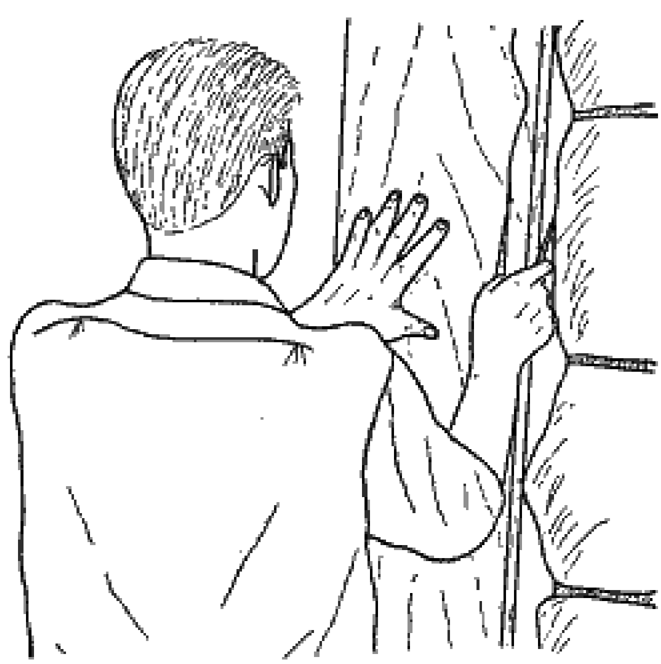

FIG. 95.—Marking a board to fit against an irregular rock wall. By means of the dividers, a mark is made on the board parallel to the surface of the wall.

98. Fitting a Board against an Irregular Surface.—The edge of a board may be marked to fit an irregular surface, as a stone wall, by holding the board firmly beside the wall, and scribing with a compass or pair of dividers, as shown in Fig. 95. One leg of the compass is moved down along the surface of the wall, and the other leg marks off a line parallel to the surface. The legs of the compass should be set apart a distance a little greater than the width of the largest space between the board and the wall. The board can then be cut to the line with such tools as the saw, chisel, and drawknife.

Questions

91. (*a*) For what kinds of work is the drawknife especially good? (*b*) What are some of the points to be observed in order to work best with the drawknife? (*c*) Should it be used with the beveled edge up or down?

92. Describe a good method of handling a hand ax in hewing.

93. (*a*) For what kind of work is the spokeshave used? (*b*) State points to be observed in its use to insure good work.

94. (*a*) For what kind of work is the wood rasp particularly good? (*b*) What other tools usually need to be used in conjunction with the wood rasp? (*c*) What kind of strokes should be used in working with a rasp? Why?

95. (*a*) In what ways is a compass saw handled differently than an ordinary cross-cut or ripsaw? (*b*) For what kind of work is a coping saw especially good? (*c*) What precautions should be observed in using a coping saw? (*d*) How is a coping saw used in connection with a "saddle" or bracket?

96. (*a*) What are the steps in the process of making a cylinder, using only hand tools? (*b*) How may an octagon be easily marked out?

97. Outline the process of making an irregular-shaped piece like a hammer handle.

98. Describe an easy method of marking the edge of a board to fit against an irregular stone wall.

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CHAPTER VIII

PAINTING, FINISHING, GLAZING

Although it may not be practical for the farmer to paint his larger buildings himself, he will find it profitable to paint some of his smaller buildings and many pieces of farm equipment.

99. Composition of Paint.—Paint is composed essentially of a pigment, such as white lead, and a vehicle, such as linseed oil. Upon drying, the vehicle forms a tough leathery film that binds the particles of pigment together and to the surface being painted. Under certain conditions, a thinner, generally turpentine, is added to paint to make it spread more easily and penetrate better. A drier is also added to the vehicle to make it dry more rapidly.

Raw linseed oil is generally used in outside paints, and boiled oil, which dries more rapidly, is commonly used in inside paints.

100. Ready-mixed Paint.—For the smaller paint jobs on the farm it is better to use ready-mixed paints made by a reliable company than to purchase the materials and mix them at home. The market offers a wide variety of paints for special purposes, and, when made by a reliable company and applied according to directions, they give more satisfactory results than home-mixed paints in the hands of anyone not an experienced painter.

101. Painting Weather.—Almost any time from April to November when it is warm and dry and not too windy or dusty is suitable for painting. A temperature of between 65 and 80° is best, and painting should not be done when the temperature is below 50°. Not only the surface to be painted, but the wood clear through should be thoroughly dry.

102. Selection of Brushes.—A 3½- or 4-in. brush is commonly used for painting large surfaces. The bristles should not be too long, not much over 4 in. long, for inexperienced painters. A flat brush 3 in. wide is a good size for painting trim, and a sash brush 1 or 2 in. wide is good for painting windows. For varnishing, use a good-quality brush that has never been dipped in paint.

103. Care of Brushes while in Use.—A brush should never be allowed to rest upright on its bristles. If you stop work for a few minutes, remove the surplus paint from the brush by wiping on the edge of the pail, and then lay it flat, across the top of the pail or on some smooth, clean surface. If the work is stopped for a longer time—overnight or a few days—the brush should be suspended in a can of turpentine and raw linseed oil in the case of paint brushes; or in turpentine or paint thinner in the case of varnish brushes. This can best be done by drilling a small hole through the handle and hanging it on a small wire hook on the side of the can, so that the bristles are covered by the liquid and yet do not touch the bottom of the can.

104. Cleaning and Storing Brushes.—When you have finished painting or varnishing, clean the brush out thoroughly with turpentine, benzene, gasoline, or kerosene, and then wash with warm soapsuds. Then shake the brush well and, while still damp, wrap in heavy paper and lay it away or hang in a dry, cool place.

Old neglected brushes can generally be reclaimed by soaking in paint remover and then washing in turpentine, alcohol, gasoline, or benzene. It is practically impossible, however, to thoroughly reclaim such a brush and do first-class work with it.

105. Preparing the Surface for Painting.—In addition to being dry, the surface to be painted should be clean—that is, free from mud, dust, grease, plaster, smoke, rust, or old loose, scaly paint. Usually a wire brush, putty knife, and dusting cloth or brush are the only tools needed for cleaning. Sometimes a surface will need to be washed with soap and water, or, if greasy, with gasoline, and then allowed to dry thoroughly. Sandpaper can sometimes be used to advantage on a rough, dirty surface.

106. Preparing Ready-mixed Paint for Use.—When paint stands for some time in a container, the heavier materials settle to the bottom. The paint will, therefore, need to be thoroughly mixed and stirred. Directions for mixing and stirring, as well as directions for addition of other materials, such as linseed oil or turpentine, are usually printed on the label of the container. These directions should be carefully followed.

107. The Priming Coat.—Linseed oil or turpentine, or both, should usually be added to paint for the priming or first coat. Oil quickly soaks into wood, and enough must be provided to properly bind the particles of pigment together on the surface as the paint dries. Otherwise the paint will not form the desired tough leathery film, but will likely become chalky and dust off, or scaly and peel off.

For new lumber that is sappy or resinous, the priming coat should have enough turpentine to partly dissolve the natural wood oils and allow the paint to penetrate. Turpentine is also added to the first coat applied over hard paint in order to partly dissolve the hard surface and thus make a better bond between the old and the new paint.

The amount of linseed oil and turpentine to add to the paint for the priming coat can be determined by reading the directions on the container, or, in the absence of specific directions, the following may be taken as a guide as to the amounts to add per gallon:

Surface	Raw linseed oil	Turpentine
New pitchy lumber	1 pt.	1 qt.
New clear lumber	1 qt.	1 pt.
Old painted surfaces, fair to bad	2 qts.	0
Hard, flinty painted surfaces	0	1 pt.
Painted surface in good condition	0	½ pt.

108. The Second Coat.—After the priming coat has dried clear through, which usually requires from 4 to 6 days, the second coat may be applied just as it comes from the can, if only two coats are to be applied. If three coats are to be applied, a little turpentine, about ½ pt. to the gallon, should be added to the second coat to keep it from drying with too much gloss and to form a better foundation for the third coat.

109. The Third Coat.—Three coats are recommended on new work and also on old work where the painting has been neglected for a long time. The second coat usually requires from 1 to 2 weeks to dry clear through. The third coat usually should be applied just as it comes from the can except possibly for the addition of a very small amount of turpentine in cool weather. Too much turpentine will cause the surface to be dull instead of glossy upon drying.

110. Handling the Paintbrush.—The brush should be held firmly but lightly, with the long part of the handle resting in the hollow between the thumb and the first finger, and with the ends of the thumb and fingers just above the ferrule. The fingers should not extend down on the bristles.

The bristles should be dipped into the paint about one-third of their length, and then the excess paint removed by gently tapping the brush against the side of the pail or by wiping over the inside edge of the pail. The paint should be applied to the surface with long, sweeping strokes, usually with the grain, and the strokes should be *feathered*, that is, the brush should be brought down against the surface gradually at the beginning of the stroke and lifted gradually at the end of the stroke. The paint should be brushed out well to form a thin even coating.

111. Painting Troubles.—*Blistering* occurs on newly painted surfaces and is caused by moisture in the wood. As the moisture comes out of the wood, small bubbles or blisters, ranging in size from a pinhead to a quarter, form in the undried paint. As these blisters dry, the paint cracks and peels off. Blistering can be prevented by having the wood thoroughly dry before painting.

Peeling.—If paint is applied over wood that has some moisture in it, and the paint has a chance to dry before the hot sun strikes it, then when the hot sun does strike it, the moisture may expand and cause the paint to crack and peel off.

Peeling will occur also when the priming coat is not properly thinned with turpentine to cause good penetration. Trouble may also occur from the use of boiled linseed oil instead of raw linseed oil, in thinning the priming coat, which would cause too rapid drying and poor penetration.

Crawling.—When paint will not stay brushed out evenly on a surface, the condition is known as crawling. It is usually caused by painting over a glossy or greasy surface. In the case of grease, the surface should be washed with gasoline, and in the case of a glossy surface, it should be roughened by sandpapering. Crawling may sometimes be caused by painting at a temperature lower than 50°. Adding a little turpentine—from ½ to 1 pt. to each gallon of paint—is sometimes recommended under such conditions to stop crawling.

Running or Sagging.—This condition is caused by using too much oil in the paint. Upon drying, the excess oil forms a skin or scum that does not adhere perfectly to the surface but sags.

Checking.—Checking is the formation of a network of fine hairlines in the last coat of paint. The small checks or cracks do not extend all the way through the paint to the surface of the wood. This condition is caused by applying the last coat before the previous coat was thoroughly dried. The top coat dries and becomes hard before the under coat dries thoroughly. Then as the under coat dries and shrinks, the outer coat being harder cannot follow, and consequently, the checks or small cracks form.

Chalking, Spotting, Washing.—The deterioration of paint on a surface is due to the decay of the linseed oil, a vegetable product, in the paint. As the linseed oil decays, particles of mineral that it has held to the surface are loosened and eventually are removed from the surface by wind and rain. If the paint deteriorates or wears off in spots, it is most likely a result of unevenness in the wood. Some spots in uneven wood require more linseed oil than other spots, and, if enough has not been supplied in the priming coat, these spots will absorb oil from the following coats and not leave enough for the later coats to properly dry and harden. Paint on these spots will then become chalky and wear off or deteriorate much faster.

When the whole surface becomes badly chalked and the paint is easily removed by rain, it is called *washing*. Such a condition is usually due to a period of wet weather when the paint is drying. The paint absorbs considerable moisture from the air, which damages the oil, and then the mineral particles are easily loosened from the surface and removed.

112. Amount of Paint Required.—The number of square feet of surface a gallon of paint will cover varies considerably with the quality of paint, the condition of the surface, and the method of application, whether brushed out thin or not. Under average conditions a gallon will cover 500 to 600 sq. ft. one coat.

113. Painting Metal Surfaces.—Metal paints differ from wood paints in that they usually have a base of red lead instead of white lead, have somewhat less oil than wood paints, and use more drier. Implement paints also have some varnish in them to give a better and more durable wearing surface. It is very important that the surface be thoroughly cleaned of grease, old loose paint, or loose rust before applying the paint.

114. Staining.—Stains are used for coloring wood. They are available in a wide variety of colors and are of three general types, based upon the vehicle or carrier used, namely, water stains, alcohol or spirit stains, and oil stains. Oil stains, although usually more expensive, are probably the most satisfactory for general use. They are easily applied and do not raise the grain like water or spirit stains. An application of linseed oil alone makes a very desirable stain.

115. Varnishing.—A varnished finish makes a very attractive appearance and has good wearing qualities. The best varnishes are made of copal gum dissolved in linseed oil and turpentine. There are various grades and kinds of varnishes on the market, and, to insure best results, a varnish made for a particular purpose should not be used for other purposes. Interior varnishes cannot be expected to give good results when exposed to the weather. Varnishes should be thinned and applied in accordance with the directions on their containers.

Varnish should always be applied with a high-grade, clean brush that has never been used for anything except varnish. Varnish is sticky and slow in drying. Dust should therefore be kept down to a minimum around freshly varnished surfaces.

116. Enamels and Lacquers.—There is on the market a wide variety of enamels and lacquers that are especially suited to finishing inside woodwork and furniture. They are available in various colors, and, although the better grades are somewhat expensive, they produce finishes that are attractive and easily cleaned and wear well unless subjected to unusual wear and abuse. Enamels are made by grinding pigments in varnish and should therefore be handled and applied like varnish. Lacquers and quick-drying enamels have more volatile vehicles or solvents, and therefore dry more quickly.

117. Whitewashing.—Whitewash affords an inexpensive means of improving the appearance and lighting of barns, poultry houses, basements and similar places. It is sometimes used for painting fences and other outside surfaces, but for such purposes its poor wearing qualities make it much inferior to oil paints.

Common whitewash is composed of lime and water and may be applied either with a brush or a sprayer.[1] If desired, a disinfectant such as carbolic acid may be added to the whitewash.

118. Spray Painting.—Applying paint with a compressed-air paint gun is a quick and effective way of painting. Somewhat more skill is required, however, than with an ordinary paint brush. In using a spray gun, one should not attempt to apply too heavy a coat. Two thin ones are better than one heavy one. The gun should be moved along at a steady speed and at a uniform distance from the surface. With some practice, one can soon make feathered strokes and satisfactory laps. It is important that the gun be thoroughly cleaned immediately after painting is stopped. Benzene or turpentine are commonly used for cleaning after painting, varnishing, or enameling, and other suitable solvents or thinners are used after applying other materials.

GLAZING

119. Replacing Broken Window Glasses.—The first step in replacing a broken window glass is to remove all the pieces of the old glass, the glaziers points, and the old putty. The rabbet (groove) should be well cleaned and then coated with linseed oil, so that, when new putty is applied, it will not dry out too rapidly. If the rabbet is not smooth and level so that it will support the glass evenly, a little putty should be put in before the new glass is inserted.

After the new pane of glass is put into place, a few brads or glaziers points are driven in with a small hammer or the edge of an old wood chisel to hold the glass firmly. Putty is then applied to the rabbet and smoothed with a putty knife to seal the glass in place.

120. Cutting Glass.—Glass is "cut" by first scratching the surface with a glass cutter and then broken by applying pressure along the scratch. To cut glass it is cleaned and placed on a flat surface. A glass cutter is then drawn along a straightedge slowly and with even pressure, entirely across the glass from one edge to the other, making a good clean scratch all the way across. The pressure should not be too heavy or the glass will splinter. The glass cutter should not be run over the scratch a second time as it would injure the cutter. After scratching, the glass is broken by applying pressure up underneath the scratch (see Fig. 96). Another method of breaking is to place the glass, scratched side up, on a flat table top with the scratch at the edge of the top, and then apply pressure downward on the overhanging part.

[1] For directions for making special whitewashes, see *U.S. Dept. of Agriculture, Farmers' Bull.* 1452, Painting on the Farm.

A good way to get glass cut to exact size is to mark out the size on paper and then place the paper under the glass. The straightedge is then easily placed to guide the cutter exactly where it should go.

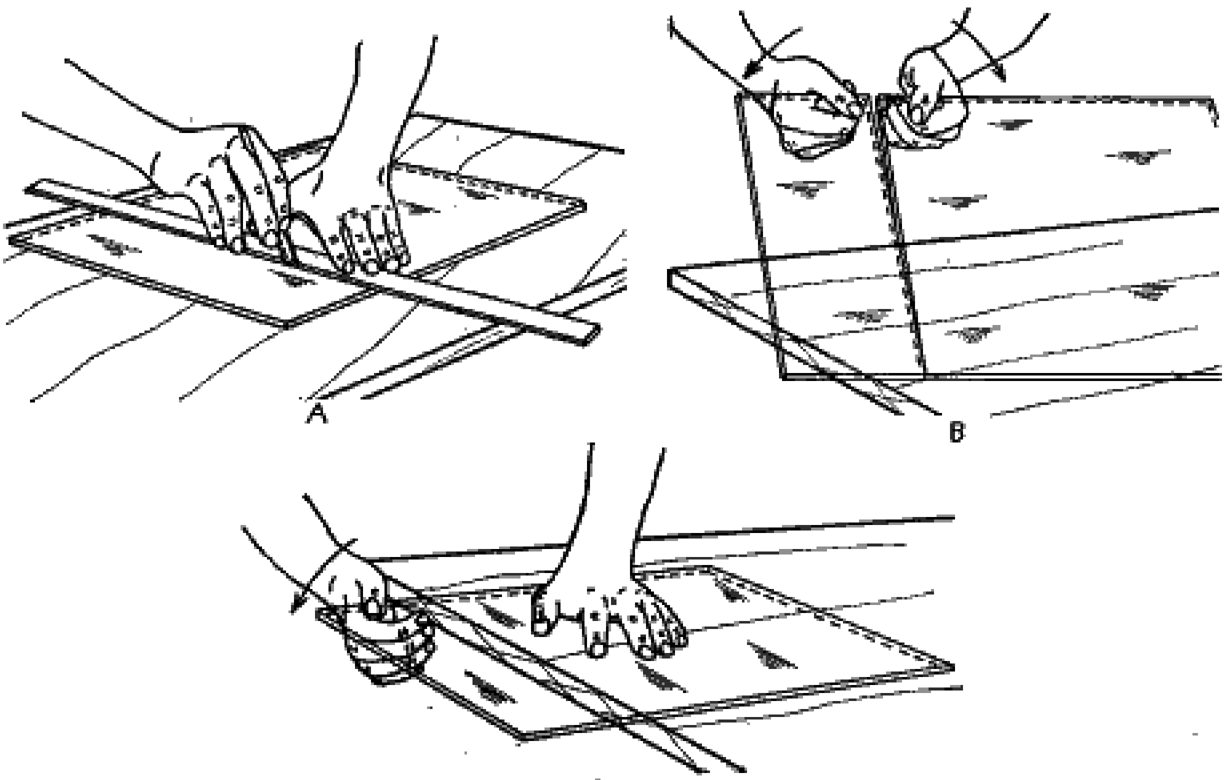

FIG. 96.—Cutting glass. The glass is first scratched by drawing the glass cutter along the straightedge, as at *A*. Firm moderate pressure is required. The glass is then broken by applying pressure with the two hands as at *B*, or by moving it to the edge of the bench, with the scratch exactly over the edge, and applying pressure down on the overhanging part as at *C*.

Questions

99. (*a*) What are the two main ingredients of paint? (*b*) How do these two ingredients act as the paint dries? (*c*) What are the purposes of thinners and driers when added to paint? (*d*) Under what conditions is boiled linseed oil used instead of raw oil in paint?

100. Under what conditions are ready-mixed paints generally more satisfactory than paints compounded and mixed on the job?

101. What kind of weather is best for painting?

102. What kinds and sizes of brushes are usually best for general painting on the farm?

103. (*a*) What care should a brush receive if painting is to be stopped for a few minutes? (*b*) If painting is to be stopped for several hours or a few days?

104. How should brushes be cleaned and stored?

105. What preparation should a surface receive before it is painted?

106. How is ready-mixed paint prepared for use on the job?

107. What material or materials are commonly added to ready-mixed paint for the first, or priming coat? Why?

108. (*a*) How long is usually required for drying of the priming coat? (*b*) What material is commonly added to the paint for the second coat, in case it is to be followed later by a third coat? Why?

109. (*a*) How long is usually required for the drying of the second coat? (*b*) What trouble may be encountered in case too much turpentine is added to the paint for the third or last coat?

110. (*a*) Explain and be able to demonstrate just how to hold a paint brush. (*b*) How deep should the bristles be dipped into paint? (*c*) What kind of strokes should be made with the brush?

111. Name some of the most common painting troubles and give their causes.

112. How may the amount of paint required for a building be estimated?

113. (*a*) In what respects is metal paint usually different from wood paint? (*b*) What special precaution should be observed before painting metal surfaces?

114. (*a*) What are the common kinds of wood stains? (*b*) What kind is usually most satisfactory? Why?

115. (*a*) What is the difference between paint and varnish? (*b*) What precautions should be observed in the selection and application of varnishes?

116. (*a*) What are the differences between enamel, paint, and varnish? (*b*) How are lacquers and quick-drying enamels different from paint?

117. (*a*) What are the main uses of whitewash? (*b*) What are the principal ingredients of whitewash?

118. What are the main points to be observed in painting with a compressed-air paint gun?

119. (*a*) Why should the rabbet of a window frame be oiled with linseed oil before new putty is applied? (*b*) What tools and materials are required for replacing a glass in a window frame?

120. (*a*) Explain and be able to demonstrate how properly to hold a glass cutter. (*b*) Why should only moderate pressure be exerted when using a glass cutter? (*c*) Why should the cutter not be drawn over a mark or scratch a second time? (*d*) After the glass is properly scratched with a cutter, how may it be broken along the line? (Two methods.) (*e*) Explain a simple method for getting glass cut to exact size.

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CHAPTER IX

CUTTING COMMON RAFTERS

Laying out a rafter is not a difficult problem if the workman understands the underlying principles. The student should, therefore, strive to understand principles rather than to rely upon certain rules and figures that may be memorized.

The main jobs in laying out a rafter are (1) determining the angles of cut at the ends of the rafter and at the bird's mouth or seat, and (2) determining the length. This is easily done by means of the carpenter's steel square and is made possible by the fact that a rafter may be considered as the hypotenuse of a right triangle, the rise and run of the rafter being the other two sides or legs of the triangle.

121. Definitions.—The *work line* is a straight line laid off about midway between the edges of the rafter and parallel to them. It is used as a base line in measuring and marking out the rafters.

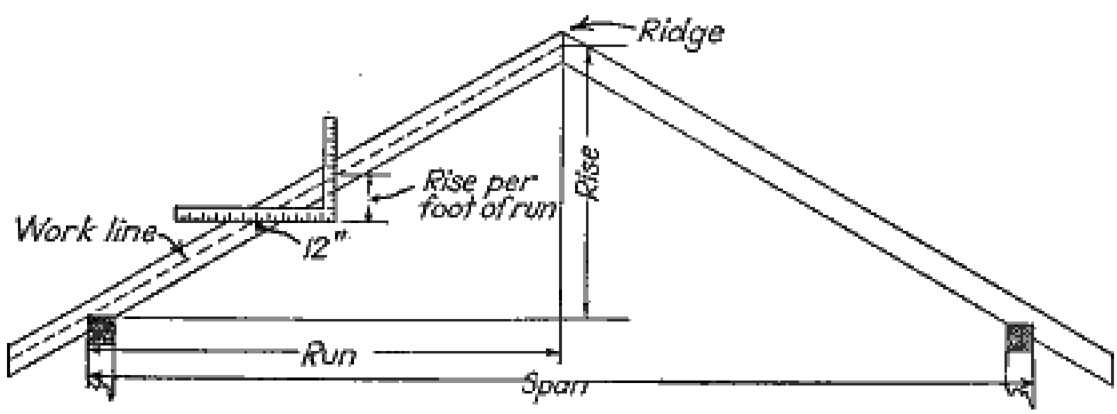

FIG. 97.—Common gable rafters.

The *run* of a rafter is the horizontal distance measured from the outside edge of the plate to a point directly below the top end of the rafter (see Fig. 97). In the case of a plain gable roof with the ridge in the middle of the building, the run is half the width or *span* of the building.

The *rise* is the vertical distance from the plate to the upper end of the rafter (upper end of the work line).

The *pitch* of a rafter is a measure of its slope and is defined as the ratio of the rise of the rafter to twice its run. Expressed as a formula,

$$\text{Pitch} = \frac{\text{rise}}{2 \times \text{run}}$$

In the case of a gable rafter, the pitch is then the ratio of the rise of the rafter to the span of the building. For a rafter having a rise of 4 ft. and a run of 8 ft., the pitch is

$$\frac{4}{2 \times 8} = \frac{4}{16} = \frac{1}{4}$$

If the rise were 5 ft. and the run $7\frac{1}{2}$ ft., the pitch would be

$$\frac{5}{2 \times 7\frac{1}{2}} = \frac{5}{15} = \frac{1}{3}$$

The relationship between rise, run, and pitch may also be expressed by another form of this formula, as follows:

$$\text{Rise} = \text{pitch} \times 2 \times \text{run}$$

For example, if it is desired to find the rise of a rafter whose pitch is one-third and whose run is 15 ft., substitute the values into the formula thus:

$$\text{Rise} = \tfrac{1}{3} \times 2 \times 15 = 10 \text{ ft.}$$

The rise per foot of run is a term used frequently in rafter work, and should, therefore, be thoroughly understood. It may be determined by dividing the rise of the rafter by the feet of run; or it may be determined by use of the formula for rise given in the preceding paragraph. For example, if the pitch is $\frac{1}{3}$, substitute into the formula, using 12 in. as the run, and we have:

$$\text{Rise} = \tfrac{1}{3} \times 2 \times 12 = 8 \text{ in.}$$

If the pitch is $\frac{1}{4}$, then:

$$\text{Rise} = \tfrac{1}{4} \times 2 \times 12 = 6 \text{ in.}$$

Table II gives the rise per foot of run for the common pitches.

TABLE II.—RISE PER FOOT OF RUN AND SQUARE SETTINGS FOR COMMON RAFTER PITCHES

Pitch	Rise per foot of run	Square setting
$\frac{1}{8}$	3	3 and 12
$\frac{1}{6}$	4	4 and 12
$\frac{1}{4}$	6	6 and 12
$\frac{1}{3}$	8	8 and 12
$\frac{1}{2}$	12	12 and 12

122. Process of Laying Out a Gable Rafter.—A gable rafter is usually laid out in the following steps:

1. Laying out the work line.
2. Marking the ridge cut or upper plumb cut.
3. Determining and marking the length of the main part of the rafter.
4. Marking the bird's mouth.
5. Marking the length of tail.
6. Shortening the rafter for the ridge board.

123. Laying Out the Work Line.—This is best done with a chalk line. If the rafter is bowed, place the bow or crown up. (This first step may be omitted if the rafter has a good straight edge from which to measure.)

124. Marking the Ridge or Upper Plumb Cut.—This is done by placing the square near one end of the stock (Fig. 98) with 12 on the body and a number on the tongue that corresponds to the rise per foot of run,

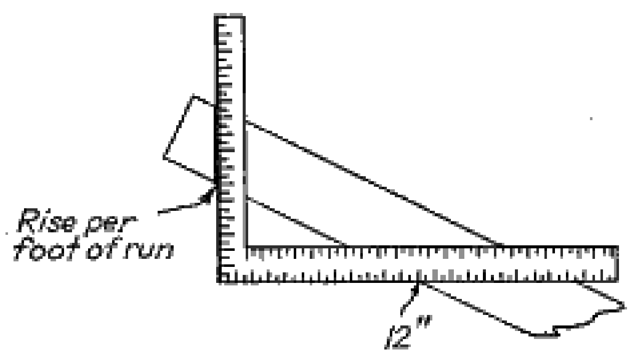

FIG. 98.—Marking the upper plumb cut.

coinciding with the work line (or one edge of the rafter in case no work line is used). A mark along the tongue will give the line for the cut.

125. Determining and Marking the Length of Main Part of Rafter. *Method* 1. *Scaling.*—Place the square on a piece of stock having a straight edge, using the side of the square with the inches divided into twelfths, and measuring the rise on one leg and the run on the other, to the scale of 1 ft. equal to 1 in. (Fig. 99). The figures on the legs of the square should coincide with the edge of the stock. Mark along the legs of the square with a sharp pencil or knife. Measure the distance between the intersections of these marks with the edge of the stock. This is the length of rafter to the scale of 1 in. equal to 1 ft. The inches and twelfths of inches on the square are simply read as feet and inches.

For example, to determine the length of a rafter whose run is 10 ft. 6 in., and whose rise is 5 ft. 3 in., set the square with $10\frac{6}{12}$ in. on the body and $5\frac{3}{12}$ in. on the tongue coinciding with the edge of the stock, and scribe along both sides of the square (Fig. 99*A*). Measuring the distance between the points of intersection of these marks with the edge of the stock, we find it to be $11\frac{10}{12}$ in. (Fig. 99*B*). The rafter length is therefore 11 ft. 10 in.

Method 2. *Use of Rafter Table.*—Probably the simplest method of determining the length of a rafter is to use a rafter table. Figure 100 shows such a table on a rafter or framing square. To use it, proceed as follows: Determine the rise per foot of run for the particular rafter to be marked out. Find this figure on the body of the square. Under this figure will be found another figure which is the length of common rafter per foot of run. Multiplying this figure by the total feet of run in the rafter gives the total length.

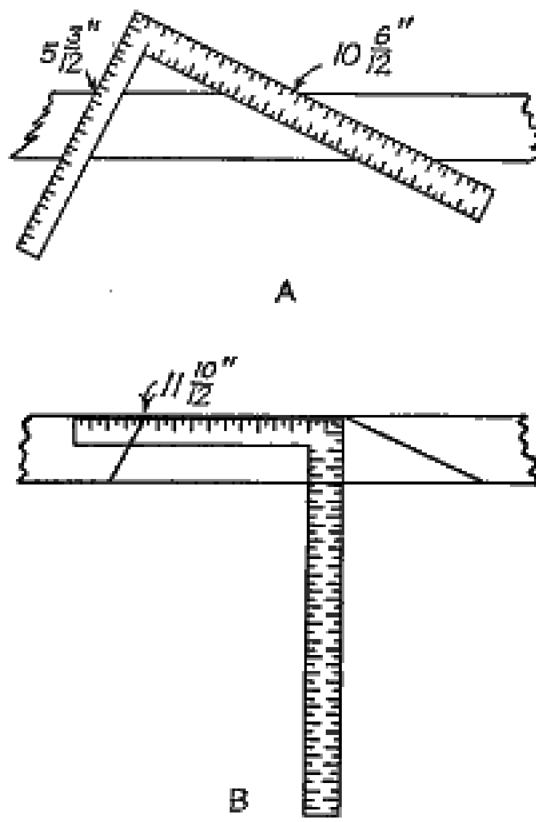

Fig. 99.—Using the scaling method to determine the length of a rafter whose run is 10 ft. 6 in. and whose rise is 5 ft. 3 in.

For example, to determine the length of a quarter-pitch rafter having a run of 10 ft., look under 6 on the body of the square (6 being the rise per foot of run for quarter-pitch rafters) and find the figure 13.42. Multiplying this by 10, we get 134.2 in. Reducing to feet, we get 11 ft. 2.2 in., or for practical purposes a little less than 11 ft. and 2¼ in.

On many squares the inside scale on one side of the tongue is graduated in tenths of inches to facilitate measuring off distances where decimal fractions are involved. If such a square is available, 2.2 in. may be measured off directly. Most squares also have a hundredths scale, which is 1 in. divided into 100 parts and from which decimal fractions of an inch may be measured off with a pair of dividers. The hundredths scale is located on the back of the square near the junction of the body and the tongue.

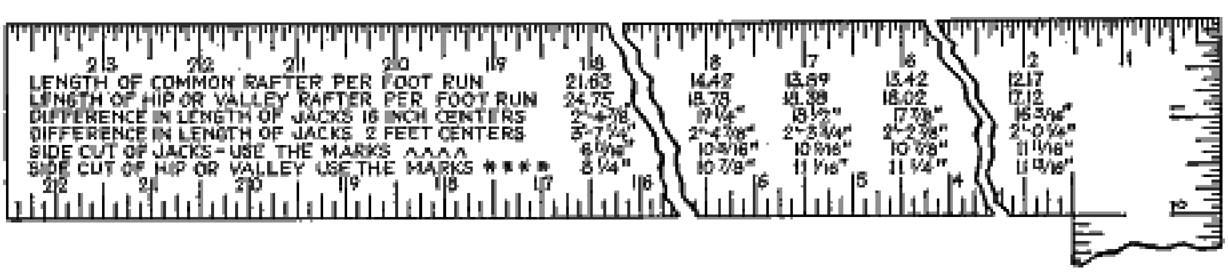

Fig. 100.—Rafter table on a rafter square.

Method 3. *Stepping Method.*—To use this method take 12 on one leg of the square and the rise per foot of run on the other and place the square with these figures coinciding with the work line (or one edge of the rafter). Carefully mark along the body and the tongue of the square, using a very sharp pencil. This marks off one step on the work line (or edge). Move the square along the stock and repeat, taking as many steps as there are feet of run in the rafter.

Another variation of this method is to use a number in one leg corresponding to the total feet of run, and a number on the other corresponding to the total rise, and to take 12 steps.

Unless the work is done very carefully there is a chance for errors in marking when the stepping method is used. For this reason, many good carpenters do not use it, or if they do use it, it is as a check upon some other method.

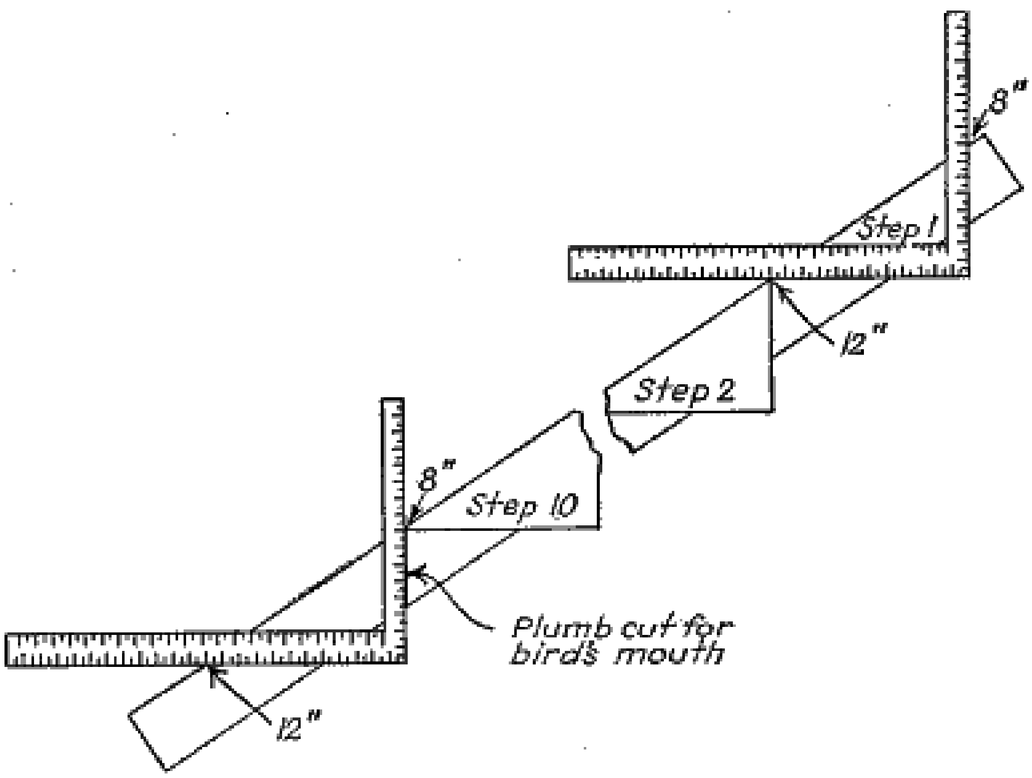

FIG. 101.—Determining the length of a one-third-pitch rafter whose run is 10 ft., using the stepping method.

Method 4. *Square-root Method.*—The length of a rafter may be determined by extracting the square root of the sum of the squares of the rise and the run. Stating this as a formula,

$$\text{Length of rafter} = \sqrt{\text{rise}^2 + \text{run}^2}$$

This method gives accurate results but requires considerable involved computation with the possibility of errors in arithmetic, or the use of tables of square roots, which are usually not available. This method therefore is seldom used by practical carpenters.

126. Marking the Bird's Mouth.—After the length of the main part of the rafter is determined and measured off on the work line (or one edge of the rafter), a plumb line is marked at the lower end just the same as at the ridge or upper end of the rafter. The horizontal cut of the bird's mouth is made to pass through the intersection of this lower plumb line and the work line (or, in case the work line is not used, through the mid-point of the plumb line). This horizontal cut may be made by placing the square with the usual figures of 12 on the body and the rise

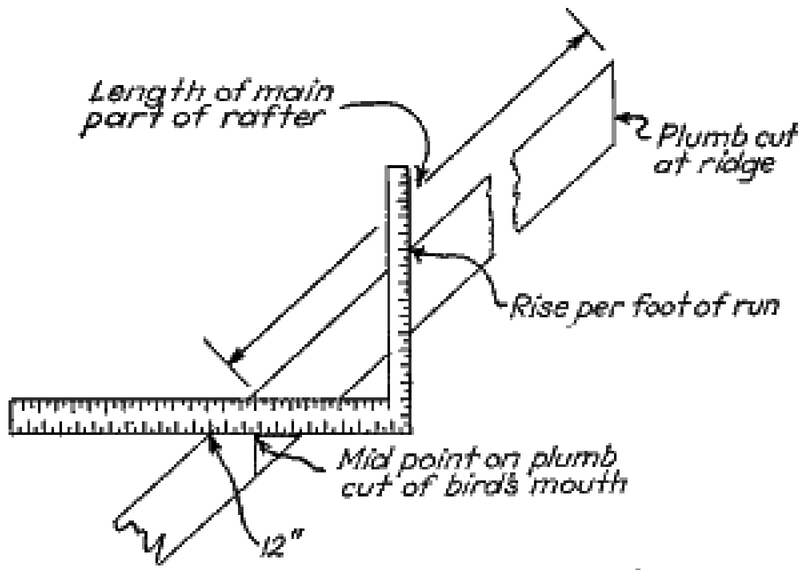

FIG. 102.—Marking the bird's mouth.

per foot of run on the tongue, coinciding with the work line (or upper edge of rafter) and moving the square up or down the stock until the edge of the body passes through the mid-point of the lower plumb line

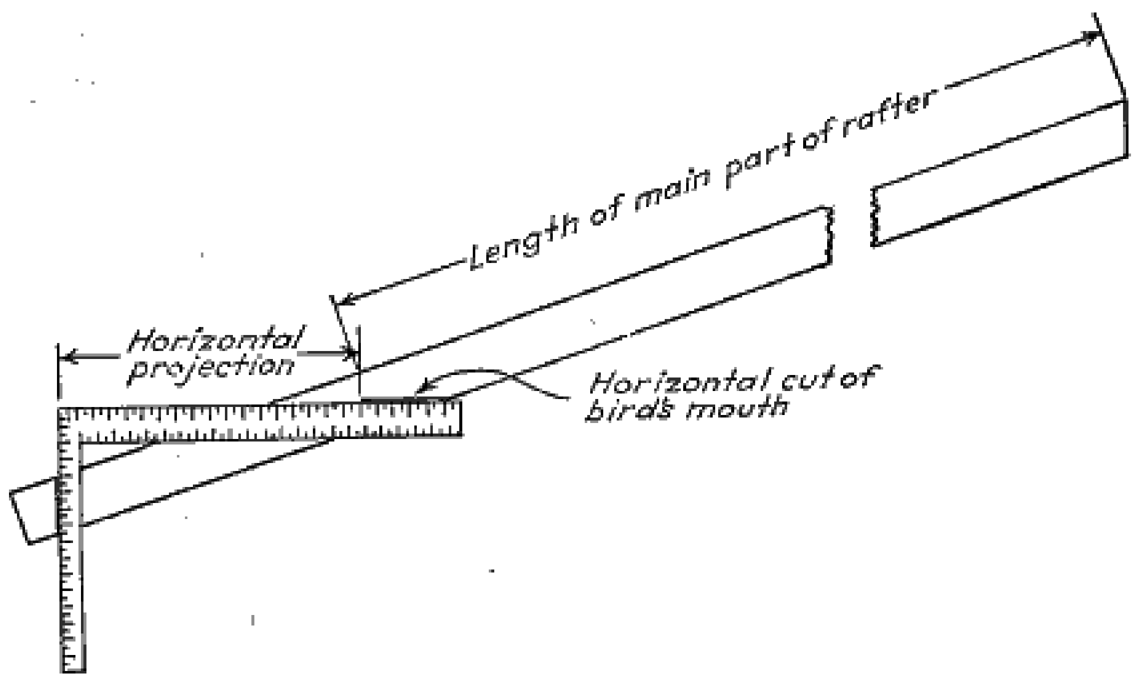

FIG. 103.—Marking off the rafter tail.

(or through the intersection of the plumb line and the work line) (see Fig. 102).

If the bird's mouth notch as marked out is so deep as to weaken the rafter, or if it is so shallow as to give inadequate bearing on the plate, the depth should be varied somewhat to give stronger construction.

127. Marking Off the Rafter Tail.—The length of the rafter tail or overhanging part and the angle of cut at the lower end of the rafter are determined as follows: place the square with the edge of the body along the horizontal cut of the bird's mouth and measure out from the plumb line of the bird's mouth, the horizontal projection (see Fig. 103). A mark along the tongue gives the end cut.

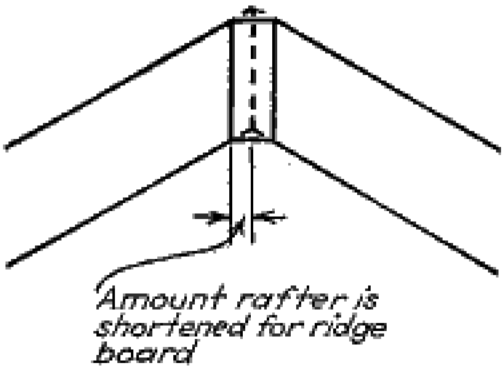

FIG. 104.—If a ridge board is used, shorten each rafter one-half the thickness of the ridge board, measuring back *perpendicular* to the plumb cut.

128. Shortening for the Ridge Board. If a ridge board is used, the rafter will have to be shortened by an amount equal to half the thickness of the ridge board, this amount to be measured back from the end of the rafter *perpendicular to the plumb cut,* and not parallel to the edges of the rafter (see Fig. 104).

Questions

121. (*a*) What is a work line? (*b*) Define: rise, run, pitch. (*c*) What is meant by "rise per foot of run"?

122. Enumerate the steps in laying out a gable rafter.

123. (*a*) How may the work line be laid off? (*b*) Under what conditions is it unnecessary to lay off a work line?

124. How is the square placed on the stock to mark the ridge or upper plumb cut of a rafter?

125. (*a*) Why do many squares have the inches on one side divided in twelfths instead of eighths or sixteenths? (*b*) Explain and be able to demonstrate the scaling method of determining rafter lengths. (*c*) What must first be known before this length may be determined? (*d*) Explain how to use the rafter table in determining rafter lengths. (*e*) Explain how to use the stepping method in determining rafter lengths. (*f*) Why is the square-root method seldom used by practical carpenters?

126. (*a*) Explain how to mark out the bird's mouth. (*b*) What points are to be considered in deciding how deep to make the bird's mouth?

127. Explain and be able to demonstrate how to mark off the tail of a rafter.

128. Explain how to shorten a rafter if a ridge board is used.

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PART II

TOOL SHARPENING AND FITTING

CHAPTER X

TOOL SHARPENING

Sharp tools are the mark of a good workman. Only a poor workman or an amateur would struggle along with a dull tool rather than take time to sharpen it. The time required for sharpening is soon repaid in faster and better work.

129. Cutting Edges Composed of Small Teeth.—The cutting edge of a sharp knife or similar tool is composed of a series of small microscopic teeth. Such tools are used with a diagonal or sawlike motion, and the small teeth aid in the cutting. The size of the teeth determines whether the edge is known as coarse or fine. For certain kinds of work, coarse edges are best, and, for other kinds of work, medium, fine, or very fine edges are required. Bread knives, kitchen paring knives, and scythes and grass blades, for example, work better when sharpened to coarse edges, while plane bits and wood chisels need fine edges, and razors still finer edges.

130. General Method of Sharpening.—The general method of sharpening edge tools is to produce first a coarse edge by grinding with a grinding wheel, or by rubbing on a coarse sharpening stone, and then to finish by whetting on the fine side of an oilstone if a fine edge is required. If a very fine edge is desired, the process is carried a step further and the tool is stropped on leather.

With very few exceptions, tools are ground with the grinding wheel turning against the cutting edge. This produces a smaller burr or wire edge. Likewise, in whetting on a stone, the tool is drawn or pushed over the stone with the cutting edge leading; or in case of back-and-forth motion, more pressure is applied during that portion of the stroke when the cutting edge is leading—not trailing. In stropping on leather, however, the cutting edge must always be trailing.

WOOD CHISELS AND PLANE BITS

When a chisel or plane bit becomes dull, it is first necessary to decide whether it needs grinding or not. If a tool is properly used and cared for, it can be resharpened many times on the oilstone before it will need regrinding. The tool should be ground if the edge is unusually dull, nicked, or if a slight bevel has been formed on the flat side by careless whetting. The tool should be ground, also, if it does not have the desired angle of bevel, or if the cutting edge is not square with the sides.

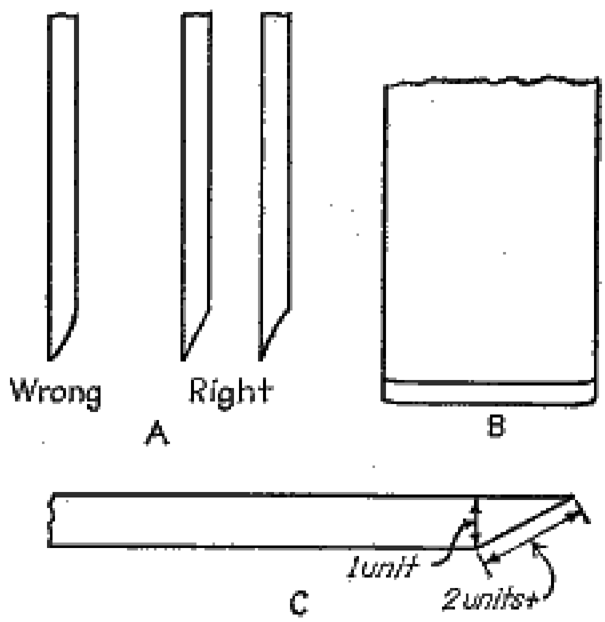

Fig. 105.—Grinding edge tools.

A. An edge tool should be ground with a straight or concave bevel—not with a convex bevel.

B. A plane for general-purpose work is usually ground with the corners slightly rounded.

C. For general-purpose work, the length of bevel on a plane bit or wood chisel should be a little more than twice the thickness of the blade.

131. Grinding Wood Chisels and Plane Bits.—For general work, wood chisels and plane bits are usually ground at an angle of about 25 to 30 deg. For softwoods, the angle may be somewhat less, and, for hardwoods, somewhat more. The smaller the angle, the easier the tool will cut, but the sooner it will become dull. A good way to check the angle of grinding is to use a T-bevel set for the desired angle, or simply grind so that the length of the bevel is a little more than twice the thickness of the blade (see Fig. 105).

The tool may be held against the grinding wheel in any manner that will produce a smooth, even bevel of the desired angle. When using a hand-operated grinder, the work

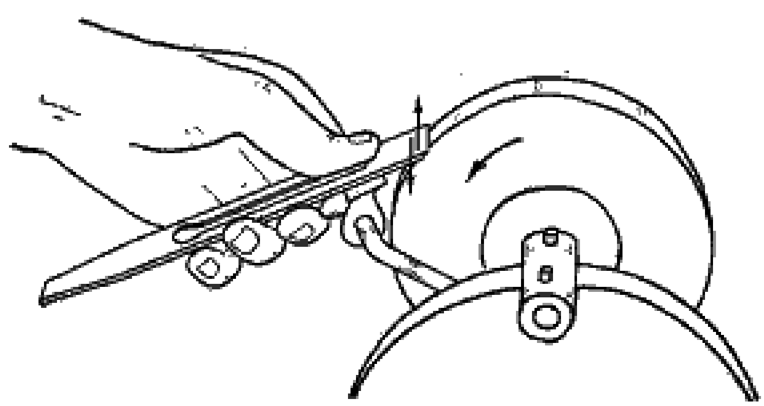

Fig. 106.—A good method of holding the tool while grinding. Note that the tool rest is adjusted to give the desired angle of bevel, and that the tool is held firmly against the rest. The tool is moved back and forth sideways across the face of the wheel.

rest should be adjusted so that the tool, when held down firmly against the rest, will come in contact with the wheel at the desired angle.

The tool should be moved from side to side across the face of the wheel to insure even grinding and to prevent overheating. *A light, yet firm pres-*

sure should be used to hold the tool against the wheel. The wheel is *turned toward the cutting edge,* not away from it, and at a *moderately fast, steady speed.* The tools should be dipped in water frequently during grinding to prevent overheating.

It is sometimes easier for beginners to hold the tool against the flat side of the wheel rather than against the usual curved grinding surface. If ground on the side of the wheel, a little more care will need to be taken to prevent overheating.

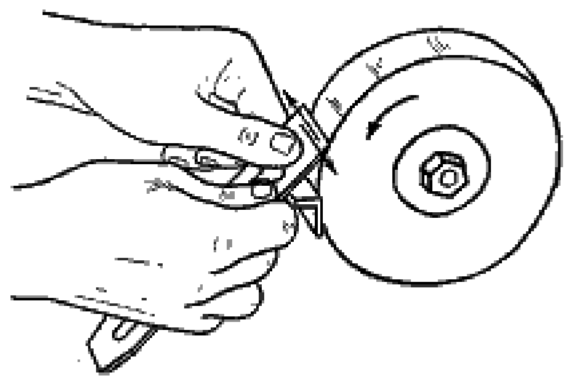

Fig. 107.—Both hands may be used to hold the tool when a power grinder is used. Grasp the tool so that when the first finger of the right hand is against the tool rest the desired angle of bevel will be produced.

The tool should be checked occasionally as the grinding proceeds, to make sure it is being ground at the desired angle and that the cutting edge is square with the sides. The try square may be used to check for squareness, care being used not to touch the cutting edge against the square (see Fig. 109). The blade of a jack plane should usually be rounded a little at the corners rather than being made perfectly straight all the way across (see Fig. 105*B*).

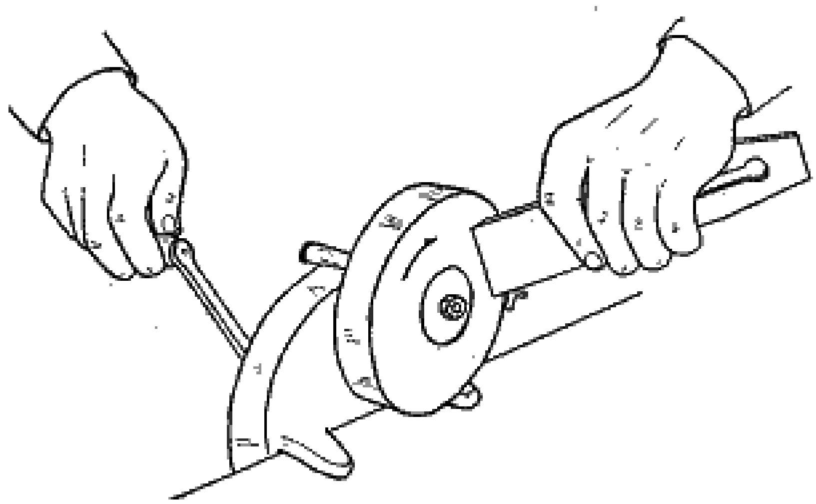

Fig. 108.—An edge tool may be ground on the flat side of the grinding wheel if desired. This produces a smoother job and is usually more easily done than grinding on the curved surface. More care must be used, however, to prevent overheating.

Some mechanics prefer to straighten the edge of a plane bit or chisel, before grinding, by rubbing it on the edge of an oilstone (see Fig. 110).

Grinding should continue until the dull edge is removed, all nicks are removed, and the edge is straight and square and the bevel is of the desired angle. The burr, or wire edge, which is left by grinding, is then removed by whetting on the oilstone. (A wire edge is a thin, rough edge that can be felt with the thumb or finger, or seen in a good light. Also, a wire edge will catch on cloth while a smooth edge will not.)

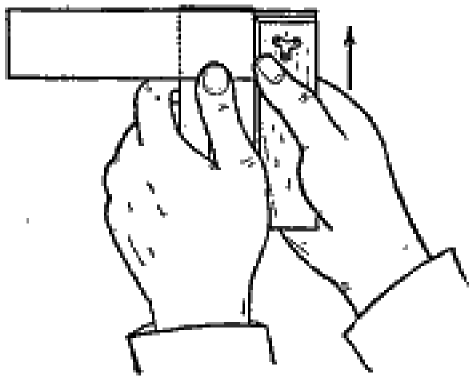

FIG. 109.—Checking an edge tool for squareness of grinding. Care must be used to prevent touching the sharp edge against the square.

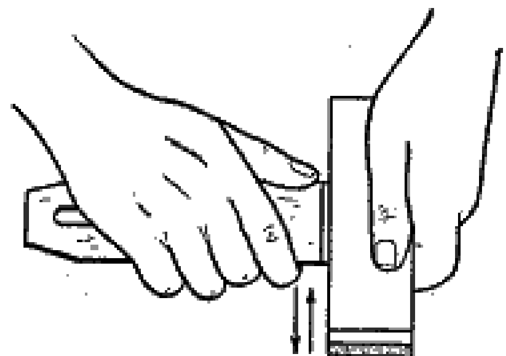

FIG. 110.—The edge of a plane bit or wood chisel may be straightened and squared on the edge of an oilstone.

132. Whetting a Wood Chisel or Plane Bit.—If the tool has a good bevel on it and is not nicked, but is simply dull, then it can be quickly sharpened by whetting on an oilstone without first grinding it.

The first step is to whet the beveled side of the tool on a coarse stone or the coarse side of a combination stone. A few drops of light oil, such as motor oil mixed with kerosene, should be used on the stone. The whetting should continue until a slight burr, or wire edge, is produced.

To keep the stone from sliding around when in use, it may be held in a wood vise, or mounted on a small board about 1 by 4 by 10 in. long. Small strips tacked to the board will hold the stone in place.

The heel of the bevel should be raised slightly while whetting. It is a good plan to place the heel down against the stone and then tilt the tool forward until oil is forced from under the front edge; and tilt forward a very little more.

A "figure 8" motion, a circular motion, or a back-and-forth motion may be used. Regardless of the kind of motion, care should be taken to prevent the stone from being worn hollow in the center and to avoid a rocking motion, which would produce a rounded instead of a flat bevel.

133. Whetting on Fine Side of Stone.—After a slight wire edge has been produced by whetting on the coarse side of the stone, or by grinding on a grinding wheel, the next step is to remove the wire edge. This is done by whetting on the fine side of the stone. The tool is honed or whetted first on the flat side and then on the beveled side. In this operation, two things are most important:

1. *Keep the tool perfectly flat against the stone when whetting the flat side.*
2. *Use very light pressure when whetting the beveled side.*

If the tool is not held perfectly flat when whetting the flat side, a small bevel may easily be produced on the flat side, and it would then be impossible to put the edge in good condition without regrinding it. If too heavy pressure is used while whetting the beveled side, the wire edge may be increased instead of decreased.

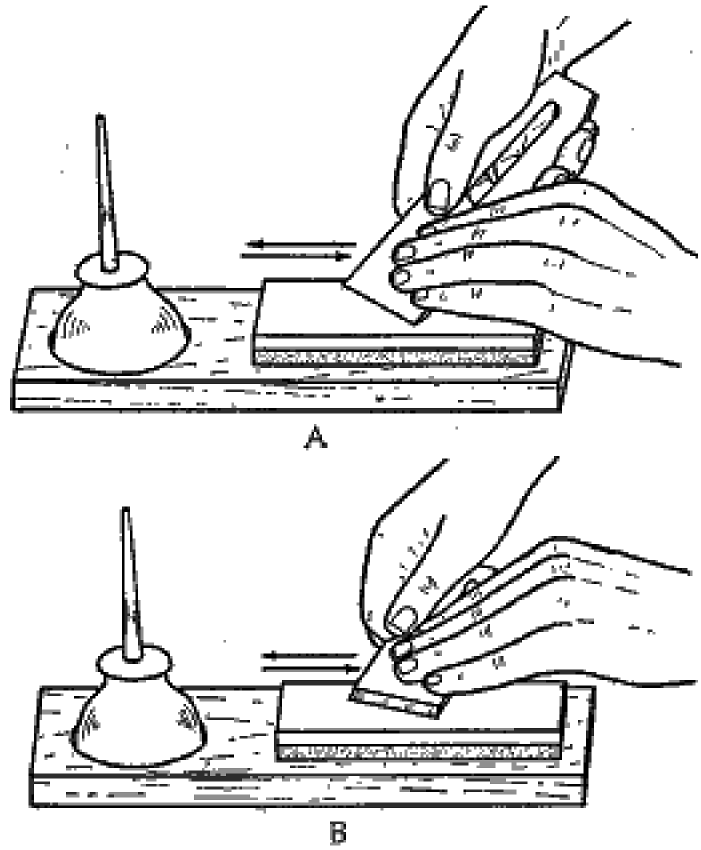

FIG. 111.—After the beveled edge is ground or whetted on the coarse side of the oilstone, the wire edge is then removed by whetting on the fine side of the stone; whetting the tool alternately on the beveled side and on the flat side. When whetting on the beveled side, raise the heel of the tool slightly and use moderate pressure. When whetting on the flat side, keep the tool *perfectly flat* against the stone.

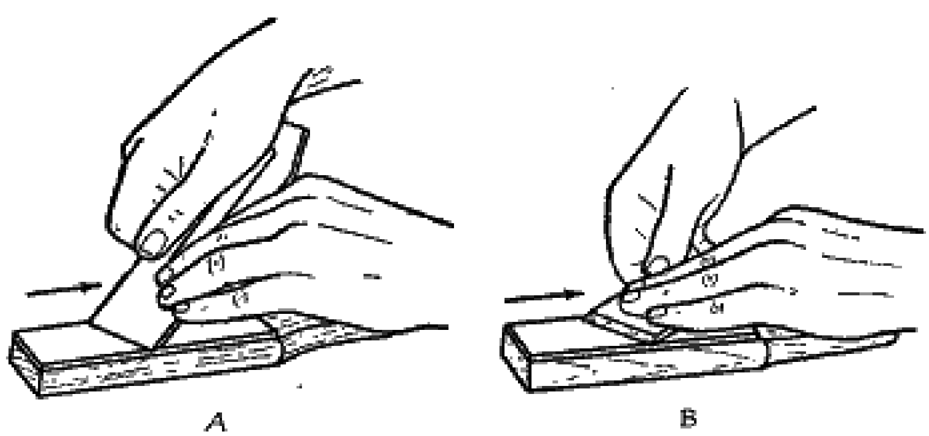

FIG. 112.—A very keen edge may be produced on a tool by finishing on a leather strop. Use drawing strokes, stropping first on the beveled side and then on the flat side.

In alternately whetting the flat and the beveled sides, make sure that the wire edge is actually turned back and forth. That is, if the tool is being whetted on the beveled side, be sure that the wire edge is actually turned from the beveled side to the flat side before reversing the tool for whetting on the flat side.

If the whetting is properly done, the wire edge will quickly become smaller and smaller, and practically disappear. The tool will then be sharp.

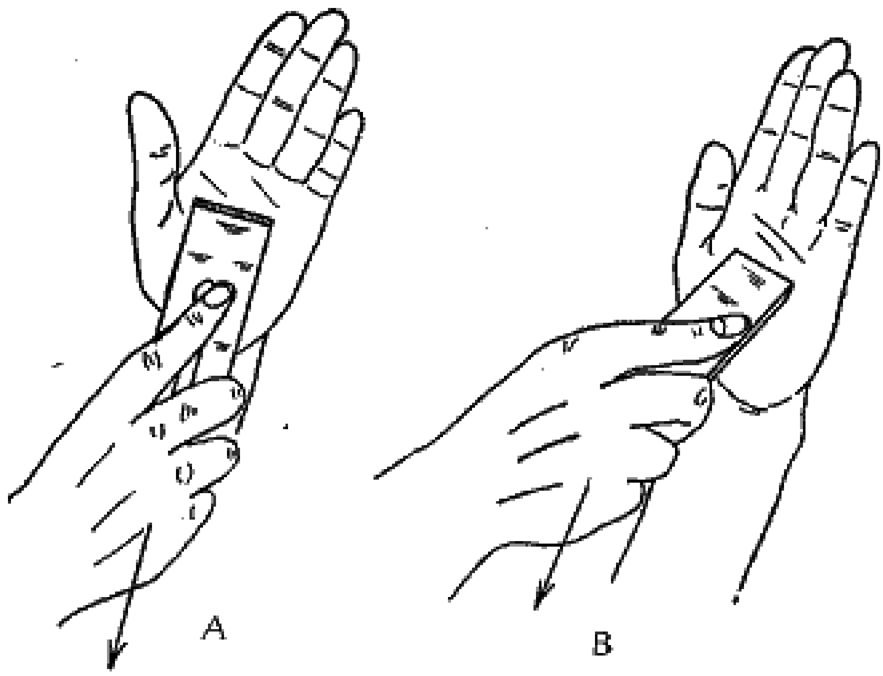

FIG. 113.—If a leather strop is not available, an edge tool may be stropped on the palm of the hand.

134. Stropping.—Stropping the tool on a piece of smooth leather, after it is whetted on the fine side of the oilstone, will produce an exceptionally fine, keen edge. A few drawing or pulling strokes with the cutting edge trailing, not leading, first on the beveled side and then on the other, is all that is required. If a piece of leather is not available, the tool may be stropped on a piece of smooth wood or even on the palm of the hand. A piece of smooth leather glued to a block of wood about 2 in. wide and 6 in. long makes a good strop.

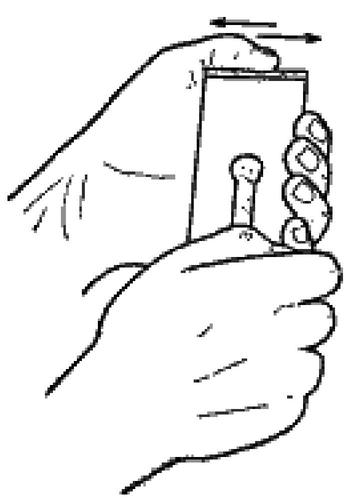

FIG. 114.—An excellent way to test a blade for sharpness is to try it on the ball of the thumb. Hold the tool firmly and draw the ball of the thumb lightly back and forth over the edge. *Do not press against the edge.* A sharp tool will "take hold" or pull on the tough cuticle. A dull tool feels smooth and will not "take hold."

135. Testing the Edge for Sharpness.—Probably the best way to tell if a tool is sharp—the way used by most mechanics—is to try the edge on the thumb. The blade is grasped in one hand with the fingers around the blade, thumb at the cutting edge, and flat side of blade toward the thumb (see Fig. 114). With very light pressure the ball of the thumb is moved along the edge from side to side. (Do not push against the edge.) If the tool "takes hold" or pulls on the calloused skin, it is sharp; if it does not take hold it is dull and should be resharpened.

Another test is to see if the tool will shave hair from the arm or wrist. It is not too much to expect a tool to shave. With a little practice, a boy should be able to put a shaving edge on a tool.

Some idea of the condition of an edge tool may be obtained by simply looking at it. If the edge is sharp it cannot be seen. If it is very dull, the edge will appear as a line or a narrow shiny surface that reflects the light. To make this test, the tool must be held in a good light and moved about slightly so the eye can easily see any reflections.

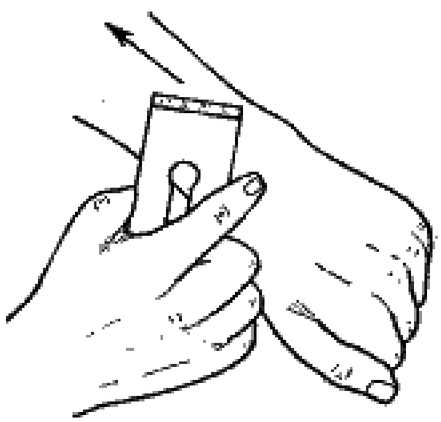

Fig. 115.

Fig. 116.

Fig. 115.—A sharp tool will easily shave.

Fig. 116.—The edge of a sharp tool cannot be seen. The edge of a dull tool can be seen as a narrow, bright, shiny line that reflects light. In making this test hold the tool in a good light and move it about so that reflections from a dull edge may easily be seen.

OTHER BEVEL-EDGED TOOLS

Practically all bevel-edged woodcutting tools may be sharpened in the same manner as plane bits and wood chisels.

136. Drawknives.—A drawknife is sharpened in the same manner as a wood chisel or plane bit, except that, in whetting, the stone may be rubbed over the edge, instead of moving the tool back and forth over the stone.

137. Pocket Knives, Butcher Knives, Bread Knives.—If the edge of a knife is quite blunt, or nicked, or not of the desired shape, it should be ground on a grinding wheel before whetting on an oilstone. Care should be used not to overheat the tool, by using only light pressure and dipping it in water frequently. The blade should be lifted occasionally to see that it is being ground at the desired angle.

If the tool is only slightly dull it may be sharpened by whetting on the oilstone. It may be sharpened by whetting altogether on the fine side of the stone, although it can generally be sharpened faster by first whetting on the coarse side, until a fine burr or wire edge is produced,

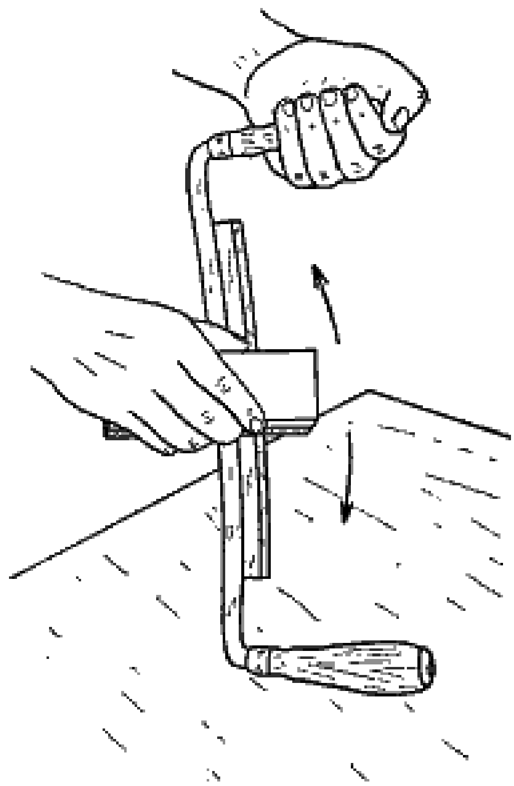

FIG. 117.—A drawknife is sharpened in the same manner as a wood chisel or plane bit, except that, in whetting, the stone may be rubbed over the edge of the tool instead of moving the tool back and forth over the stone.

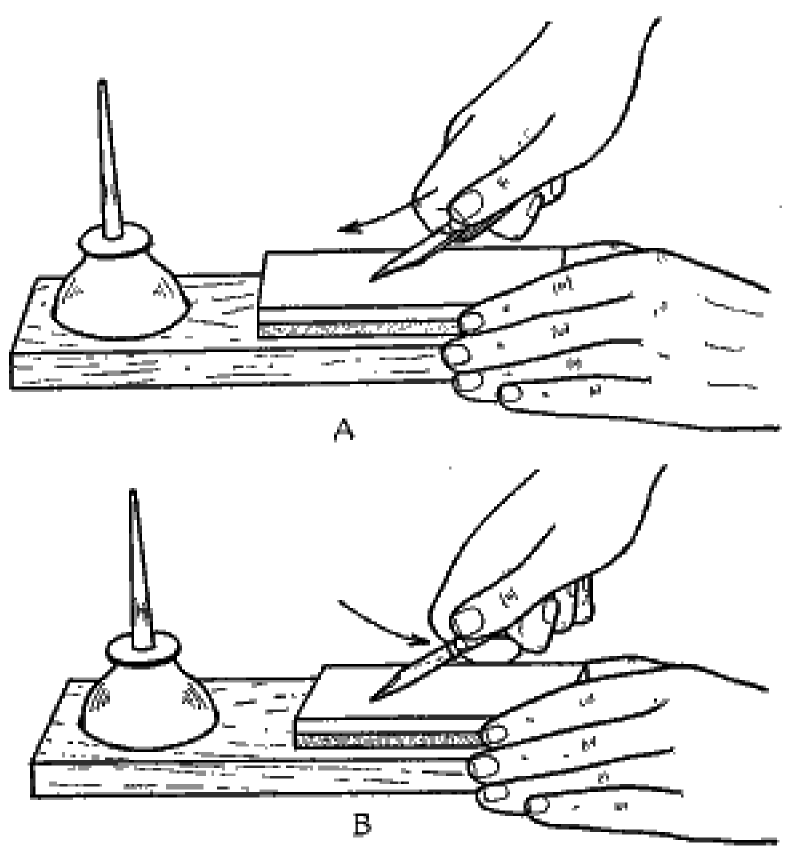

FIG. 118.—In sharpening a pocketknife, raise the back of the knife slightly to keep the cutting edge in contact with the stone. Moderate pressure should be used, and oblique angling strokes should be made, with the cutting edge leading, not trailing.

and then finishing on the fine side. The back of the knife must be raised slightly while whetting to keep the cutting edge in contact with the stone. Moderate pressure is applied, and oblique angling strokes used, with the cutting edge leading—not trailing. An extremely smooth keen edge can be produced by finishing on a leather strop.

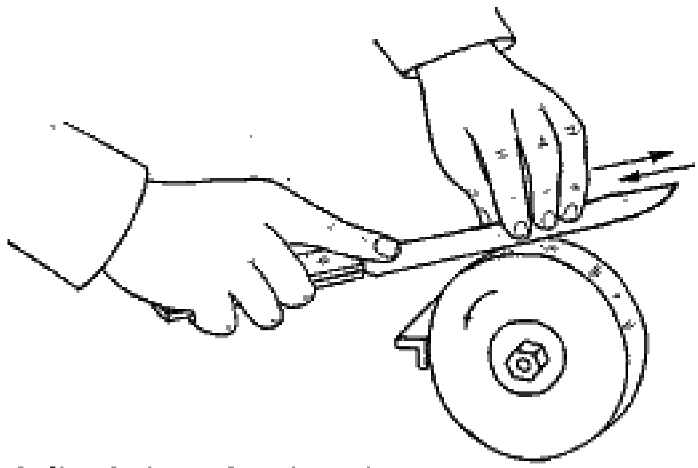

FIG. 119.—In grinding knives, the wheel should turn against the cutting edge. Hold the knife at an angle to the wheel, use moderate pressure, and move it slowly from side to side.

It is not necessary to put a smooth edge on a bread-slicing knife. Many prefer to leave a light wire edge on the blade, as it will cut practically as well and stay sharp longer than if whetted to a smoother edge.

The edge of a butcher knife can be kept in good cutting condition by using a sharpening steel on it occasionally. The steel does not really sharpen the knife, but simply removes bits of fat and tissue and straightens the microscopic teeth that form the edge.

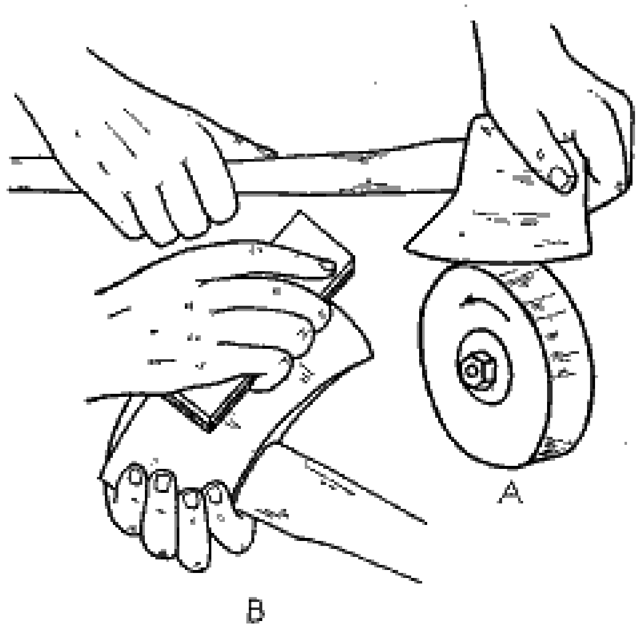

FIG. 120.—Sharpening an ax. After grinding, a smooth edge may be produced by rubbing with an oilstone.

138. Axes and Hatchets.—Axes and hatchets are best sharpened on a fine grinding wheel, care being taken to grind at the desired angle and not to overheat the tools. A thicker edge is needed for splitting than for chopping. After grinding, a keen smooth edge can be produced by rubbing with an oilstone.

139. Scythes and Grass Sickles.—Scythes and grass sickles are easily sharpened on a grinding wheel. Such tools do not require keen cutting edges like plane bits and are commonly left with the wire edge on them. A blade should be lifted frequently while grinding to make sure that it is being ground at the original bevel. The grinding is best done by holding the blade at a considerable angle to the grinding wheel (see Fig. 121).

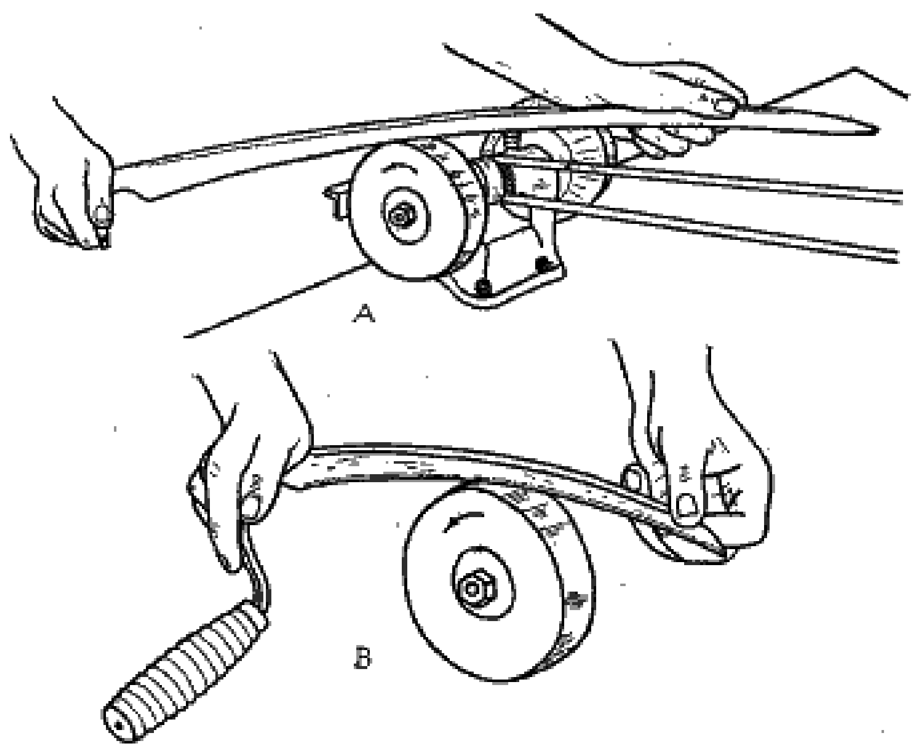

FIG. 121.—Scythes and grass sickles are easily sharpened on a grinding wheel, although they may be sharpened by rubbing with a scythe stone or by filing.

Scythes and sickles may also be sharpened by stroking with a scythe stone, or by filing—either plain straight filing or draw filing (see Art. 197). It is a good plan for the workman to keep a scythe stone or file with him when using a scythe or sickle, for resharpening the blade every 20 or 30 min.

140. Mower Sickles.—Mower sickles can best be ground on special grinders made for that purpose. With a little practice and patience, however, mower sickles can be satisfactorily ground on an ordinary wheel. The grinding may be done either on the flat vertical side of such a wheel, or on the regular curved grinding surface.

Two important points should be observed in grinding a mower sickle: (1) grind at the original bevel, and (2) use light or moderate pressure to prevent drawing the temper.

Special sickle grinders are available which hold the sickle in the proper position against the grinding wheel. With such a grinder, it is a simple matter to do a good job of grinding.

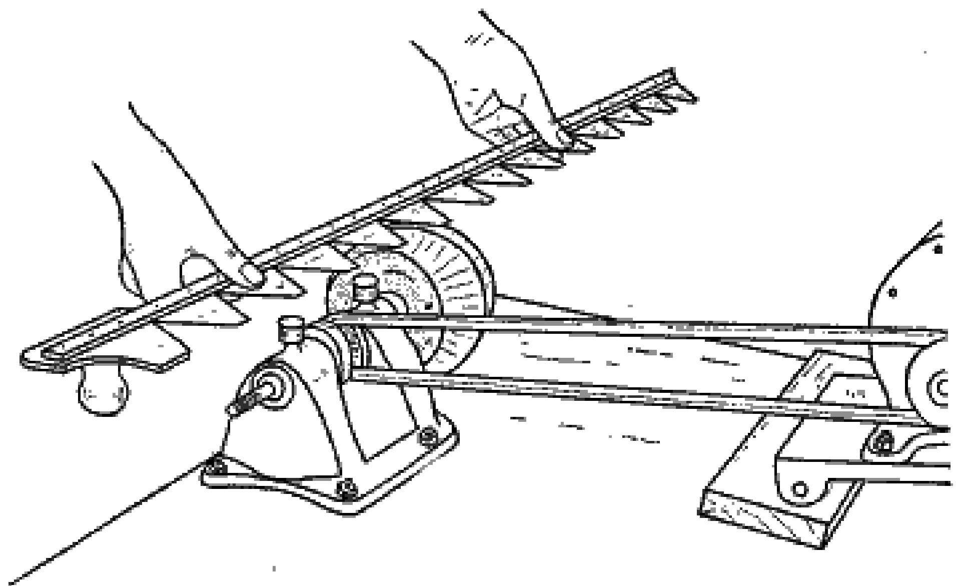

FIG. 122.—Mower sickles are ground easiest on special grinders made for that purpose, although they can be satisfactorily sharpened on an ordinary grinding wheel.

141. Ensilage-cutter Knives.—Ensilage-cutter knives are sharpened by grinding on a grinding wheel, using the precaution of grinding at the

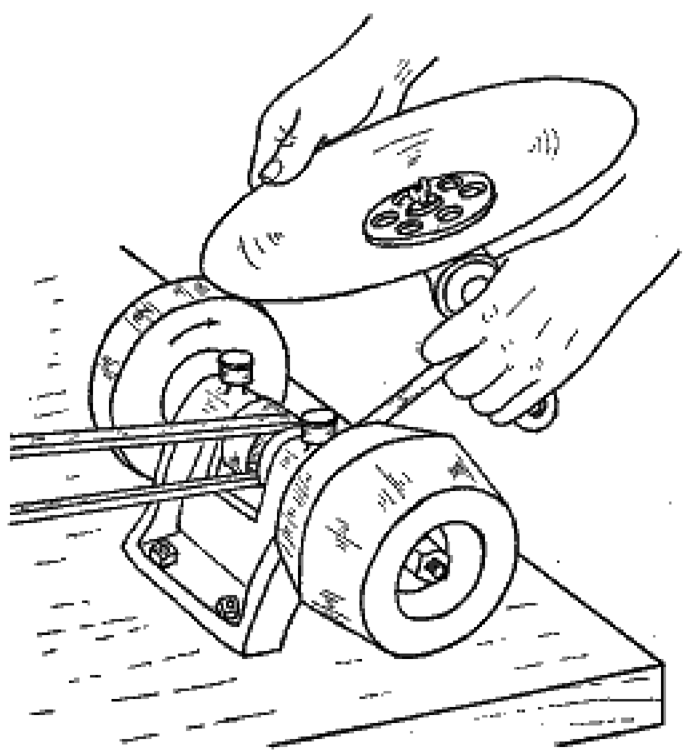

FIG. 123.—Disks and colters can best be ground on grinders with attachments to hold the the disks properly against the grinding wheel.

original bevel, and with only a moderate pressure to prevent drawing the temper. If there are large nicks, they may be best removed by placing the knife flat on the work rest and moving it back and forth with the cutting edge square against the revolving wheel. The edge is then ground back to the desired bevel.

142. Rolling Colters; Disks.—Many farmers prefer to have their colters and disks sharpened on a special rolling machine that sharpens the edge of a disk or colter by passing it between large rollers under heavy pressure. Disks and colters may be sharpened on a grinding wheel, however. Some sort of a support to hold the disk in place greatly facilitates the work. Some tool grinders have attachments for properly holding disks in place against the wheel.

143. Hoes; Spades; Shovels.—Such tools as hoes, spades, and shovels are usually best sharpened by plain filing, or by draw filing (see

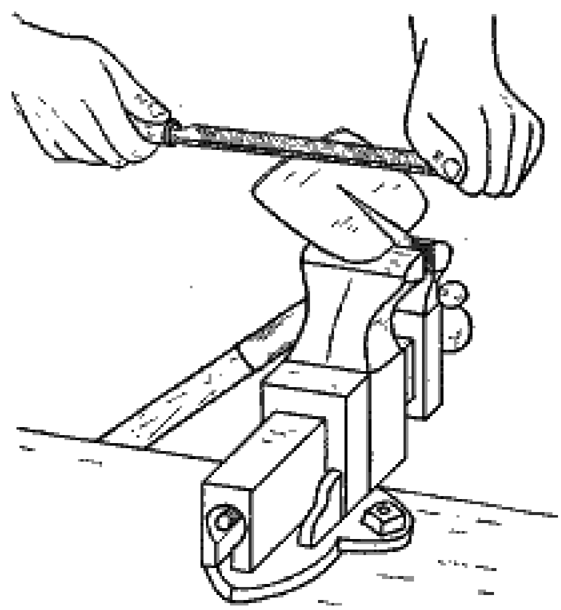

FIG. 124.—Hoes, spades, and shovels are easily sharpened, either by plain filing or by draw filing (see Art. 197.)

Art. 197), care being used to maintain the original angle of bevel. If a vise is not at hand the tool can frequently be held satisfactorily by cramping the handle against a box, a tree, or a fence post.

144. Scissors; Snips.—Scissors or snips may be sharpened by grinding or filing the beveled edge carefully at the original angle, and then whetting on an oilstone. Some scissors may be too hard to file and can be sharpened only by grinding. If the scissors are not too dull, the beveled edges may be renewed by whetting on an oilstone. After the beveled edges are renewed (by grinding, filing, or whetting), the blades are then smoothed by whetting on the fine side of an oilstone, care being used to keep the blades perfectly flat when whetting the flat side, and at the correct angle when whetting the beveled edge.

145. Wood Auger Bits.—Two important points should be observed in sharpening a wood auger bit:

1. The spurs or scoring nibs must be sharpened by filing on the inside only, so that they will cut a circle of the exact diameter the auger is supposed to bore. If they are sharpened by filing on the outside, they will cut a circle too small and the auger will not feed into the wood. In case the scoring nibs have become bent outward, or have burrs on the outside, they may be dressed lightly on the outside with a small file, keeping it perfectly flat against the outside of the auger.

2. The cutting lips should be filed on the top side (the side next to the shank) care being taken to remove the same amount of material from each of the two cutting

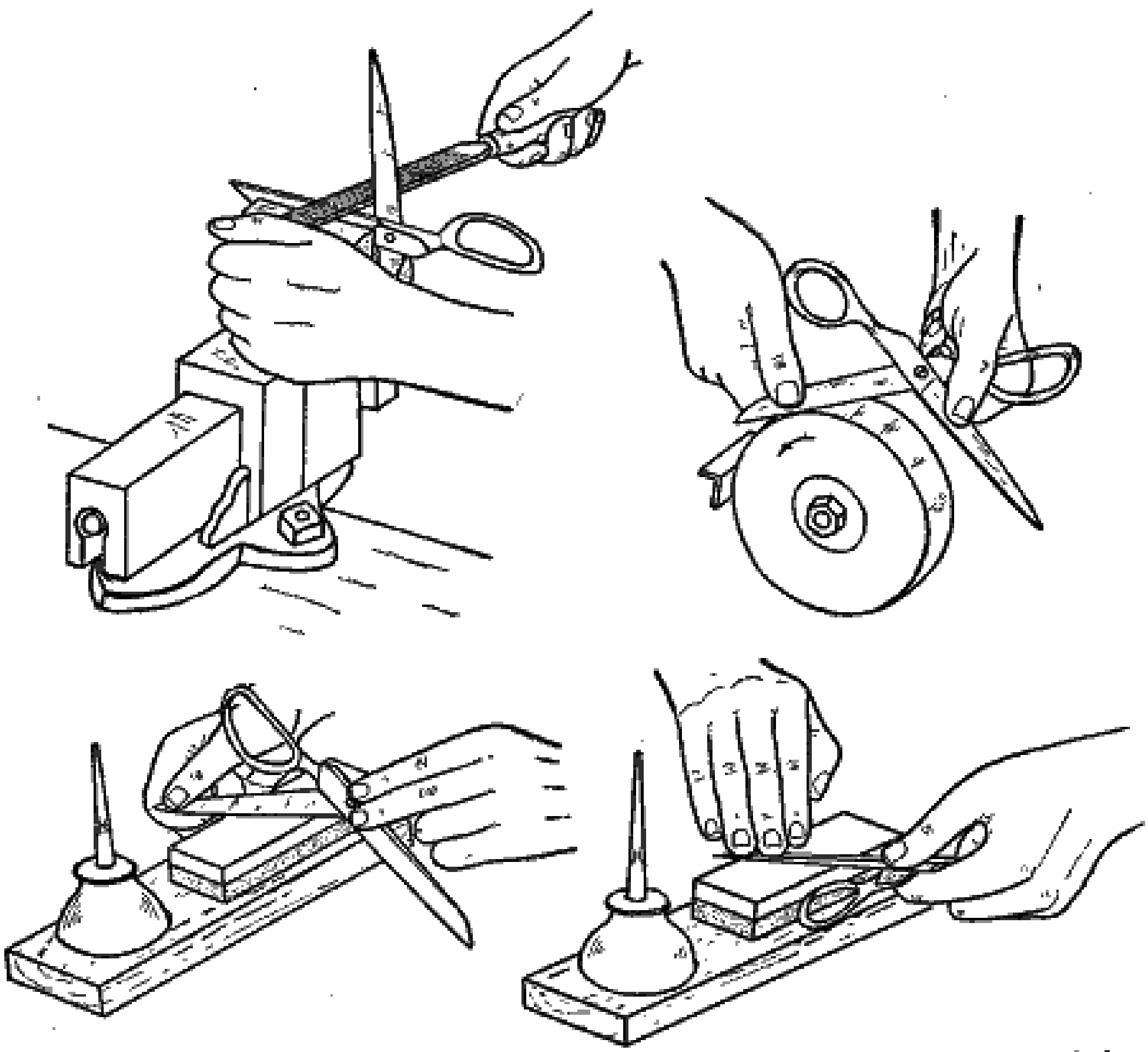

FIG. 125.—Scissors may be sharpened by filing or grinding the beveled edges and then finishing on the oilstone, alternately whetting the flat side and the beveled edge of each blade.

edges. Filing on the bottom side would be more likely to change the suction or angle of clearance, as well as to make it more difficult to remove the same amount from each lip.

A small special file, known as an *auger-bit file*, is best for filing a bit. A small triangular or three-cornered file, or a small flat file, may be used, however, if the workman is careful.

146. Wood Scrapers.—The first step in sharpening a hand wood scraper is to draw-file the edges square and straight, rounding the corners slightly. A smooth mill file should be used. The scraper should then be whetted on an oilstone, first on edge and then on the flat sides to make

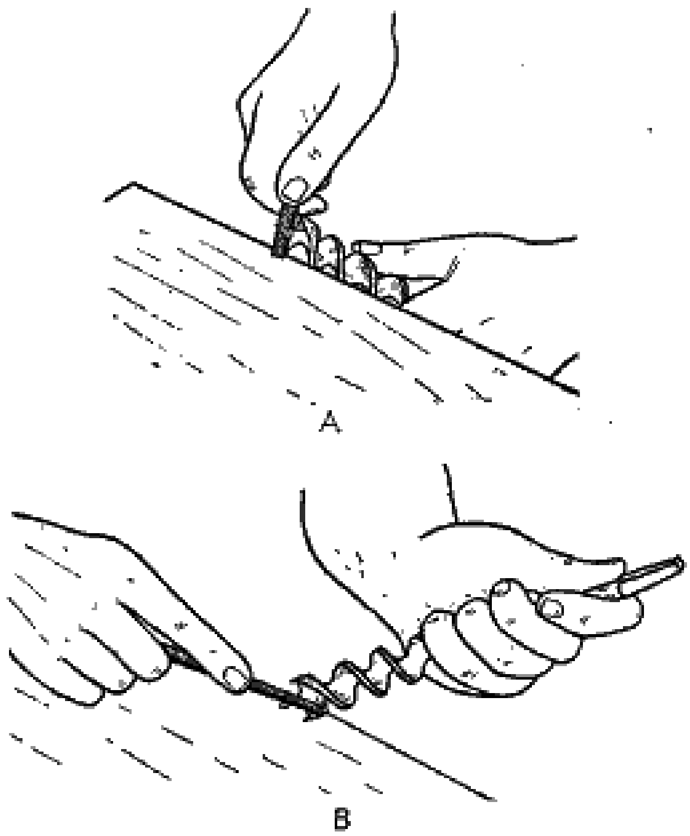

FIG. 126.—Two points are important in sharpening auger bits: *A*, file the spurs on the inside only. *B*, file the cutting lips on the top side (next to shank).

corners smooth and sharp. A burnisher, or other piece of hard, smooth steel, is then drawn over the edge three or four times, using a firm, moder-

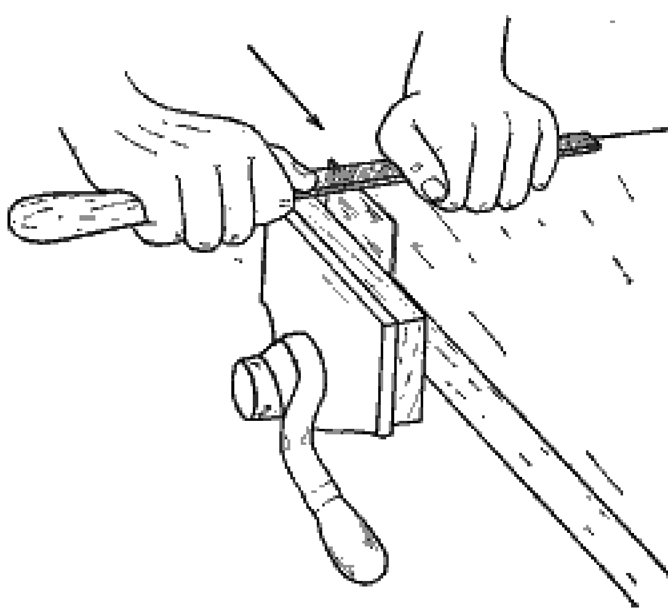

FIG. 127.—The first step in sharpening a very dull scraper is filing it. The edge should be kept square and straight. The corners may be rounded slightly.

ate pressure and holding the burnisher flat against the scraper. The burr is then turned from the edge to the flat side of the scraper with

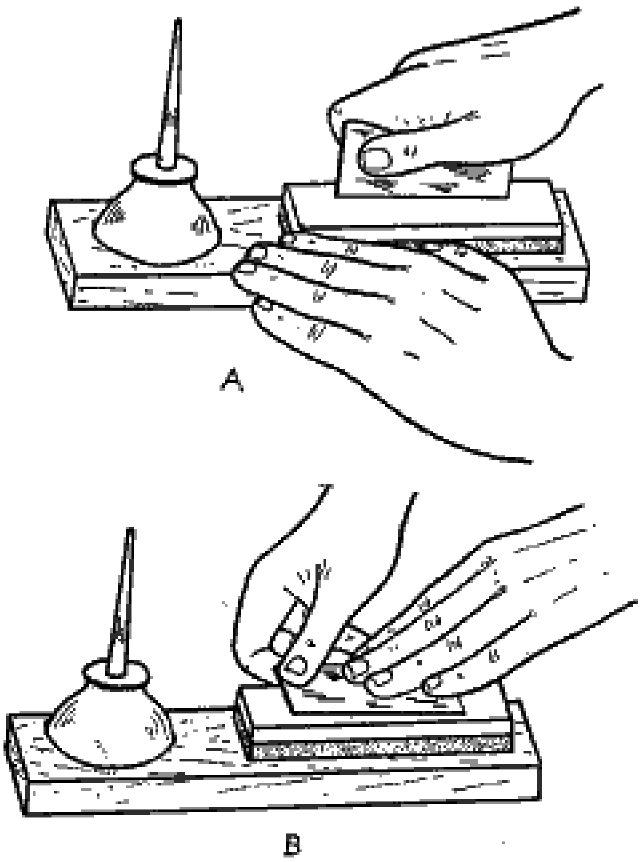

Fig. 128.—After filing, whet the scraper alternately on edge and on the flat sides, using the fine side of the oilstone.

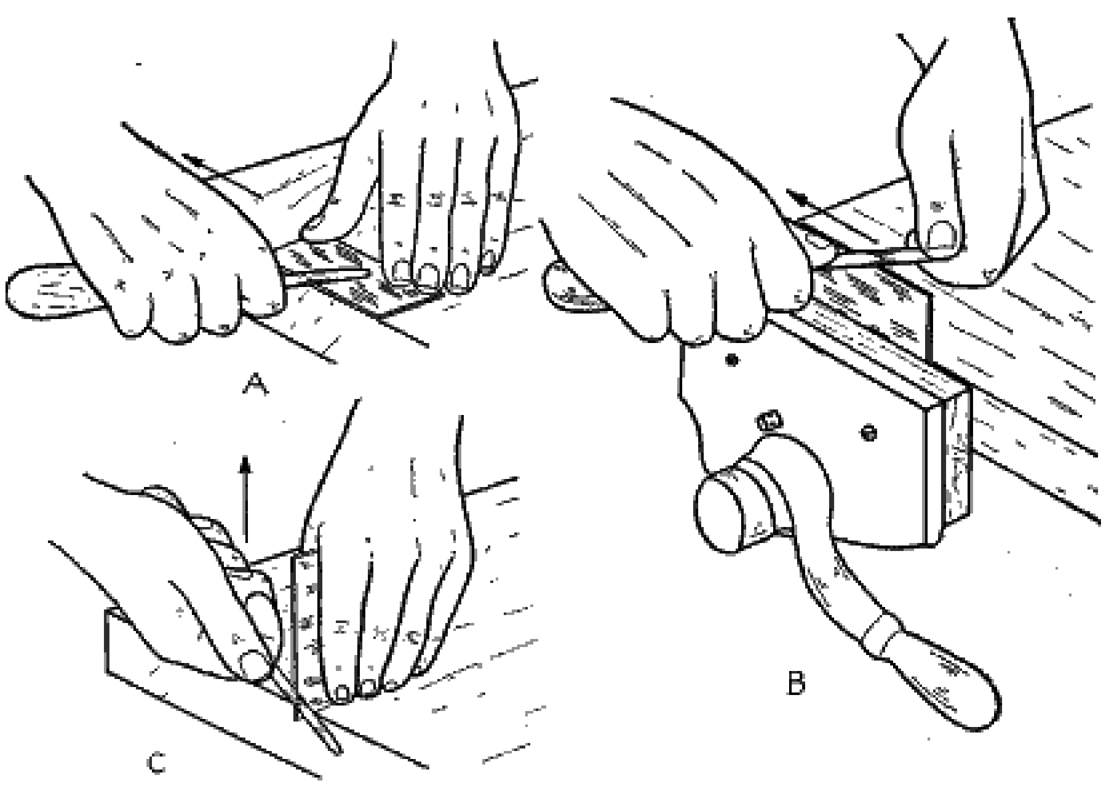

Fig. 129.—Forming the scraping burr on a scraper. Draw the burnisher over the edge three or four times, using moderate pressure, and keeping it flat against the scraper, as at *A*. The burr is then turned with three or four strokes as at *B* or *C*. The burnisher should be pulled with the handle end slightly ahead. A little oil on the burnisher makes it work better.

three or four additional strokes with the burnisher, the first stroke being made with the burnisher square with the edge, and each additional stroke at a slightly smaller angle (see Figs. 129, 130, and 131). The burnisher should be pulled toward the workman, with the handle end slightly ahead. A little oil on the burnisher makes it work better.

Fig. 130.—In turning the burrs of a scraper, the burnisher is held at 90 deg. to the scraper on the first stroke, and then gradually tilted until it makes an angle of about 85 deg. on the last stroke.

The edge of a scraper may be renewed several times with the burnisher before it will need refiling and whetting.

A cabinet scraper is usually sharpened with a beveled edge. Some mechanics prefer hand wood scrapers with beveled edges also. When a scraper is sharpened to a beveled edge, the angle of bevel is usually about 45 deg. or about double that of a plane bit.

Fig. 131.—*A*. Shape of scraping burr after burnisher has been used on flat sides of scraper.

B. Shape of burr after burnisher has been used on edge of scraper.

The first step in sharpening a beveled edge scraper is to file the edge at the desired bevel. The scraper is then whetted on an oilstone, first on the beveled side and then on the flat side, to remove the wire edge left by filing. The job of sharpening is then finished by burnishing in much the same manner as a square-edged scraper. A few strokes are made with the burnisher flat against the flat side of the scraper. The scraping or cutting burr is then turned with a few strokes of the burnisher on the beveled edge. The first stroke is made with the burnisher practically flat against the bevel, with each succeeding stroke at a little greater angle until finally the burnisher makes an angle of about 75 deg. with the flat side of the scraper. In case the burr is turned too much, it may be raised somewhat by drawing the point of the burnisher along under the burr (see Fig. 132*D*).

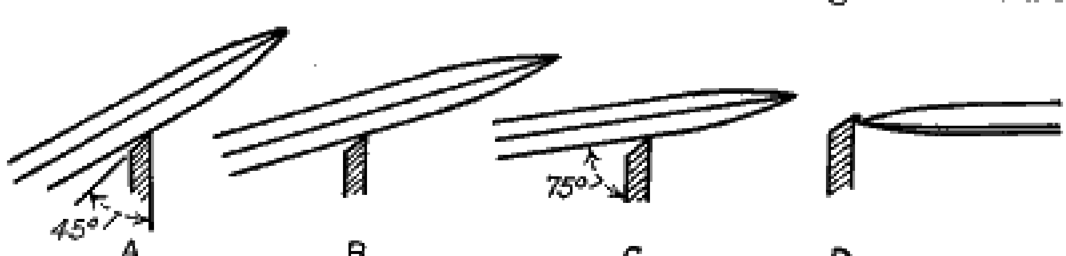

Fig. 132.—Steps in turning a burr on a beveled-edge scraper. In case the burr is turned too much, it may be raised somewhat, as at *D*.

COLD CHISELS; PUNCHES; SCREW DRIVERS

147. Cold Chisels.—For general cutting, cold chisels should be ground with the bevels on the cutting edge making an angle of about 70 deg. with each other. For special work, such as cutting thin metal or soft metal, a keener edge may be ground. The chisel should be held against the grinding wheel as shown in Fig. 133. Note that the tool is

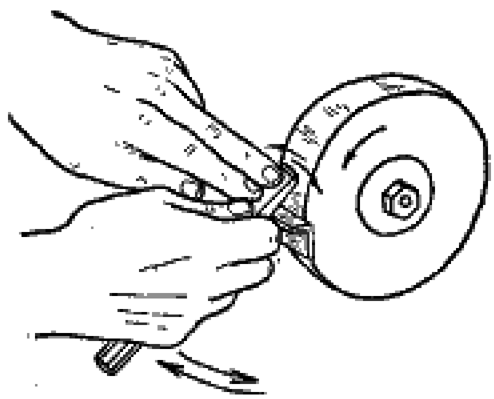

FIG. 133.—Grinding a cold chisel. Hold the chisel firmly against the work rest, with the first finger of the right hand touching the underside of the rest. Press the cutting edge of the chisel against the wheel with the fingers of the left hand and swing the handle of the chisel back and forth with a wrist action of the right hand.

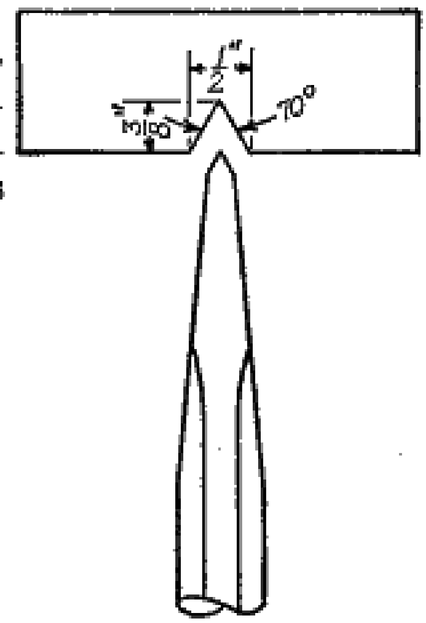

FIG. 134.—For general work, the cutting end of the cold chisel should be ground to an angle of about 70 deg. A gage for checking the angle of grinding can be easily made of sheet metal.

grasped firmly in the right hand with the first finger against the work rest. When the chisel is lifted for inspection or for dipping into water, it may be placed back against the wheel in exactly the same position if the mechanic is careful not to release his hold. Note, also, that the tool is held against the wheel with the first two fingers of the left hand while the right hand is used to swing the handle back and forth. This grinds the corners of the chisel back a little and gives a slightly curved cutting edge. With the corners thus relieved, there is less danger of breaking them off. A simple gage for checking the cutting angle of a chisel is easily made of sheet metal (see Fig. 134). The chisel should be dipped into water occasionally while grinding to prevent drawing the temper.

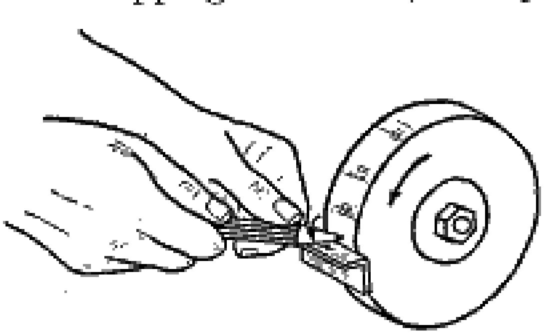

FIG. 135.—A center punch may be easily ground by holding it against the grinding wheel at the desired angle and rolling it slowly. The tool should also be moved from side to side to distribute wear over the wheel.

148. Center Punches.—A center punch may be ground easily by holding the end flat on the work rest with the thumb and first finger of the left hand while rolling the tool slowly with the right hand. The tool should be moved back and forth across the work rest to distribute the wear evenly over the grinding wheel. The point of a center punch should be ground to an angle of about 60 deg.

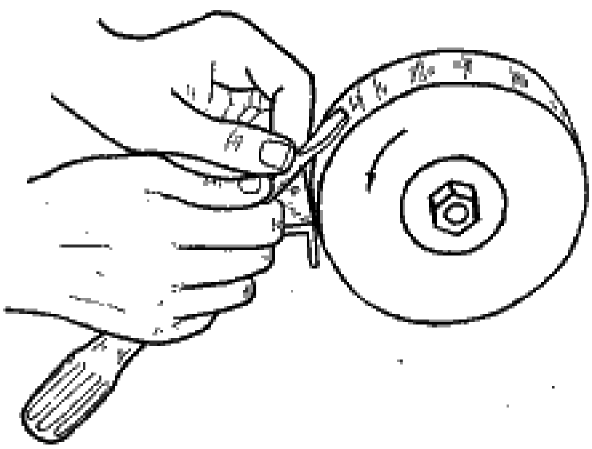

FIG. 136.—A screw driver is easily sharpened by filing or grinding. Care should be exercised to shape the end to fit the screw slot.

149. Prick Punches; Scratch Awls.—Prick punches and scratch awls (scribers) are ground in the same manner as center punches, except that the points are made much sharper.

150. Screw Drivers.—A screw driver should be ground to a very blunt end with the sides perfectly straight or slightly hollow or concave, never convex (see Fig. 137). The end of the blade should fit the slot in the head of the screw snugly. If the end is ground to an edge like a knife, it will easily slip from the slot and mar the screwhead.

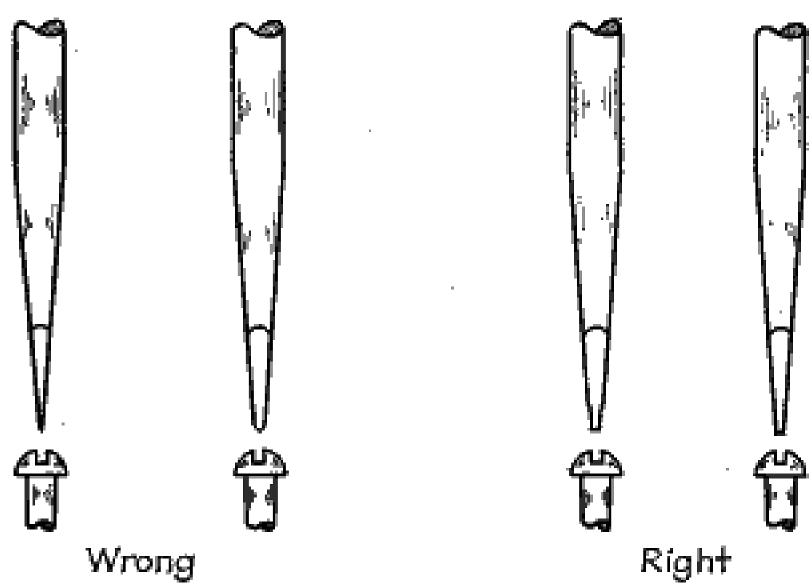

FIG. 137.—Right and wrong shapes of screw-driver ends.

TWIST DRILLS

Sharpening of twist drills is one of the most important grinding jobs in the farm shop. Most difficulties in drilling and most drill breakage can be traced to faulty sharpening.

151. Requirements of a Properly Sharpened Drill.—The two main requirements of a properly sharpened drill are:

1. The cutting lips must have clearance or be ground off behind the cutting edge to allow the drill to bite into the metal. The proper amount of clearance is about 12 deg.

2. The cutting edges should be exactly the same length and make exactly the same angle with the central axis of the drill, the proper angle being 59 deg., or practically two-thirds of a right angle. (The axis is an imaginary line exactly in the center of the drill running from one end of the drill to the other.)

152. Clearance.—If the cutting lips do not have clearance, the drill cannot bite into the metal, and if there is too much clearance the drill

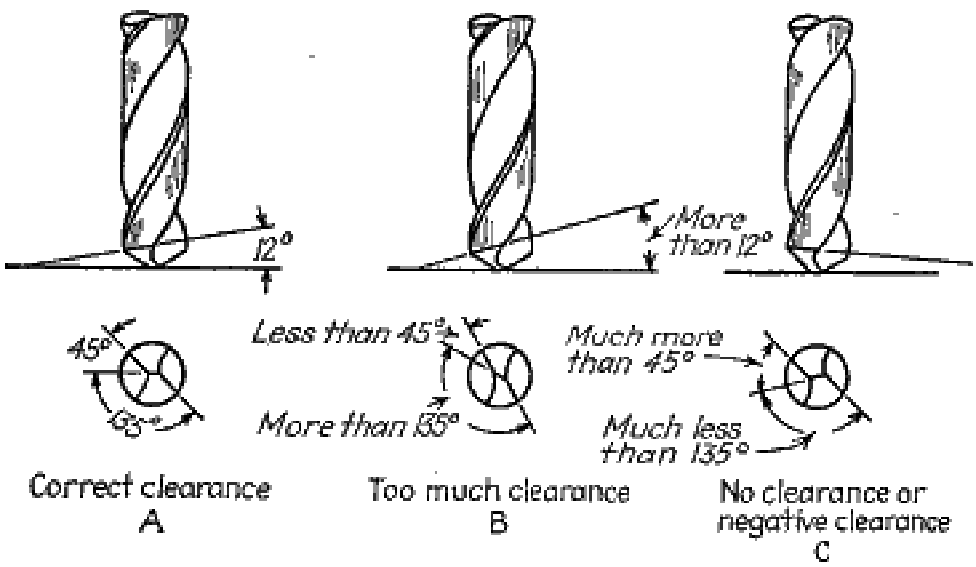

FIG. 138.—The lip clearance of a twist drill may be judged by noting the angle between the cutting edges and the short line across the end of the drill.

may take too deep a bite or gouge. A good mechanic soon learns to judge the clearance of a drill by simply looking at the cutting end. The amount of clearance is indicated by the angle between the short line across the end of the drill and the cutting edges. The clearance will be about right when this angle is from 120 to 135 deg. (one and a half right angles or somewhat less. See Fig. 138). An angle greater than this indicates too much clearance (Fig. 138*B*) and an angle less than this indicates not enough clearance (Fig. 138*C*). The amount of clearance can also be judged by observing the outer edge, or periphery of the cutting end, or by standing the drill vertically, point down, against the bench top beside a rule (Fig. 139) and then turning the drill slowly. The heel of the cutting end should register slightly higher on the rule than the front edge.

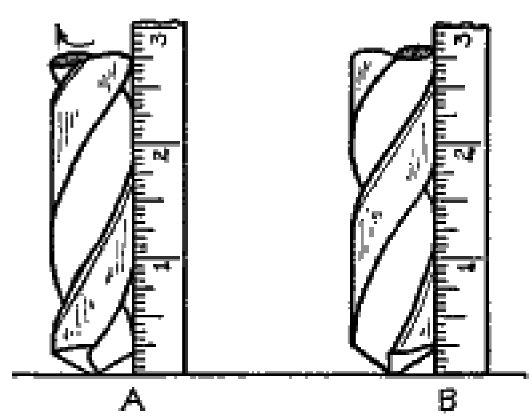

FIG. 139.—Lip clearance may also be judged by standing a drill beside a rule and rotating it. The heel of the cutting end should register higher on the rule than the front cutting edge.

153. Length and Angle of Cutting Edges.—If both cutting edges are the same length and make the same angle with the central axis, the point of the drill will be centered. If the point is not centered, the drill will make an oversize hole, and one lip will do more than half of the cutting. If the lips are not ground at the proper angle of 59 deg. with the axis, the cutting edges will be slightly curved instead of straight and the drill will be too pointed or too blunt. The length and angle of the cutting lips can best be checked with a gage (see Fig. 140). Such a gage can be made easily from heavy sheet metal.

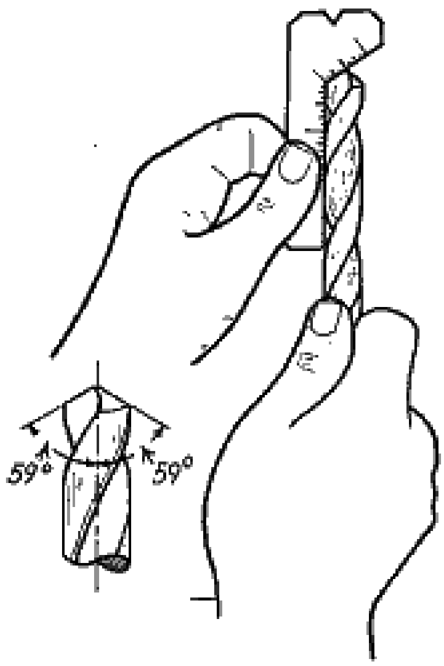

FIG. 140.—Checking the cutting lips for (1) length and (2) angle with the central axis of the drill. Both lips should be the same length and make an angle of about 59 deg. with the central axis. (The notch in the end of the gage is for checking the angle of bevels on a cold chisel.)

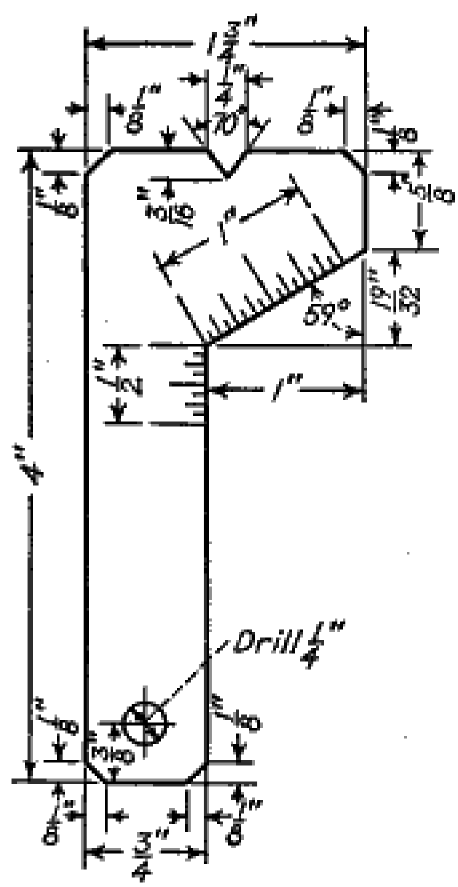

FIG. 141.—Plan for a home-made twist-drill and cold-chisel grinding gage.

154. Placing the Drill in Position for Grinding.—The work rest on the grinder should be adjusted to about the same level as the wheel shaft. The drill is then placed on the work rest with:

1. The cutting end at about the same height as the other end.
2. One cutting lip horizontal.
3. The axis of the drill making an angle of about 59 deg. with the cutting surface of the wheel (see Fig. 142).

(If desired, a line may be filed on the work rest at the 59-deg. angle.)

With the wheel turning at normal speed, the drill is then *slowly*, yet firmly, forced against the wheel, and the cutting end *slowly* elevated by lowering the other end. As the point is elevated, it must be pushed forward somewhat to keep it in contact with the wheel. The second lip of the drill is ground by simply turning the drill half around and grinding

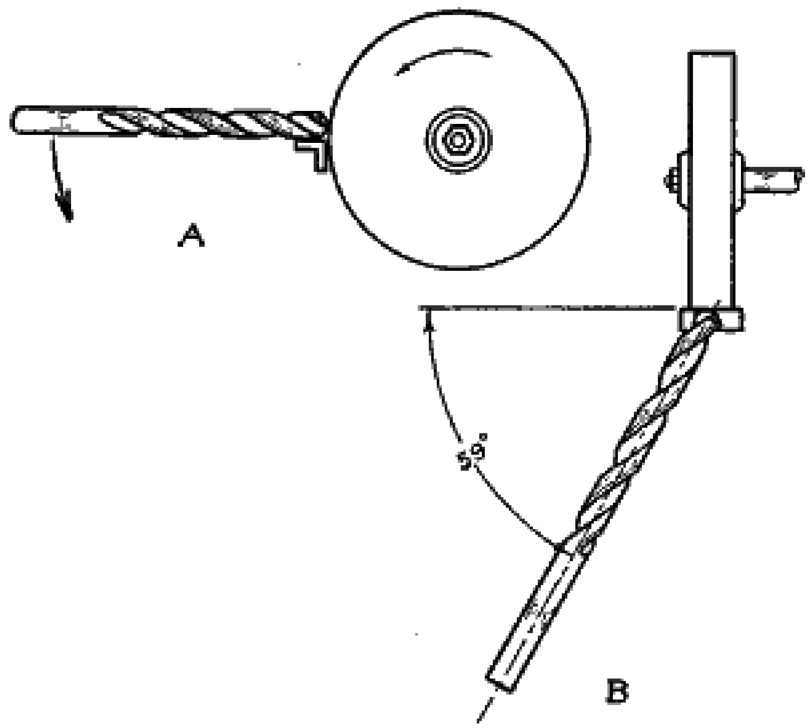

FIG. 142.—Side view (*A*) and top view (*B*) of a drill in proper position for grinding. The end of the drill is placed flat on the work rest, with one cutting lip horizontal and against the grinding wheel, and with the axis of the drill making an angle of about 59 deg. with the surface of the wheel. The cutting end of the drill is then firmly forced against the revolving wheel and slowly raised by pushing down on the other end.

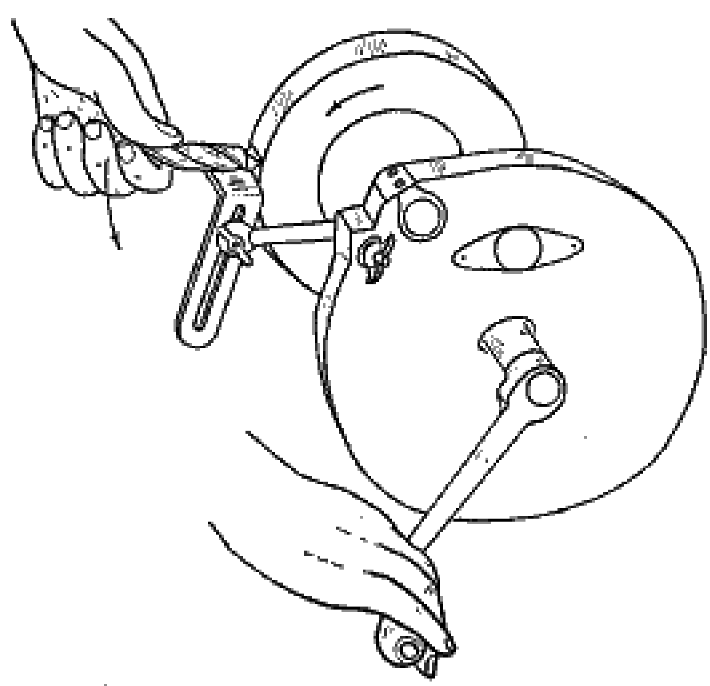

FIG. 143.—Grinding a twist drill with a hand grinder.

it in identically the same manner. It is important that *slow, deliberate* motions or strokes be used in manipulating the drill against the wheel.

With a hand-operated grinder the drill is held in the left hand while the right hand turns the crank. Where a power-driven grinder is used and both hands are free to hold the drill, the first finger of the left hand may be placed on the work rest, and the drill rocked over it.

The progress of grinding should be checked after every few movements or strokes against the wheel, both for clearance and for length and angle of the cutting lips. If more clearance is needed, more grinding should be

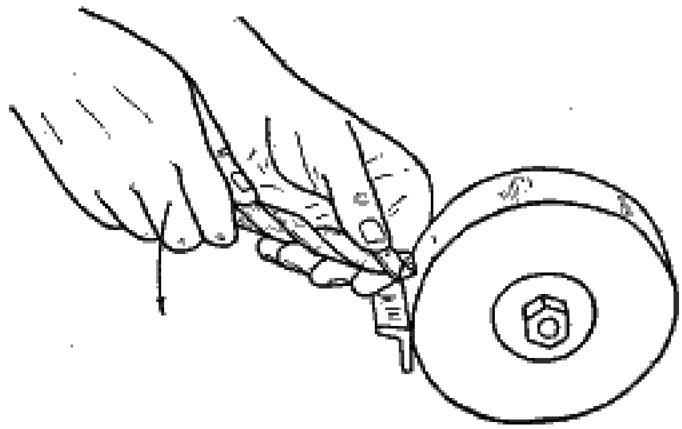

FIG. 144.—With a power-driven wheel the end of the drill may be supported by the first finger of the left hand, which is placed on top of the work rest.

done on the last part of the stroke by using more pressure or slower motion on the last part of the stroke. If less clearance is needed, less pressure or slightly faster motion should be used toward the end of the stroke. If there is a tendency to get too much clearance, possibly the drill is pointed too high up on the wheel at the beginning of the stroke.

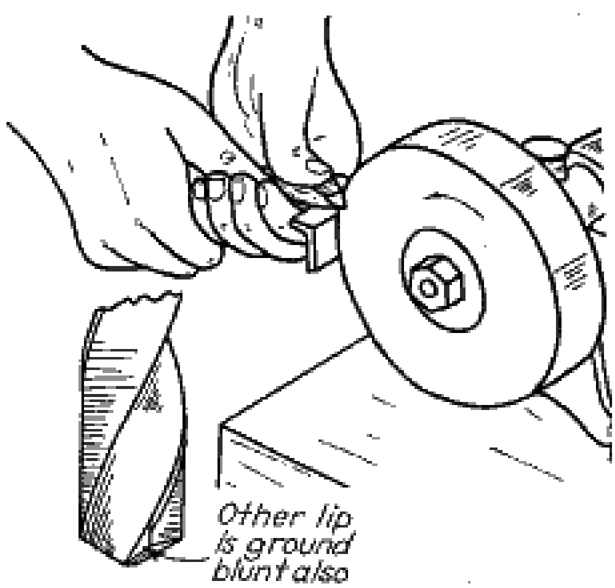

FIG. 145.—For drilling extremely hard or soft materials, the cutting edges may be ground blunt to give a scraping action.

Of course the drill should be dipped into water frequently while grinding, to prevent overheating and drawing the temper.

Instead of grinding against the curved face of the wheel, some mechanics prefer to hold the drill against the flat side. This is all right, but if the side of the wheel becomes slightly grooved or out of shape after considerable use, it will be more difficult to dress than the curved grinding surface.

155. Grinding a Drill for Soft or Hard Materials.—For drilling brass or other soft metals, or for drilling hard materials where heavy pressure is required, a drill ground with the usual shape has a tendency to gouge. To prevent this, the cutting lips may be made blunt by grinding narrow, flat surfaces on the front edges, the surfaces being parallel to the axis of the drill (see Fig. 145). The drill then has more of a scraping action.

CLEANING TOOLS

156. Removing Rust.—Brisk rubbing with an oily rag will remove light rust, while fine abrasive of some kind will be needed to remove deep rust. Extra-fine grades of sandpaper and emery cloth or steel wool are satisfactory for most tools, although pumice stone and water is recommended for renewing highly polished surfaces, provided they are promptly dried and given a light coat of oil.

It is a good plan to go over the metal parts of tools in the shop occasionally with an oily rag to prevent rusting. In case tools are to be stored for a considerable time, a heavy coat of oil is advisable.

Questions

129. (*a*) Why are many edge tools used with a diagonal stroke or motion? (*b*) What is the chief difference between coarse-edged tools and fine-edged tools?

130. (*a*) What is the general method of sharpening edge tools? (*b*) Should the grinding wheel turn toward or away from the edge of the tool? Why?

131. (*a*) What determines whether a tool should be ground on a grinding wheel or sharpened altogether on an oilstone? (*b*) At what angle should wood chisels and plane bits be ground? (*c*) What simple method may be used for checking to see if the angle of bevel is about right? (*d*) Why should a tool be moved back and forth across the face of the grinding wheel while grinding? (*e*) What particular precaution should be observed in grinding a tool on the flat side of a wheel? (*f*) How may a wire edge be detected?

132. (*a*) What kind of oil should be used on an oilstone? (*b*) What kinds of motion may be used in whetting an edge tool on an oilstone?

133. What two particular precautions should be observed in whetting to remove a wire edge? Give reasons.

134. (*a*) Why should a tool be drawn over the strop with the cutting edge trailing instead of leading? (*b*) How may a tool be stropped in case a leather strop is not available?

135. (*a*) Explain and be able to demonstrate how to test the sharpness of a tool on the cuticle of the thumb. (*b*) How may the sharpness of a tool be judged by simply looking at it?

136. In what respects is a drawknife sharpened differently from a plane bit or wood chisel?

137. (*a*) What points should be observed in sharpening a pocketknife, bread knife, or butcher knife? (*b*) Just how can the use of a sharpening steel improve the cutting action of a butcher knife?

138. What is the method generally used for sharpening an ax or hatchet?

139. (*a*) Why are grass sickles and scythes not whetted on an oilstone? (*b*) May such tools be sharpened by draw filing?

140. What precautions should be observed in grinding mower sickles?

141. How are large nicks best removed from ensilage-cutter knives?

142. Besides grinding, how may rolling colters and disks be sharpened?

143. (*a*) May hoes and spades be sharpened by draw filing? (*b*) How may a hoe be held while filing in case a vise is not available?

144. (*a*) What equipment is needed to sharpen scissors and snips? (*b*) What is the process of sharpening such tools?

145. (*a*) What are the two main points to be observed in sharpening wood auger bits? (*b*) What difficulties are likely to be encountered if these points are not observed? (*c*) What kinds of files are used in sharpening auger bits?

146. (*a*) What part of a wood scraper does the cutting? (*b*) What tools or equipment are needed to sharpen wood scrapers? (*c*) Outline the process of sharpening a scraper. (*d*) How much pressure is needed in using the burnisher?

147. (*a*) For general work, what should be the angle between the bevels on a cold chisel? (*b*) Just how is the chisel held and manipulated while grinding it? (*c*) What is the advantage of grinding the corners of the chisel back, or making the cutting edge curved?

148. (*a*) How should the center punch be held and manipulated while grinding? (*b*) At what angle should the point be ground? (*c*) What precautions should be observed in grinding a center punch to avoid excessive wear and abuse of the grinding wheel?

149. Just how are prick punches or scratch awls ground differently from center punches?

150. (*a*) Describe the shape of a properly fitted screw-driver bit. (*b*) What are common mistakes in grinding screw drivers?

151. (*a*) What are the requirements of a properly sharpened twist drill? (*b*) What is meant by the "central axis" of a drill?

152. (*a*) How will a drill act if the lip clearance is too much? If too little? (*b*) How may one tell by looking at a drill if the clearance is satisfactory or if it is too much or too little? (Specify angles, etc.)

153. Why is it important that the cutting lips be the same length and make the same angle with the central axis of the drill?

154. (*a*) Explain and be able to demonstrate just how to place a drill against a grinding wheel and manipulate it while grinding. (*b*) What kind of strokes or motions should be used? (*c*) In case it is observed that a drill is being ground with too little lip clearance, just how would you change the grinding operations or motions?

155. (*a*) How may a drill be ground especially for hard or soft metals? (*b*) How would such a drill work better than one ground in the usual shape?

156. (*a*) How may rust be removed from tools? (*b*) How may tools be kept from rusting?

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CHAPTER XI

GRINDING AND SHARPENING EQUIPMENT

157. Grindstones.—A few years ago the grindstone was a common piece of equipment on the farm, but, with the great improvement made in artificial abrasives and grinders, it now has been largely replaced by the new and faster-cutting grinders. Although a grindstone cuts much slower (unless it is power driven and considerable pressure is used), it puts a very fine cutting edge on a tool without danger of drawing the temper and is preferred by many for the sharpening of edge tools, mower sickles, ensilage-cutter knives, etc.

158. Grinders for the Farm Shop.—Every farm shop should have a grinder of some kind for sharpening tools and for the many odd grinding jobs that arise, such as grinding metal parts to fit, grinding hard materials that cannot well be filed or otherwise shaped, etc. A hand-operated grinder that clamps to the work bench is recommended if a larger power-driven grinder cannot be afforded. If electricity is available, a bench grinder carrying two wheels and driven with a V-belt from a $\frac{1}{4}$-hp. motor is a very practical unit. Interchangeable wheels may be used, and one of them may well be a special double-cone wheel for grinding mower sickles. Where electricity is not available, it is sometimes possible to use a small gas engine for power. For general grinding, a good belt-driven grinder is usually preferred to a motor grinder with wheels mounted on the ends of the motor shaft, because the wheels are more accessible on a belt-driven outfit.

In selecting a grinder of any kind, it is important to get one that is sturdy and well-built, with good bearings that can be adequately lubricated and that are well protected from grit and dirt. Good, sturdy, adjustable work rests are also important.

159. Good Grinding Wheels Are Important.—The secret of success with a grinder is to select good wheels that are suited to the kind of grinding to be done. In order to be able to select wheels and to use them most effectively, one should understand how they are made and how they grind.

160. Electric-furnace Abrasives.—The abrasive particles from which modern grinding wheels are made are products of the electric furnace. Certain materials are mixed and chemically combined into large crystalline masses under the intense heat of the furnace. After cooling, these large pieces are broken and crushed to small particles. These small particles, which are very hard and have sharp corners, are then cemented together to form various kinds and shapes of grinding wheels and sharpening stones.

Two principal kinds of abrasives are made in the electric furnace: (1) aluminum oxide, which is used for grinding materials of high tensile strength like steel, and (2) silicon carbide, which is used mainly for grinding materials of low tensile strength like cast iron.

161. Action of a Grinding Wheel.—The hard sharp particles on the surface of a grinding wheel cut or scratch the material being ground. After a certain amount of grinding, these particles become dull and are pulled from the wheel under the grinding pressure. A good grinding wheel that is suited to the work being done gradually but slowly wears away, "shedding" the particles as they become dull and keeping sharp particles constantly exposed. If the particles do not shed fast enough, the surface of the wheel becomes glazed and rubs instead of cutting, thereby causing excessive heat, which would draw the temper of tools. If the particles shed too fast, the wheel does not hold its shape well, and it soon wears out. The rate of shedding is determined by the kind, strength, and amount of cement or bonding material used in making the wheels. Wheels that shed easily are known as *soft*, and wheels that shed slowly are known as *hard*. A soft wheel, although it wears away somewhat faster, has less tendency to heat the work and is therefore preferred for grinding tools.

162. Grain.—The coarseness or fineness of grinding wheels is designated by a number representing the size of grains or particles used in making the wheel. A grain of 36, for example, means that the finest screen through which the particles will pass has 36 meshes to the inch.

For grinding tools like plane bits and knives, a medium-fine grain of about 80 is best. For fast cutting where a highly polished surface is not necessary, a grain of about 30 may be used. The speed with which a wheel runs affects the smoothness of grinding; the faster it runs, the smoother it will grind.

163. Emery Wheels.—Emery, which is a mineral found in nature, was at one time used extensively for making grinding wheels. The particles are tough and tend to become dull more quickly than abrasives made in the electric furnace. Also, emery usually contains some impurities, principally iron. Emery wheels, therefore, tend to glaze more rapidly and cause more heating while grinding. Consequently, emery is not now used in the better grinding wheels.

164. Grinding-wheel Speeds.—Speed is important. A hand-driven grinder should be turned at a moderately fast steady speed, but not fast enough to make the gears "whine" or to cause excessive vibration. A power-driven grinder should be run at a speed that will give the wheels a surface speed of from 4,000 to 5,000 ft. per minute, provided the grinder is ruggedly built, the bearings are tight, and there is no serious vibration. Many of the smaller lightweight grinders will have to be driven considerably slower because of vibration. The surface speed of a wheel may be determined by multiplying the diameter in inches by 3.1416 and by the number of revolutions per minute, and then dividing by 12. The r.p.m. of different sizes of wheels to give 3,000, 4,000, and 5,000 ft. per minute is given in Table III.

TABLE III.—REVOLUTIONS PER MINUTE REQUIRED FOR VARIOUS SURFACE SPEEDS OF GRINDING WHEELS

Diameter of wheel, in.	3,000 ft. per minute	4,000 ft. per minute	5,000 ft. per minute
4	2,865	3,820	4,775
6	1,910	2,546	3,183
8	1,433	1,910	2,387
10	1,146	1,528	1,910
12	955	1,273	1,592
14	819	1,091	1,364
16	716	955	1,194

165. Testing and Mounting a New Wheel.—Sometimes wheels are cracked in shipment. Before mounting a new wheel, therefore, it should be tested for hidden cracks or flaws. This may be done by striking a light blow with a small hammer. If the wheel is sound, it will ring; if there are flaws, it will give a dull thud.

The wheel is fastened to the grinder spindle or shaft by a nut that clamps the wheel between two flanges or disks. The nuts should be drawn up only moderately tight, and there should be washers of heavy paper, rubber, or leather between the flanges and the wheel. These precautions should be taken to prevent undue strain on the wheel, which might cause it to crack.

166. Truing and Dressing the Wheel.—The farm shop equipment should include a grinding-wheel dresser. It is an inexpensive tool, and a grinding wheel must be dressed occasionally if it is to continue to give good service.

A wheel should be dressed if any of the following conditions exist: (1) if the surface is glazed and the dull particles need to be removed; (2) if the pores of the wheel are clogged with dirt, grease, brass, lead, etc.; and (3) if the grinding surface is grooved or otherwise out of shape.

Any of these conditions can be remedied by holding the dressing tool firmly against the wheel while it is turning. If a wheel requires dressing too often it is an indication that it is too soft, too hard, or otherwise unsuited to the kind of grinding being done.

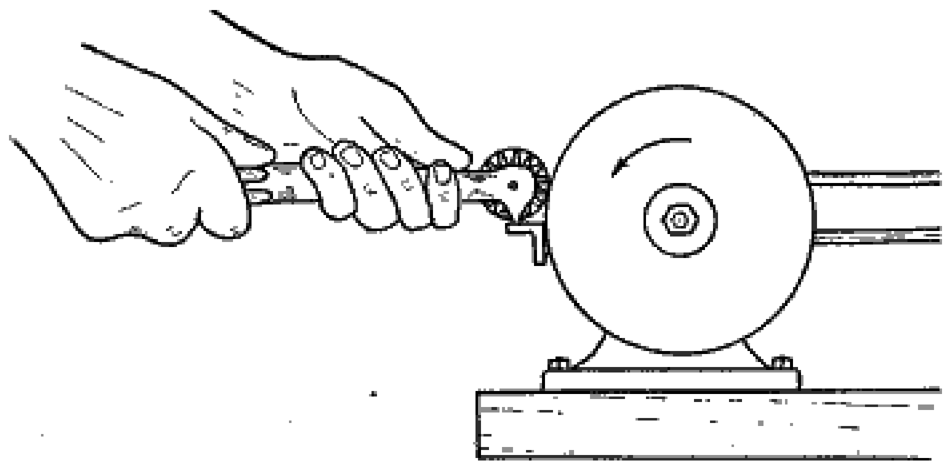

FIG. 146.—Dressing a grinding wheel. The cutting surface of the wheel is easily and quickly trued, cleaned, and renewed by simply holding the tool firmly against the wheel while it is turning.

167. Safety Precautions. *Goggles; Safety Glass Shields.*—It is best to wear goggles while grinding. When goggles are not worn, glass shields, made of shatterproof glass and mounted on the grinder, are recommended. In any event it is advisable for the operator to stand slightly to one side so his face will not be in line with the grinding wheel and there will be the least danger from flying sparks, grit, and bits of metal.

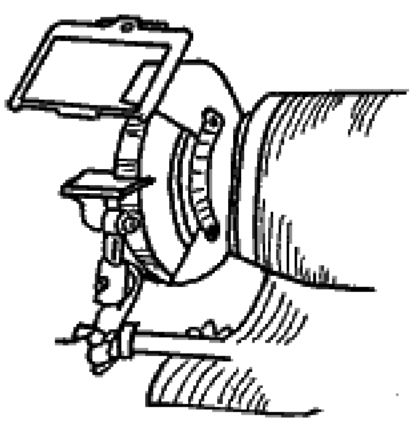

FIG. 147.—Shatterproof glass shields afford protection against flying particles of grit and metal.

Wheel guards should be used on high-speed power-driven grinders. They keep most of the particles of grit and steel from flying outward toward the operator, and they also provide a certain measure of protection in case a wheel should break while in use.

Adjustment of Work Rests.—The work rest should be set as close to the wheel as possible without touching. This is very important. If the rest is too far from the wheel, the piece being ground may catch and wedge between the wheel and the rest and possibly chip or break the wheel or spring the grinder spindle.

Adjustment of Bearings.—Bearings should be kept tight and well lubricated. Loose bearings not only allow vibration and cause inferior grinding but also introduce an element of danger, especially on high-speed grinders.

168. Oilstones.—An oilstone for sharpening keen-edged tools is practically indispensable in the farm shop. Two kinds of stones are available, natural stones and those made of artificial or electric-furnace abrasives.

The artificial abrasive stones are generally preferred as they are more uniform. A combination stone with one side made of coarse or medium abrasive and the other made of fine abrasive is recommended. The coarse side is used for faster cutting during the first part of the sharpening and the fine side for finishing to a keen, smooth edge.

A light oil, such as kerosene and motor oil mixed in equal parts, is used on an oilstone to float off the small cuttings of steel and to prevent the surface from becoming clogged with dirt. If a stone is used dry it soon becomes slick and will not cut fast. A dirty stone can be cleaned by

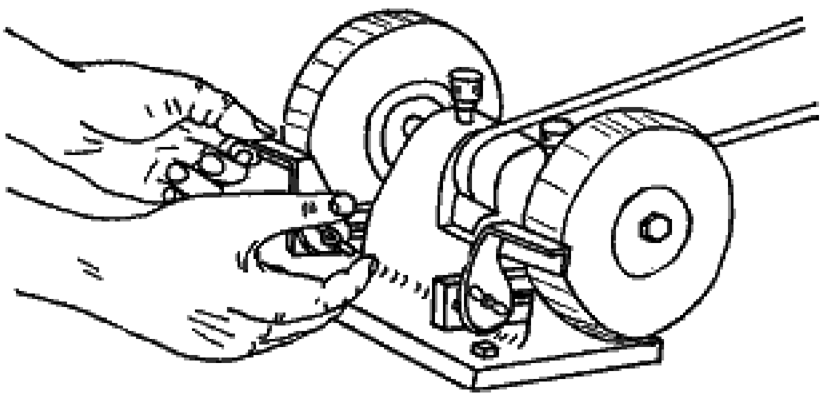

FIG. 148.—One of the most important safety precautions in the use of a grinding wheel is to keep the work rest adjusted so that it just clears the wheel.

placing it in a pan and heating it in an oven or over a fire, or by washing in gasoline or kerosene.

Points on Grinders and Their Use

1. Select a good-quality wheel that is suited to the kind of grinding to be done.
2. Well-built, sturdy grinders with good bearings are worth the small additional cost over cheap grinders.
3. With a hand grinder, turn with a moderately fast, steady speed.
4. Keep the work rest adjusted as close to the wheel as possible without rubbing.
5. Hold the tool against the wheel with a light to medium pressure.
6. Move the tool from side to side while grinding to distribute the wear evenly on the wheel and prevent grooving and also to insure even grinding of the tool and to prevent overheating.
7. Keep the bearings well lubricated.
8. Keep the bearings tight.
9. Dress the wheel whenever it becomes dull (surface glazed), whenever the pores become clogged, or whenever it becomes worn out of shape.
10. It is best to use goggles when grinding or to have the grinder equipped with safety-glass eye shields. The operator should stand slightly to one side with his face out of line with the wheel to lessen the danger from flying sparks, grit, and bits of metal.
11. A wheel may be tested for hidden flaws by striking lightly with a small hammer. A clear ring indicates a sound wheel; a dull thud, a wheel that is cracked.
12. The nut that holds the wheel in place should be drawn up only moderately tight.
13. Use washers of heavy paper or similar material between the mounting flanges and the wheel.

14. A combination oilstone with coarse or medium grit on one side and fine grit on the other is needed for whetting keen-edged tools.

15. A light oil, such as kerosene and motor oil mixed in equal parts, should be used on an oilstone.

Questions

157. What are the advantages and disadvantages of the grindstone as compared to the newer type grinding wheels?

158. (*a*) What kinds of grinders are suited to use in the farm shop? (*b*) What are some important points to consider in the selection of a grinder?

159. Why is it important to understand how grinding wheels are made and how they grind?

160. (*a*) What is the general process of making grinding abrasives in the electric furnace? (*b*) How are wheels made from the abrasive particles? (*c*) What are the two general kinds of abrasives in common use?

161. (*a*) What is a dull grinding wheel? (*b*) How can a grinding wheel be self-sharpening? (*c*) What determines the rate of shedding of particles from the surface of wheel? (*d*) What is meant by a hard or a soft wheel?

162. (*a*) What is meant by the grain of a grinding wheel? (*b*) What besides the particle size determines the smoothness with which a wheel will grind? (*c*) What particle sizes would you recommend for wheels for the farm shop?

163. (*a*) In what respects is emery different from abrasives made in the electric furnace? (*b*) Just why is emery inferior to good electric-furnace abrasives for use in grinding wheels?

164. (*a*) How fast should a hand tool grinder be turned? (*b*) State a general rule regarding proper speed for power-driven grinding wheels. (*c*) What factors must be known before one can calculate the surface speed of a wheel in feet per minute?

165. (*a*) How may a grinding wheel be tested for hidden cracks or flaws? (*b*) What precautions should be observed in mounting a new wheel on a grinder?

166. (*a*) What conditions would indicate that a wheel should be dressed? (*b*) Just how may a wheel be dressed?

167. (*a*) How may a workman protect his eyes and face from flying sparks, grit, and bits of metal? (*b*) Why is it important to have the work rests set close to the wheels? (*c*) Just how close should they be set? (*d*) What troubles or difficulties are likely to occur from operating grinders with loose bearings?

168. (*a*) What kind of oilstone is generally recommended for the farm shop? (*b*) Why should oil always be used on an oilstone? (*c*) What kind of oil should be used? (*d*) How may a dirty stone be cleaned?

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CHAPTER XII

SAW SHARPENING

Filing and setting a saw is considered by some to be a difficult job not to be attempted by the average farmer or farm boy. With some study and practice, however, most boys of high school age who have a reasonable amount of mechanical ability can learn to sharpen saws quite acceptably.

Before attempting to sharpen a saw, one should have clearly in mind the proper shape of the teeth, and it is desirable also to understand the cutting action of a saw.

169. Shape of Saw Teeth.—There are two principal differences in the shape of ripsaw and hand crosscut saw teeth. One difference is in the

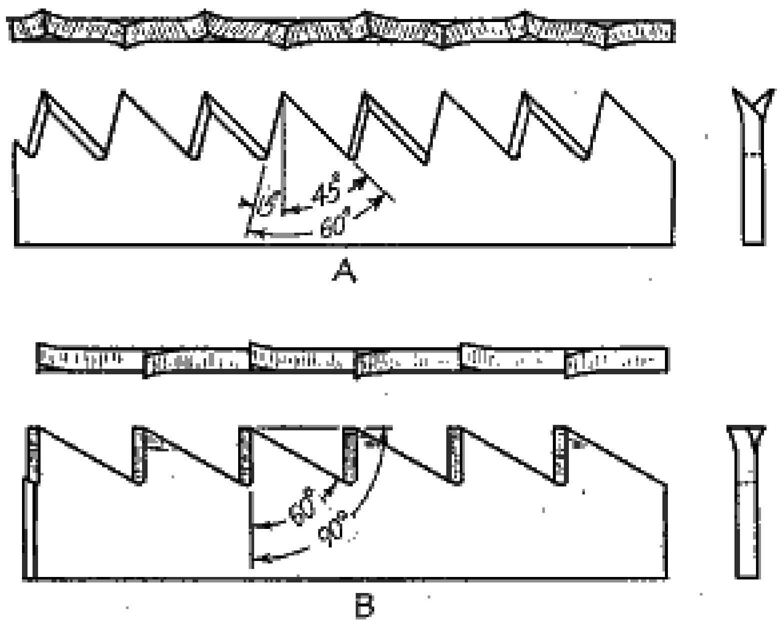


FIG. 149.—*A*. Hand crosscut saw. *B*. Ripsaw. There are two chief differences in the shape of crosscut and ripsaw teeth:

1. Crosscut saw teeth are beveled; ripsaw teeth have square edges.
2. The front edges of ripsaw teeth are perpendicular to the tooth line, while the front edges of crosscut saw teeth make an angle of about 15 deg. with the perpendicular.

hook or pitch of the teeth. The front edge of a ripsaw tooth is perpendicular to the tooth line of the saw, while the front edge of a crosscut saw tooth makes an angle of from 12 to 15 deg. with the perpendicular (see Fig. 149).

The second chief difference is that the crosscut saw tooth is beveled, while the ripsaw tooth is not. In filing ripsaw teeth, therefore, the file is pushed straight across the blade; and in filing crosscut saw teeth, the file must make an angle with the saw blade to form the bevel. The usual angle is between 45 and 60 deg. A 45-deg. angle gives a wider bevel and a keener edged tooth, which is desirable for sawing softwood; while a 60-deg. angle gives a narrower bevel and a blunter tooth that will stay sharp longer in sawing hardwood. The narrower bevel, produced by filing at about 60 deg. to the blade, is usually preferred for general-purpose farm saws.

The front edge and the back edge of a handsaw tooth make an angle of 60 deg. with each other, regardless of whether it is a ripsaw or crosscut saw tooth.

170. Set of Teeth.—It will be noted upon examining a saw that the points of the teeth are bent outward, one tooth in one direction and the next tooth in the opposite direction. This alternate bending of the teeth gives a saw what is called *set* and causes it to cut a kerf (groove) that is slightly wider than the thickness of the saw blade, thus preventing binding or pinching.

171. Cutting Action of Handsaws.—The ripsaw is used for cutting wood lengthwise of the grain or fibers. The teeth act like a series of small

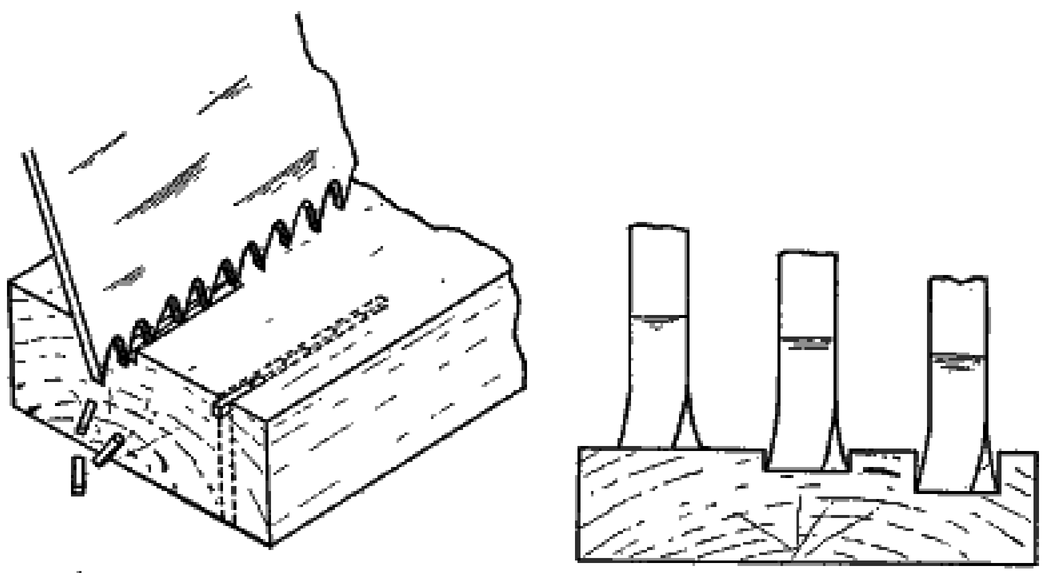


FIG. 150.—Cutting action of a ripsaw. The teeth act like a series of small chisels following each other and cut off the ends of the fibers.

wood chisels following each other, and cut off the ends of the fibers (see Fig. 150).

The crosscut saw of course is used for cutting across the grain or fibers. It first makes two parallel incisions with the points of the teeth, thus severing the fibers; and then forces out the wood between the incisions in the form of sawdust (see Fig. 151).

172. Steps in Sharpening a Saw.—There are three chief operations or steps in fitting a saw, namely, (1) jointing, (2) setting the teeth, and (3) filing. A fourth operation, that of side dressing or side jointing, may be, but is not generally, performed on farm saws.

173. Jointing.—Jointing is done by running a mill (flat-type) file over the ends of the saw teeth, lengthwise of the saw, using light pressure and keeping the file square with the saw blade. Jointing has a two-fold

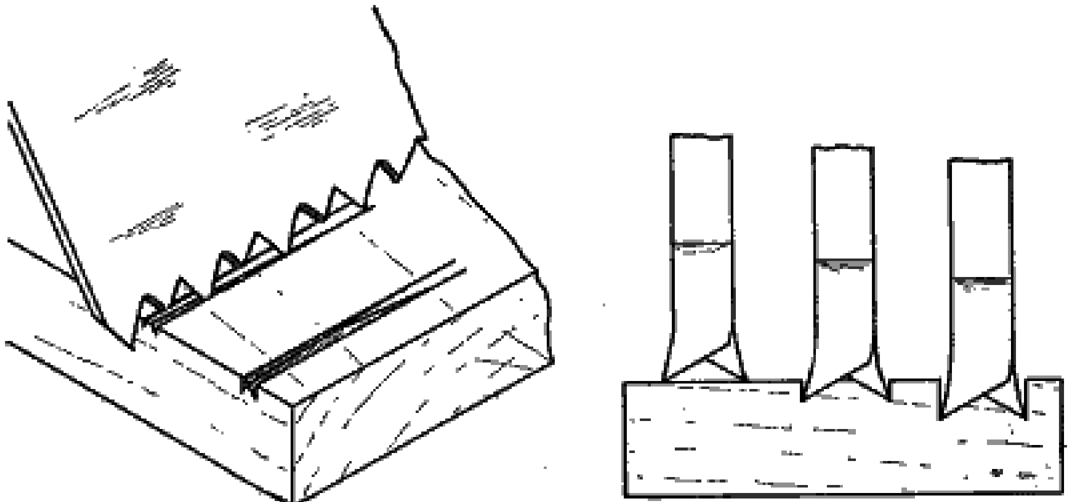


FIG. 151.—Cutting action of a hand crosscut saw. The points of the teeth make two parallel cuts, severing the fibers.

purpose: (1) to make the teeth all the same length and (2) to serve later as a guide to indicate when the teeth are filed enough. Jointing leaves a small flat shiny surface on the point of each tooth. When this surface *just* disappears in filing, the tooth is sharp and should not be filed further.

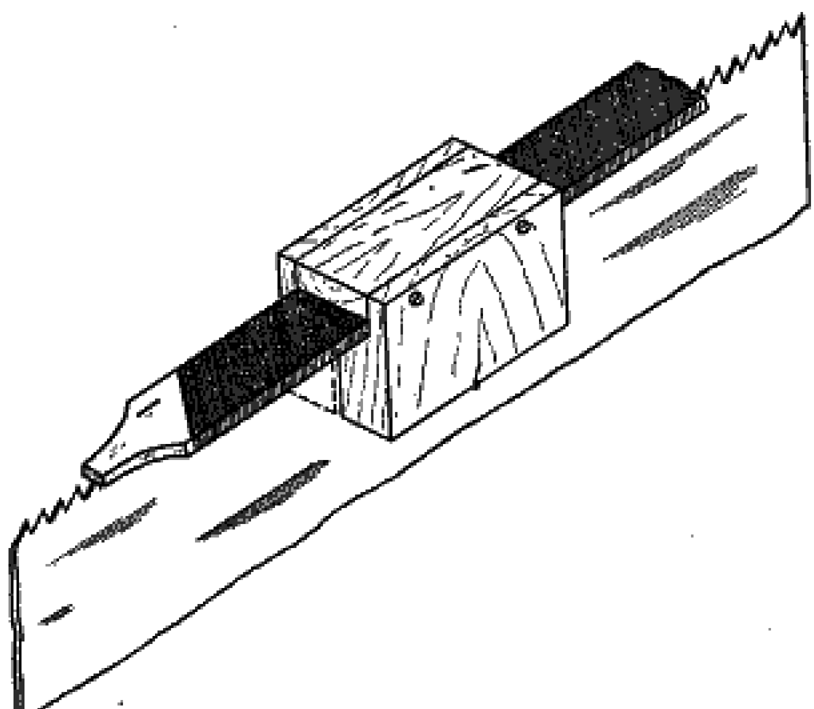


FIG. 152.—The first step in fitting a saw is usually to joint it to even the length of teeth. Jointing may be done with a file held in a homemade holder.

In jointing it is important that the file be kept square with the saw blade. This can be done by grasping the file with both hands, holding it by the edges, thumbs on top and first fingers underneath (see Fig. 153).

A wooden square-edged block or a special tool may also be used to hold the file in proper position (see Fig. 152). The tooth line should be straight, or curved out slightly in the middle of the saw, giving it a "breast" effect.

The saw should be jointed until there is a small shiny surface on the point of each tooth, except possibly an occasional very short tooth.

If the teeth of a saw are of uniform length, and require but light filing, many experienced mechanics omit jointing. By filing each tooth the same number of strokes, they are able to keep the teeth uniform in length without first jointing them.

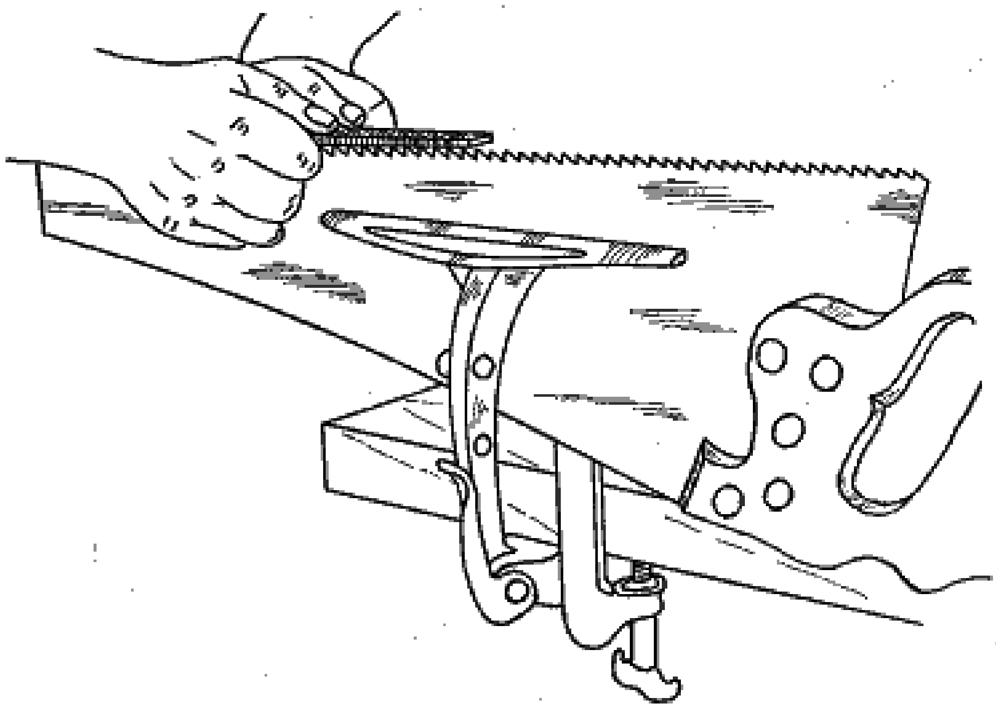


FIG. 153.—A saw may be jointed with a file held in the hands if care is used to keep it square with the saw blade.

174. Setting.—After jointing, the saw teeth are next set, unless they are very uneven in shape and size. In this case, the teeth should be filed to approximately the correct shape and size before setting, and then filed again after setting.

A saw may not need setting every time it is to be filed, particularly if only a light filing is required. A saw can sometimes be filed two or three times before it needs to be reset.

Setting is commonly done by means of a small tool known as a *spring saw set*. The tool is placed over a tooth, and the grips squeezed together which pushes a small plunger against the end of the tooth, forcing it over against the anvil of the set. In setting the teeth, begin at one end of the saw and set every other tooth, being careful to bend the teeth in the same direction they were originally set. Then reverse the saw and set the remaining teeth.

Most saw sets are adjustable, and, when using one with which you are not familiar, it is best to set a few teeth first and examine them closely before setting the whole saw. If the teeth are not set enough, or too much, the tool should be adjusted accordingly.

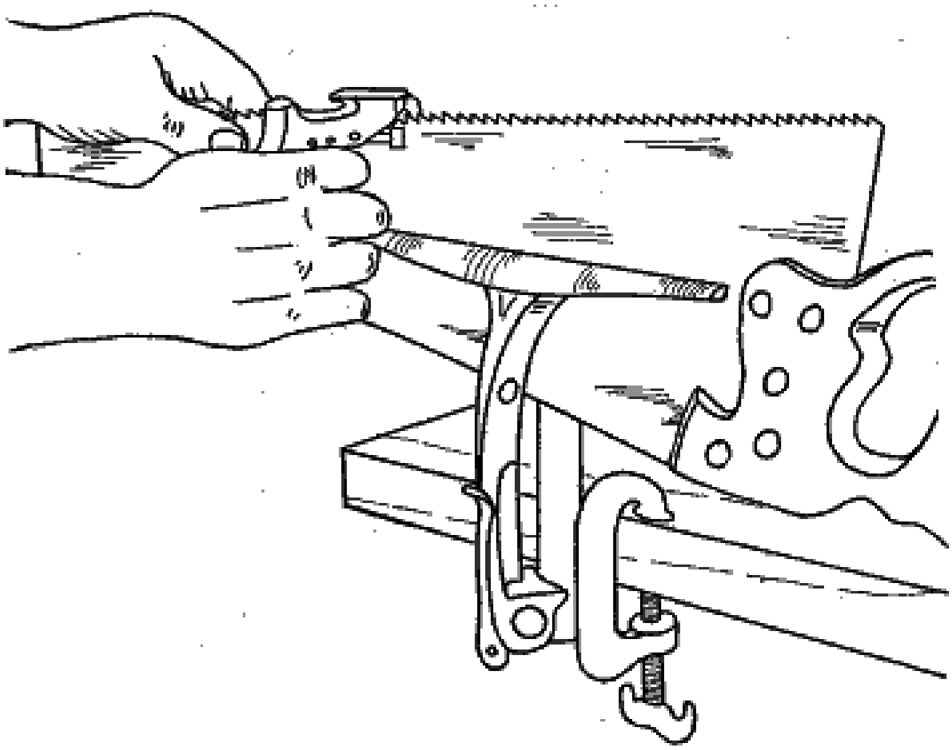


FIG. 154.—Setting a saw with a spring saw set. Half the teeth are set from one side; then the saw is reversed in the clamp and the other half set from the other side.

175. Depth and Amount of Set.—Only the point of the tooth, or from one-third to one-half the length of the tooth, should be bent in setting. If the depth of set is too much, some teeth may be broken out, or the blade may be kinked or cracked.

The amount of set a saw should have depends upon the kind of wood to be sawed and upon the thickness of the saw blade above the teeth. The better saws are ground thinner above the teeth and therefore require very little set. Green or wet wood will require more set than dry, well-seasoned wood; and softwoods, more than hardwoods. For average work bending the teeth out 1/100 in. should be ample. Too much set causes the saw to cut too wide a kerf, resulting in poorer control of the saw and extra work to push it. Too little set causes pinching or binding of the blade in the kerf.

176. Filing a Hand Crosscut Saw. *Placing Saw in Clamp.*—The saw should be held securely in a saw vise or clamp with the teeth projecting between 1/8 and 1/4 in. above the jaws—just enough for the file to clear the jaws easily. If the teeth project too far above the clamp, the saw will chatter and the file will screech. A clamp made of two one by fours and used in an ordinary vise is quite satisfactory.

For best work the top of the saw clamp should be at about the height of the arm pits or possibly an inch or two lower. One must be constantly on guard while filing to maintain the desired shape of teeth, and this can best be done when the sides of the teeth are easily seen; hence, the rather high position of the saw while filing it.

Work in a Good Light.—In order to avoid eyestrain and to insure a good job of filing, *good light is absolutely essential.* It is usually best to work in front of a window where the light will shine on the teeth and it will be easy to see the reflections from the small shiny surfaces left by jointing.

Kinds of Files to Use.—The kind and size of file to use depends upon the size of the saw teeth and the preference of the mechanic. In general, 6-in. slim taper saw files are recommended for saws with seven to nine

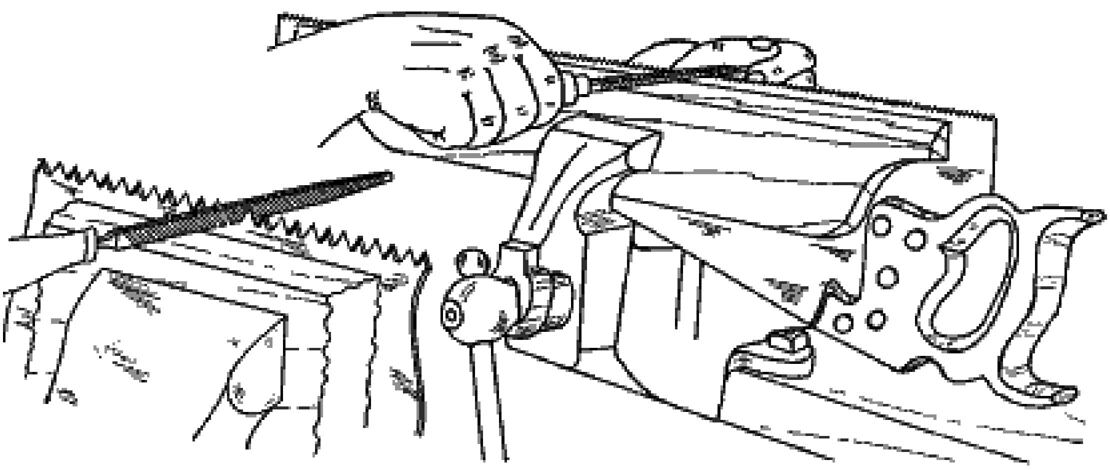


FIG. 155.—Filing a crosscut saw held in a homemade clamp and machinist's vise.

points per inch and 7-in. slim taper files for saws with five to six points per inch. Some mechanics prefer blunt files instead of tapered ones.

Using the File.—The file handle should be held firmly in the right hand (assuming the workman is right-handed), and the tip of the file held lightly between the thumb and first finger of the left hand. The file should cut on the forward stroke only, *and should be lifted slightly on the return stroke. Slow, even, full-length strokes should be used.* A file should not be allowed to slide along without cutting. If the file is sharp, a slower stroke with a little more pressure will usually remedy the trouble. If it is dull, it should be discarded and a new file used.

First Position.—Place the saw in the vise with the handle to the right. Start at the end of the saw (see Fig. 156*A*). Place the file in the gullet (V-notch between two teeth) to the left of the first tooth that is bent out toward you. Place the file across the saw blade at an angle of about 60 deg. with the file pointing toward the handle of the saw. Press the file firmly into the gullet and let it find its own bearing against the teeth. Do not point the file upward nor downward, but keep it level. (If the file tends to screech it may be pointed upward very slightly.) Push the file forward, cutting the back edge of one tooth and the front edge of the adjacent one with the same stroke. Lift the file slightly on the return stroke, and continue filing until about half of the flat shiny surfaces made by jointing are filed away.

Then move the file two gullets to the right (towards the handle) and file in a similar manner. Continue filing in every other gullet until you reach the handle.

Second Position.—Turn the saw around in the clamp and place the file in the gullet to the right of the first tooth that is set out toward you (see Fig. 156*B*). With the file pointing toward the handle of the saw and making an angle of about 60 deg. with the saw blade, push it forward,

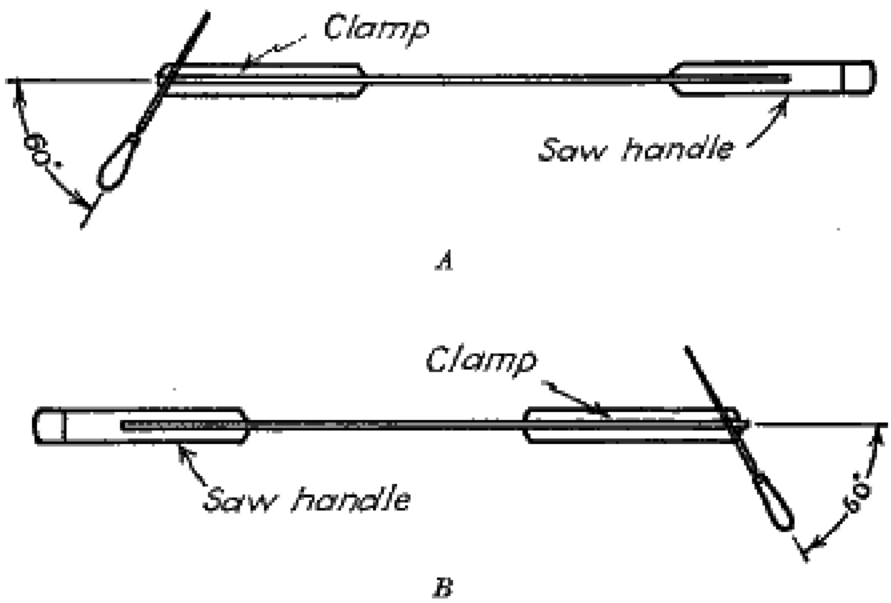


FIG. 156.—The two positions for filing a hand crosscut saw.

A. First position.—Begin at the tip of the saw and work toward the handle. Hold the file at an angle of about 60 deg. to the saw blade and be sure that the file cuts the front edge of each tooth at an angle of about 15 deg. from the vertical.

B. Second position.—After half the teeth are filed, turn the saw around in the clamp and file the other half from the other side.

cutting away the remaining half of the flat, shiny surfaces made by jointing. In a similar manner, file in every second gullet until you reach the handle of the saw.

Final Touching Up.—After filing a saw it should be carefully examined to see if any blunt tooth points remain from jointing. If they do, then these teeth should be filed until the flat points just disappear. Some mechanics prefer to simply repeat the filing process described above, filing in first position and in second position, but filing only those teeth that still have flat points.

Keeping Proper Shape and Angle of Teeth.—It is very important that the front edges of the teeth be filed to a pitch of 12 to 15 deg. from the vertical (see Fig. 149*A*). It is important also that the file be held at a uniform angle of about 60 deg. with the saw blade in order to produce the proper bevel. By placing the file in a gullet between two properly filed teeth and letting it seek its own position, the desired angles for filing can be determined. The beginner must be constantly on guard, however, to keep this position after it is determined.

Filing the teeth in pairs with a short broad tooth next to a long slim one is a common trouble among beginners and is the result of not maintaining the proper slope of 12 to 15 deg. on the front of each tooth. To correct the trouble, therefore, first be sure that the file is held so as to give the proper angle of 12 to 15 deg. on the front of the teeth, and then press the file firmly against the broad tooth and lightly, if at all, against the narrow one, as it is pushed through the gullet between them.

177. Filing a Ripsaw.—The same general procedure is used for filing ripsaws as for hand crosscut saws. There are two points of difference, however, that need to be kept in mind:

1. The front edges of the teeth are perpendicular to the tooth line instead of at an angle of 12 to 15 deg. to the perpendicular.
2. The edges of the teeth are not beveled but are square with the saw blade (see Fig. 149).

Except for the difference in angles of filing required by these two differences, a ripsaw is filed exactly the same as a crosscut saw.

178. Side Dressing or Jointing.—A saw is side dressed or side jointed by laying it on a flat board or bench and rubbing the saw lightly on the sides with the edge of an oilstone or with a fine file. The object is to smooth off any rough edges left from filing and to even up the set in the teeth. Side dressing is usually not necessary for general sawing.

If after trying a saw it is found to be set unevenly and tends to run to one side of the line, it may be side dressed on the side that leads away from the line. Side dressing may also be used to reduce the amount of set in case the saw cuts too wide a kerf.

Points on Sharpening Handsaws

1. Always work in a good light so that the points of the teeth may be easily seen.
2. Set only the points of the teeth—not more than one-third to one-half the length of the teeth.
3. The top of the saw clamp should be at about the height of the arm pits.
4. Allow the teeth to project above the saw clamp from ⅛ to ¼ in. just enough for the file to clear the jaws of the clamp.
5. File on the forward stroke only. Lift the file slightly on the back stroke.
6. Use long, slow, even strokes. If the teeth are reasonably uniform in shape and size, each tooth will require about the same number of strokes.
7. Just barely file away the flat shiny surfaces on the points of the teeth left by jointing.
8. Have no slope to the front edges of ripsaw teeth. Make them perpendicular to the line of the teeth.

9. Slope the front edges of crosscut saw teeth 12 to 15 deg. from a perpendicular to the line of teeth.

10. In filing a crosscut saw, point the file toward the handle of the saw, keeping the angle between the file and the saw blade at about 60 deg.

11. In filing a ripsaw, file straight across, keeping the file at right angles to the saw blade.

12. Do not point the file upward or downward, but keep it level.

13. If the teeth are uneven in size, first be sure the file is held to give the proper slope on the front edge of the teeth, and then press hard against the big ones, and lightly, or not at all, against the small ones.

179. Selecting Saws for the Farm Shop.—Every farm should have a crosscut hand saw. A saw 26 in. long and with 8 points per inch is usually recommended for general work. A coarser saw with 6 or 7 points per inch will saw somewhat faster but will leave rougher edges; and a finer

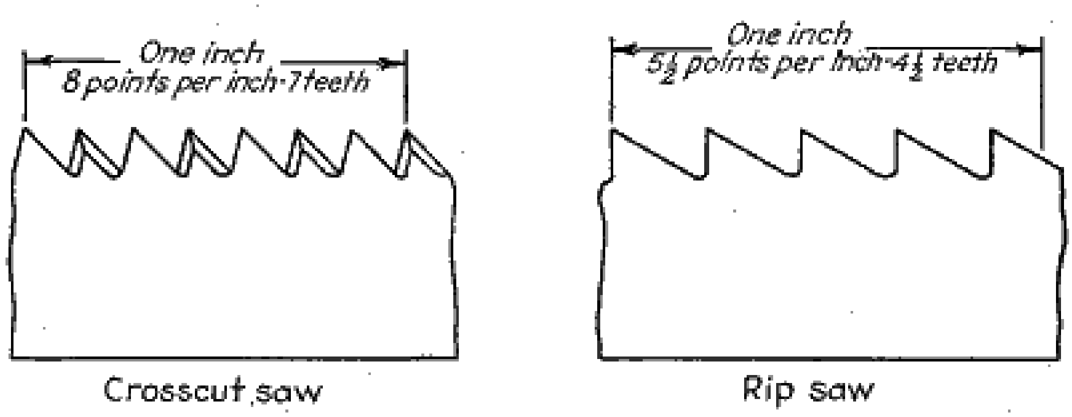


Fig. 157.—The size of teeth is designated by the number of points per inch. There is always one more point than there are teeth per inch. For average farm shopwork, a hand crosscut saw with 8 points per inch and a ripsaw with 5, 5½, or 6 points per inch will be quite satisfactory.

saw with 10 or 11 points per inch will do smoother work but will saw slower.

Where it can be afforded, a ripsaw should also be included in the shop tools. A ripsaw 26 or 28 in. long and with 5, 5½, or 6 points per inch is usually preferred.

There is always one more point per inch than complete teeth per inch. An 8-point saw, for example, really has but seven teeth per inch (see Fig. 157). This is because of the custom of counting the first and last points in an inch.

180. Cleaning Rusty Saws.—Saws should be oiled occasionally with light oil to prevent rusting. If a saw has become rusty, however, it may be cleaned by rubbing with pumice stone and water, or pumice stone and oil. Sand paper or emery paper would scratch a saw blade and is, therefore, not recommended. After cleaning, a saw should be thoroughly dried and oiled.

181. Sharpening Bucksaws and Pruning Saws.—The same general principles used in setting and filing crosscut handsaws apply in setting and filing bucksaws and pruning saws. The shape and angles of the teeth of bucksaws and pruning saws are different from handsaws, however, and therefore the file must be held differently when filing them. The proper shape of teeth can be determined by looking at some of the teeth near the ends of the saw that have not been used a great deal. Holding the file firmly between two of these teeth near the end of the blade will give the correct angles for filing.

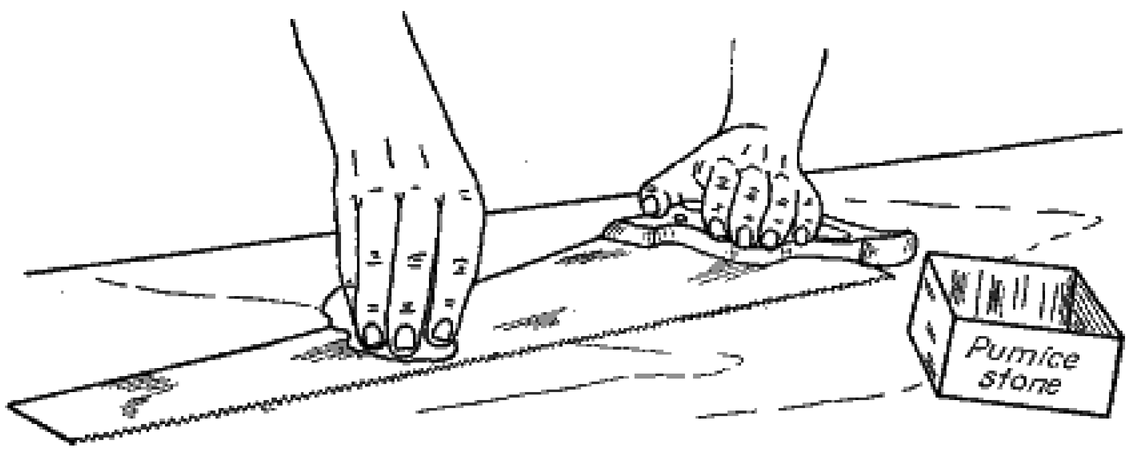


FIG. 158.—A rusty saw may be easily cleaned by rubbing with pumice stone and water, after which it should be wiped dry and oiled.

182. Sharpening Crosscut Timber or Log Saws.—To sharpen timber or log saws, one should have a combination jointer and raker gage, and a saw set for such saws. It is possible, however, to set a timber saw with a hammer and setting block. A mill (flat-type) file about 8 in. long is used to file the teeth.

The operations in fitting a timber saw are (1) jointing, (2) filing down the raker teeth, (3) setting the cutting teeth, and (4) filing the teeth.

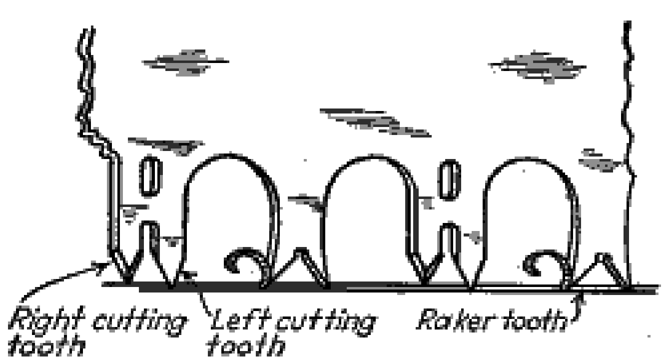


FIG. 159.—How a crosscut log saw works. The right and left cutting teeth make incisions and the raker teeth cut out the wood between incisions.

Jointing.—To joint a timber or log saw, place a file in the jointing tool and file down the teeth until the shortest of the cutting teeth is reached. If the saw is in fair shape, very light jointing is all that is necessary. It is very difficult to hold a file in the hands and joint the teeth of a timber saw because the teeth are too long.

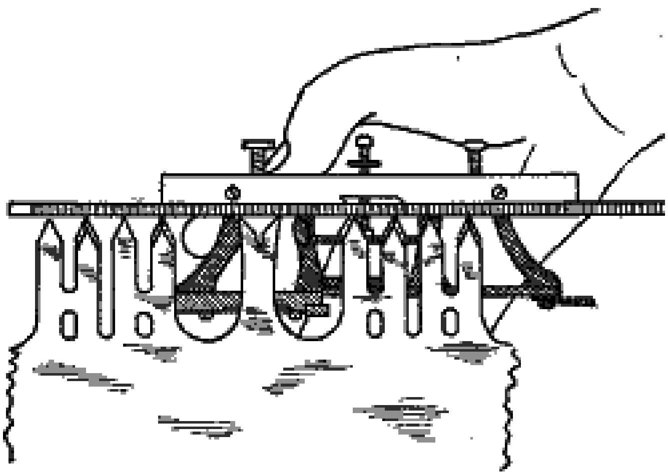
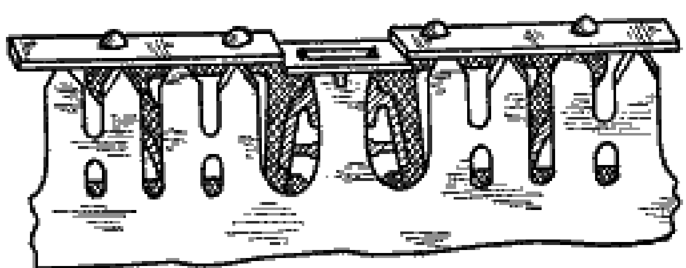


FIG. 160.—Jointing a crosscut log saw.



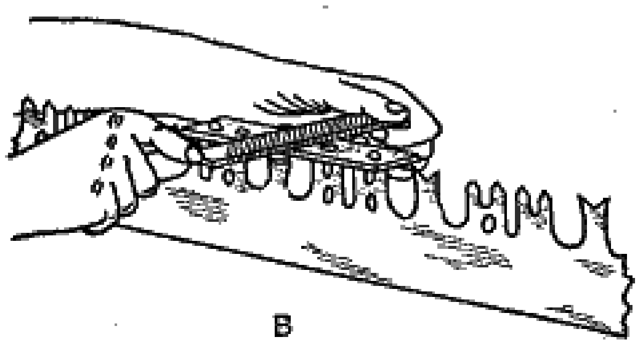


FIG. 161.—*A*. A saw tool in place ready for filing down the rakers. Rakers should be filed $\frac{1}{64}$ to $\frac{1}{32}$ in. shorter than other teeth.
B. Filing down the rakers.

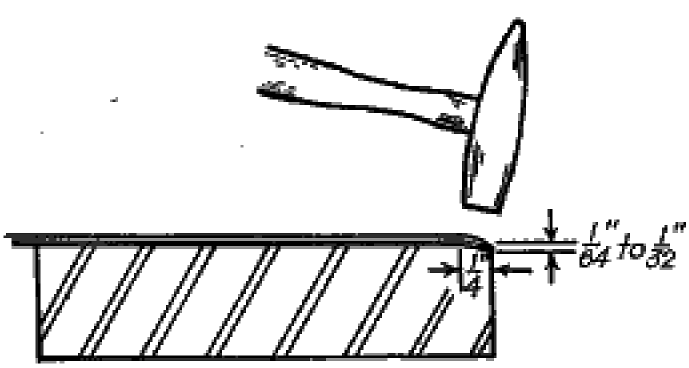


FIG. 162.—A homemade setting block for setting timber or log saws.

Filing Down the Rakers.—The rakers, or those teeth which shave off and carry out the wood between the two parallel incisions made by the cutting teeth, should be a little shorter than the cutting teeth, the exact amount varying with the kind of wood to be sawed. In general they should be about $\frac{1}{64}$ in. shorter for hardwoods, and about $\frac{1}{32}$ in. shorter for softwoods. To file down the rakers the raker gage is placed on the saw, and the points of the rakers filed down even with the gage.

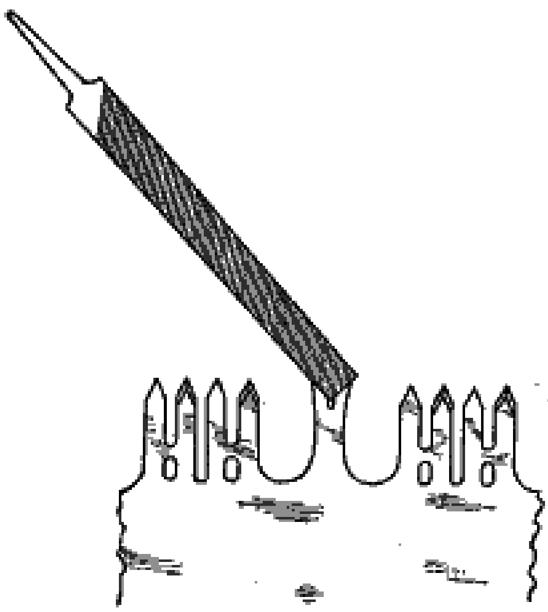


Fig. 163.—The gullets of the raker teeth should be filed so that the square end of the file will fit. Care should be taken not to file the rakers too short.

Setting the Teeth.—The teeth may be set with a hammer and setting block or with a spring saw set. Many prefer the spring set. Not more than $\frac{1}{4}$ in. on the end of a tooth should be bent. A homemade setting block can easily be made by filing a corner of a piece of iron as shown in Fig. 162.

Filing the Teeth.—The rakers are filed on the inside of the end notch with a flat file. The angle at the center of the notch should be about a right angle. Care should be exercised not to file the teeth shorter than the length to which they were jointed. It is a good practice to file half of the rakers from one side of the saw, and the other half from the other side.

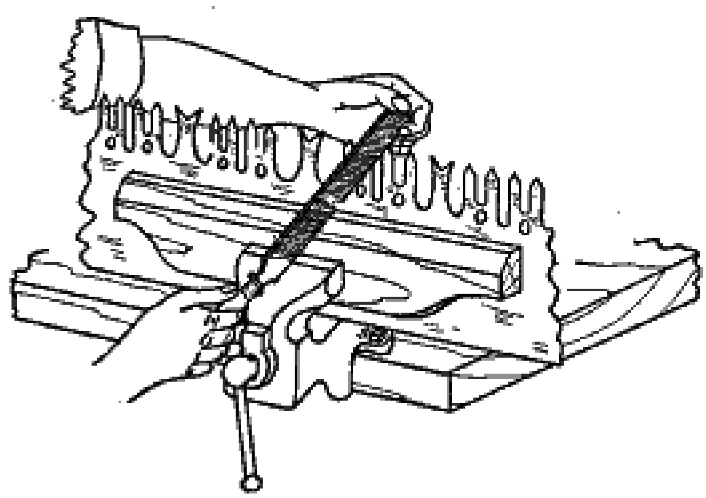


Fig. 164.—Filing the cutting teeth of a crosscut log saw.

The cutting teeth are filed much in the same manner as the teeth of a crosscut handsaw. Half of the teeth are filed from one side and half from the other. The angle of the points and the width of the bevel on the cutting teeth depend upon the kind of wood to be sawed. For softwoods, a long point with a wide bevel is recommended, and for hard woods, or knotty or frozen wood, a blunter point with narrower bevel is recommended.

Gumming a Saw.—After several filings, the gullets between the teeth of a timber saw become so shallow that they can not well hold all the sawdust made by the teeth. Consequently the sawdust binds against the sides of the saw kerf and makes the saw pull hard. The saw should then be gummed, that is, the gullets should be filed or ground deeper. It is a very slow, tedious job to gum a saw with a file. The best method is to use a special thin grinding wheel made for this purpose. A special stand or work rest can be made in front of the grinder to support the saw while it is being gummed. It is best not to do all the gumming in a gullet at one time, but to grind a little in one gullet and then proceed to the next, going over the saw three or four times to complete the job. This avoids overheating the saw and drawing the temper.

183. Sharpening Circular Saws.—In sharpening a circular saw, the same general operations are performed as in fitting a handsaw or a timber saw. The operations are (1) jointing or truing, (2) gumming, if needed, (3) setting, and (4) filing. Not all the operations need be done every time the saw is fitted.

Jointing a Circular Saw.—A circular saw is jointed to make it truly circular, or to make the tooth points all the same distance from the center of the saw. Jointing is usually best done by leaving the saw mounted on its own shaft and turning it slowly backward by hand while holding a file firmly yet lightly against the ends of the teeth. An easy method of holding the file in proper position is to adjust the saw so that the teeth barely project through the slot in the saw table, and then hold the file flat on the table over the slot.

Gumming a Circular Saw.—A circular saw may be gummed in the same manner as a timber saw. It may be done with a round file or a flat file with a round edge; but a much easier way is to use a special saw-gumming wheel. Circular saws with certain kinds of teeth, such as fine-toothed crosscut saws, do not require gumming.

Setting a Circular Saw.—The teeth of a circular saw may be set with a hammer and setting block or with a large spring saw set. The amount and depth of set required will depend upon the kind of a saw, whether it is a ripsaw, a cutoff saw, a cordwood saw, etc., and upon the kind of wood to be sawed. If, after fitting a saw, it is found to bind in the saw kerf, it is a simple matter to give it a little more set.

Filing a Circular Saw.—The kind of a file to use in filing a circular saw will depend upon the shape and size of teeth. For a crosscut saw, usually a three-cornered file about 8 in. long is used. For a ripsaw or a cordwood saw, a mill (flat-type) file about 8 or 10 in. long is used.

In filing a circular saw, care must be taken to preserve the original angle of bevel and the original pitch of the teeth. The proper position for the file can be determined by pressing the file into a gullet, or against the side of a properly filed tooth, and allowing it to "seat" against the tooth.

Questions

169. What are the two main differences in shape of crosscut and ripsaw teeth?

170. (*a*) What is set in a saw? (*b*) Why is it needed?

171. (*a*) Just how do the teeth of a ripsaw act in ripping a board? (*b*) Describe the action of crosscut saw teeth in sawing a board.

172. What are the steps performed in sharpening a handsaw?

173. (*a*) What is meant by "jointing" a saw? (*b*) What are the two main purposes of jointing? (*c*) What are the important points to be observed in jointing a saw? (*d*) Under what conditions might the process of jointing be omitted?

174. (*a*) Should a saw be set every time it is filed? (*b*) Just how does a saw set bend the teeth? (*c*) Explain and be able to demonstrate just how a saw is set.

175. (*a*) What is meant by "depth of set"? (*b*) In general how much should the depth of set be? (*c*) What is meant by "amount of set"? (*d*) What kinds of wood require the most set? (*e*) For average work, how much should the teeth be bent out in setting?

176. (*a*) In placing a saw in a clamp preparatory to filing, how far should the teeth project above the jaws of the clamp? (*b*) What is the best height for the clamp or vise? (*c*) How should the clamp be placed with respect to a window or lamp to give best light? (*d*) What kinds and sizes of files are best for filing handsaws? (*e*) How should the file be held, and what kind of strokes should be made? (*f*) What is the first position for filing a saw? (*g*) Does the file cut on both the forward and on the return stroke? (*h*) Should the file cut on only one tooth at a time? (*i*) How can the workman know when a tooth is filed enough and yet not too much? (*j*) What is the second position for filing a handsaw? (*k*) What is the cause of getting the teeth filed in pairs with a short broad tooth next to a long slim one?

177. In what respects is the process of filing a ripsaw different from filing a crosscut saw?

178. (*a*) What is meant by "side jointing" a saw? (*b*) How is it done? (*c*) What is the purpose of side jointing?

179. (*a*) What kind and size of handsaw would you recommend for the farm shop? (*b*) What kind and size of ripsaw would you recommend? (*c*) What is meant by an "8-point" saw?

180. (*a*) How may a saw be kept from rusting? (*b*) How may rust be cleaned from a saw?

181. (*a*) In what ways are pruning saws and bucksaws sharpened differently from handsaws? (*b*) How may the proper shapes and filing angles usually be determined for such saws?

182. (*a*) What tools are needed for sharpening log saws? (*b*) What are the steps or operations in sharpening and fitting such saws? (*c*) What different kinds of teeth does such a saw have, and just what is the purpose of each? (*d*) How much shorter should the rakers be than the other teeth? (*e*) How are the teeth of a log saw set? (*f*) What is the proper shape of the notch on the end of the rakers? (*g*) What kind of file is used in sharpening a log saw? (*h*) What is meant by "gumming" a saw? (*i*) How is a saw gummed? (*j*) What difficulties are likely to be encountered if a saw is not gummed when it needs it? (*k*) What particular precaution should be observed when gumming a saw with a grinding wheel?

183. (*a*) What are the operations in sharpening a circular saw? (*b*) How may the teeth of a circular saw be jointed? (*c*) How may they be set?

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PART III

COLD-METAL WORK

CHAPTER XIII

GENERAL BENCH AND VISE WORK

Cold-metal work constitutes one of the most important phases of farm shopwork. Most farm machinery and many small appliances used on the farm are made of metal. Many valuable repair jobs can be done with only a few simple hand tools, such as a vise, a hack saw, a hammer, cold chisels and punches, and a few files, drills, and threading tools.

LAYING OUT AND MARKING METAL

184. Metal-marking Tools.—Careful measuring and marking of the work before cutting and shaping usually save time and insure a better job.

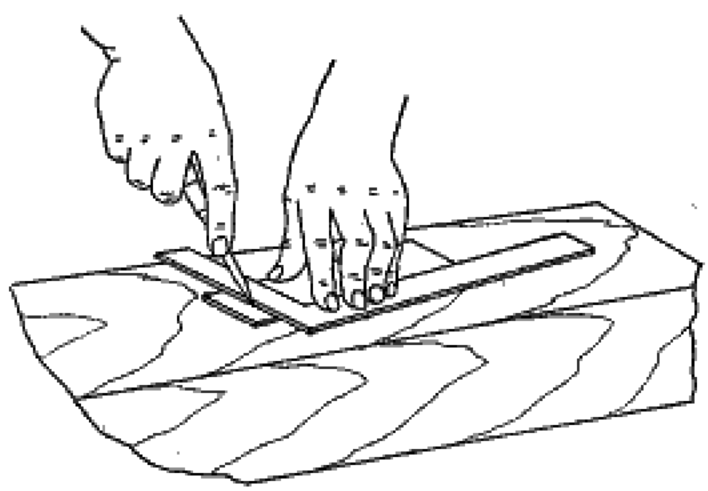


Fig. 165.—A marking awl or scriber should be used in marking metal. Time spent in careful measuring and marking is time well spent.

Measuring and marking on metal is done in much the same manner as on wood, except that a marking awl or scriber is recommended for marking metal. An old saw file ground to a needle point makes a very good scriber. A center punch, or a prick punch that is ground to a sharper point than a center punch, is also valuable for marking locations for bends, drill holes, saw cuts, etc.

CUTTING WITH THE COLD CHISEL

The cold chisel is an inexpensive tool that has a wide variety of uses. And like most other tools its usefulness is greatly increased when it is kept well sharpened and used properly (see page 103 for methods of grinding the cold chisel). Good cold chisels may be bought, or, if a blacksmith's forge is included in the shop equipment, they may be made and tempered at home.

The size of the chisel should be suitable for the work being done. Use heavy chisels for heavy cutting and smaller chisels for light cutting. If the chisel is too small for the work, there is not only danger of breaking it, but it may vibrate and sting the hands when struck, and of course it will not cut so fast as a larger one.

185. Holding the Chisel; Striking.—The chisel should be held firmly enough to guide it yet loosely enough to ease the shock of hammer blows and keep the hand from becoming tired. Always hold the hammer handle near the end and strike blows in accordance with the kind of cutting done—heavy blows for heavy cutting and light ones for light work. Light blows are struck mostly with motion from the wrist; medium blows with motion from both wrist and elbow; and heavy blows with motion not only from the wrist and elbow, but also from the shoulder.

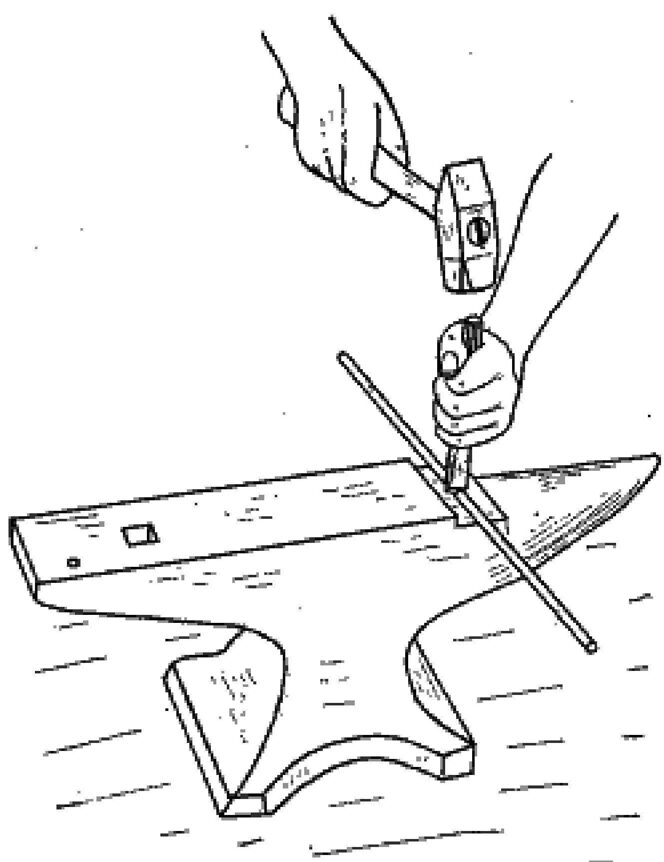


FIG. 166.—In cutting with the cold chisel at the anvil, always work over the chipping block—not over the face of the anvil. Hold the chisel firmly, yet loosely enough to ease the shock of hammer blows.

186. Cutting on the Anvil.—All cutting with the chisel on the anvil should be done on the chipping block, the small depressed surface at the base of the horn. The chipping block is soft, while the face of the anvil is hardened. Cutting through a piece on the face of the anvil would not only dull the chisel, but it would damage the face, which should be kept smooth for good blacksmithing.

Nick Deeply, Then Break.—Bars and rods can generally be cut most easily by nicking them deeply on two or more sides and then breaking them by bending back and forth. Rods may be held in a vise for bending, or if small enough they may be inserted in one of the punch holes in the anvil.

187. Cutting in the Vise.—If a heavy vise is available, small and medium sizes of rods or bars may be clamped in the vise and nicked

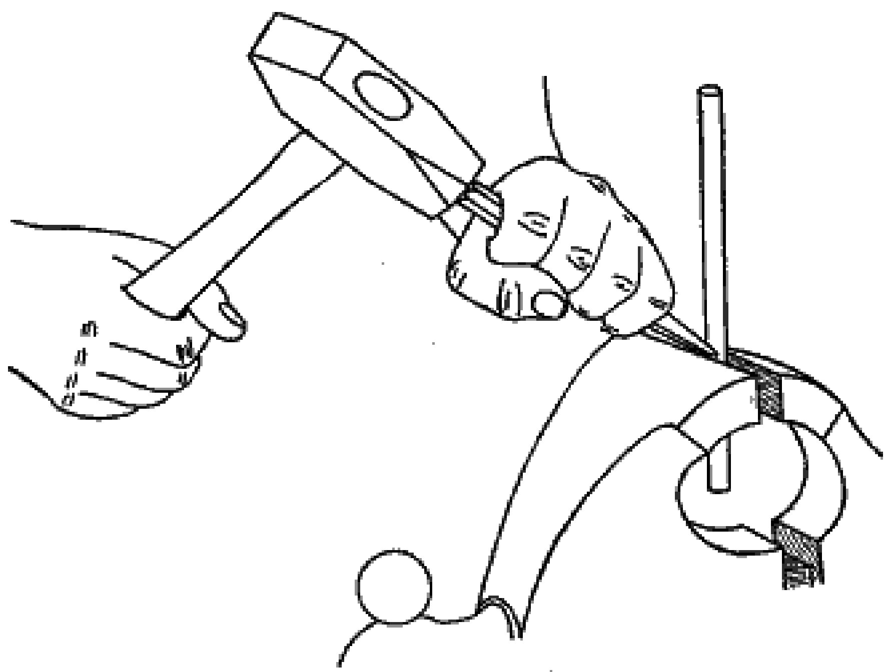


FIG. 167.—Bars and rods may be cut roughly to length by nicking deeply on two or more sides with the cold chisel and then bending back and forth. When cutting in the vise, always cut as close to the vise jaws as possible and always strike so that the force of the blow is against the stationary jaw—not the movable one.

deeply by chiseling close to the jaws. The rods are then easily broken by bending. Hammering should always be done so that the force of the blows comes against the stationary jaw of the vise and not against the movable one.

188. Shearing Thin Bars.—Thin bars and band iron up to about $\frac{3}{16}$ in. thick can usually be more easily cut by clamping in a vise and shearing with a cold chisel, than by sawing. The bar or band iron should be securely clamped in the vise with the cutting line just even with the top of the jaws. The chisel is then put in place at one edge of the piece, with one bevel of the cutting end flat against the top of the vise jaws, and with the handle at an angle of about 60 deg. to the line of cutting. The chisel when thus used acts as one blade of a pair of shears, and the stationary vise jaw as the other blade (see Fig. 168).

When the chisel is properly placed, tap it lightly once or twice to get the proper direction for striking, and then strike firm, well-directed blows. It is important to keep the chisel placed so that it cuts close to the vise jaws, and yet does not cut into them and thus damage the vise and dull the chisel. Driving too straight against either the flat surface or against the edge of the piece will not give a good shearing cut. Also, driving too straight against the edge will cause the work to slip in the vise.

When properly done, the metal cuts fast and easily, leaving a surface that is smooth enough for most work. Where smoother work is required, the surface is readily dressed with a file.

Sheet metal that is too thick for easy cutting with snips can be easily cut with a cold chisel and vise in the same manner as thin bars.

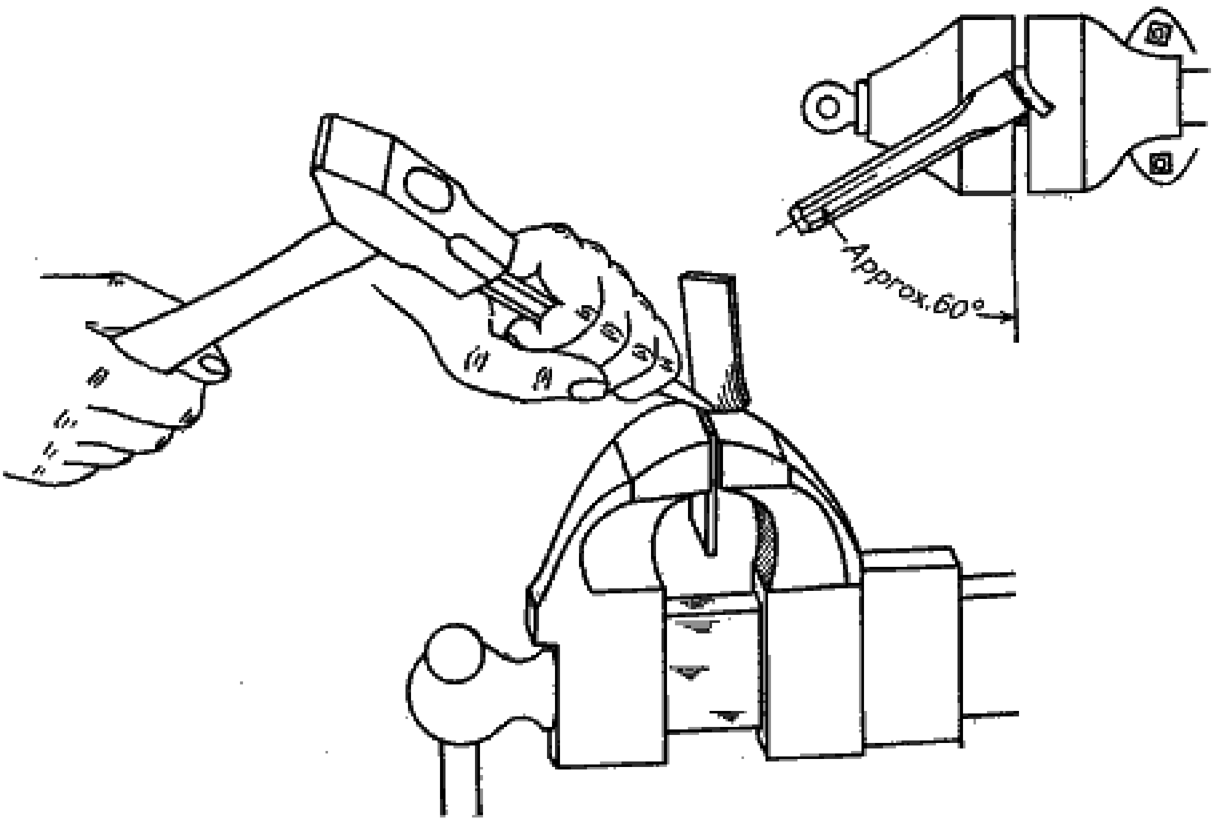


FIG. 168.—Thin bars are easily sheared with a cold chisel and vise. Keep the lower bevel of the chisel flat against the vise and the chisel handle at an angle of about 60 deg. with the line of cutting.

189. Heavy Cutting with the Chisel.—Extra-heavy cutting with the cold chisel can best be done by having a helper strike with a sledge hammer. Of course, a very heavy chisel would have to be used, and both the work and the chisel must be securely held in place. It is safer to use a heavy chisel, called a *cold cutter*, which has a handle in it.

190. Use of Slitting Chisel.—A special kind of cold chisel, known as a slitting chisel, is very useful for fast cutting of thick sheet iron, as cutting out the head of an oil drum, or cutting it in two in the middle. The slitting chisel instead of being ground with a beveled cutting end is ground with a blunt square end. The chisel is thicker at the cutting end than a little farther back. It shears out a ribbon of steel just as wide as the cutting end.

A slitting chisel may be started in the middle of a piece of sheet iron by first drilling a hole. The chisel should usually be held at an angle of

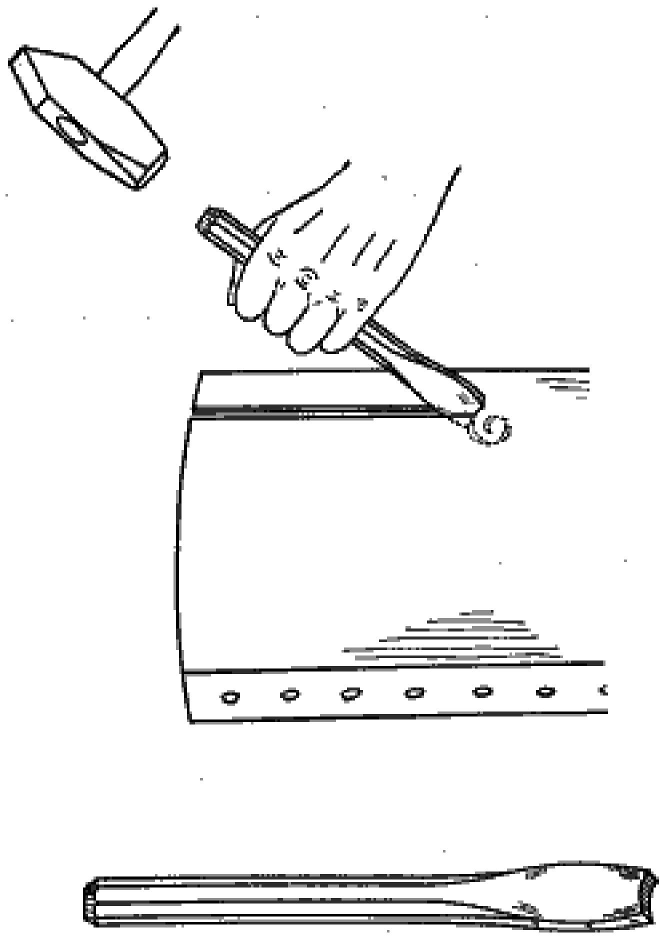


FIG. 169.—Heavy sheet metal, oil drums, water tanks, etc., are easily cut with a slitting chisel.

about 45 deg. to the surface of the metal being cut. A little experimenting will quickly indicate the best cutting angle.

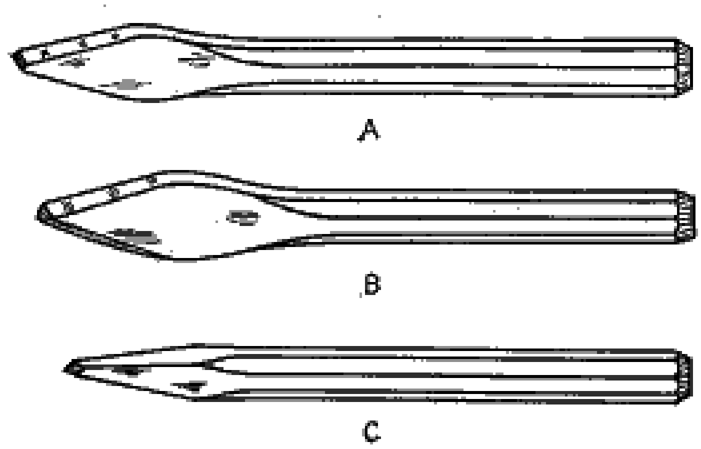


FIG. 170.—Types of special grooving chisels that may be made in the farm shop.
A. Cape chisel for cutting keyways.
B. Round-nosed chisel for cutting round grooves.
C. Diamond-point chisel for cutting grooves.

191. Cutting Slots and Grooves.—Other special chisels, such as those illustrated in Fig. 170, will occasionally be found useful in cutting grooves and slots, such as oil grooves in a bearing, or keyways in a shaft. If a forge is available, such chisels may be made at home.

192. Grinding the Chisel for Special Work.—For cutting brass, lead, babbitt, or very thin sheet metal, it is best to use a chisel that has been ground to a keen edge of possibly 30 to 45 deg. instead of the usual angle of 65 or 70 deg.

Points on Cutting with the Cold Chisel

1. Always use a sharp chisel and one of a size suited to the cutting to be done.
2. Hold the chisel firmly enough to guide it, yet loosely enough to ease the shock of the hammer blows.
3. Grasp the hammer handle near the end.
4. Tap the chisel once or twice to get the direction of striking and then use firm, well-directed blows.
5. For light chiseling strike blows with wrist motion only; for heavier work use both wrist and elbow action; and for very heavy work use motion from the shoulder as well as wrist and elbow.
6. In cutting at the anvil, always work over the chipping block and not the face of the anvil.
7. Nicking a bar deeply and then breaking it by bending is usually easier than cutting it all the way through with a chisel.
8. In hammering in a vise, always strike so the force of the blow comes against the stationary jaw and not against the movable jaw.
9. For shearing in a vise, clamp the work tight and place the chisel so as to get a good shearing cut. Keep the bevel on the end of the chisel flat against the top of the vise jaws. Hold the chisel at an angle of about 60 to 70 deg. to the line of cutting.
10. A slitting chisel is very useful for fast cutting of thick sheet iron, such as cutting an oil drum in two.
11. Faster cutting can be done on heavy work by having a helper strike with a sledge. Cold cutters with handles are better for such work than plain chisels.
12. For cutting brass and similar soft materials or thin sheet metals, the chisel cuts smoother and faster if ground to an angle of 30 to 45 deg. instead of the usual angle of 65 to 70 deg.

FILES AND FILING

A file is a very valuable cutting tool. On many jobs in the farm shop a good workman can do better and faster cutting with a file than with a grinding wheel. Unless properly cared for and used, however, the file will do only moderately satisfactory work.

193. Care of Files.—A file is a hardened steel tool that has a series of small sharp cutting edges or points on its surface. Files should therefore not be thrown around with wrenches and other tools, nor should they be kept on shelves or in drawers where they will be scraped against each other or against other tools. A good method of keeping them when not in use is to hang them on a rack or on hooks by the handles. The handles of course should be kept tight on the tangs.

FIG. 171.—A good way to keep files is to hang them by their handles on a rack. A file should not be thrown in a drawer nor on a shelf where the sharp cutting edges might be dulled by contact with other files or tools.

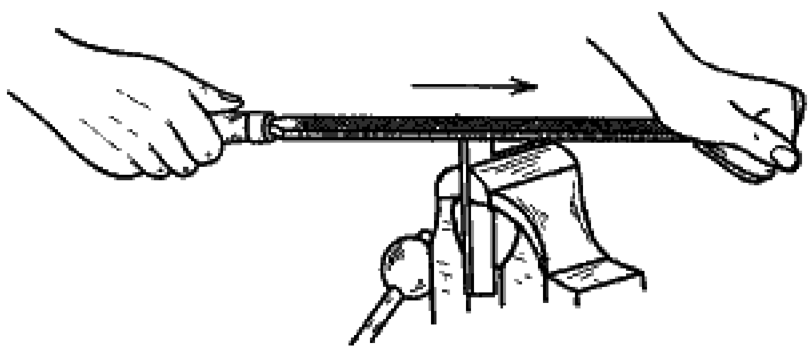


FIG. 172.—A good way to hold a file for heavy filing. The handle is held firmly, yet not squeezed too tightly, with the right hand. Notice that the thumb is on top. Moderate to heavy pressure is applied with the left hand.

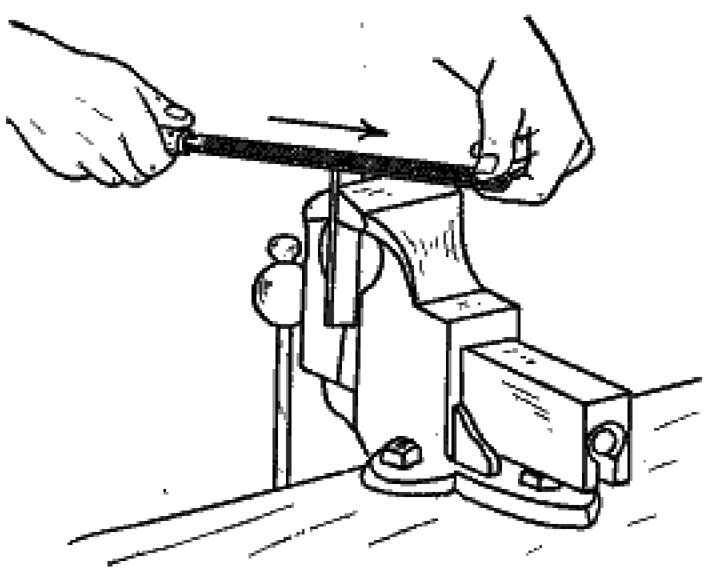


FIG. 173.—A good way to hold the file for light filing. The end of the file is held between the thumb and first finger of the left hand.

194. Holding the File.—The work to be filed should be held securely in a vise at about elbow height, possibly a little lower for rough, heavy filing, and a little higher for light filing.

For heavy filing, the file handle should be grasped firmly, yet not squeezed too tightly, with the right hand, *thumb on top*, and moderate to heavy pressure applied on the end of the file with the base of the thumb of the left hand. For light filing, the end of the file is held between the end of the thumb and the fingers of the left hand, and light to moderate pressure is applied.

195. Using the File; Body Position.—Probably the most important thing to observe in filing is to *use rather slow, full-length strokes and to release the pressure on the back stroke.*

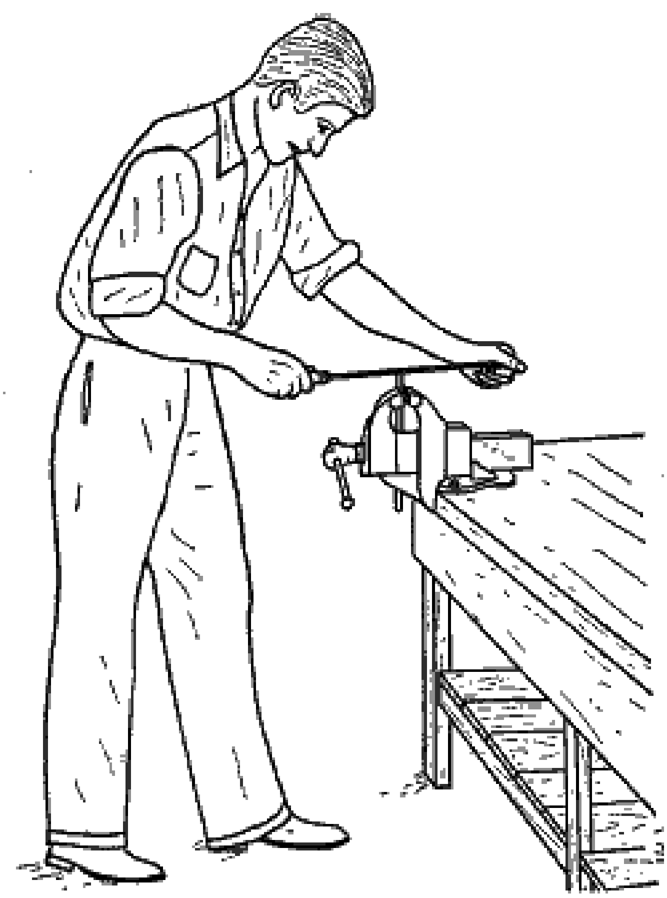


Fig. 174.—In filing, stand with the left foot 10 or 12 in. ahead of the right, with the body leaning forward slightly at the hips. Use rather slow, full-length strokes, and release the pressure on the back stroke.

In heavy filing, the file should be pushed with a combination slow rythmic swing from both the body and the arms. The workman should stand in front of the vise, with the right foot about 10 to 12 in. back of the left, and with the body bending forward slightly at the hips.

The forward stroke is then started by gradually leaning the body forward and at the same time pushing with the arms somewhat faster than the body moves. The forward stroke of the file is finished with motion from the arms only, while the body moves back into position for the next cutting stroke.

Never Use Short, Jerky Strokes.—Only a poor workman would use fast, short, jerky, or seesaw strokes. When used in such a manner, the file cuts slowly, does poor work, and soon becomes dull.

When a file is pushed too fast, it slides over the metal without properly engaging it, which causes the slow cutting and quick dulling of the teeth. Also, the work is likely to vibrate, causing screeching. A file should always be pushed slowly enough for the teeth to "take hold" and cut.

196. Keeping the Surface Flat and Straight.—In order to keep the file level during the cutting stroke and to prevent rounding the work, more pressure should be used on the front end of the file at the beginning of the stroke, and then the pressure gradually shifted to the handle end as the file is pushed forward.

197. Draw Filing.—Draw filing is a quick, easy method of filing long narrow surfaces or round rods. The file is grasped on each end as shown

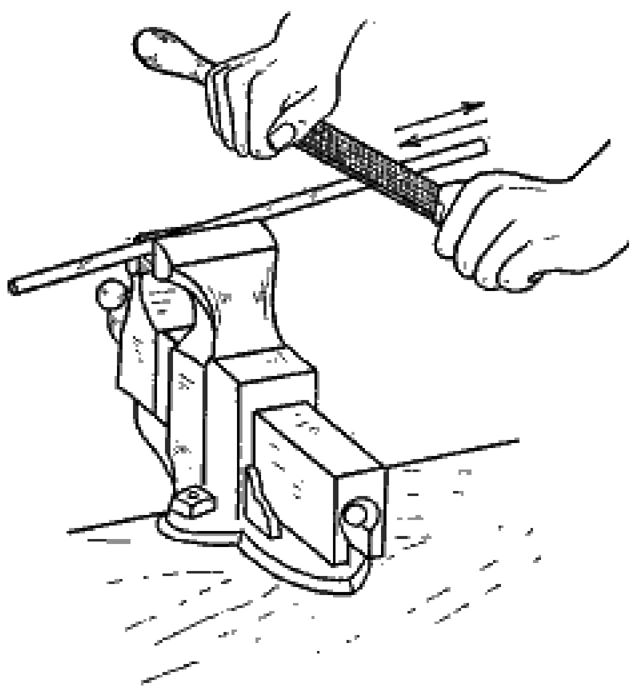


Fig. 175.—Draw filing is an excellent method for filing long, narrow surfaces. The file is pushed back and forth sideways, and pressure is applied on both the forward and back strokes. Use moderately slow strokes.

in Fig. 175 and pushed back and forth sideways, using pressure on both the forward stroke and the back stroke.

In blacksmithing, draw filing can often be used to smooth up a round rod or other piece of work better than hammering. If the work is to be filed while hot, an old file should be kept for this purpose, as the heat would soon damage a good one.

198. Scratching; Clogging.—Small particles of metal will often tear out and push along ahead of the file teeth and scratch the work. This is more likely to occur with a new file than with an old one, or when filing on narrow work, especially if too much pressure is used. Rubbing the file with a piece of chalk will help to prevent such scratching.

A file also is likely to become clogged and slick when filing soft metals or dirty, greasy pieces. The teeth may be cleaned by using a small fine wire brush, called a *file card*, or a piece of wire sharpened to a fine point.

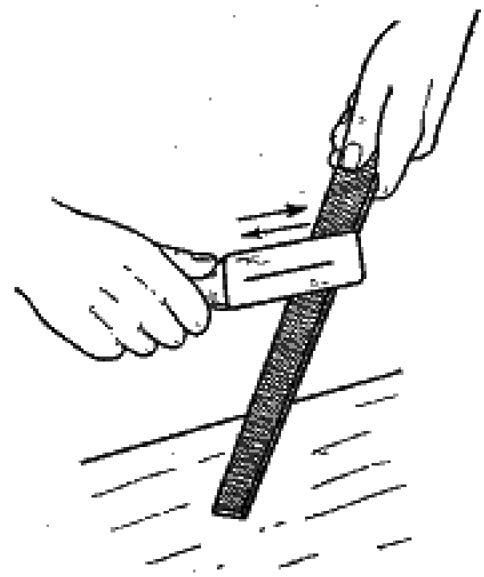


FIG. 176.—When a file becomes clogged with dirt, grease, or metal cuttings, it may be cleaned with a small wire brush known as a *file card*.

199. Filing Soft Metal.—It is difficult to file soft metal with an ordinary file, because of the tendency of the teeth to clog. Draw filing, however, usually works reasonably well and better than straight cross filing.

200. Filing Cast Iron.—Cast iron has a hard outer surface that would quickly damage the teeth of a good file. In filing cast iron, it is therefore good practice to use an old file for cutting through this outer surface before using a good file.

201. Kinds and Sizes of Files.—There are many styles and kinds of files. They may be classified according to (1) size; (2) kind of teeth; (3) shape, style, or use; and (4) degree of coarseness of fineness.

Size of Files.—The size of a file is designated by its length, measured exclusive of the tang.

Kinds of Teeth.—A file with one series of chisel-like teeth running at an angle across the face, is known as a *single-cut file*. A *double-cut* file has a second series crossing the first at an angle. A third kind, used on rasps, consists of raised points on the surface, rather than chisel-like teeth.

Shape, Style, or Use.—Files are commonly named to indicate (1) their general style or shape, as *flat, square, round, half-round, three-cornered* (*triangular*), etc.; or (2) their particular use, as *mill*, and *auger bit*.

A particular kind of file is always made in just one kind of teeth. A *flat* file, for example, cannot be obtained with either single-cut or with double-cut teeth. It is made in double-cut only. Likewise, a *mill* file is made in single-cut only.

A *flat* file is commonly used for general rough or fast filing. A *mill* file, so called because of its use in woodworking mills for sharpening saws and planer knives, is very much like the *flat* file except that it is somewhat thinner, is tapered less in width towards the point, and is made with single-cut teeth.

Fineness or Coarseness of Cut.—The fineness or coarseness of files is commonly designated by the following series of terms, which are arranged in order of coarsest first: *rough, coarse, bastard, second cut, smooth*, and *dead smooth*. These terms are relative, however, and vary with the kind or style of file, and with the length or size of file. For example, a mill bastard file is finer than a flat bastard file of the same size; and an 8-in. bastard file is finer than a 10-in. bastard file.

202. Files for General Farm Shop Use.—For rough, fast cutting, flat bastard files of 10- or 12-in. size are good; and for finer work, mill bastard files of 8- or 10-in. size are quite satisfactory. A mill smooth file may occasionally be useful for very fine filing.

One or two round bastard files (commonly called rattail files) from 6 to 12 in. long, would be useful for enlarging round holes and filing inside rounded corners. A few triangular saw files, one or two square files, an auger-bit file, and possibly a half-round bastard file, would occasionally be useful in the farm shop. A half-round bastard or smooth wood rasp is sometimes needed for making irregular-shaped wood pieces. Ordinary files can of course be used on wood also.

Points on Filing

1. Clamp the work to be filed firmly in the vise to prevent chattering.
2. The work should be at about elbow height for average filing, possibly a little lower for heavy filing and a little higher for light filing.
3. Exert just enough pressure on the file to keep the teeth engaged and cutting.
4. Use moderately slow, long, full-length strokes.
5. Always release the pressure on the back stroke.
6. Never use short, jerky strokes.
7. Do not allow the file to slip over the work, as this dulls the teeth.
8. Do not allow files to be thrown around against tools or against each other, as this will damage the teeth.
9. A good way to keep files is to hang them up by their handles.
10. If a file tears and scratches the surface of the work, rub the teeth with chalk.
11. Keep the teeth of the file clean by means of a file card or brush.
12. Draw filing works well on long narrow surfaces.
13. Draw filing on soft metals gives rapid cutting with a minimum of clogging of the teeth.
14. In filing cast iron, the hard outer surface should first be removed with an old file before using a good one.
15. An 8- or 10-in. mill bastard file is good for fine filing around the farm shop, and a 12-in. flat bastard file is good for fast, rough filing.

HACK SAWING

The hand hack saw is one of the most useful tools for cutting metal. Like the file, however, it is often not used properly. Although the hack saw can be used with fair satisfaction by an inexperienced workman, a little thought and study given to its proper use will result in faster and better work and less dulling and breaking of blades.

203. Kinds of Hack-saw Blades.—Good work with a hack saw depends not only upon proper use but upon proper selection of blades for the work to be done. There are three general kinds of blades available: (1) *all hard*, (2) *flexible*, and (3) *high-speed steel*. All-hard blades have the whole blade tempered. They are suitable for general use where the work to be sawed can be held securely. The flexible blades have only the teeth hardened without hardening the back. They are used where there is danger of cramping and breaking the blade, as in sawing in awkward positions, where the work cannot be held securely, or for sawing flexible material like armored electric cable. High-speed steel blades are made of a special steel and will cut faster and last many times longer than regular blades, provided they are carefully used and not broken.

204. Teeth per Inch.—Use of saw blades with the wrong size of teeth is the most common cause of breaking blades. In general, larger teeth should be used for sawing thick pieces and soft materials, and smaller teeth for thin pieces and hard materials. Fine teeth lessen the danger of breaking the blade.

Hand hack-saw blades are commonly available with 14, 18, 24, and 32 teeth per inch. A blade with 14 teeth per inch is used for sawing thick bars and soft materials. It is seldom needed in the farm shop, a blade with 18 teeth per inch usually being satisfactory for the heavier sawing. For general use in the shop, a blade having 24 teeth per inch is best for beginners, although 18 teeth per inch might be better for an experienced workman. A blade with 32 teeth per inch is best for sawing thin metal and tubes with walls thinner than about $\frac{1}{16}$ in. A general rule is to use a blade that will always have at least two teeth cutting at the same time. This lessens the tendency of teeth to catch on the work and break out of the blade.

205. Hack-saw Frames.—Hack-saw frames are available with different styles of hand grips and in fixed lengths, or adjustable to take blades from 8 to 12 in. long. A sturdy, durable frame, with a comfortable grip, preferably of the pistol or full-hand type, should be selected for the farm shop.

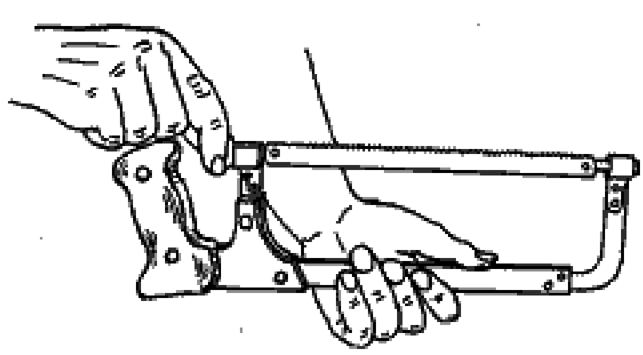


FIG. 177.—The blade should be tightened until it gives a clear humming note when picked with the thumb. After sawing a few strokes, a new blade will stretch and need to be retightened a little.

206. Tightening the Blade in Frame.—The blade should be inserted in the frame with the teeth pointing away from the handle, and tightened

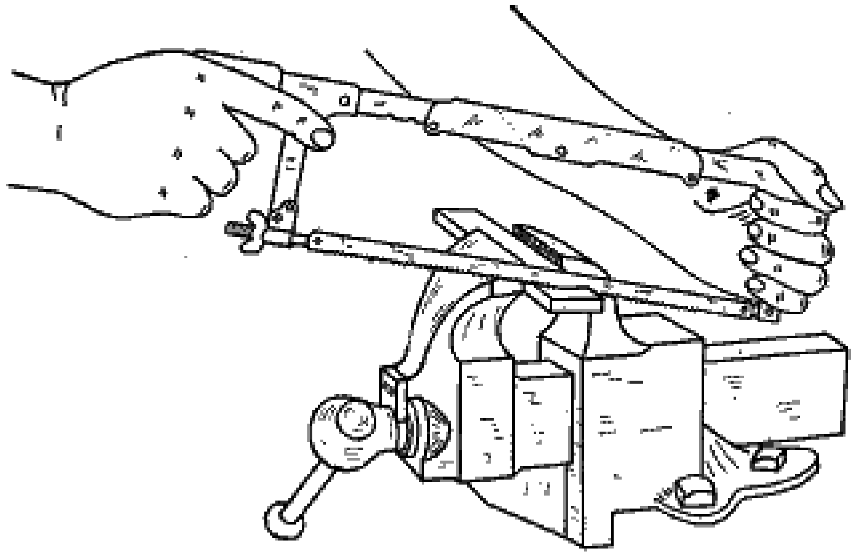


FIG. 178.—Grip the saw with the first finger of the right hand alongside the handle. The left hand should hold the front end of the frame to help guide it and to apply pressure.

until it gives a clear humming note when picked with the thumb. After sawing a few strokes, the blade will stretch a little and will need to be retightened. It is important that the blade be kept tight but not over-strained. A slack blade is likely to drift or cut at an angle instead of straight, and it is likely to buckle and break.

FIG. 179.—In sawing with a hack saw, stand at ease with the right foot 10 or 12 in. back of the left, and with the right forearm, elbow, and shoulder in line with the saw. Use long, even strokes, swaying the body back and forth slightly in rhythm with the arm strokes.

207. Holding the Saw; Position for Cutting.—The handle of the hack saw is gripped with the right hand much as is a hand wood saw. The left hand holds the front of the frame to help guide it and apply pressure. The workman should stand at ease, with the right foot 10 or 12 in. back of the left, and with the right forearm, elbow, and shoulder in line with the saw. The saw should be pushed with a light sway of the body as well as with motion from the arms, much as a file is pushed. See Art. 195, page 139. Possibly a little less arm motion is used in sawing than in filing.

208. Use Long, Slow, Even Strokes. Sawing should be done with long, even, steady strokes, and not too fast. Sixty cutting strokes per minute should be the maximum—40 to 50 are usually better.

Pressure is exerted on the forward stroke and released on the backstroke, lifting the blade slightly. Just enough pressure should be used to make the teeth cut and keep them from slipping. If they slip, little or no cutting is done, and the blade is quickly dulled. Too much pressure increases the danger of breaking the blade.

Sawing too fast is usually accompanied by short strokes and heavy dragging on the back strokes, with consequent quick dulling and excessive wear in the middle portion of the blade. Also, with fast sawing there is more danger of catching and breaking the blade.

If a blade starts to cut to one side, it is best to turn the stock a quarter or half turn and start a new cut.

In case a blade is broken and a new one must be used, always start in a new place, possibly on the opposite side of the stock. A new blade would bind and there would be danger of breaking it if it were used in a cut started by an old blade.

209. Holding the Work.—A piece to be sawed should be held securely. If possible, clamp it in a vise with the place to be cut close to the vise jaws.

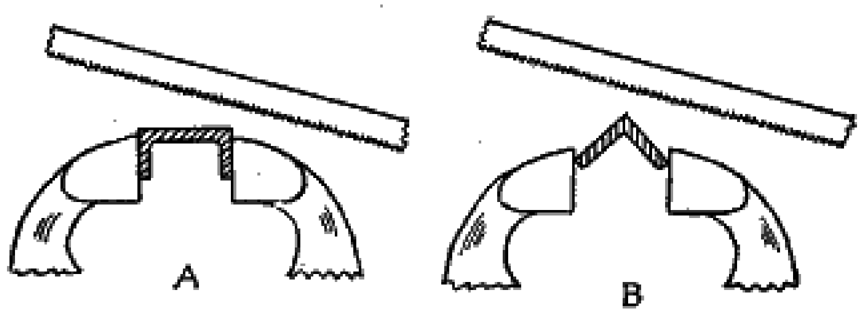


FIG. 180.—Suggested methods of holding irregular work for hack sawing. In cutting channels and angle iron, keep as many teeth in contact with the work as possible.

A beginner sometimes makes the mistake of sawing too far from the vise, thus allowing the work to spring and vibrate and the saw to screech. Where a vise is not available, sometimes two nails can be driven part way into the bench top, and the work held by cramping it between the nails. Sawing can best be done if the work is at about elbow height.

In fastening irregular-shaped pieces, as angle irons, channel irons, etc., in a vise, they should be placed so that the saw will make an angling cut and enough teeth will engage at a time to prevent catching and breaking. At least two teeth, and preferably more, should always be in contact with the work. In sawing thin bars, $\frac{1}{8}$ to $\frac{1}{4}$ in. thick, it is usually better to clamp them flatwise in the vise, rather than on edge, and to saw with the front end of the saw slightly lowered. Sawing across the wide surface instead of the edge not only lessens the danger of stripping teeth but also prevents vibration. To hold a piece of metal in a vise without marring, it may be clamped between two pieces of wood.

210. File Notch to Start Saw.—It is a good plan to file a notch for starting the saw, particularly in the case of beginners or when starting on the corner of a bar. The notch helps get the saw started in the right place and decreases the danger of breaking teeth from the blade.

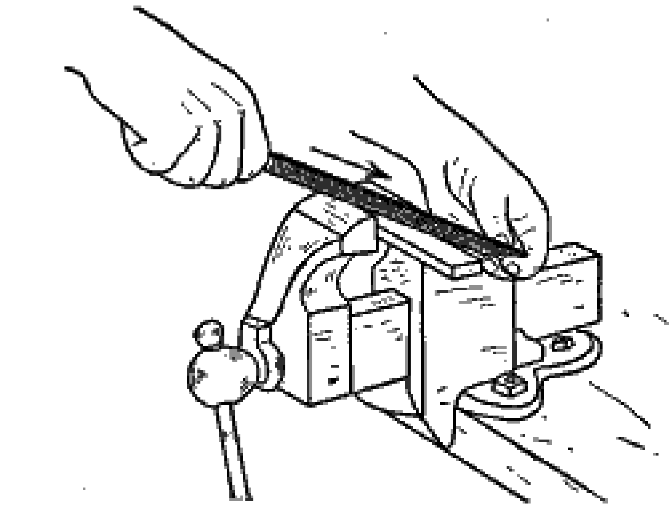


FIG. 181.—A file notch makes it easy to start the hack saw exactly on a line and decreases the danger of breaking teeth from the blade.

211. Sawing Thin Sheet Metal.—A small piece of thin sheet metal may be easily sawed by clamping it between two pieces of wood in a vise and sawing through both wood and metal. Larger pieces of sheet metal that cannot be held in a vise may be clamped or otherwise fastened to the bench top with the part to be sawed projecting over the edge.

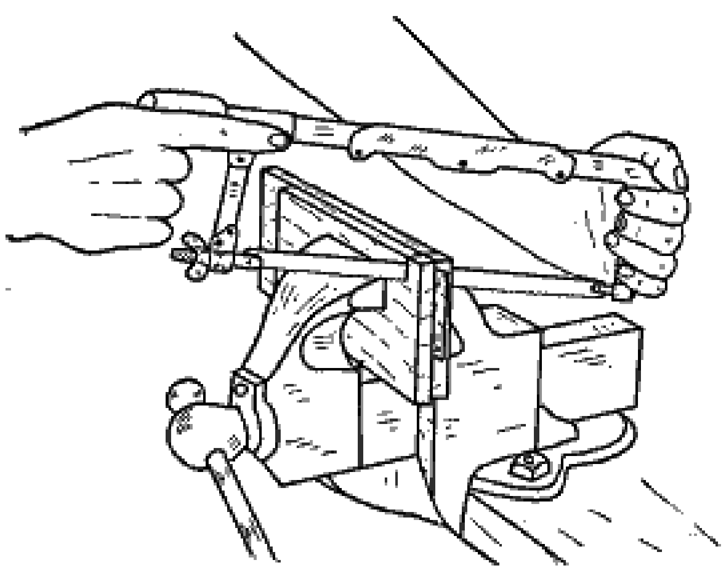


FIG. 182.—A small piece of thin metal may be sawed easily by clamping it between pieces of wood in a vise and sawing through both wood and metal.

212. Sawing Tool Steel.—Tool steel should be in the softened or annealed state before sawing. Otherwise, the saw blade will be dulled quickly. Although tool steel may be clamped in the vise and sawed as any other steel, it is generally best to saw only a deep nick (about one-fourth or one-fifth of the way through the bar) and then break the bar by clamping in the vise and striking a sharp blow with a hammer. The bar should be clamped with the nick on the side to be struck with the hammer, and just even with the movable vise jaw. Heavy hammering in the vise should always be done so the force of the hammer blows will come against the stationary jaw.

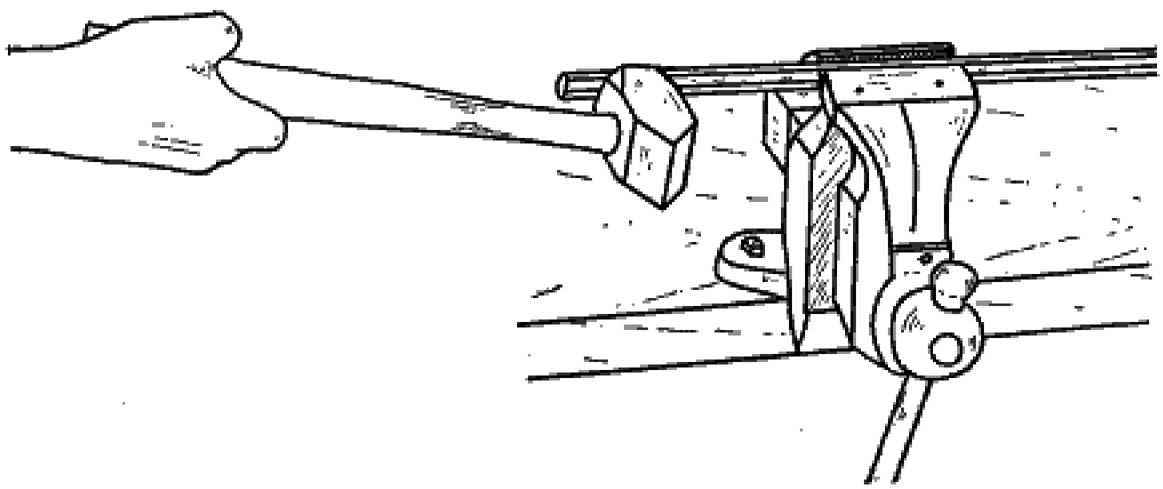


Fig. 183.—A practical method of cutting tool steel is to saw a deep nick with the hack saw, clamp it securely in a vise with the nick even with the movable vise jaw, and then break it with a sharp hammer blow.

212a. Sawing Wide Slots.—It is sometimes desirable to make a wide slot in a bolthead so that it may be held or turned with a screw driver. Such a slot is easily made by using two saw blades in the hack-saw frame

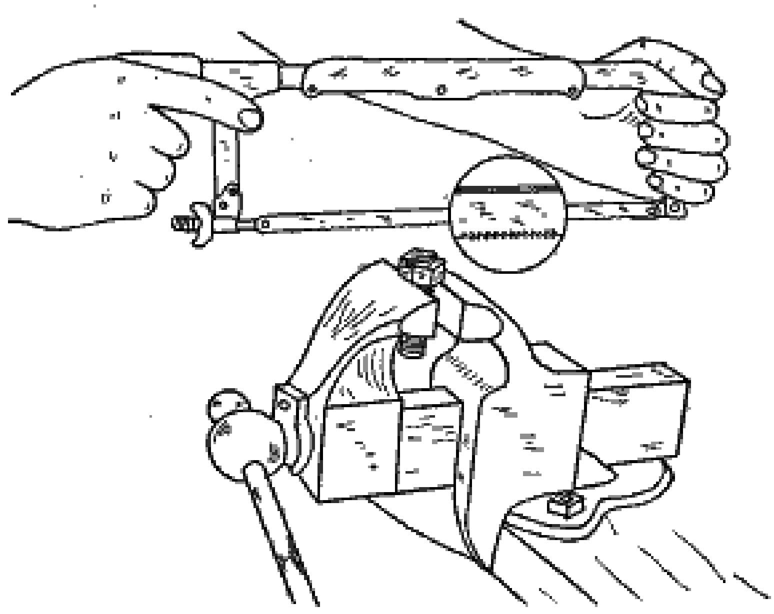


Fig. 183a.—Wide slots are easily made with the hack saw by using two or more blades instead of one.

instead of one. If for some reason a still wider slot is needed, three or even more blades might be used.

Points on Hack Sawing

1. Clamp the work in a vise if possible.
2. Saw as close to the vise jaws as possible in order to keep the work from vibrating.

3. Use a flexible blade for sawing flexible material, or where the work cannot be securely held.

4. It is a good plan to start the saw in a notch made with a file.

5. Use a blade with a suitable number of teeth per inch. Twenty-four is about right for general use, especially for beginners. Eighteen teeth per inch might be better for an experienced workman.

6. Use a blade with 32 teeth per inch for sawing thin metal.

7. At least two teeth should be kept in contact with the work when sawing.

8. Coarser teeth saw faster; finer teeth lessen the danger of breakage.

9. Keep the blade tight yet not overstrained. If it is properly stretched, it will give a clear humming note when picked with the thumb.

10. Use just enough pressure to make the teeth cut.

11. Release the pressure on the back stroke.

12. Use long, even, slow strokes—not over 60 cutting strokes per minute; 40 or 50 are usually better.

13. Never allow the saw to rub or slip instead of cutting. Rubbing or slipping dulls the teeth.

14. To saw irregular-shaped pieces, clamp them cornerwise in the vise, so as to allow plenty of teeth in contact with the work.

15. Clamp thin bars flatwise rather than on edge. This prevents vibration and lessens danger of stripping teeth.

16. Thin sheet metal may be easily sawed by clamping between two pieces of wood.

17. Tool steel is readily cut by sawing a deep nick and then clamping in the vise and breaking with a hammer.

18. Two or more blades may be used in a hack-saw frame for sawing wide slots.

BENDING COLD IRON AND STEEL

Although it may be necessary to heat large pieces of iron or steel to bend them satisfactorily, many small pieces can be bent better and more easily cold.

213. Bending in the Vise.—With a good machinist's or blacksmith's vise, rods and bars up to 5⁄16 or 3⁄8 in. thick can be readily bent. Many appliances and repairs can be made with stock of this size and smaller. Care should be exercised, of course, not to do too heavy hammering or bending in a small vise, lest the vise be damaged or broken.

A simple and easy way of making a small bend in strap iron or thin bars is to bend the stock around a pipe or rod of suitable size. The end of the stock may be clamped beside the pipe or rod in a vise and then bent around the pipe or rod by pulling or hammering (see Fig. 184).

For making a uniform bend of large size, the end of the stock may be slipped between the loosely adjusted jaws of a vise and bent by pulling. When the bar is bent slightly the pull is released and the bar allowed to slip through the jaws about 1⁄2 in., and then the bar is bent a little more by further pulling. Thus a series of very short bends is made, which gives a reasonably smooth bend of rather large curvature (see Fig. 185).

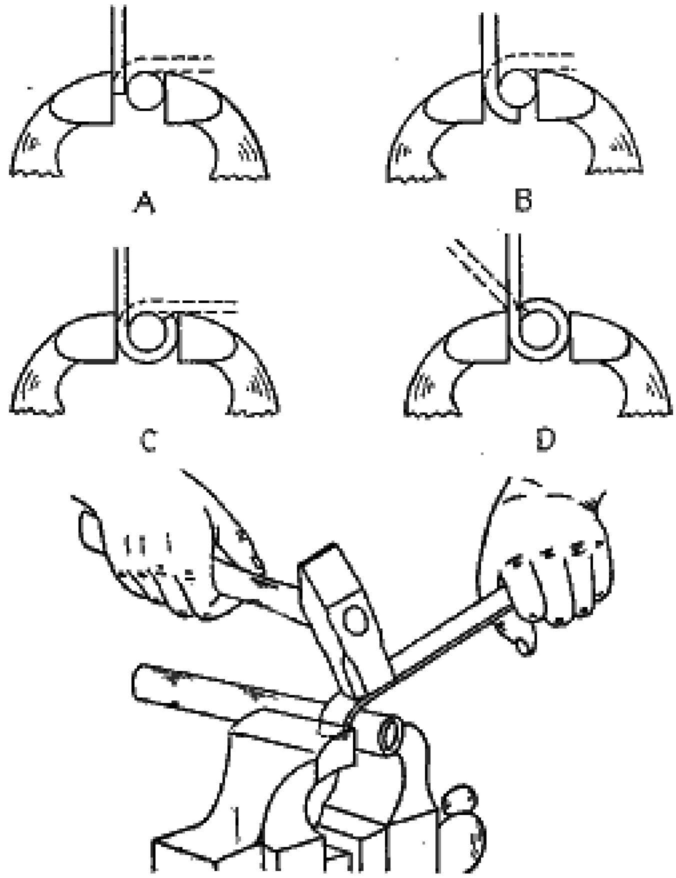


FIG. 184.—Short bends of a definite size, or a small eye, may be made by clamping the end of the bar against a pipe or rod held in the vise, and then bending it around the pipe or rod.

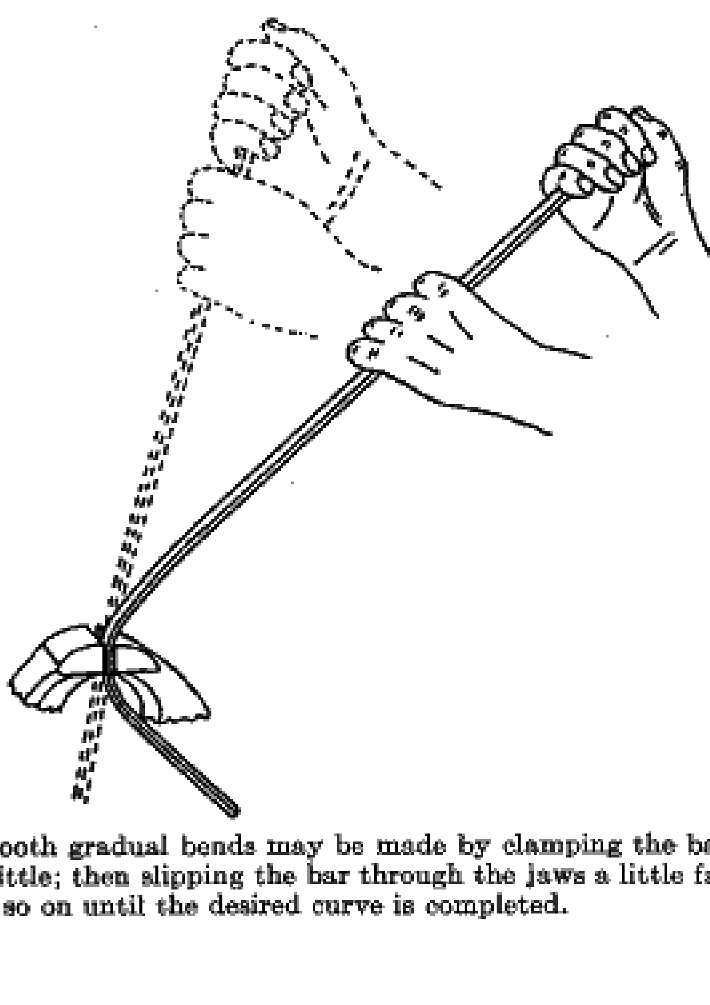


FIG. 185.—Smooth gradual bends may be made by clamping the bar loosely in a vise and bending it a little; then slipping the bar through the jaws a little farther and bending a little more; and so on until the desired curve is completed.

RIVETING

Riveting offers a convenient and easy method of securely holding parts together. It is easily done and requires very few tools. Many repairs can be made on farm machinery and equipment by riveting.

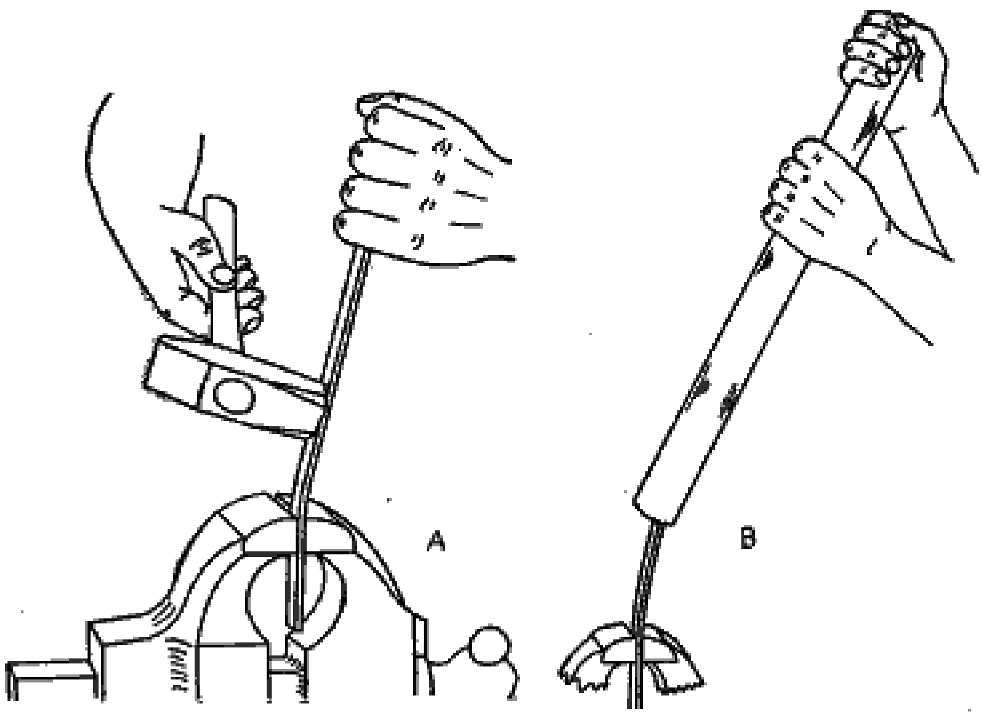


FIG. 186.—Short bars or bars too heavy to be bent by hand, may be bent by hammering, as at *A*, or by pulling on a pipe slipped over the end as at *B*.

214. Procedure in Riveting.—A hole is first drilled through the parts to be held together, and then a soft steel rivet is inserted and hammered

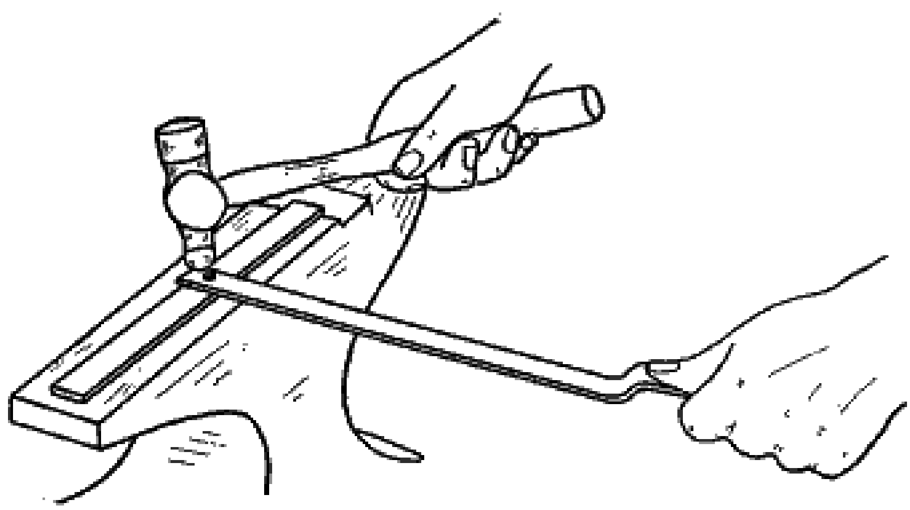


FIG. 187.—A neatly rounded head may be formed on a rivet by first striking a few medium-heavy blows and then finishing by light peening with a small ball-peen hammer.

tightly in place. For some work the rivets are heated and hammered down while hot; but, for most farm shopwork, cold riveting is quite satisfactory.

To form a round head on a rivet, a rivet set is used. Where such a tool is not available, the rivet may be hammered down with a few medium-heavy, carefully directed blows and then finished by light peening with a small ball-peen hammer.

Where it is desired to fasten pieces together and yet not have the rivet heads protrude from the surface, the holes may be countersunk as indi-

FIG. 188.—Methods of heading rivets.
A. Flat head made by straight hammering.
B. Head rounded with rivet set.
C. Head rounded with small ball-peen hammer.
D. Ends of rivet hammered into countersunk holes with ball-peen hammer.

cated in Fig. 188*D* and the ends of the rivet peened into the countersunk holes.

Cutting Rivets to Length.—To cut a rivet to the desired length it may be clamped in a vise with the head up and then sheared with a cold chisel. Holding the chisel near the cutting end with the thumb and first two fingers will allow the palm of the hand to cover the rivet and keep it from

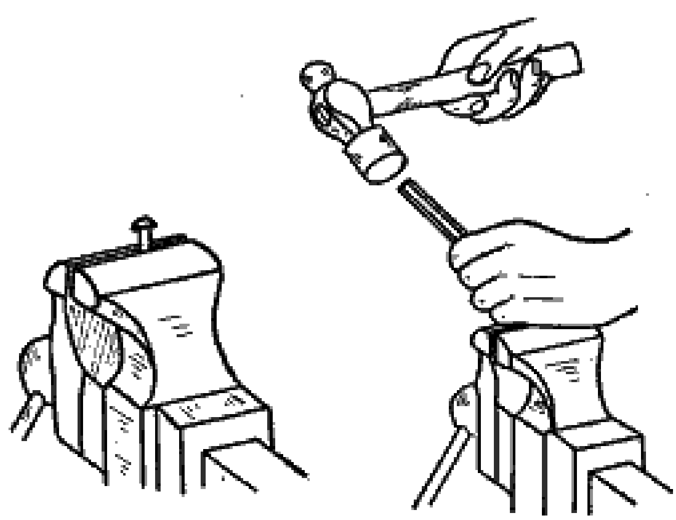


FIG. 189.—Rivets may be cut to length easily by clamping in a vise and shearing with a sharp cold chisel. Placing the hand over the top of the rivet keeps it from flying away and being lost as it is cut off.

flying off and becoming lost as the chisel cuts through (see Fig. 189). Rivets may also be cut with heavy pincers, with small boltcutters, or with a hack saw.

Questions

184. (*a*) What tools are used in laying out work and marking on metal? (*b*) Why is a pencil not satisfactory for such work?

185. (*a*) What difficulties are likely to occur if a light cold chisel is used for heavy cutting? (*b*) How should the cold chisel be held in the hand?

186. (*a*) On what part of the anvil should cutting with the cold chisel be done? Why? (*b*) What is the best procedure for cutting heavy bars and rods?

187. When chiseling is done in a vise, against which jaw should the force of the blow fall?

188. (*a*) What important points should be observed in shearing thin bars held in a vise? (*b*) At what angles should the chisel be held?

189. (*a*) What is a cold cutter? (*b*) What is it used for?

190. (*a*) For what kind of work is the slitting chisel especially well suited? (*b*) How is it different from an ordinary cold chisel? (*c*) What kind of a cutting or chip does it make? (*d*) How may it be started in the middle of large piece of metal?

191. What other kinds of special chisels may be used for cutting grooves, keyways, etc.?

192. How should a chisel be ground for cutting soft metal or very thin sheet metal?

193. How should files be kept when not in use? Why?

194. How should a file be held in the hands for heavy filing? For light filing?

195. (*a*) What kind of strokes should be made when filing? (*b*) What is the best filing stance or body position for filing? (*c*) Describe and be able to demonstrate how to hold and use a file properly. (*d*) What troubles are likely to occur if short, fast, jerky strokes are used?

196. What special precaution should be observed when filing a surface perfectly flat?

197. (*a*) What is draw filing? (*b*) For what kind of work is it especially good?

198. (*a*) Under what conditions or for what kind of work is a file likely to scratch rather than cut smoothly? (*b*) How can the trouble be remedied? (*c*) What might cause file teeth to become clogged?

199. (*a*) Why is soft metal difficult to file? (*b*) Can draw filing be done on soft metal to advantage?

200. What is the best procedure for filing cast iron?

201. (*a*) How is the size of a file designated? (*b*) What are the differences between single-cut files, double-cut files, and rasps? (*c*) What does the name of a file usually indicate? (*d*) Give several terms that designate the coarseness or fineness of files, giving them in the order of coarsest first.

202. Make a list of a few different kinds and sizes of files you would recommend for the farm shop.

203. (*a*) What different kinds of hack-saw blades are commonly available? (*b*) What are the particular advantages of each?

204. (*a*) How is the size of teeth in a hack-saw blade designated? (*b*) What sizes of teeth are commonly available? (*c*) What size or sizes would you recommend for the farm shop? (*d*) What trouble is likely to occur if the teeth are too large for the work? (*e*) State a general rule that may be used as a guide in selecting blades with the proper size of teeth.

205. What type of hack-saw frame would you recommend for the farm shop?

206. (*a*) How tight should a blade be stretched in a saw frame? (*b*) What difficulties are likely to develop if the blade is too loose?

207. (*a*) How should the hack saw be held? (*b*) What is the proper stance or body position for hack sawing? (*c*) How does the proper sawing stance compare with the proper filing stance?

208. (*a*) What kind of strokes should be made with the hack saw? (*b*) About how many cutting strokes should be made per minute? (*c*) How much pressure should be exerted on the saw? (*d*) What difficulties may arise from sawing too fast?

CHAPTER XIV

DRILLING TOOLS AND THEIR USE

A few tools for drilling holes in metal will enable a farmer to make many handy appliances and to make many repairs on his machinery and equipment that would otherwise be impossible.

DRILLING EQUIPMENT FOR THE FARM SHOP

215. Drilling Machines.—*The post drill* is probably the best drilling machine or tool for general work inside the shop. It is especially good for drilling holes of the larger sizes—above ½ in. in diameter. A power-driven post drill may be desirable under some conditions, although it is not hard work to turn the drill by hand, especially if the drill bits are kept sharp.

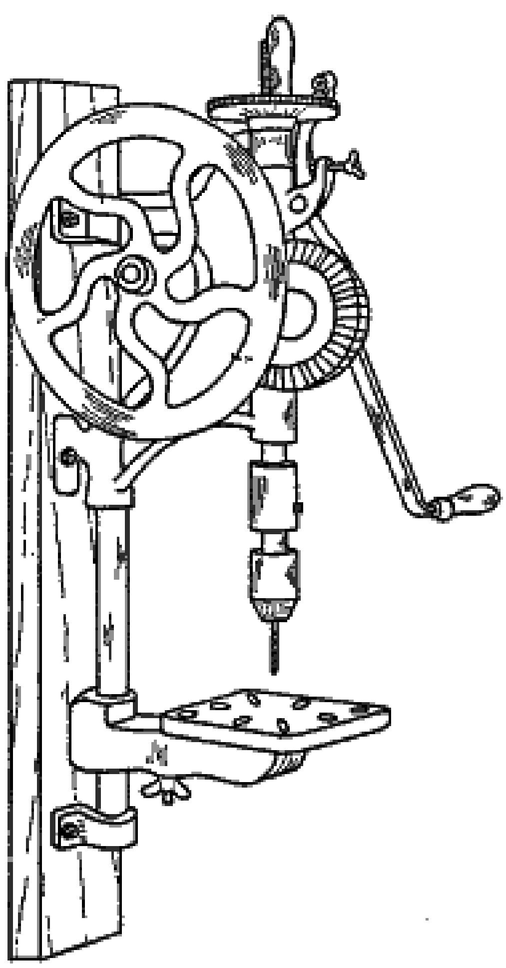


FIG. 190.—The post drill is an excellent piece of equipment for the farm shop.

The carpenter's brace can be used for drilling holes in iron and steel. For holes about ¼ in. in diameter, it works very well but is somewhat slow for holes of larger size. Small drills are easily broken in a brace if the workman is not careful.

The chain drill, used with the carpenter's brace, makes a very effective drilling combination. Holes can be drilled much faster and easier than with the brace alone. With a chain drill the workman does not have to push hard against the brace, as the pressure for drilling is supplied by simply turning a knob. The chain drill can be used in the shop, or it can be taken to the machine shed or the field. Thus a hole may be drilled in a machine or implement without having to take it, or a part of it, to a shop. Chain drills are available with either automatic or plain hand feeds. The plain-feed drills are cheaper and for farm shop use are practically, if not altogether, as good.

The hand drill is one of the most useful tools for drilling small holes in lightweight metal and in wood. For the farm shop, one that takes drills up to ¼ in. in diameter is large enough. (See Art. 66, page 51.)

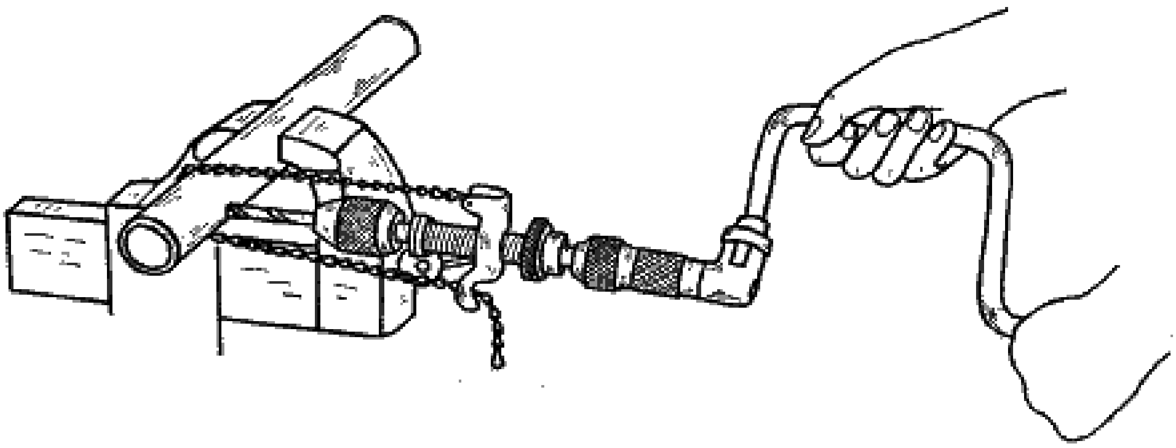


FIG. 191.—The chain drill is good for drilling holes in parts of machines and implements when it is not convenient to take these parts to the shop, as well as for drilling in the shop.

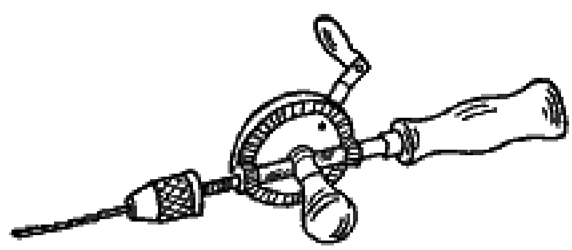


FIG. 192.—The hand drill is one of the most useful tools for drilling small holes, either in metal or wood.

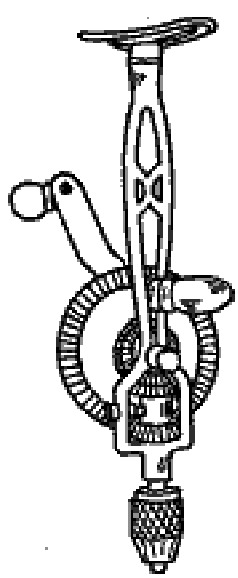


FIG. 193.—The breast drill is similar to the hand drill but is larger.

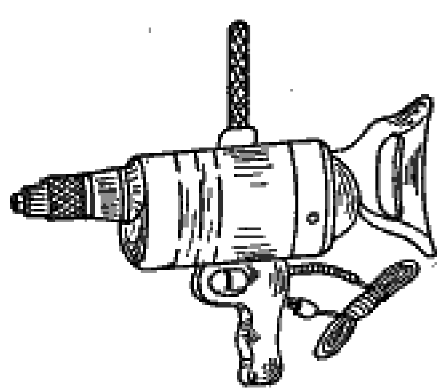


FIG. 194.—The electric drill is an excellent tool where electricity is available.

The breast drill is very much like the hand drill, except that it is larger and pressure can be applied by leaning against it. Although a useful tool, it is not greatly needed in the farm shop. A hand drill works just as well or even better for small holes, and a chain drill or a post drill works better on drills larger than 5⁄16 in. in size.

The electric drill is an excellent tool where electricity is available. It is somewhat expensive, however, for most farm shops.

216. Twist-drill Bits.—Twist drills are available in two qualities—carbon-steel drills and high-speed drills. The high-speed drills stay sharp longer but cost considerably more. Carbon-steel drills are usually quite satisfactory for the farm shop, particularly if they are kept sharp.

Kinds of Shanks.—Twist drills are available in various kinds of shanks, the following being the most common:

1. Bit stock or square taper to fit a carpenter's brace.
2. Straight round shank.
3. Blacksmith's drill shank (straight round with one flat side).
4. Morse taper (round taper with a flat tang on end).

Bit-stock drills are held in two-jaw chucks like those on the carpenter's brace. They are a little harder to center in the chuck than the straight round-shank drills, which are held in three-jaw chucks. The flat-sided blacksmith's drills are held in special chucks furnished on post drills. Some of these chucks have flat-sided holes or sockets to receive the drills, and a drill must be inserted with its flat side against the flat side of the hole. To keep the drill from falling out of the chuck a setscrew is tightened against the drill. The setscrew does not keep the drill from slipping around in a rotary direction in this kind of chuck, however, for this is done by the flat-sided socket of the chuck. Drills with Morse taper shanks are made mostly in the larger sizes. They are used in machine shops and are usually not found in farm shops.

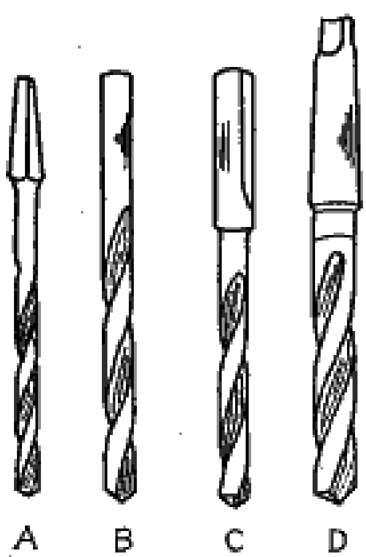


FIG. 195.—Types of drill bits classified according to kind of shanks:
A. Bit-stock drill.
B. Straight round shank drill.
C. Blacksmith's drill (straight round shank with flat side).
D. Morse taper drill.

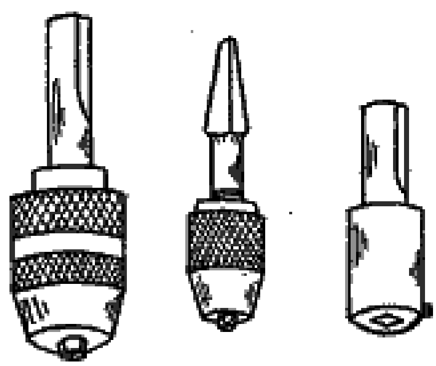
217. Sizes of Drills for the Farm Shop.—A set of drills ranging by sixty-fourths or by thirty-seconds from 1⁄16 to 1⁄4 in., and a set ranging by sixteenths from 1⁄4 to 1⁄2 in. would meet most of the drilling needs on an average farm. The small set would be useful in drilling holes in sheet metal for rivets and screws, for drilling out old rivets, and for drilling holes in wood for wood screws. The larger set would be adequate for drilling holes for most bolts and rods. If a post drill is available, it would be well to have two or three drills larger than 1⁄2 in., possibly 5⁄8, 3⁄4, and 1 in.

Other Sizes of Drills.—Small drills are available in sets with the sizes designated by letters from *A* to *Z*, and by wire-gage numbers from 1 to 80. These two systems simply give finer graduation in sizes than the fractional-inch system, the wire-gage system having 80 drills graded in size from 0.228 to 0.0135 in., and the letter system having 26 different sizes ranging from 0.234 to 0.413 in. These drills are commonly used by machinists and by jewelers and would seldom be needed in a farm shop.

218. Drill Chucks.—Drilling tools and machines may be purchased with different kinds of chucks for holding the drills. Breast drills, hand drills, and electric drills are commonly furnished with three-jaw chucks for taking straight round-shank drills. The carpenter's brace has a two-jaw chuck that takes the square taper shank. Chain drills may be purchased with either type of chuck. Post drills take blacksmith's drill bits with flat-sided round shanks.

In order to use different styles of drill bits in different machines, adapting chucks are used. For instance, a small three-jaw chuck that has a square taper shank may be used in a carpenter's brace to hold straight round-shank drills. Likewise, adapting chucks are available for holding straight round-shank bits, or for using square taper shank bits in a post drill (see Fig. 196).

219. Taper reamers are valuable for enlarging holes. They are especially useful in assembling machinery when boltholes in iron or steel parts do not quite line up. A few turns with a taper reamer will usually allow the bolt to go in. Taper reamers are commonly made with square taper shanks and are used in the carpenter's brace.



A B C

FIG. 196.

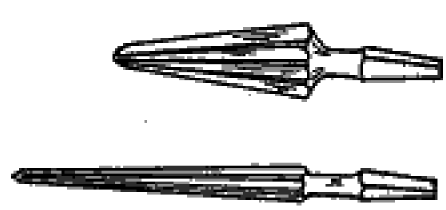


FIG. 197.

FIG. 196.—Types of adapting chucks:
A. Three-jaw chuck to fit into a post drill and hold straight round-shank drills.
B. Three-jaw chuck to fit into a carpenter's brace and hold straight round-shank drills.
C. Chuck to fit into a post drill and hold bit-stock drills.
FIG. 197.—Taper reamers are valuable for enlarging holes in metal.

220. Suggested Set of Drilling Equipment.—The following suggestive list of drilling equipment would make an excellent assortment for the farm shop:

1 post drill with automatic feed.
  1 set of blacksmith's drill bits for post drill (1/4, 5/16, 3/8, 7/16, 1/2, 5/8, 3/4).
  1 three-jaw chuck to hold straight round-shank bits in post drill.
  1 chuck to hold bit-stock drills in post drill.
1 carpenter's brace, 10-in. sweep, ratchet type.
  1 set bit-stock drills (1/4, 5/16, 3/8, 1/2).
1 chain drill, plain hand feed, with two-jaw chuck to hold bit-stock drills.
1 hand drill, three-jaw chuck to hold straight round-shank drills up to 1/4 in.
1 set straight round-shank drills (1/16, 3/32, 1/8, 5/32, 3/16, 7/32, 1/4).

DRILLING HOLES IN METAL

221. A Properly Sharpened Drill Essential.—A properly sharpened drill is the first requirement for satisfactory drilling. A drill that is not properly ground will require excessive effort to use it; it will cut slowly; it will do poor work; and there will be danger of breaking it. Drills that are used much require frequent grinding. Any one who expects to use drills with satisfaction or profit to himself, should therefore become proficient in grinding them. See page 104 for information on drill sharpening.

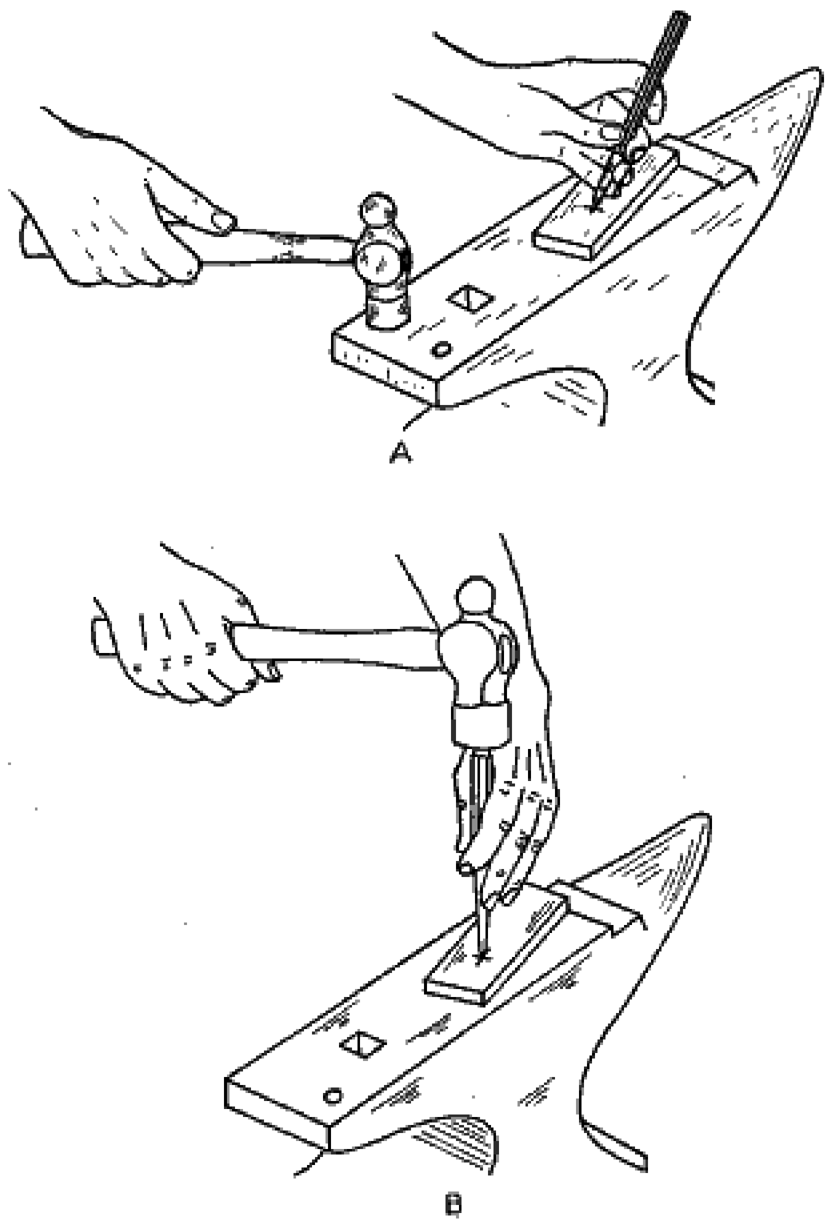


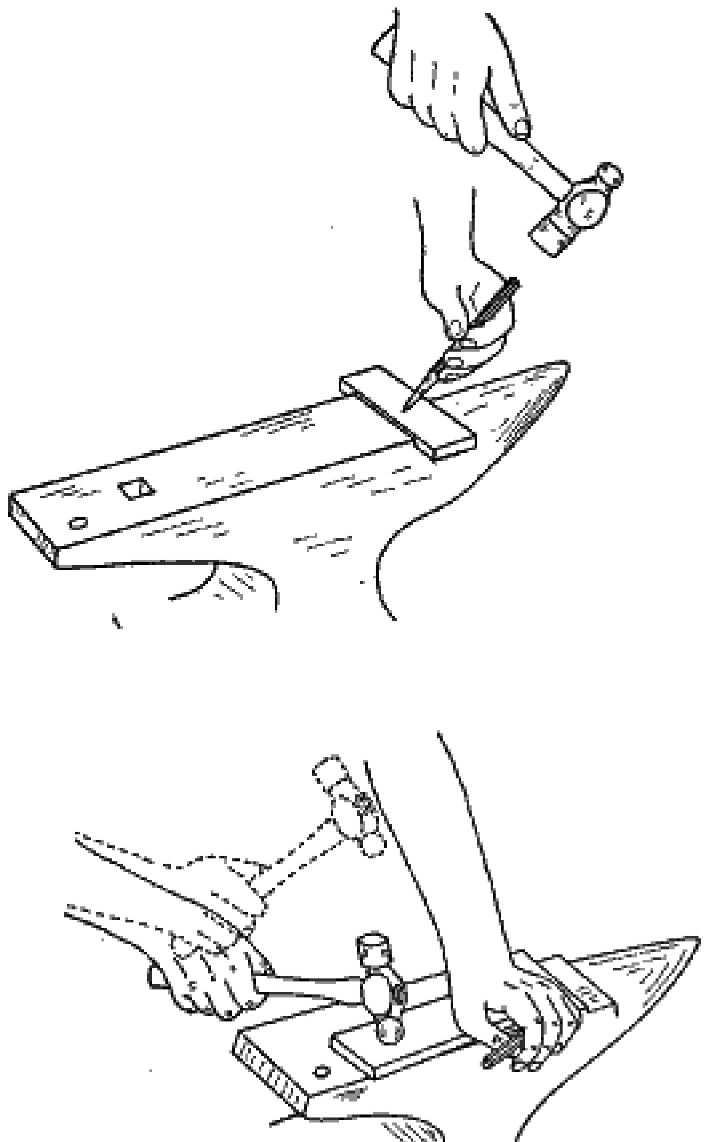
Fig. 198.—A drill should be started in a deep center-punch mark.

A. The point of the center punch can be placed easily in the desired location by steadying the hand against the work.

B. Once the center punch is correctly placed, strike one or two light taps to get the direction of striking and then follow with one or two firm, well-directed blows.

222. Center Punching.—A twist drill should be started in a *deep* center-punch mark—one that is big enough to take the point of the drill.

Otherwise, the drill will likely "wander" and drill the hole off center or not exactly in the right place. For accurate work, the location of the hole should first be marked by the intersection of two scratch lines made with a scriber or scratch awl and a square. In the case of small rectangular pieces, the center can be located by drawing diagonals. A very satisfactory scriber can be made by grinding the end of an old saw file to a needle point.



B

FIG. 199.—In the event a punch mark is not properly located, it may be changed by driving the punch at an angle, as at *A*, or it may be hammered out with a ball-peen hammer, as at *B*, and a new one made. Still another method is to turn the bar over and make a punch mark and drill from the other side.

The crossing point of the two lines is first marked by a light dot made with a sharp center punch. If upon inspection it is found that the dot is exactly in the right place, then a large, deep punch mark is made and the drilling can proceed. In case the dot is not properly located, however, it should be shifted by driving the punch at an angle or it may be hammered out with a ball-peen hammer and a new punch mark made.

223. Lubricant for Drills.—When drilling in mild steel, the drill should be lubricated with lard oil or a threading oil. Turpentine or kerosene is recommended for drilling hard steel or other very hard materials. Drills may be used in cast iron or brass without a lubricant, although many mechanics prefer to use lard oil. Ordinary lard, when melted, makes a good lubricant for drills and other cutting tools.

A lubricant helps to cool the drill, and it makes it cut easier and smoother. If a good lubricant is used, the drill will stay sharp longer. A squirt can of lard oil or threading oil should therefore be kept handy when drilling is done.

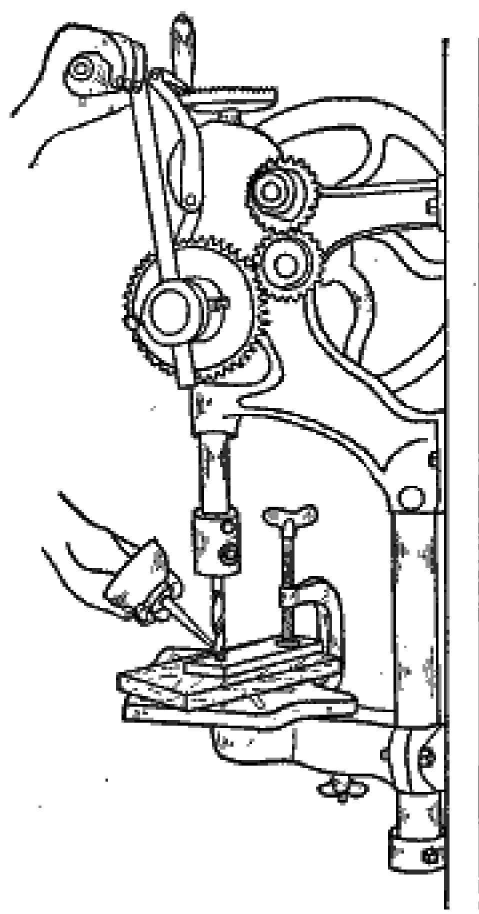


FIG. 200.—It is a good plan to clamp the work to the drill table. Lubricate the drill with lard oil or threading oil when drilling in steel.

224. Holding Work on Drill Table; Safety in Drilling.—When using a power drill, the piece being drilled should be clamped or otherwise firmly held on the drill table or platen. If it is not, the drill may catch and throw the piece off the table, possibly breaking the drill or injuring the operator or both. A method sometimes used to hold small pieces is to bolt a board to the drill table and then drive nails in the board to keep the piece from turning.

When drilling with a hand-driven post drill, the work may be held on the drill table by hand if it is long and a firm hold can be secured. Holding small pieces by hand, even on a hand-driven drill, is not safe.

225. Preventing Drill Breakage.—Most drill breakage occurs just as the drill goes through the piece being drilled. To prevent such breakage the piece should be securely held, and the pressure on the feed should be lightened just as the drill goes through. Turning the drill at a higher speed will also help.

In case a drill gouges and catches just as it starts through and there is difficulty getting the hole finished, the trouble can usually be overcome by turning the work over and drilling from the other side.

226. Drilling Holes through Round Rods.—In drilling a hole in a rod, there is a tendency for it to roll on the drill table, increasing the danger of breakage and making it difficult to get the hole drilled straight through on a diameter. To keep the rod from rolling, it may be placed in a

V-notch sawed in the surface of a two-by-four or a two-by-six block. A deep center-punch mark, of course, should be made to start the drill.

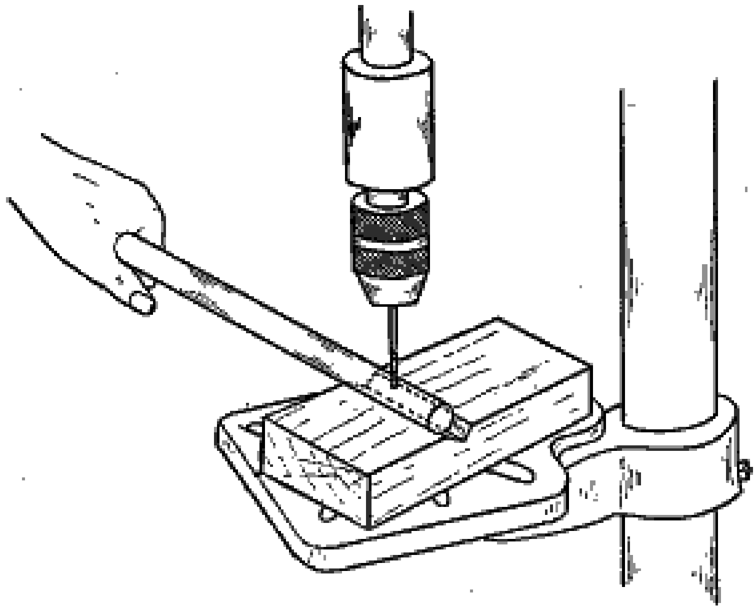


FIG. 201.—A V-notch sawed in a block of wood is useful for holding round rods or pipes while holes are being drilled in them.

227. Drilling Large Holes.—Where large holes are to be drilled, it is generally easier to drill through first with a small drill, and then follow it with a drill of the desired size. Where extreme accuracy is required in locating a large hole, a small hole is sometimes drilled through first to serve as a pilot for keeping the large drill centered.

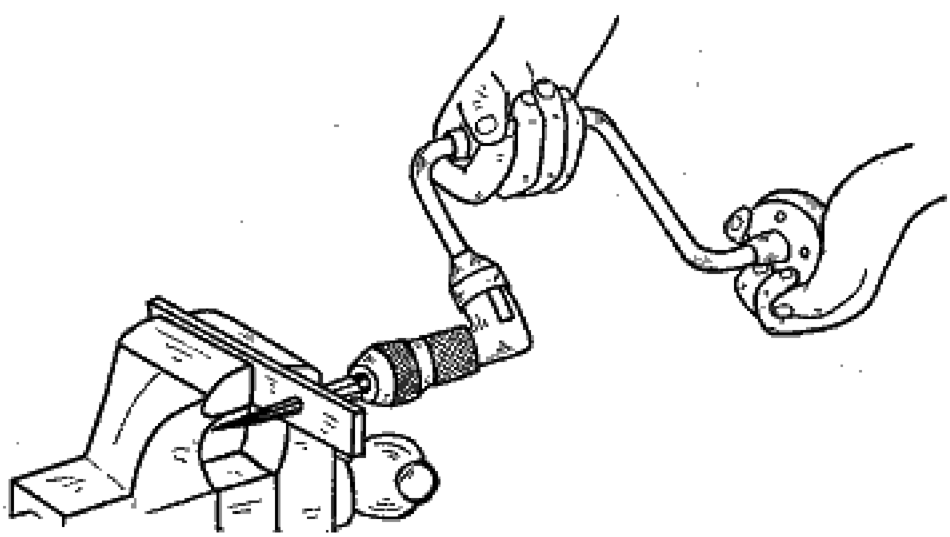


FIG. 202.—Enlarging a hole with a repairman's taper reamer.

If a drill of the desired size is not available and if a slightly tapered hole will do, a hole may be drilled first somewhat smaller than the desired size, and then enlarged with a taper reamer.

228. Speeds for Drills.—If a post drill or other drill is to be driven by power, one should know the desired speed for the drill bit, in order that suitable sizes of pulleys, gears, etc., may be used. For general drilling in mild steel with carbon-steel drills, a peripheral speed of about 30 to 35 ft. per minute gives good results. (The peripheral speed of a drill is the speed of a point on the periphery or outside edge of the drill.) Higher speeds can be used for drilling cast iron and brass.

The peripheral speed of a drill, in feet per minute, is found by multiplying its diameter in inches by 3.1416, dividing by 12, and multiplying by the revolutions per minute the drill turns. Table IV gives revolutions per minute required for different sizes of drills to give a peripheral speed of 30 ft. per minute. It will be noted that small drills need to run very fast, and large ones very slow.

TABLE IV.—REVOLUTIONS PER MINUTE REQUIRED FOR VARIOUS SIZES OF DRILLS TO GIVE A PERIPHERAL SPEED OF 30 FT., PER MINUTE

Diameter of Drill, Inches	R.p.m. to Give 30 Ft. per Minute
1/16	1833
1/8	917
1/4	458
5/16	367
3/8	306
7/16	262
1/2	229
5/8	183
3/4	153
1	115

In drilling small holes by hand, the drill should be turned as fast as possible without letting it wobble. Wobbling, of course, increases the danger of drill breakage.

Power-driven post drills are often driven too fast for drilling large holes. In cases where they cannot be driven slowly enough by power, it is frequently better and practically as easy to turn the drill by hand. If a drill is driven too fast, the cutting lips have a tendency to slide over the metal instead of cutting into it. There is also danger of overheating the drill and drawing its temper.

229. Drilling Holes in Thin Metal.—There is a tendency for a drill to gouge and to catch when drilling thin metal. This can be prevented by placing the metal between two pieces of hardwood and drilling through wood, metal and all.

230. Countersinking can frequently be done to advantage in riveting and in making holes to receive flat-headed wood screws. Countersinking can best be done with a regular countersinking tool, although very good work can be done with a twist drill. A drill ground at the regular angles will not countersink a hole at quite the right angle for a flat-headed wood screw. Quite acceptable work can be done, however, by using a drill just a little larger than the diameter of the screw head and drilling just deep enough for the drill to cut a full-diameter hole.

An old drill too short for regular drilling can be ground to make a very good countersink. The cutting lips should be ground at an angle of about 40 to 45 deg. with the central axis of the drill, instead of the usual angle of 59 deg.

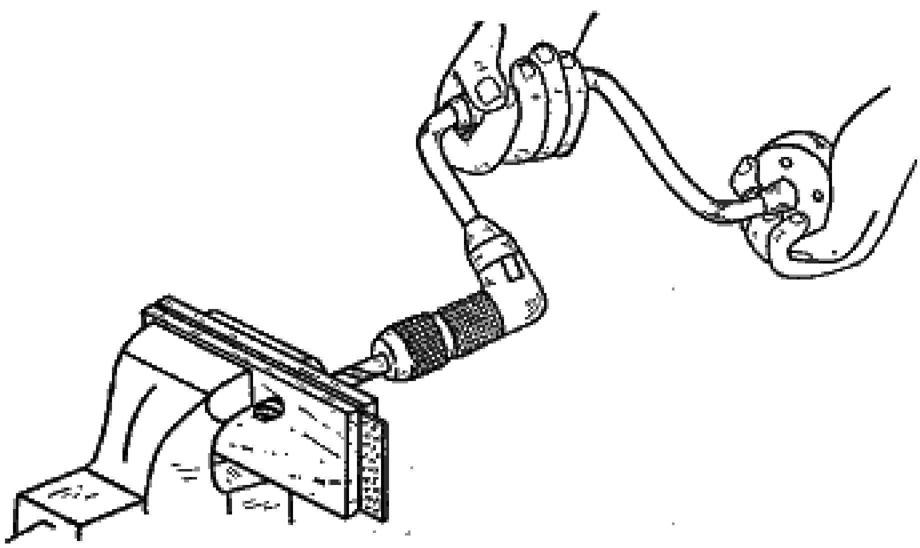


FIG. 203.—Holes may be drilled easily in thin metal by clamping it between two pieces of wood and drilling through both wood and metal.

Practical Points on Drilling

1. A properly sharpened drill is the first requirement for satisfactory work.
2. Always insert the drill carefully in the chuck.
3. Do not allow the drill to slip in the chuck, as it will damage both the drill and the chuck.
4. Start the drill in a large, deep, center-punch mark accurately located.
5. Use lard oil or a threading oil when drilling in steel.
6. In drilling a large hole, a small drill may be used first, followed by a drill of the desired size.
7. Securely fasten the work to the drill table when using a power drill.
8. A block of wood on the drill table prevents drilling holes into the table.
9. Use lighter pressure just as the drill goes through, and run the drill faster if possible. This lessens danger of drill breakage.
10. Large drills can be turned too fast for good work.
11. Small drills work best when turned fast.
12. An old drill ground with the cutting lips at about 40 to 45 deg. with the axis of the drill, instead of the usual angle of 59 deg., makes a good countersink.
13. A taper reamer is valuable in enlarging holes, and in reaming out holes in machine parts that do not line up.
14. To keep round rods from rolling on the drill table, lay them in a V-notch cut in a wooden block.

Questions

215. (*a*) What drilling machines or tools would you recommend for the farm shop? (*b*) What are the particular advantages and limitations of the post drill? The carpenter's brace? The chain drill? The hand drill?

216. (*a*) What kinds or qualities of twist drills are available? (*b*) What kinds of shanks are available on twist drills? (*c*) What are the advantages and disadvantages of the various kinds of shanks?

217. (*a*) What is the common system of designating sizes of twist drills? (*b*) What other systems are sometimes used? (*c*) What sizes of twist drills would be desirable for the farm shop?

218. (*a*) What kinds of drills are held in two-jaw chucks? In three-jaw chucks? (*b*) What kind of chucks do post drills usually have? (*c*) How may round-shank drills be used in the carpenter's brace? (*d*) How may round-shank drills, or bit-stock drills, be used in a post drill that has a chuck to hold blacksmith's drills?

219. Of what particular use are taper reamers in the farm shop?

220. Make a list of drills and drilling equipment you would recommend for the farm shop.

221. Besides cutting slowly, what other troubles or difficulties may arise from using a dull drill?

222. (*a*) Why should a large center-punch mark always be used for starting a twist drill? (*b*) Outline a procedure for getting the punch mark located exactly right. (*c*) In case it is found that the punch mark is not properly located, what would you recommend?

223. (*a*) Why are lubricants used when drilling most metals? (*b*) What materials may be used as lubricants? (*c*) What metals require no lubricants when being drilled?

224. (*a*) How may the work being drilled be fastened to the drill table? (*b*) What troubles may occur if the work is not securely fastened on a power-driven drill? (*c*) Under what conditions is it not necessary to fasten the work to the table of a hand-operated post drill?

225. (*a*) What precautions should be taken to prevent drills from catching just as they go through the work? (*b*) In the event a drill gouges and catches just as it starts through, what would you recommend?

226. (*a*) What difficulties may be encountered in drilling holes through round rods? (*b*) How may these troubles be avoided?

227. (*a*) What advantage is there in drilling a small hole first and following through with a large drill, when a large hole is to be made? (*b*) Under what conditions may a large hole be made by first drilling a small hole and then enlarging it with a taper reamer?

228. (*a*) What is meant by the peripheral speed of a drill? (*b*) What is a desirable peripheral speed for general drilling in mild steel? (*c*) How fast should a hand drill or other hand-operated tool be turned in drilling small holes? (*d*) What difficulties may be encountered if a drill is driven too fast?

229. (*a*) What difficulties are likely to be encountered in drilling thin metal? (*b*) How may these difficulties be avoided?

230. How may twist drills be used for countersinking holes in metal in case a special tool is not available?

References

Boss, Dent, and White: "Mechanical Training."
Roehl: "Farmer's Shop Book."
Van Leuven: "Cold Metal Work."
Tustison and Kranzusch: "Metalwork Essentials."
Radebaugh: "Repairing Farm Machinery and Equipment."
Burghardt: "Machine Tool Operation." Part I.
Sharp and Sharp: "Principles of Farm Mechanics."

CHAPTER XV

BOLT-THREADING EQUIPMENT AND ITS USE

A few threading tools will enable a farmer to make many handy appliances as well as to make certain repairs on farm machinery and equipment, such as rethreading bolts with battered threads, making bolts to

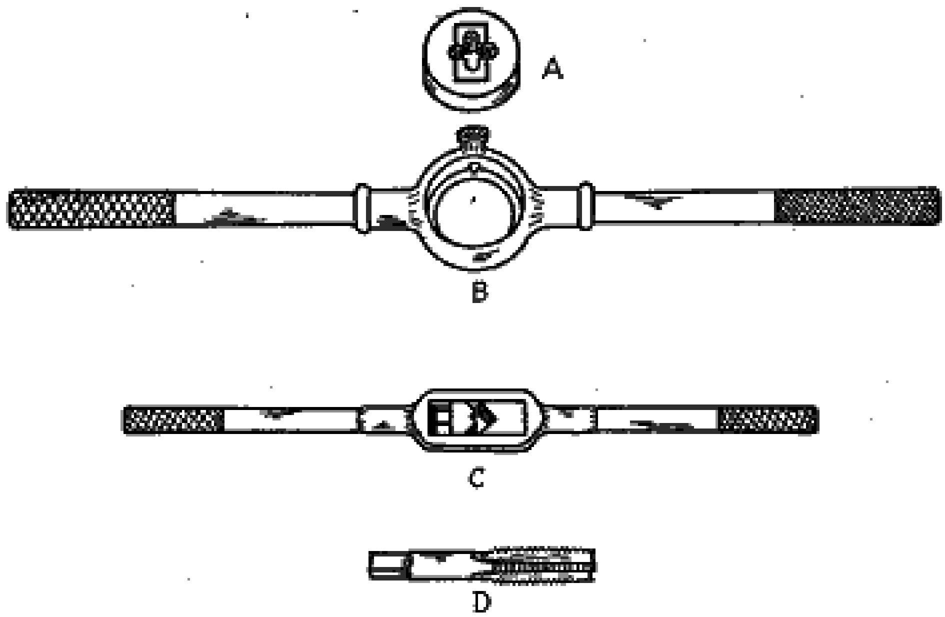


FIG. 204.—Threading tools. *A*, die; *B*, stock for holding die; *C*, tap wrench; *D*, tap.

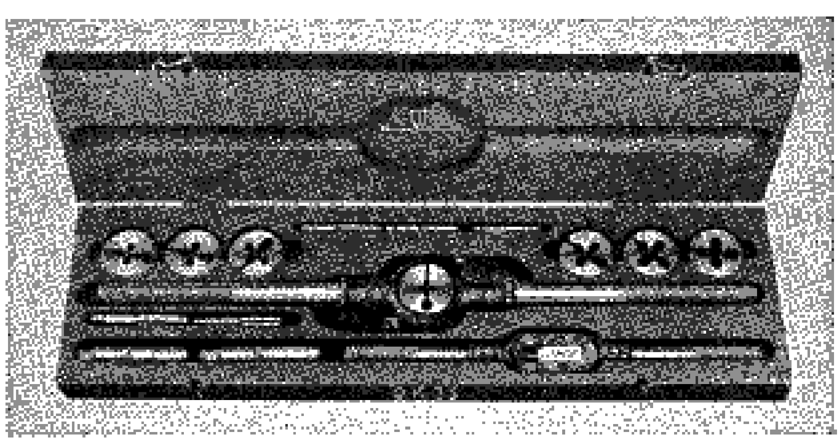


FIG. 205.—A set of taps and dies, known as a *screw plate*, is a valuable asset in the farm shop.

exactly the length needed, making truck and wagon-bed irons, long brace rods, etc.

Threads are cut on a rod or bolt by a small hardened steel tool called a *die*. The die proper, which is replaceable and usually adjustable, is held in a handle called a *stock*. The tool used for cutting threads inside a hole, as in a nut which screws on a bolt, is called a *tap*. A set of taps and dies is called a *screw plate*.

231. Kinds of Threads.—U.S.S. (United States Standard) threads are most commonly used on farm machinery and equipment. S.A.E. (Society of Automotive Engineers) threads are used on automobiles, tractors, engines, and other machines where extra-strong steel bolts are used. S.A.E. threads are similar to the U.S.S. threads but are finer, and there are more threads per inch. Nuts may be drawn up tighter on bolts with S.A.E. threads, and they will not shake loose so easily.

On small bolts and screws used in carburetors, magnetos, and similar small apparatus, *machine screw threads* are commonly used.

Pipe threads are used on pipes and on such parts as grease-cup connections and fuel- and oil-tube connections on engines and machinery. (See pages 172 to 181 for a more complete discussion of pipe threads and pipe-threading tools.)

232. Bolt-threading Equipment for the Farm Shop.—A set of taps and dies that will cut the five most common sizes of U.S.S. threads (¼, 5/16, ⅜, 7/16, and ½ in.) will prove quite an asset in the farm shop. If it can be afforded, a set that will cut ⅝- and ¾-in. threads also would of course be better. A set that would cut both U.S.S. and S.A.E. threads up to and including the ¾-in. size would be ideal but would be rather expensive and hardly justified for most farm shops.

A split adjustable type of die is preferred by most mechanics. Such dies can be adjusted to cut threads slightly smaller or larger than standard.

A set of taps and dies for cutting machine-screw threads would seldom be needed on the farm, nor would a complete set of pipe-threading tools. Pipe taps and dies to cut the two smaller sizes, ⅛ and ¼ in., might be useful for making repairs occasionally on oil and grease connections and brass-tube connections on machinery.

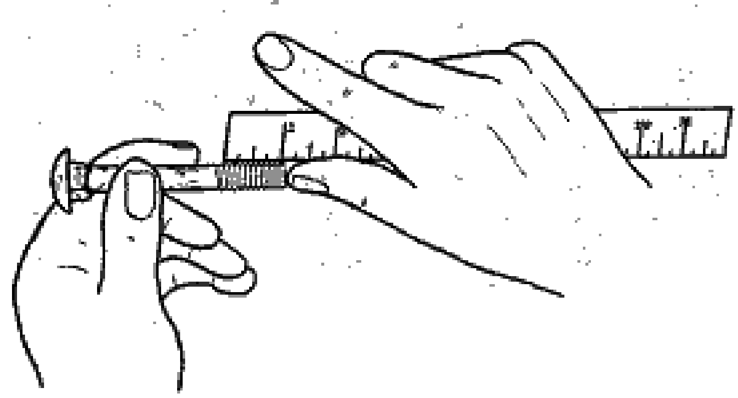


FIG. 206.—The number of threads per inch on a bolt may be determined by measuring with a rule and counting, or by reading the markings on a tap or die that cuts the same thread.

233. Determining Number of Threads per Inch.—To determine the number of threads per inch on a bolt, it may be held against a tap from a set of taps and dies, to see if the threads on the bolt and tap correspond. If they do, then the number of threads per inch may be read from the markings on the tap. Likewise, dies from the set may be tried on the

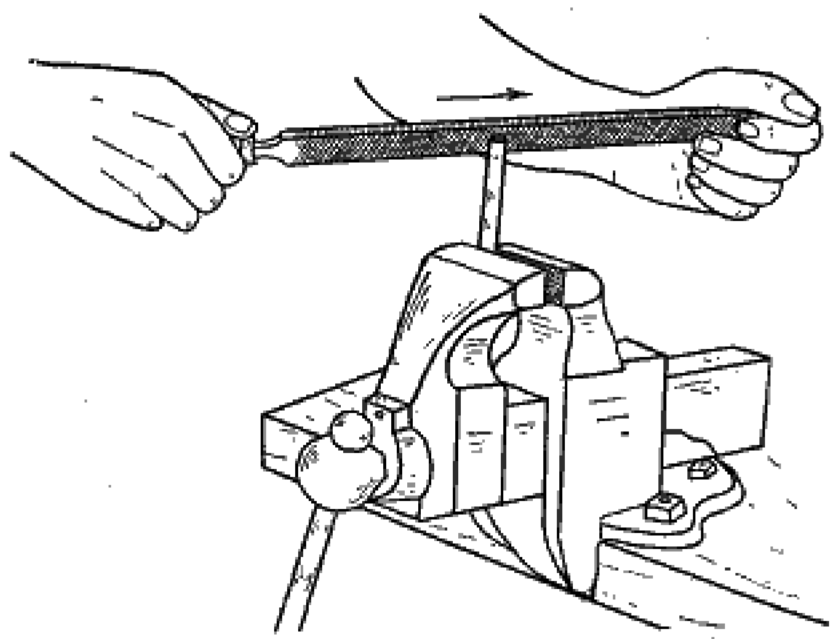


FIG. 207.—To enable the die to start easily, the end of a rod should be tapered slightly by filing, grinding, or hammering.

bolt until one is found that fits perfectly, and the threads per inch and the size of bolt determined from the markings on the die. The number of threads per inch can also be determined by placing a rule against the threaded end and counting the threads for one inch.

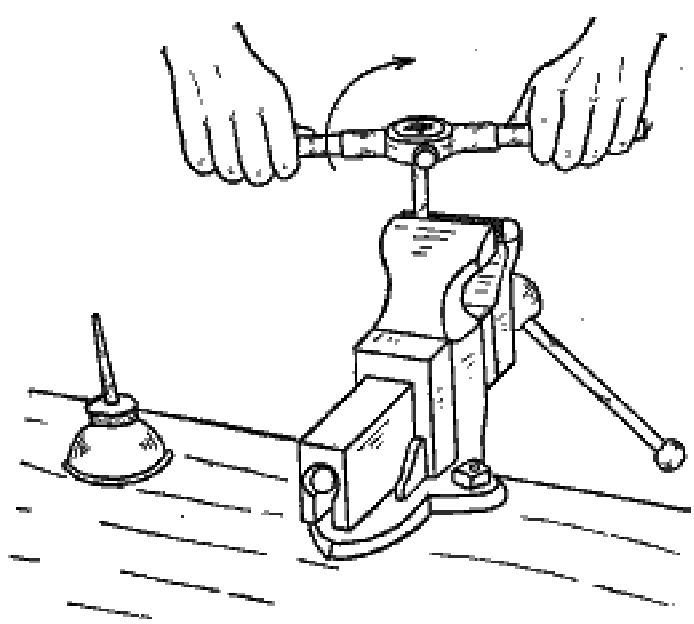


FIG. 208.—Be sure to start the die straight, exerting equal pressure on the two handles.

234. Threading a Rod or Bolt.—The end of a rod to be threaded should first be slightly tapered by filing, hammering, or grinding, so the die will start on easily. Care should be exercised to start the die straight on the rod. Equal pressure should be exerted on the two handles of the stock. After the die is started it will feed itself onto the rod.

Lard oil or threading oil should be used on the die when cutting steel. It will make the die cut easier, cut a smoother thread, and the die will stay sharp and last much longer.

Dies should be turned around and around in the forward direction without backing up until the thread is finished. If chips and cuttings have a tendency to collect in the die and clog it, they should be punched out with a small nail, a wire, or a small piece of wood. If allowed to accumulate, they will cause rough or torn threads. When the thread is cut as far as desired, the die is simply screwed back off. Before putting the die away, the cuttings should be shaken from it and the excess oil wiped off.

235. Tapping Threads in a Hole or Nut.—If a threaded hole is to be made in a piece of metal, a hole of suitable size must first be drilled.

TABLE V.—TAP-DRILL SIZES

U.S.S. THREADS (U.S. Coarse)		S.A.E. THREADS (U.S. Fine)	
Size of tap	Size of drill	Size of tap	Size of drill
$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{7}{32}$
$\frac{5}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$
$\frac{3}{8}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{5}{16}$
$\frac{7}{16}$	$\frac{11}{32}$ or $\frac{3}{8}$	$\frac{7}{16}$	$\frac{3}{8}$
$\frac{1}{2}$	$\frac{13}{32}$ or $\frac{7}{16}$	$\frac{1}{2}$	$\frac{7}{16}$
$\frac{5}{8}$	$\frac{1}{2}$		
$\frac{3}{4}$	$\frac{5}{8}$		

PIPE THREADS (Briggs Standard)		MACHINE-SCREW THREADS			
Size of tap	Size of drill	Size of tap	Threads per inch	Size of tap drill	Size of body drill
$\frac{1}{8}$	$\frac{11}{32}$ or $\frac{3}{8}$	2	56	50	42
$\frac{1}{4}$	$\frac{7}{16}$	3	48	47	39
$\frac{3}{8}$	$\frac{5}{8}$	4	36	44	33
$\frac{1}{2}$	$\frac{11}{16}$ or $\frac{3}{4}$	6	32	36	28
		8	32	29	19
		10	32	20	11
		10	24	25	11
		12	24	16	$\frac{7}{32}$
		14	20	10	$\frac{1}{4}$

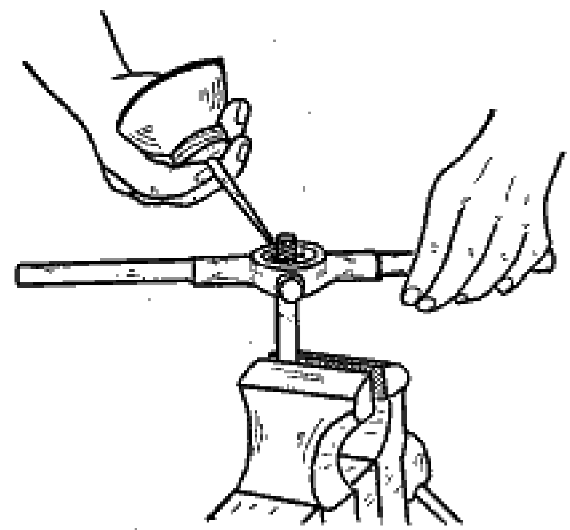


FIG. 209.—The die should be kept well lubricated with lard oil or a threading oil. Oil makes the die turn easier, cut smoother threads, and last longer.

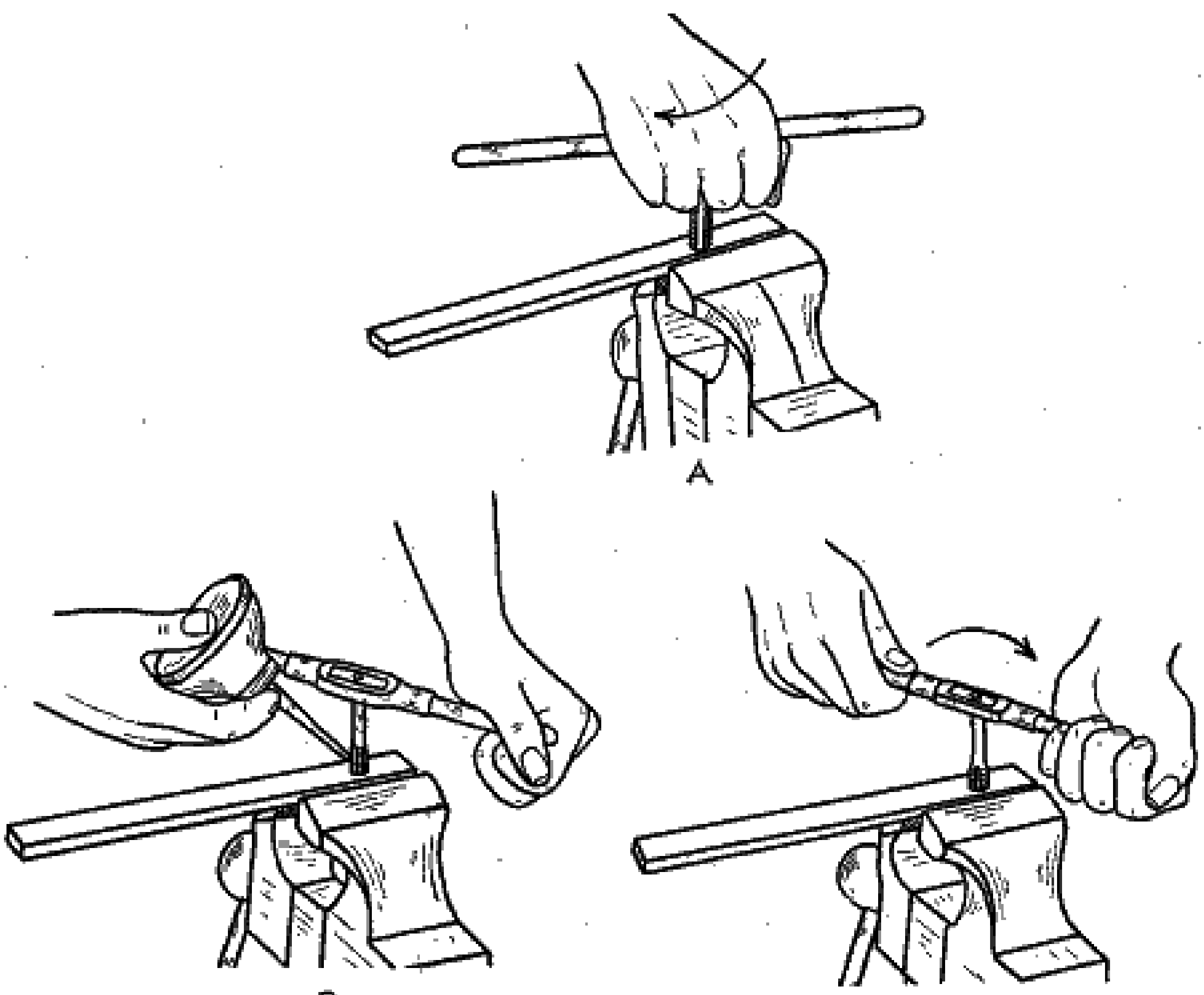


FIG. 210.—Tapping threads in a hole.

A. Care must be used to start the tap straight into the hole. Use one hand, pressing straight against the top of the tap, and turn slowly with a wrist motion.

B. Once the tap is well started, stop and oil it with lard oil or threading oil.

C. Then turn steadily by applying equal pressure with both hands.

The hole must be drilled somewhat smaller than the size of bolt to be screwed into the hole, usually $\frac{1}{16}$ in. smaller for bolts from $\frac{1}{4}$ to $\frac{1}{2}$ in. in size.

Probably the best method to determine the exact size of drill to use is to refer to a table, such as Table V. In the absence of such a table, a hole somewhat smaller than the bolt may be drilled in a piece of scrap material, and the tap tried in it. If the hole does not prove to be the proper size, a drill a size larger or smaller should be used. A taper reamer can be used to easily and quickly enlarge a hole that is too small.

After a hole of the correct size has been drilled, the tap is placed in the hole and pressure applied as the tap wrench is slowly turned. Care must be used to get the tap started straight into the hole. A good way is to use only one hand until the tap starts, pushing firmly with the palm against the center of the tap wrench, and giving it a slow twist with the wrist. After the tap starts, the pressure is released and the turning is done by using a hand on each end of the tap wrench, being careful to pull with equal force with each hand.

Lard oil or threading oil should be used on taps as on other cutting tools when working in steel.

236. Tapping Threads in a Blind Hole.—Where threads are to be tapped in a hole that does not go entirely through the stock, a regular taper tap may be used to cut threads as far as it will go. A plug tap, which has a blunter and less tapered end, is then used to cut threads nearly to the bottom of the hole. If threads are to be cut all the way to the bottom, a bottoming tap, which has little or no taper on the end, is then used to finish the work.

237. Making a Bolt.—A very simple way to make a bolt is to cut off a rod to the desired length, thread both ends, and screw on nuts. With a small assortment of nuts, and a few different sizes of rods, one can easily make a bolt for almost any occasion or emergency. Moreover, the bolt is practically as good as a bolt that is bought and usually just as cheap or cheaper. If desired, one of the nuts may be riveted onto the rod to prevent loosening.

Points on Cutting Threads

1. Taper the end of a rod slightly before starting the die. Use a file, a hammer, or a grinder.
2. Start a die or a tap slowly and carefully and get it straight.
3. Use equal pressure on the handles of the stock or tap wrench.
4. Always use lard oil or a threading oil when threading steel. It will make the tool cut easier and smoother and last longer.
5. Taps and dies should not be backed up until the thread is completed.
6. If chips and cuttings tend to clog the tool, remove them with a small nail or wire or piece of wood.

7. Be sure the proper size of hole is drilled before tapping. A hole that is too small can be easily and quickly enlarged with a taper reamer.

8. A bolt is easily made by threading both ends of a rod and using nuts on both ends.

9. Remove the cuttings and wipe off excess oil before putting taps and dies away.

Questions

231. (*a*) What different kinds of threads are used on farm machinery and equipment? (*b*) What are the chief differences between these kinds of threads?

232. What sizes and kinds of taps and dies should be included in the farm shop equipment?

233. How may the number of threads per inch on a bolt be determined?

234. (*a*) What important points should be observed in threading a bolt or rod? (*b*) Why should lard oil or threading oil be used on taps and dies? (*c*) What is a common cause of rough or torn threads?

235. (*a*) How may a workman determine the proper size of hole to drill to receive a tap? (*b*) Explain and be able to demonstrate a good method of starting a tap straight in a hole.

236. (*a*) What is meant by tapping threads in a blind hole? (*b*) Just how is this done?

237. (*a*) Describe a simple method of making a bolt from a short rod. (*b*) What particular advantage does this method have?

References

Boss, Dent, and White: "Mechanical Training."
Roehl: "Farmer's Shop Book."
Van Leuven: "Cold Metal Work."
Tustison and Kranzusch: "Metalwork Essentials."
Radebaugh: "Repairing Farm Machinery and Equipment."
Burghardt: "Machine Tool Operation." Part I.
Sharp and Sharp: "Principles of Farm Mechanics."

PART IV

CHAPTER XVI

PIPEWORK ON THE FARM

238. Pipe Tools for the Farm Shop.—On a farm that uses much machinery and equipment, a few pipe tools will often save considerable time and repair expense. Fortunately, not many tools are required in order to do a moderate amount of pipework.

Wrenches.—At least one, and preferably two, pipe wrenches should be included in the shop equipment. Wrenches of 14- and 18-in. sizes are most useful. Wrenches with all-steel handles are usually better for farm work than those having wooden grips.

Vise.—The most practical kind of vise for holding pipe on most farms is a regular steel blacksmith's or machinist's vise that is equipped with pipe jaws. Such a vise can be used not only for pipework, but also

Fig. 211.—Every well-equipped farm shop should have at least one pipe wrench, preferably two.

for other iron and metal work. Where considerable pipework is to be done, a regular pipe vise may be advisable. For an occasional job, pipe can be held in an ordinary flat-jaw vise with the aid of a pipe wrench with the handle cramped against the bench (see Fig. 212).

Pipe Cutter.—For an occasional job of pipe cutting, a hack saw is quite satisfactory. Where considerable pipe is to be cut, a pipe cutter will be better and more economical.

Dies and Taps.—A set of pipe dies will be needed only when a large job of pipe fitting, such as installing a water system, is undertaken, or where considerable pipework is to be kept in repair. Pipe dies and taps in the two smallest sizes (1/8 and 1/4 in.) may be justified for such work as repairing grease and oil pipes on machinery and engines.

Sets of pipe-threading tools do not normally include taps, as pipe fittings that screw onto pipes are threaded at the factory, and therefore there is little use for taps.

One-piece dies are generally preferred over two-piece dies, because of the ease with which they may be changed in the stock. A stock with a ratchet handle is much easier to use than a plain stock for threading any but the smallest sizes of pipe. The ratchet handle can be worked back and forth through that portion of the turn where force can be best applied.

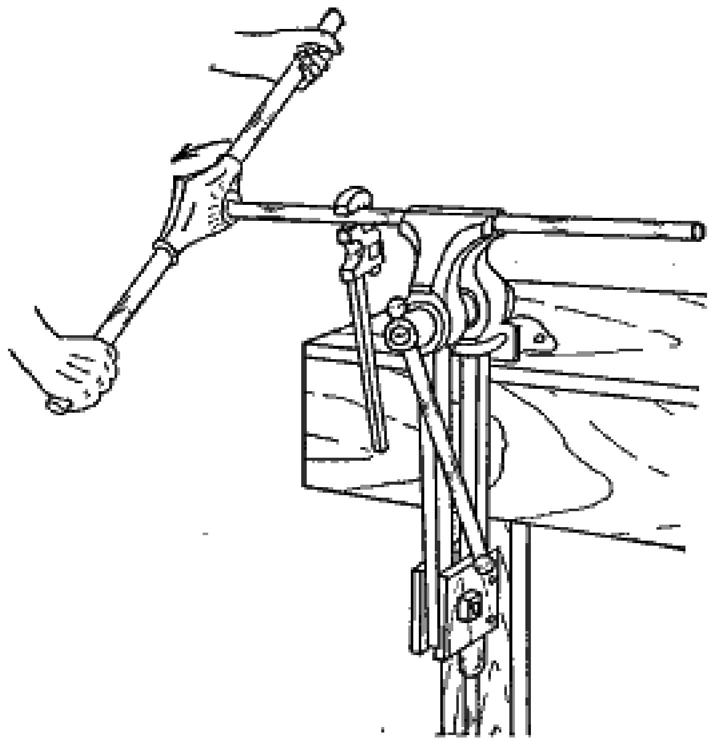


FIG. 212.—For an occasional job of pipework, the pipe can be held in an ordinary vise with the aid of a pipe wrench.

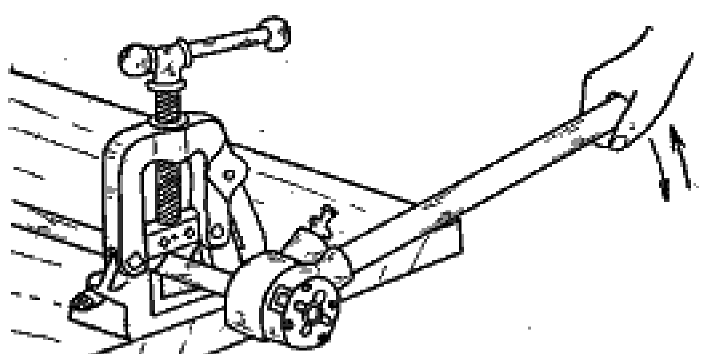


FIG. 213.—The ratchet die, although more expensive than the plain die, is much easier to operate and is preferred by many mechanics.

Ratchet equipment costs more, however, and for an occasional threading job the extra expense may not be justified.

239. Kinds and Sizes of Pipe.—Pipe is available in either black or galvanized iron. Black pipe is used for oil, air, or gas. Galvanized pipe should be used for a water-supply system. Galvanized pipe will, of course, last longer when used under conditions that tend to cause rusting and corrosion.

Pipe fittings are made of cast iron or of wrought iron. Wrought-iron fittings are available in either black or galvanized finish.

Pipe Measured by Inside Diameter.—The size of a pipe is designated by its inside diameter. The actual inside diameter of a pipe, however, is slightly more than its nominal diameter. For instance, a ½-in. pipe measures actually a little more than ½-in. in diameter. Pipe is made in sizes ranging from ⅛ to ½ in. by steps of ⅛ in., and from ½ to 1½ in. by steps of ¼ in.

The size of pipe fittings is designated by the size of the pipe upon which they fit, and not by the diameter of the fittings themselves. For example, a ½ in. elbow has an inside diameter of about ¾ in., so that it will screw over the outside of a pipe that has an *inside* diameter of ½ in.

240. Pipe Threads.—Pipe threads, known as Briggs standard threads, are tapered 1⁄16 in. per inch of length. They are tapered so that the farther a fitting is screwed onto a pipe, the tighter the joint will become. This makes it possible to make a joint tight without having any tension or end pull on the pipe. Bolt threads are straight, that is, they are cut on a cylinder, and a nut is made tight by drawing it up against the piece being held in place by the bolt.

Pipe threads are much larger than the corresponding size of bolt threads, owing to the system of indicating pipe sizes. For example, a ½-in. bolt die cuts threads on the outside of a rod ½ in. in diameter; and a ½-in. pipe die is much larger, because it cuts threads on the outside of a pipe that has an inside diameter of ½ in.

Pipe threads are used on some spark plugs, and bolt threads are used on others. A ½-in. spark plug that uses a ½-in. *pipe* thread is about the same size as a ⅞-in. plug, which uses a ⅞-in. *bolt* thread.

241. Pipe Fittings and Valves.—There are many and various kinds of fittings and valves used in pipework. The most common ones are described below:

The coupling is simply a short sleeve threaded on the inside at both ends and is used for joining two pieces of pipe in a straight line and where at least one of the pieces can be turned.

The union is used for joining pipes where neither can be turned. It consists of three pieces, one to screw onto each of the two ends being joined, the third part being a nut for drawing the other two parts tightly together. There are two general kinds of unions, one that requires a gasket to make a tight joint, and one that does not. The parts of a union that requires no gasket fit together much like an engine valve fits into its seat.

A nipple is simply a short piece of pipe threaded on both ends.

The elbow or "ell" is used for making right-angle turns in a line of pipe. A 45-deg. elbow is used for making a turn of 45 deg.

The *street ell* is similar to the ell, except it has one end threaded on the outside, so that it may be screwed *into* a fitting such as a tee. It can be used instead of an ell and a short nipple. It is also frequently used in piping to give a certain degree of flexibility to allow a limited movement of parts without causing undue strain on the joints (see Fig. 223).

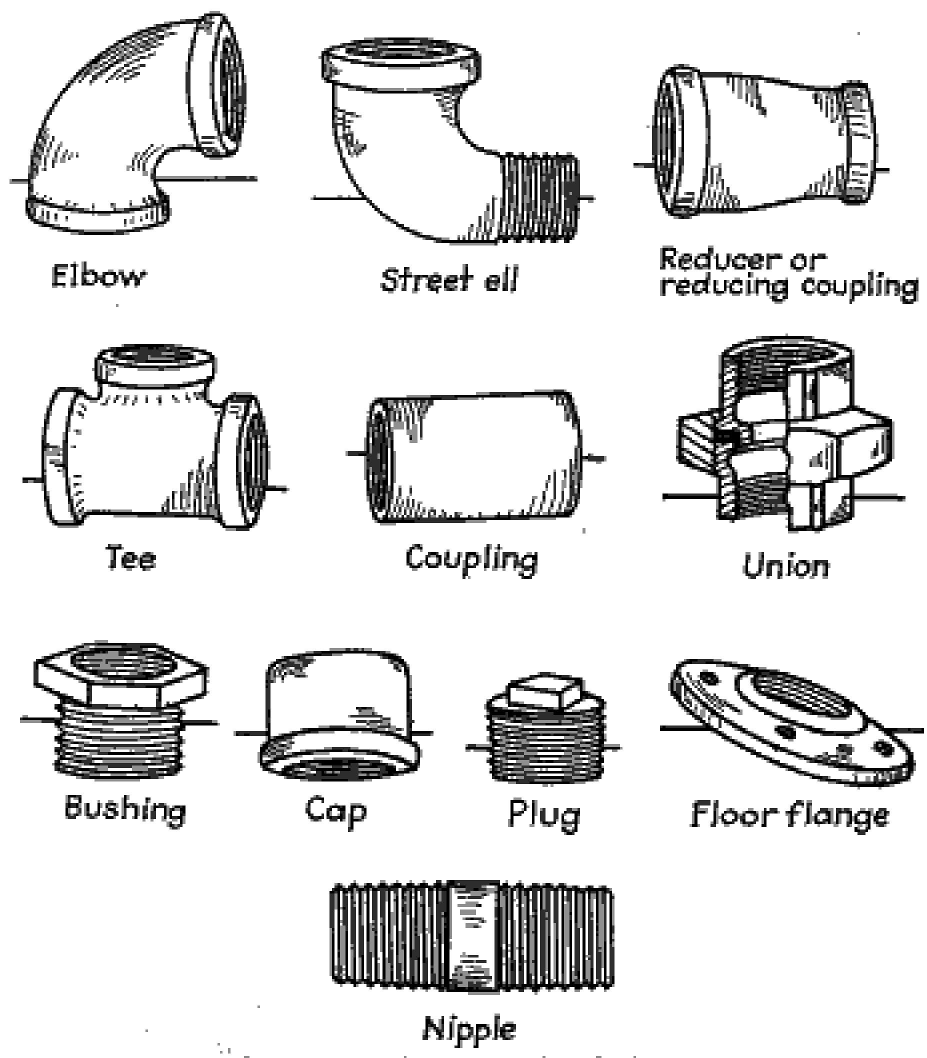


Fig. 214.—Common pipe fittings.

A tee is used for joining a side branch to a main line of pipe.

A reducing coupling is a coupling with one end made to fit one size of pipe, and the other end a different size.

A bushing is a short sleeve used to reduce the size of a threaded opening. It is threaded on the inside, and also on the outside at one end. The other end is hexagon shaped to receive a wrench.

A cap is used to screw over the threaded end of a pipe, thus stopping it.

A plug is used to screw into a threaded opening, such as one outlet of a tee, and thus stop the opening.

A floor flange is used for fastening the end of a pipe to a wall or floor, as in stair rails.

A check valve is used to prevent a backflow in a pipe. Two general styles are in common use, the lift valve and the swing valve.

A stop-and-waste cock is commonly used in a supply pipe. When it is turned off it allows the water in the pipes beyond the cock to drain out.

The globe valve is the most commonly used type of shutoff valve. In passing through it, water must make two right-angle turns. It should

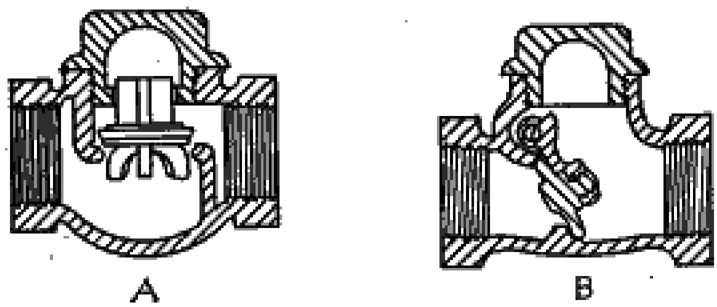


FIG. 215.—Check valves. *A*, lift type; *B*, swing type.

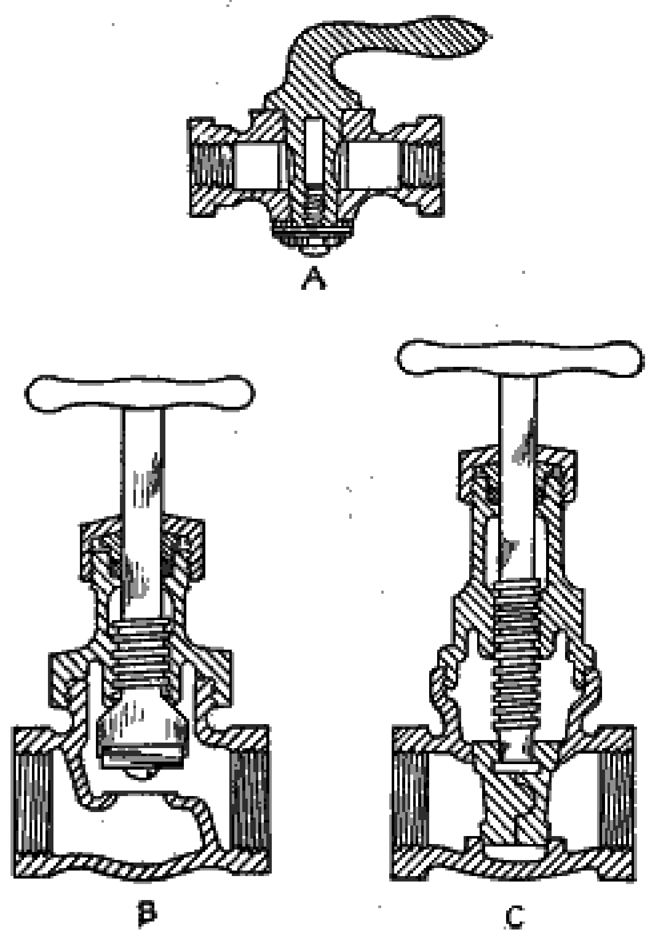


FIG. 216.—Shutoff valves. *A*, stop-and-waste cock; *B*, globe valve; *C*, gate valve.

be installed so that when it is turned off there will be no pressure on the packing around the valve stem. This not only lessens the possibility of leakage around the stem, but it also enables the stem to be repacked without turning off the pressure on the whole line.

The gate valve offers less resistance to the passage of water through it than does the globe valve; but it is not so easily repaired and is used less.

It is used in places where it is important not to impede the flow and where the valve would have to be closed only rarely, such as at a pump or storage tank where the valve would need to be closed only when repairs are made on the system. In a gate valve the flow is stopped by lowering a wedge-shaped gate into a seat.

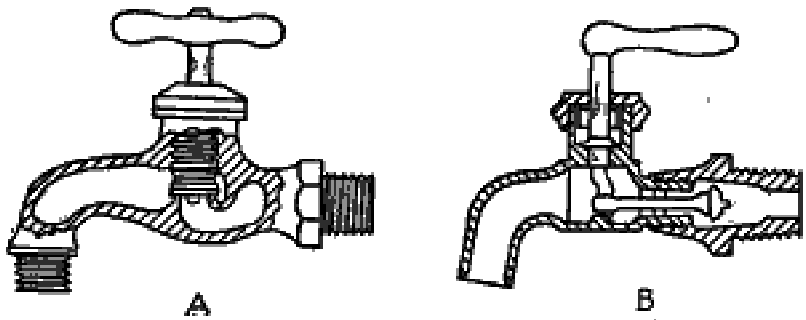


FIG. 217.—Faucets. *A*, compression bib; *B*, Fuller's bib.

The compression bib is the most common type of faucet. In principle it is very similar to the globe valve. When it is closed a composition disk is held against a seat. When the disk becomes worn it is easily replaced or turned over.

The Fuller's bib is a faucet in which the flow of water is stopped by pulling a rubber ball or valve disk onto a seat. It is a little more difficult to renew the ball or disk in a Fuller's bib than the disk in a compression bib. Both the compression bib and the Fuller's bib may be purchased plain or with ends threaded to receive a hose connection.

242. Planning a Job of Pipework.—To insure a good job and to prevent waste of materials and time, it is always advisable to take measurements before doing any cutting. If the job is a large one and involves the use of many pieces and joints, a sketch or rough drawing should be made to show dimensions and kinds of fittings to be used. If dies are not available at home, careful measurements may be made and pipe bought already cut to length and threaded.

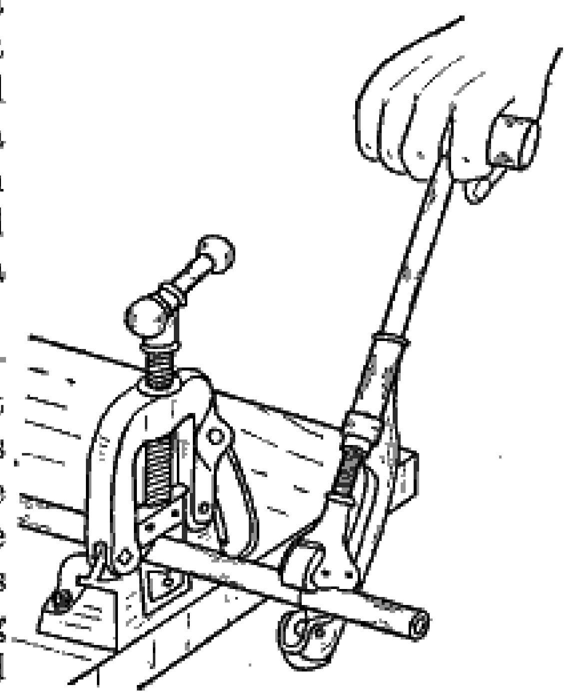


FIG. 218.—Although a hack saw is satisfactory for an occasional job of pipe cutting, a pipe cutter is recommended where much pipe work is to be done.

243. Cutting Pipe.—If a hack saw is to be used, careful work will be required to prevent catching and breaking out some teeth or breaking the blade. A fine-toothed blade (24 teeth per inch) is usually best. If a pipe cutter is used, it should be carefully placed on the pipe, to insure cutting to the desired length, and then turned around the pipe, the handle being tightened a little each round to force the cutting wheel into the pipe. As with other cutting tools, lard oil or a threading oil should be used.

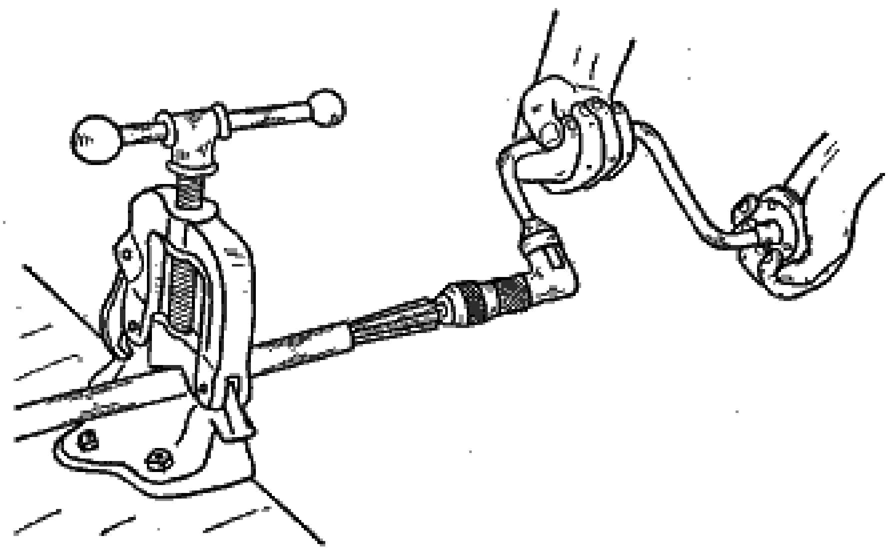


FIG. 219.—Reaming the inside of a pipe to remove the burr left by the pipe cutter. The burr may be removed with a round or half-round file if a reamer is not available.

244. Reaming Pipe.—A pipe cutter leaves a burr on the inside of the pipe, which should be removed to prevent decreasing the carrying capacity of the pipe. This burr can be removed with a reamer used in a carpenter's brace, or with a round or half-round file.

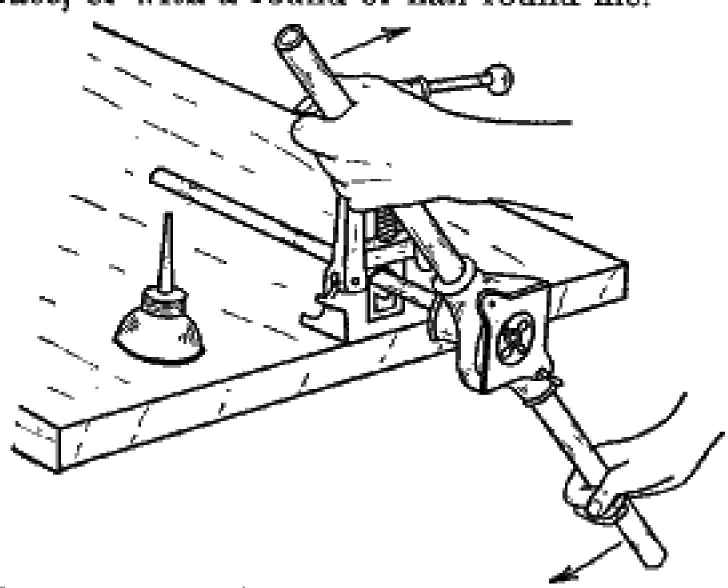


FIG. 220.—Threading pipe. The die should be kept lubricated with lard oil or threading oil. The die should be stopped and backed off when about one thread projects through the die.

245. Threading Pipe.—Firm pressure is needed to start the die, after which it will feed itself onto the pipe. The die should be kept well lubricated with lard oil or threading oil and screwed on until about one thread projects through the die. If it is screwed on further the end of the pipe that projects through the die will have straight threads instead of tapered threads.

246. Making a Short Nipple.—If a short nipple is needed and one is not at hand, it can be made by first cutting a piece of the desired length from the end of a threaded pipe. The piece is then screwed into a coupling on the end of another pipe held in the vise (see Fig. 221). The piece in the vise should be threaded back far enough for the coupling to screw almost all the way onto it. The short piece will then screw up against the end of the long piece without becoming tight in the coupling. The end of the short piece can now be threaded with a die that has been fitted with a guide large enough to go over the coupling.

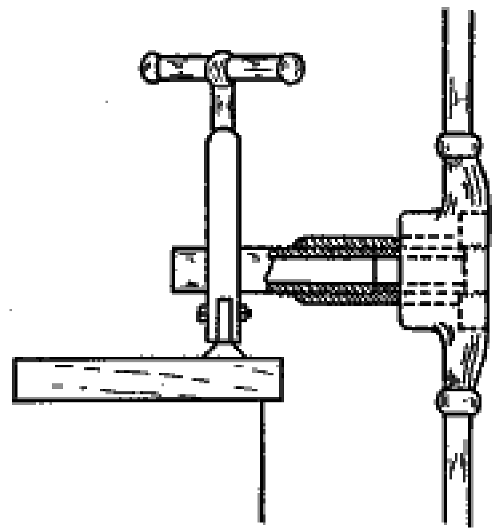


FIG. 221.—Threading a short nipple. Three points are important: (1) The pipe held in the vise is threaded far enough to allow the coupling to screw most of the way onto it. (2) The short piece being threaded butts against the piece held in the vise. (3) A guide large enough to slip over the coupling is used in the stock.

To remove the short nipple without marring the threads, the coupling is first backed off the long piece a litte. The nipple is then easily removed.

247. Cutting a Gasket for Union.—A good way to cut a gasket for a union is to place the gasket material (usually sheet rubber or fiber) over one end of the union and cut it to shape with light blows from a hammer;

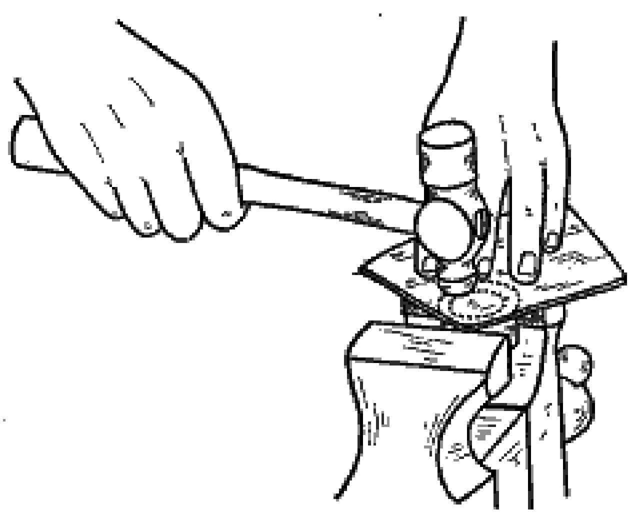


FIG. 222.—A gasket for a union may be cut by placing a sheet of gasket material over one end of the union and hammering with a light hammer; or the material may be marked with a few taps and then cut with a knife, scissors, or snips.

or the material may be simply marked with a few light taps, and then cut with a sharp knife, snips, or scissors.

248. Thread Compound.—In order to insure tight joints, the threads may be coated with some sort of thread compound before they are screwed together. Thick paint, a mixture of graphite and heavy grease, or a paste of Portland cement and linseed oil may be used for this purpose. Such material may be applied to the threads on the outside of the pipe or to the threads on the inside of the fitting. On pressure lines, a tighter joint will result if it is applied in the fitting; and on suction lines, if applied to the threads on the pipe. When applied in the fitting, however, any excess material will be left inside the pipe. Where this would be objectionable, as in the case of pipes for drinking water, the material should be applied to the threads on the pipe.

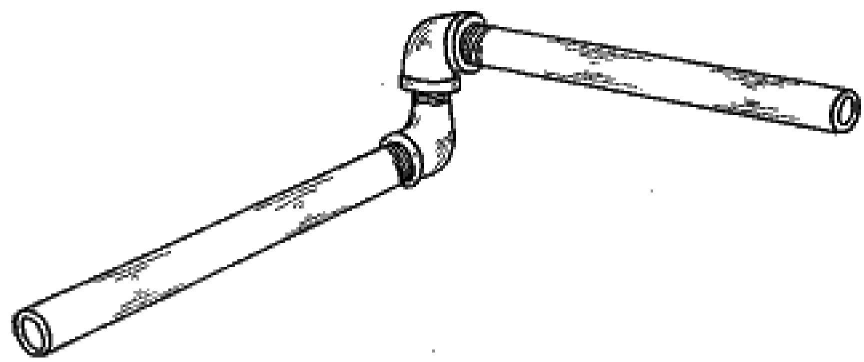


FIG. 223.—A street ell in combination with an ell is often used to form a sort of "universal joint" to allow slight movement of the pipes without placing undue strain on the joints.

249. Removing a Leaky Section.—It is sometimes desirable to remove a leaky section in a long run of pipe without having to unscrew several joints to get it out. In such a case the leaky piece may be sawed or otherwise cut and removed without disturbing adjacent lengths. Two shorter pieces are then cut and threaded and installed in place of the leaky section by means of a union.

Questions

238. (*a*) What pipe tools would you recommend for the farm shop? (*b*) What sizes of pipe wrenches are best? (*c*) How may pipe be held in an ordinary vise with the aid of a pipe wrench? (*d*) How may pipe be cut if a pipe cutter is not available? (*e*) Why are pipe taps not ordinarily included in sets of pipe dies? (*f*) What is the chief advantage of a ratchet type of pipe stock?

239. (*a*) Under what conditions would you recommend black pipe and under what conditions would you recommend galvanized pipe? (*b*) How is the size of pipe measured? (*c*) How is the size of pipe fittings designated?

240. (*a*) Why are pipe threads tapered? (*b*) Why are bolt threads not tapered?

241. (*a*) What are the principal common pipe fittings and for what purposes are they used? (*b*) What is the difference between a coupling and a union? (*c*) What are the two kinds of unions available? (*d*) What are the principal kinds of valves and faucets? (*e*) Under what conditions would a gate valve be used instead of a globe valve? (*f*) What particular precaution should be observed in installing a globe valve? Why?

242. Why should pipework be carefully planned before starting a job?

243. (*a*) Just how is a pipe cutter manipulated in cutting pipe? (*b*) What is the recommended tooth size for hack-saw blades for cutting pipe?

244. What methods may be used for removing the burr left on the inside of the pipe by the pipe cutter?

245. (*a*) How far should the pipe die be threaded onto a pipe? (*b*) Why should it not be threaded further? (*c*) Should lard oil or threading oil be used on pipe dies?

246. (*a*) Explain and be able to demonstrate just how to make a short nipple. (*b*) Why can the nipple not be held in a vise while being threaded?

247. (*a*) How may a gasket be easily cut to fit a union? (*b*) What purpose does a gasket serve?

248. (*a*) What materials may be used on pipe threads to insure tight joints? (*b*) Should the material be applied to the threads inside the fittings or to the threads on the outside of the pipes?

249. How may a faulty section in a long run of pipe be removed without unscrewing several joints?

References

Boss, Dent, and White: "Mechanical Training."
Radebaugh: "Repairing Farm Machinery."
Tustison and Kranzusch: "Metalwork Essentials."

PART V

CHAPTER XVII

SOLDERING AND SHEET-METAL WORK

250. The Principle of Soldering.—Soldering is the process of joining pieces of metal by fusing their surfaces together with solder, an alloy of tin and lead. (An alloy is a mixture of metals, brought about generally by melting or fusion.) The solder commonly used is composed of equal parts of lead and tin and has a melting temperature of 401°F.,[1] which is lower than that of either lead or tin.

If molten solder is placed on a piece of metal that has been cleaned, fluxed (that is, treated with certain chemicals or materials), and heated somewhat above the melting point of solder, then the solder will spread over the metal and adhere to it. In fact, the solder and the surface of the piece fuse and mix together, forming an alloy of solder and the metal. When two pieces of metal are joined by soldering, the molten solder runs between them, fills up any spaces, and fuses with and penetrates into the surfaces of the pieces. Upon cooling, the solder solidifies and binds the pieces together.

Soldering is, therefore, an alloying process, and it is important that conditions be kept favorable for alloys to form while soldering. The two most important conditions are:

1. The metals to be joined must be thoroughly cleaned of all grease, dirt, and oxide or tarnish and kept clean (usually with the aid of fluxes).
2. The pieces themselves must be heated and kept somewhat above the melting point of solder for a short time.

If insufficient heat is applied to the pieces, the solder will not intermix well with the surfaces being joined, and poor work will result.

251. Cleaning the Work; Action of Fluxes.—Solder will not stick to metal that is dirty or coated with oxide or tarnish. One of the first steps in soldering, therefore, is to thoroughly remove all dirt and oxide. This is commonly done by mechanical means, such as scraping with a dull knife, filing, or rubbing with steel wool or very fine emery cloth. All metals oxidize to some extent when exposed to the air even for short periods. When metal is heated, as it must be in soldering, the oxidation

[1] Machinery's Handbook, p. 1380, 8th ed.

takes place much more rapidly. Therefore, after a piece is cleaned, a flux, usually in the form of a liquid or paste, is applied to exclude the air and thus prevent oxidation until the part can be soldered.

Most fluxes also have a certain solvent action to remove any oxide not removed by mechanical means. Some fluxes have a very strong solvent action, and can be used to remove oxides without first scraping the work. Such fluxes are usually quite corrosive, however, and their use is advised only when necessary.

Flux also fills the space between the soldering iron and the piece being soldered, and thus better enables the heat to flow from the iron to the work.

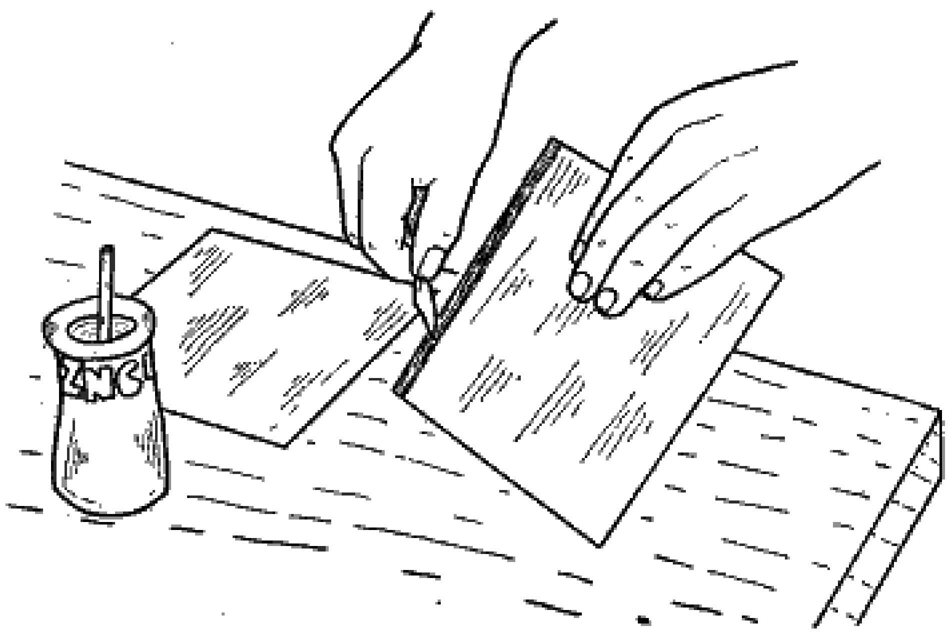


FIG. 224.—One of the first steps in soldering is to clean the work thoroughly. This may be done by scraping with a dull knife.

A flux, therefore, may be considered as facilitating the soldering process in the following ways: (1) removing oxides, (2) preventing oxidation while the work is being heated, and (3) aiding the flow of heat from the soldering iron to the work.

252. Kinds of Fluxes.—Various materials in the form of pastes, liquids, or powders are used as soldering fluxes on different metals.

Soldering pastes under different trade names are available at hardware stores. They are compounded from various materials, and most of them make excellent fluxes for most common metals. They are easily applied and are generally less mussy and less corrosive than liquid fluxes.

Muriatic acid (commercial hydrochloric acid) is a very effective flux for soldering galvanized iron and zinc. It is sometimes used also for iron and steel. It may be bought at drug stores. Because of its corrosive nature, muriatic acid must be used sparingly and with care.

Zinc chloride, or *cut acid*, as it is frequently called, is a common flux that can be used on most metals. It may be prepared as follows:

1. Drop small pieces of zinc into a bottle about half full of muriatic acid, adding more pieces from time to time until no more zinc will dissolve and there is a slight excess of zinc left in the bottle. The resulting liquid is zinc chloride. Zinc may be obtained from an old fruit jar lid, or the shell of an old dry cell battery. Zinc from such sources should be carefully cleaned before using.

2. After all chemical action has stopped, strain the zinc chloride through a cloth, or allow the dirt to settle and pour off the clear liquid.

3. Dilute the zinc chloride with one-fourth to one-half its volume of water.

Care should be taken not to get the acid on the hands or clothing. *Neither acid nor zinc chloride should be kept around tools;* nor should zinc chloride be made around tools, as the vapors or fumes will cause severe corrosion. If acid or other flux should be spilled on tools, it should be wiped off at once and a liberal coating of grease or oil applied.

Rosin is sometimes used for soldering bright tin. A small quantity of powdered rosin is sprinkled on the part to be soldered, and when the hot soldering iron is applied, it melts and spreads over the surface. Rosin is a very mild flux. It is used where extreme caution must be taken against corrosion.

Tallow is a good flux for soldering lead. After the lead is thoroughly scraped, it should be heated slightly, after which the tallow is applied to the warm surface.

Sal ammoniac is a good flux for brass and copper. It is commonly used in cleaning and tinning soldering irons. It may be obtained in cakes or in lumps or powdered form. A teaspoon of powdered sal ammoniac, or the equivalent in lump form, dissolved in water, makes a good cleaning solution into which soldering irons may be dipped quickly while hot and thus cleaned.

Small cakes of sal ammoniac, especially prepared for cleaning and tinning irons, are available at hardware stores. These are quite satisfactory and their use is generally recommended.

253. Applying Fluxes.—Liquid fluxes can be easily applied with a medicine dropper or a hollow glass tube. By lowering the tube down into the bottle of flux, and then placing a finger tightly over the upper end, a small amount of flux may be held in the bottom end of the tube and transferred to the metal being soldered. Small brushes can be used for applying fluxes that are not too corrosive.

Paste fluxes may be spread on the work with a small piece of wood, such as a match stick, preferably after the work has been heated slightly.

Care should be taken not to use more flux than necessary, nor to get the flux on parts not to be soldered, because many fluxes are corrosive, and all of them are somewhat mussy.

254. Kinds of Solder.—Solder is available in the form of bars, solid wire, hollow wire filled with a flux core, or ribbon. For large jobs requiring considerable solder, it is usually bought in bars. For the occasional repair job on the farm, acid-core wire solder or paste-core wire solder is very convenient and usually more satisfactory. Flux-core wire solders are more expensive than plain solder, but where only a small amount of soldering is to be done, the added convenience of having the flux in the solder is well worth the small extra cost.

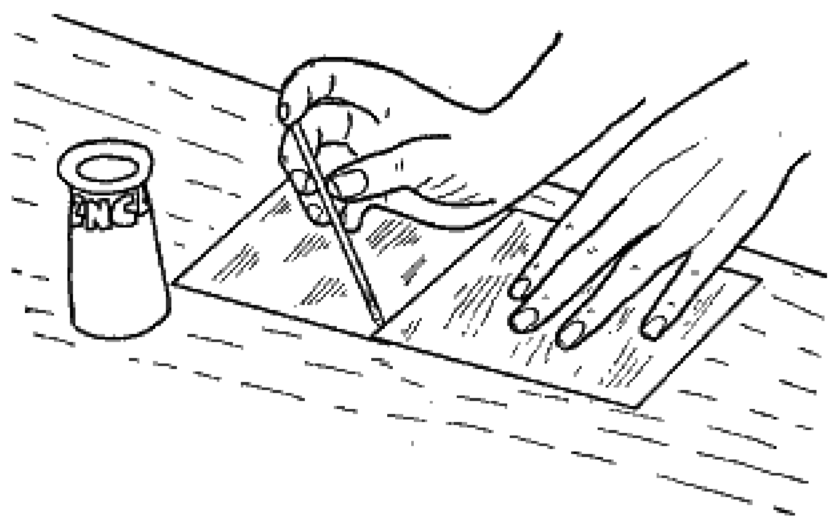


FIG. 225.—After the work is cleaned, flux is applied. Liquid fluxes can be applied easily with a medicine dropper or a hllow glass tube.

255. Soldering Irons.—Soldering irons are really made of copper. In fact they are sometimes called soldering coppers. Copper is used because of its resistance to oxidation and corrosion and because of its ability to readily absorb and give up heat.

The best size of iron for average farm shopwork is one that weighs about 1 lb. In general, the larger the iron that can be conveniently handled, the better. Large irons require heating less often. An iron that is too large, however, is clumsy and cannot be handled with ease.

Electric soldering irons may be used if electric current is available. They are somewhat more expensive than ordinary irons, however, and are not generally used for occasional jobs of soldering in the farm shop.

256. Heating the Soldering Iron.—The gasoline blowtorch is quite satisfactory for heating soldering irons on the farm. It furnishes a clean intense flame, and it can be readily taken to wherever it is needed. Any kind of heat that is reasonably clean, however, may be used for heating soldering irons. For occasional use, irons may be heated on a gas, gasoline, or kerosene cook stove, in a coal stove, blacksmith's forge, or even in a wood or coal fire built on the ground. When a coal or woodfire is used, it is best to allow it to burn down to glowing coals, so as not to smoke the iron or get it dirty; or a short piece of pipe may be put into the fire, and the iron heated inside the pipe in order to keep it clean.

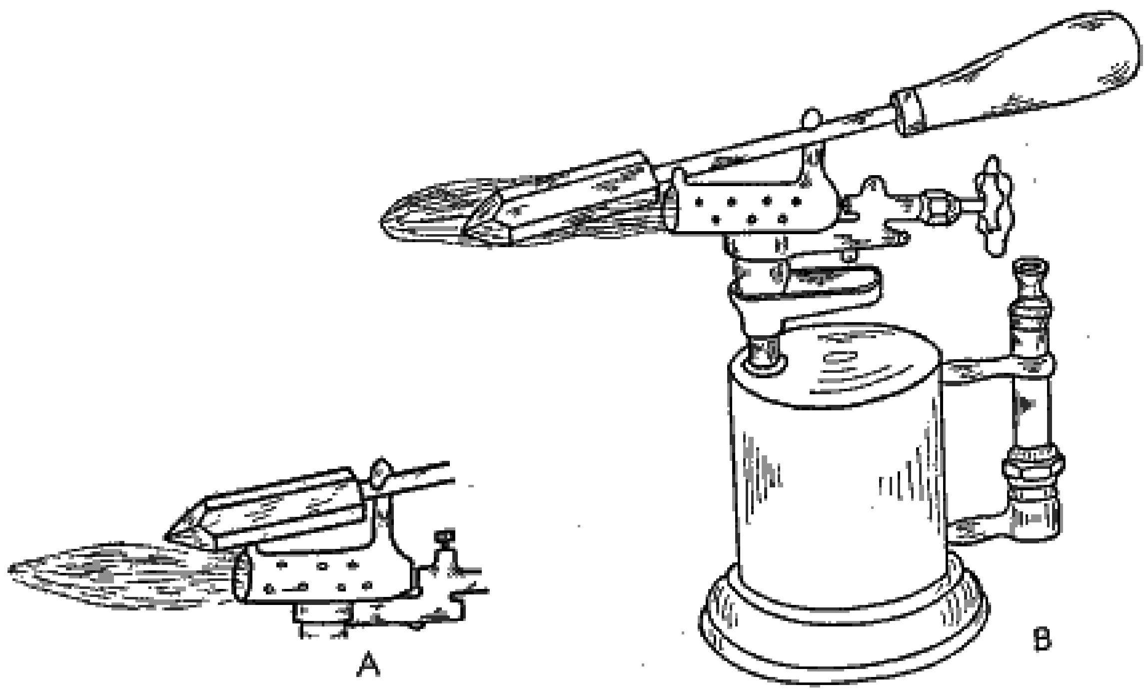


FIG. 226.—The gasoline blowtorch is commonly used for heating soldering irons. Once an iron is heated, it may be kept at working temperature without overheating by pulling it back out of the flame as at *A*. If the point of the iron changes from a silver to a yellowish color, it is too hot.

257. Cleaning and Tinning the Soldering Iron.—By tinning an iron is meant simply coating the faces of the pointed end with solder. Good work cannot be done unless the iron is kept well tinned. Every one who expects to do soldering work should therefore become proficient in tinning an iron.

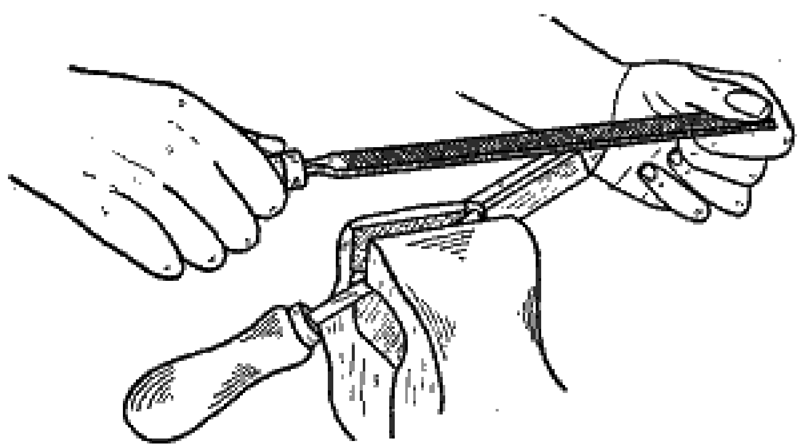


FIG. 227.—A clean, well-tinned iron is essential. If the surface of the iron is pitted or rough from overheating, it may be smoothed and cleaned by filing, either while hot or cold.

If the surface of an iron is pitted and rough from overheating, it may be smoothed and cleaned by filing, either while hot or cold. In extremely bad cases, the end of the iron may be hammered, hot or cold, to smooth and reshape the point. Care should be taken not to get the point too long nor too short but to retain the original shape.

After cleaning, the iron is tinned by heating it and applying flux and solder. Probably the best way to do this is to rub the hot iron in 2 or

3 drops of molten solder on a cake of sal ammoniac. Another way is to dip the hot iron quickly into a cleaning fluid (which can be made by dissolving sal ammoniac in water), and then to rub it in molten solder.

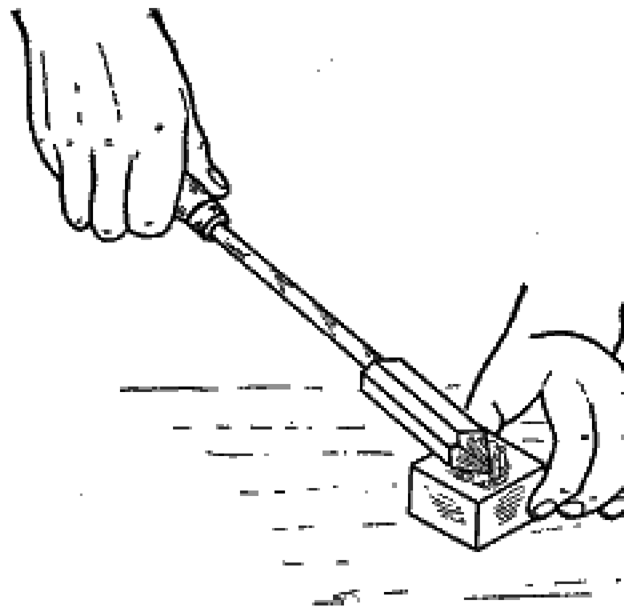


FIG. 228.—Rubbing a clean hot iron in a few drops of molten solder on a cake of sal ammoniac is a good way to tin it.

258. Keeping the Iron in Good Condition.—A good workman is always careful to keep his iron *clean, well tinned, and at a good working temperature.* Only poor work can be done with an iron that is too cold. The solder will melt and spread slowly and unevenly, and the work will

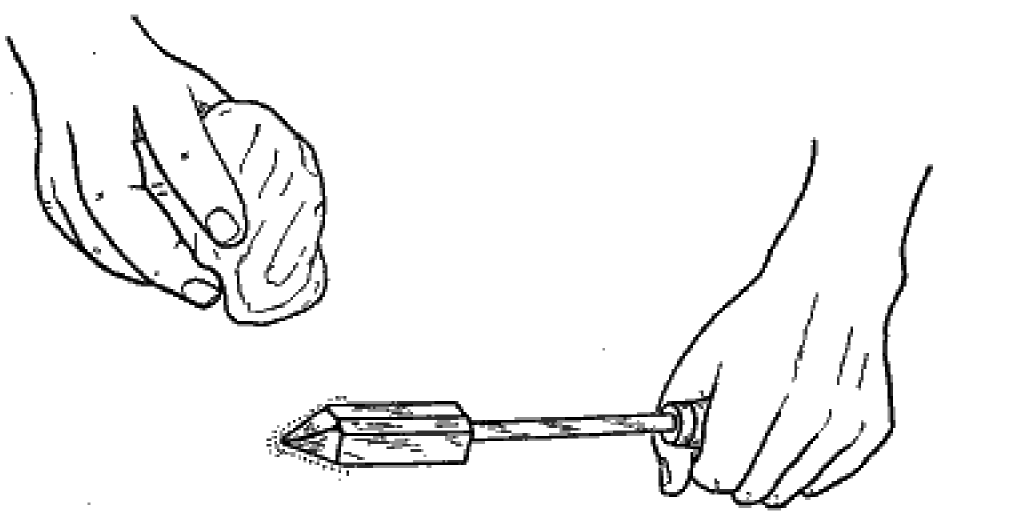


FIG. 229.—In order to keep the iron clean, it should be wiped quickly with a clean, damp cloth frequently while soldering.

be rough and lumpy, rather than smooth and mirrorlike. It will be difficult, or impossible, to heat the work up to the melting point of solder, and consequently a poor bond will be formed between the solder and the metal.

On the other hand, it is a common mistake of beginners to overheat the iron, and burn off the tinning. In this condition the iron is practically worthless for soldering, and it must be retinned. If the tinning begins to turn from a silverish to a yellowish color it is getting too hot and should be removed from the flame or placed in a cooler part of the fire. Therefore, an iron should be heated until it will readily melt solder, but not so hot that the bright tinning on the point begins to turn yellow.

Any time that the iron becomes a little dirty it should be cleaned while hot by (1) wiping it quickly with a damp cloth, by (2) dipping it quickly and only for an instant into a cleaning fluid, or by (3) rubbing it on a cake of sal ammoniac. The iron will usually need such a cleaning immediately after every heating.

259. Heating the Work Being Soldered.—As previously explained, metal to be soldered must be heated somewhat above the melting point

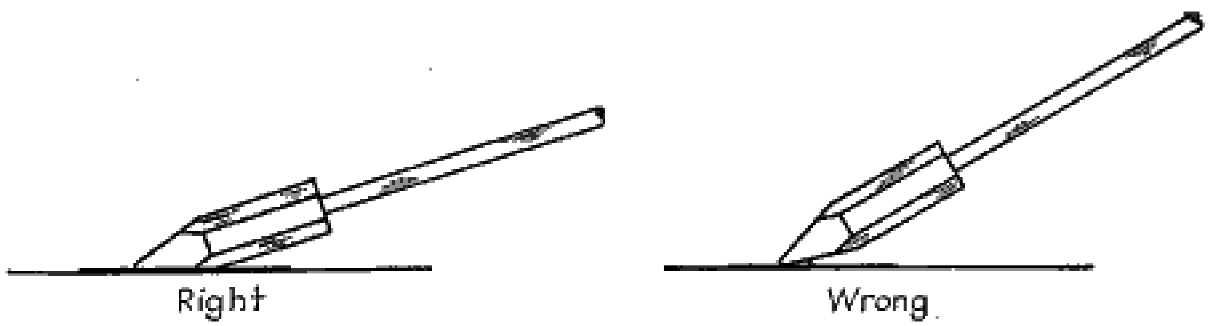


FIG. 230.—The whole face of the soldering iron—not just the point—should be pressed firmly against the work.

of solder, otherwise only rough, poor work can be expected. Failure to observe this principle frequently accounts for the difficulty experienced by many beginners, especially when working on large pieces.

For ordinary work, the heat is applied by *pressing the soldering iron firmly against* the metal to be soldered. The flat face of the iron—not just the point—should be held against the metal. *The iron should be moved slowly over the work,* so as to allow time for the heat to flow from the iron to the metal.

Heat may also be applied to the work by the direct flame of a torch. This method is especially good when working on large pieces.

260. Applying Solder to the Work.—Generally the best method of applying solder to small pieces is to pick it up on the iron, a drop or two at a time, and transfer it to the work. To get solder from a bar to the iron, allow the bar to project over the edge of the bench, or a block or brick on the bench, and *bring the hot iron up against the bar from beneath,* melting one or two drops off onto the iron.

Where considerable solder is required, it may be melted off the end of a bar and allowed to drop directly onto the piece being soldered; or the end of the bar may be held against the point of the iron as it is drawn along slowly over the work.

When using wire solder, the iron is put in place on the metal to be soldered and then raised slightly at the heel to allow the wire to be fed under it.

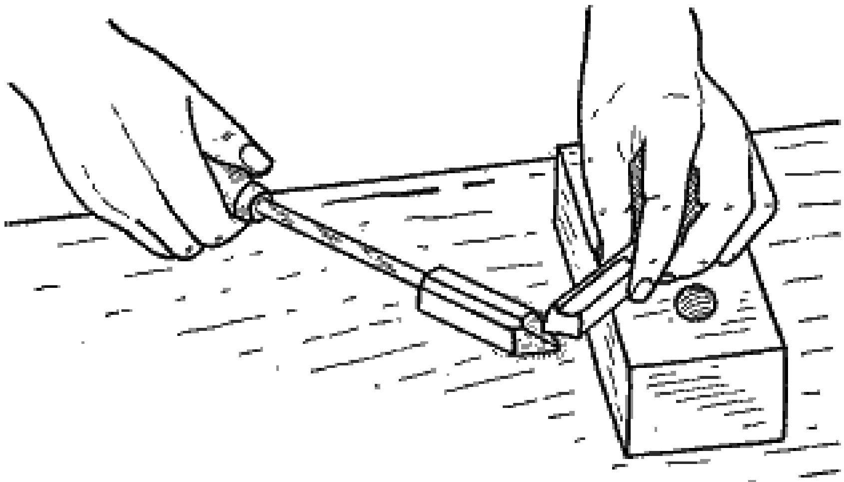


FIG. 231.—A good way to pick up solder with a hot iron is to bring the iron up under the end of a bar of solder.

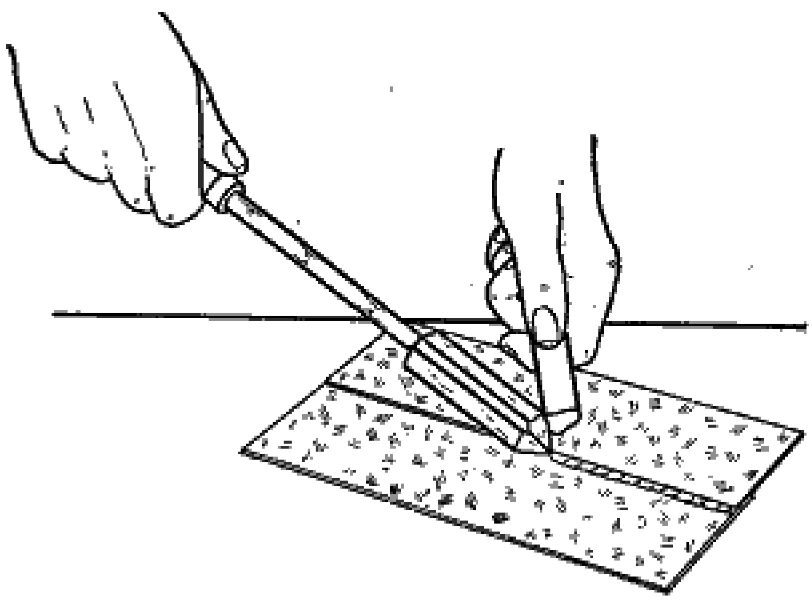


FIG. 232.—When considerable solder is required, the end of the bar may be held against the point of the iron as it is drawn along *slowly* over the work.

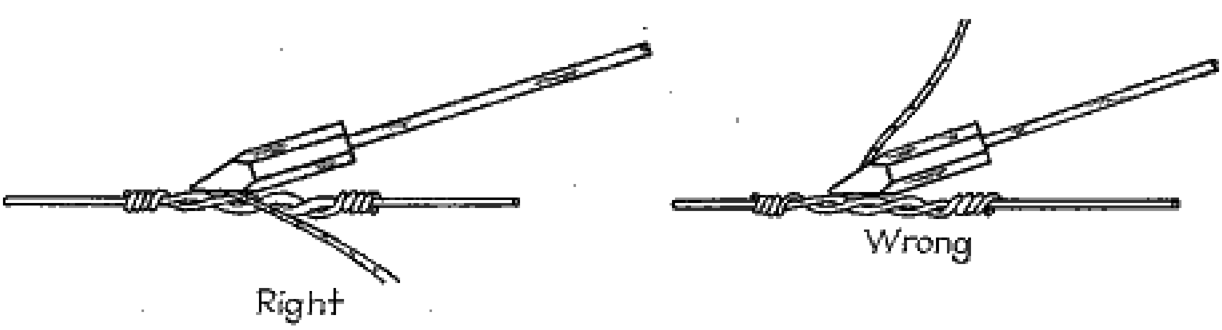


FIG. 233.—In using flux-cored solder, apply it to the work and to the face of the iron in contact with the work. In this way the flux does not evaporate or waste away before reaching the work.

261. Keeping the Work Clean.—After every application of the iron, the solder should be given a moment to cool, and then the work should be wiped with a damp cloth to remove the dirt that accumulates. If the iron is to be applied to the work again, then a light coat of flux should be

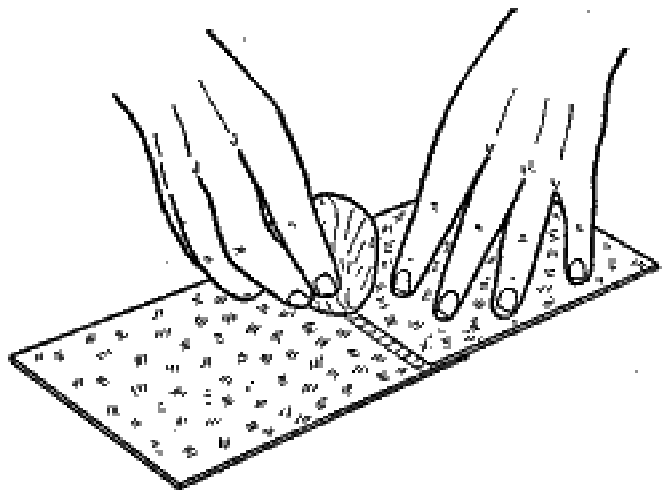


FIG. 234.—The work should be kept clean by wiping occasionally with a damp cloth. When the job is done, all excess flux should be wiped off to promote cleanliness and prevent corrosion.

put on, because the metal tarnishes or oxidizes very rapidly when hot. When the job is completed, all excess flux should be wiped off. This is especially important if acid or other corrosive flux has been used.

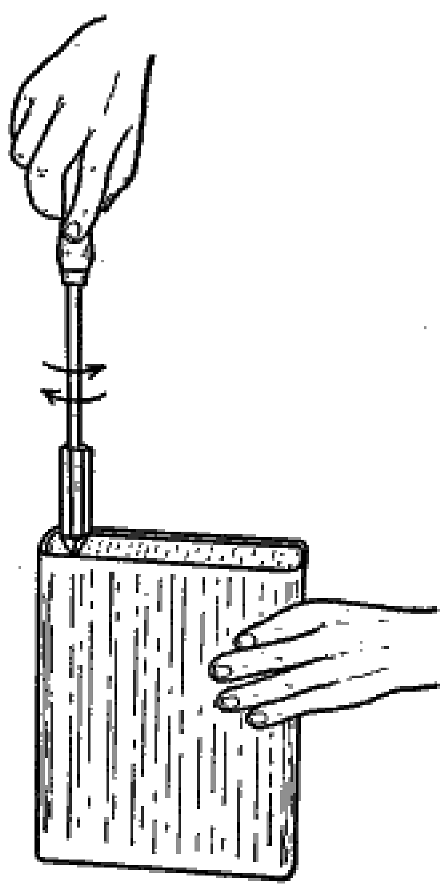


FIG. 235.—A small hole may be soldered by cleaning and fluxing and then rotating a well-tinned hot iron back and forth slowly with the point in the hole.

262. Repairing Small Holes.—The metal should be thoroughly cleaned around the hole, and then a suitable flux applied. A drop of solder may then be melted over the hole and smoothed out with a clean, well-tinned iron. Firm pressure should be used and the iron should be moved about slowly so as to thoroughly heat the metal around the hole. Sometimes it works well to put the point of the iron straight down into the hole and rotate it back and forth slowly.

263. Repairing Holes with Rivets and Solder.—A hole that is too large to be stopped with a drop of solder may be plugged with a rivet. The hole should first be thoroughly cleaned, and then a short copper or galvanized rivet inserted and hammered down. The rivet, of course, should be clean. Flux is next applied and solder is flowed over the rivet and around the hole. By careful work a smooth, neat job results.

264. Sweating on Patches.—A hole too large to be stopped with a rivet may be repaired by sweating a patch of metal over it. The metal around the hole is cleaned, fluxed, and coated with solder; and the patch itself is likewise cleaned, fluxed, and coated with solder. The patch is then put in place over the hole, and fluxed, and heat applied from a hot, well-tinned iron. After the solder is well melted, the patch is held in place with the tang of an old file, or a short piece of scrap iron or wood,

Fig. 236.—An effective way of repairing a medium-sized hole is to clean the metal around the hole, insert a rivet, and then apply solder.

until the solder cools. *A tempered tool, such as a screw driver or an awl, should never be used for this purpose,* as the heat will draw the temper. Also the flux will likely cause the tool to rust. It may be necessary to add a little solder around the patch to make a smooth job. Care will have to be used not to melt the whole patch loose. Use a well-tinned, hot iron, and do not hold it in one place too long. Work on first one edge of the patch and then the other. In this way, there is less danger of melting the patch loose.

In repairing a hole in a pail or vessel, it is always a good plan to solder both the inside and the outside of the patch, so as to leave no rough surfaces to catch and hold dirt.

265. Soldering a Seam or Joint.—When soldering two pieces together with a plain lap joint, it is best to "tack" the pieces in place first with a

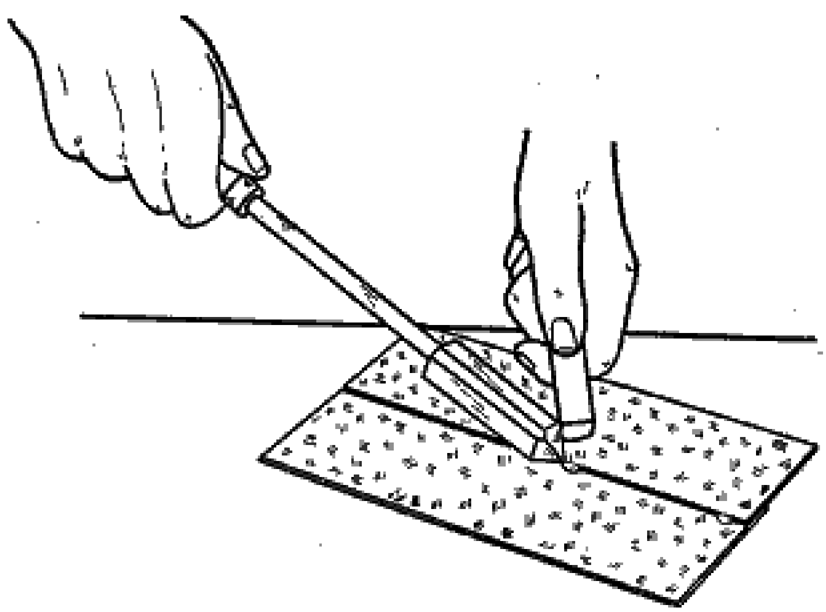


Fig. 237.—In soldering a lap joint, it is best first to "tack" the pieces at intervals and then solder the remainder of the seam.

little solder at intervals along the joint. The hot iron is then moved along, keeping it pressed firmly against the work while solder is fed into the seam by touching it to the iron. If the pieces have a tendency to melt apart, they may be held together with the end of an old file or a piece of scrap iron while the solder cools.

For many jobs a hook or lock joint may be used, thus eliminating any difficulty in keeping parts together while soldering, as well as making a stronger joint. See Art. 271, page 194.

266. Repairing a Leaky Tube.—To repair a leaky tube, such as a fuel line or oil line on an engine, the *metal around the hole must first be thoroughly cleaned by scraping, filing, etc., and then fluxed and coated with solder.* A piece of sheet metal may then be wrapped snugly around the tube and soldered in place; or clean, bright copper wire may be wrapped tightly and closely around the tube a short distance both ways from the leak, and then solder flowed evenly over the wrapping.

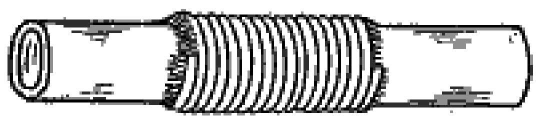


FIG. 238.—A leak in a tube may be repaired easily by (1) cleaning, fluxing, and tinning; (2) wrapping tightly with clean wire; and (3) applying solder over the wire.

267. Soldering Aluminum.—Soldering aluminum is quite difficult, and success can be insured only by very careful work. Only special aluminum solder and special flux, or a special fluxed solder, should be used. Such solders are commonly furnished with directions for use, and these should be carefully observed.

The first step in soldering aluminum is to thoroughly clean the parts to be soldered. Since aluminum conducts heat away so much faster than most common metals, care must be taken to thoroughly heat it. A heavy iron is therefore better than a small one. The iron should be heated somewhat hotter than for ordinary soldering. It is sometimes advisable to play the blowtorch on the iron while it is in use, or even to heat the metal directly with the flame. To tin aluminum, some of the special solder is melted onto the surface and then a clean, hot, well-tinned iron is rubbed firmly and slowly back and forth in the molten solder. If the solder does not adhere to the metal, quickly wipe off the molten solder with a small piece of steel wool, and then apply more solder and continue to rub with the iron, being sure the iron stays clean and hot.

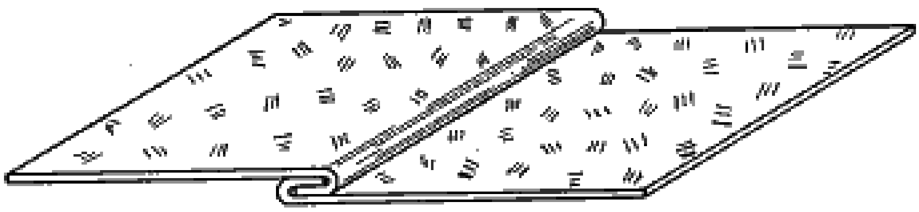
The foregoing methods will be found helpful also where old rusty or dirty metal must be soldered.

268. Causes of Difficulty in Soldering.—The following are common causes of difficulty or failure in soldering.

1. Lack of thorough cleaning of parts to be soldered.
2. Failure to keep parts clean by occasional wiping with a damp cloth during soldering process.
3. Use of wrong flux.
4. Use of iron that is not hot enough (leaving rough work).
5. Use of dirty, poorly tinned, or overheated iron.
6. Failure to apply a little flux after every application of the hot soldering iron.
7. Failure to sufficiently heat the pieces being soldered.
8. Failure to wipe off excess flux when the soldering is done, resulting in later corrosion.

WORKING SHEET METAL

269. Laying Out and Marking Sheet Metal.—In making appliances of sheet metal, it is very important first to mark out the pattern accurately on the metal, so that it may be cut with snips. Marking is best done with a sharp-pointed instrument, such as an old saw file that has been ground to a needle point, or an awl. A pencil makes a line that is too wide and indistinct. Also it is easily erased or smeared by handling. Circles and



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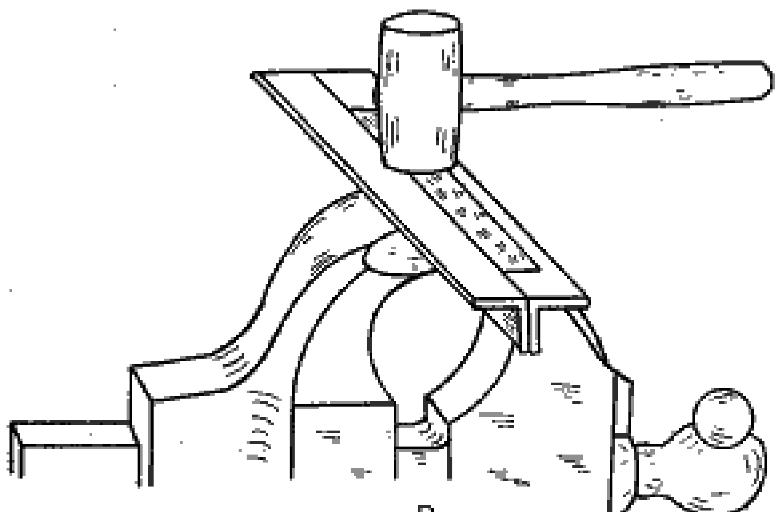


B

Fig. 239.—*A.* The hook or lock joint is a good method of joining pieces of sheet metal. It is easily soldered.

B. Bends for the hook joint are easily started by extending the metal over the edge of a bench or anvil and bending with a hammer or mallet; or by clamping the metal between irons in a vise and bending.

arcs are marked with dividers. A square should be used to insure accurate marking of lines at right angles. In marking out patterns for many appliances, it is best to lay off two base lines at right angles to each other and to do all measuring and squaring from these; or to straighten one edge of the stock and square one end with it and then use this edge and end as base lines.

270. Cutting Sheet Metal.—The best tool for the average job of sheet-metal cutting is a pair of tinner's snips. For an occasional job of cutting light sheet metal, a pair of old scissors works very well. Sheet metal, particularly the heavier gages, may also be cut by clamping in a metal-working vise and shearing with a cold chisel. The chisel should be sharp and held with the cutting edge just above the top of the vise jaws. The handle of the chisel should be held to one side so as to give an angling shear cut (see Art. 188, page 134).

271. Folding Edges and Forming Joints.—Frequently a hook or lock joint as illustrated in Fig. 239 can be used to advantage in making appliances of sheet metal. It is strong, easily made, and gives a neat, finished appearance to a piece of work.

To start a hook joint, the edge of the sheet metal is extended over the edge of a bench and bent down with a mallet or a hammer. The metal may also be clamped in a vise and bent, or it may be bent over the edge of an anvil, or a bar of iron clamped in a strong vise. After the edges are folded back, the parts are hooked together and hammered down in place with a mallet or a hammer. The joint is now ready for cleaning and fluxing if it is to be soldered.

272. Riveting Sheet Metal.—In making and repairing sheet-metal appliances, riveting can frequently be done to advantage. Locations for

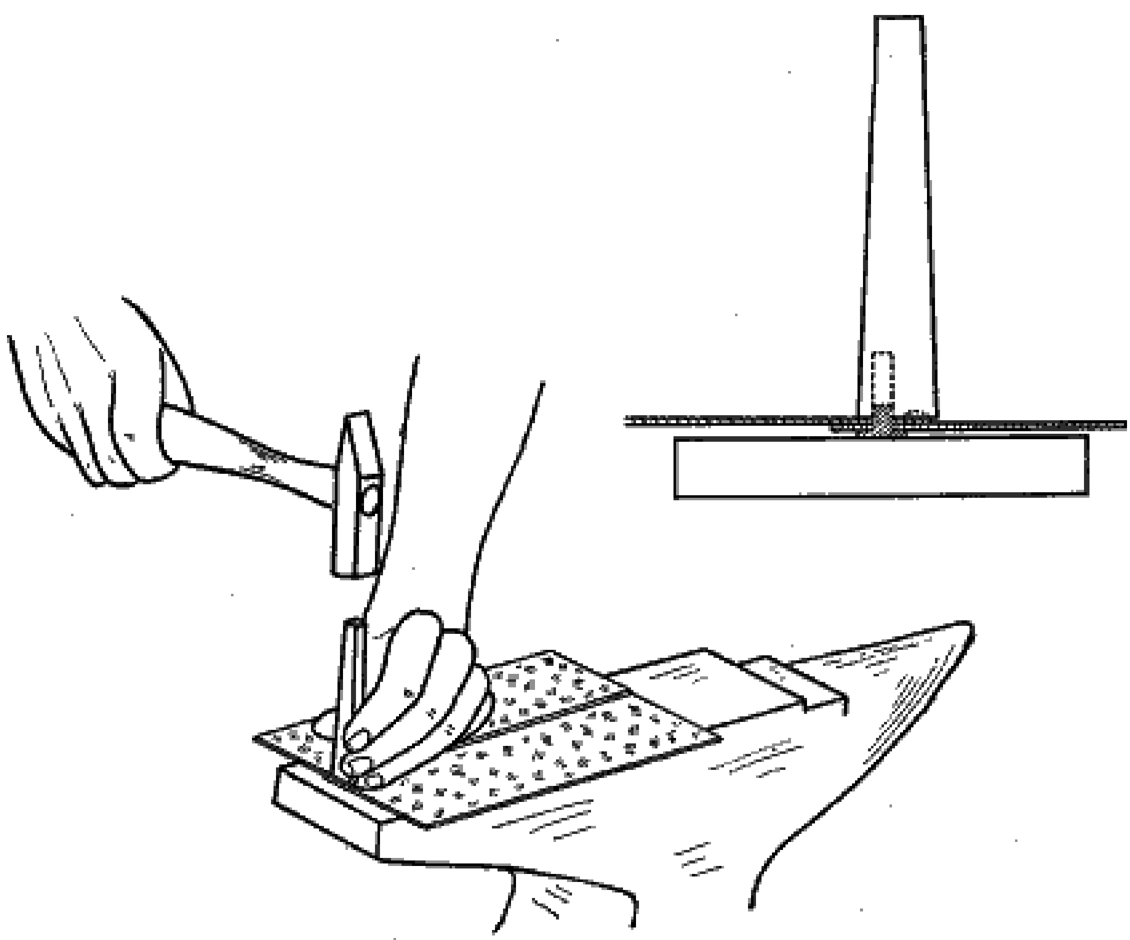
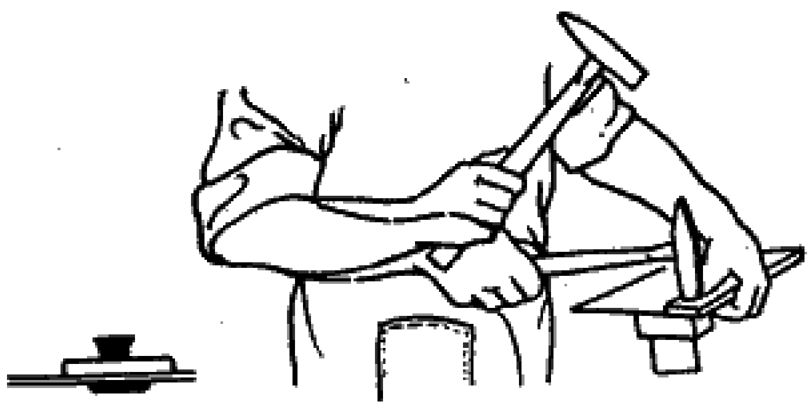


FIG. 240.—A good way to put a rivet through sheet metal is to place the rivet on an anvil and drive the sheet metal down over the rivet with a rivet set, making the rivet cut its own hole.

rivet holes may be accurately marked with an awl or center punch; then the holes may be drilled or punched and the rivets inserted and hammered down. A better way, however, is to place the rivet on an anvil, or other solid piece of iron, such as a bar held in a heavy vise; and then drive the sheet metal down over the rivet with a rivet set, making the rivet cut its own hole. A rivet set is essentially a small bar of steel with a hole drilled up into it to receive the end of the rivet, and with a cup-shaped depression for use in forming rounded heads on the rivets as they are hammered down.

A good way to punch holes in sheet metal is to use a solid punch over end-grain wood or over a block of lead.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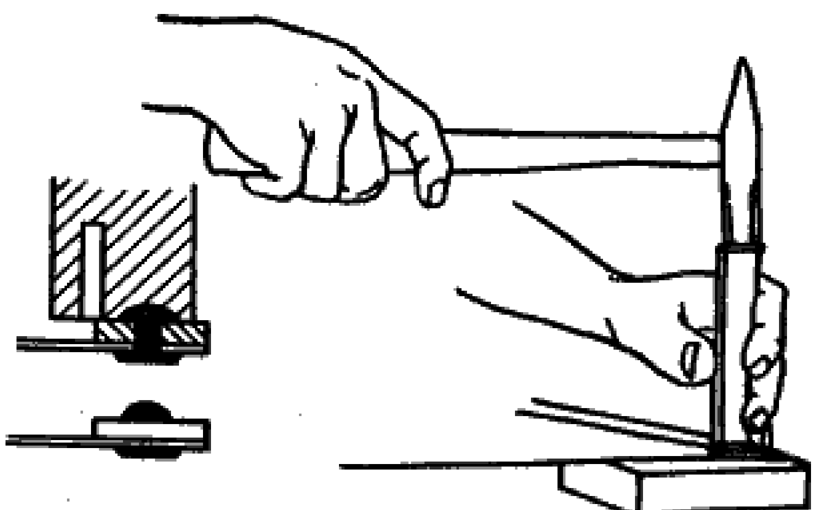
B

FIG. 241.—*A*. In hammering down the end of the rivet, strike a few straight, medium-weight blows. Heavy blows or too many blows will cause the metal to stretch and buckle around the rivet.

B. The job may then be finished with the cuplike hollow in the rivet set. (*Courtesy, Stanley Tools, New Britain, Conn.*)

In hammering down the end of a rivet, a few straight, medium-weight blows should be used. Heavy blows or too many blows will cause the metal to stretch and buckle around the rivet. If a rivet starts to bend, it should be cut off and removed and a new one inserted.

THE GASOLINE BLOWTORCH

The gasoline blowtorch is not only useful for heating soldering irons but for many other jobs about the farm, such as heating a nut that is stuck on a bolt, warming the intake pipe on an engine on a cold morning, or thawing a frozen pump or water pipe.

Fuel is forced from the reservoir in the base of the torch to the burner on top by air pressure, which is supplied by a small hand-operated pump. The burner, after it is "generated" by heating, vaporizes the gasoline and mixes it with air in the proper proportions for burning.

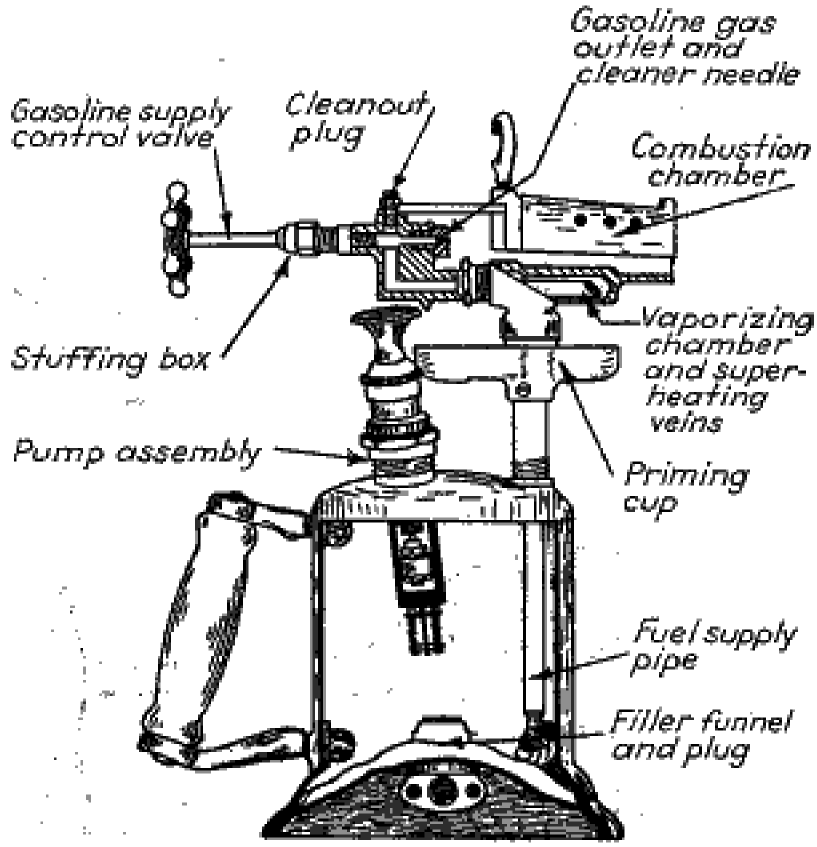

Fig. 242.—Details of a gasoline blowtorch.

273. Fuel for the Torch.—Ordinary, untreated motor gasoline is commonly used in blowtorches. Stove or lamp gasoline is better, however, as it is less likely to gum or clog the passages in the torch. Gasolines treated with lead should not be used because of their poisonous nature.

274. Operating the Torch.—The blowtorch is operated in the following manner:

1. *Fill the fuel chamber* with clean gasoline through the filler plug in the bottom. Only moderate pressure should be used in tightening the plug. If gasoline leaks around it, a little laundry soap rubbed on the threads will usually stop it.

2. *Pump air into the chamber.* Ten or twelve strokes of the pump will usually be enough if the pump is in good condition.

3. *Fill the priming cup* by opening the control valve a little and placing the thumb over the end of the burner to deflect the gasoline down into the cup. Be careful not to let gasoline overflow onto the torch or bench. If it does, wipe it up thoroughly before lighting.

4. *Light the gasoline* in the priming cup and protect the flame from any strong winds or drafts. It is essential that the burner be well heated to vaporize the gasoline.

5. *Light the torch* by opening the control valve just before the gasoline in the priming cup burns out. Do not open the valve too soon. Give the burner time to heat. If necessary use a match, applying it to the air holes in the side of the burner and not at the end of the burner.

6. *To turn the torch out, turn the control valve just enough to stop the flow of gas, and no tighter.* Screwing the valve too tight is likely to damage the seat. The sheath around the needle valve will contract when the torch cools, forcing the valve very tight against its seat and possibly damaging the valve or the seat.

275. Blowtorch Troubles. *Pump Troubles.*—If the pump fails to pump air, it is due most likely to drying out of the pump leather. The remedy is to remove the pump plunger and oil the leather. It is a good plan to put a drop or two of oil on the leather once a week when the torch is used regularly. After the leather becomes worn it should be replaced with a new one.

Another common cause of pump trouble is improper action of the check valve on the bottom of the pump. The valve is usually made of cork and is held against its seat by small springs. If the valve becomes cracked, or if dirt prevents it from seating, the air in the torch will leak back through the pump and the plunger will not stay down. Sometimes a check valve will stick shut and not open to admit air from the pump to the fuel chamber.

In case of trouble with the valve, the pump should be removed and the valve examined. If only dirty, it may be readily cleaned; if it is cracked, a new piece of cork will have to be installed.

Gasoline Leaks.—Leaks around the threaded joints may be stopped by unscrewing them and applying common laundry soap to the threads. If gasoline leaks around the stuffing box of the control-valve stem, the valve should first be closed, and then the stuffing box nut tightened *slightly* with a wrench.

Torch Burns with Pulsating Red and Blue Flame.—If there is a strong pulsating flame, first red and then blue, the burner is not hot enough. The flame should be turned out and the priming cup refilled and the torch regenerated. The cup probably cannot be filled from the torch itself, and gasoline will have to be put in the cup with a squirt can. Sometimes a torch can be made to warm up by pointing the flame straight down against a concrete floor. The burner is thus heated so that it can better vaporize the gasoline.

Torch Burns with Weak Flame.—If the flame is weak and cannot be increased by opening the control valve further, then there is either (1) not enough air pressure in the chamber, or (2) the gasoline passages are partly clogged. More air should be pumped into the chamber. If this does not remedy the trouble, then it can be assumed that the control-valve orifice or some of the other gasoline passages are partly clogged.

If a small particle of carbon or dirt is lodged in the control-valve orifice, closing the valve and then opening it two or three times will usually dislodge the particle.

If this fails to remedy the trouble, it is likely that the fuel-supply tube or some of the passages in the vaporizing chamber are clogged with dirt, gum, or carbon, especially if the torch is old or has been in use a long time. Many torches have a cotton wick in the fuel-supply pipe to strain the gasoline and to prevent pulsation of the flame. After long use the wicking may disintegrate or become clogged with dirt and have to be replaced.

If the passages are clogged, the torch should be taken apart very carefully and cleaned. Soaking the parts in kerosene, gasoline, or in alcohol will help to clean them. The passages may be blown out with air pressure or with a tire pump. Running small wires through the passages will sometimes help. Care should be exercised not to damage the small parts, particularly the control-valve orifice and the threaded plugs and openings. All threads should be coated with laundry soap before reassembling.

BLOWTORCH TROUBLE CHART

Symptoms	Trouble	Remedy
Pump plunger will not stay down	Leaky or stuck check valve on pump	Remove pump and repair valve
Pump will not pump air; plunger works up and down easily	Pump leather dry or worn	Oil leather or replace with new one
Torch burns with blue and red flame alternately and with pulsations	Torch not thoroughly generated before lighting	Refill priming cup and generate the burner again
Torch burns with weak, small flame	Not enough air pressure in fuel reservoir; control-valve orifice clogged; or fuel passages clogged	Pump more air into reservoir; close valve and reopen two or three times; or carefully take torch apart and clean, or send to factory for overhaul
Gasoline leaks around threaded joints	Threads do not fit perfectly	Take joints apart, coat threads with laundry soap and reassemble
Control valve hard to open	Valve turned too tight when torch was turned out	In turning out torch, screw valve just tight enough to stop flow of gas—no tighter

Manufacturers will ordinarily repair torches at reasonable cost if they are sent back to the factory. This may be more satisfactory than attempting to clean and repair them at home.

Questions

250. (*a*) What is soldering? (*b*) What is an alloy? (*c*) State two important conditions that should be met to facilitate soldering.

251. (*a*) How may metals be cleaned preparatory to soldering? (*b*) What purposes do fluxes serve?

252. (*a*) What materials are used for soldering fluxes? (*b*) What kind of flux would you recommend as most satisfactory as a general-purpose flux for most common metals? (*c*) Give directions for making a common flux. (*d*) For what purpose are small cakes of sal ammoniac particularly good? (*e*) In what other forms is sal ammoniac sometimes used?

253. (*a*) How may liquid fluxes be easily applied? (*b*) How may paste fluxes be applied? (*c*) Why should no more flux be used than necessary?

254. (*a*) In what forms is solder commonly sold? (*b*) What forms or kinds of solder are usually preferred for the farm shop?

255. (*a*) Of what material are soldering irons made? Why? (*b*) What size of irons is best for average shopwork? (*c*) In what respects are large irons better than small ones?

256. (*a*) What kind of heat is desired for heating soldering irons? (*b*) How may soldering irons be heated in a coal fire without getting them dirty?

257. (*a*) What is meant by tinning a soldering iron? (*b*) What procedures may be used for tinning an iron?

258. (*a*) How will a cold iron affect the quality of work done? (*b*) What difficulties arise from overheating an iron? (*c*) How may a workman tell if his iron is getting too hot? (*d*) What different methods may a workman use to keep his iron clean?

259. (*a*) How hot should the metal being soldered be heated? (*b*) What important points should be observed in heating the work with a soldering iron? (*c*) For what kind of soldering may the work be heated directly with a blowtorch to advantage?

260. (*a*) What is the best way of applying small amounts of solder to the work? (*b*) What method may be used when large amounts of solder are required? (*c*) What is the proper way of applying wire solder to the work when soldering with soldering iron?

261. (*a*) How often, or when, should the work be wiped to keep it clean? (*b*) What should be used for wiping it?

262. What points should be observed in soldering small holes in sheet metal?

263. (*a*) Just how may a hole be repaired with a rivet and solder? (*b*) What important points should be observed?

264. (*a*) What are the steps in the process of sweating a patch over a hole? (*b*) Why should a tempered tool never be used to hold the patch in place while it is being soldered? (*c*) What precautions should be taken to prevent melting the whole patch loose while finishing the job?

265. (*a*) What is meant by "tacking" a joint or seam? (*b*) Why is it desirable to tack a plain lap joint first when soldering it? (*c*) Is it necessary to tack a hook or lock joint?

266. (*a*) Explain how a leaky tube may be effectively repaired. (*b*) What important points should be observed in doing this work?

267. (*a*) Outline the process of soldering aluminum. (*b*) Why is aluminum difficult to solder?

268. What are some of the more important causes of difficulty in soldering?

269. (*a*) How can sheet metal best be marked? (*b*) Why is a pencil not satisfactory for marking sheet metal? (*c*) Why is it best to do all measuring and squaring from two base lines laid off at right angles to each other?

270. What methods may be used for cutting sheet metal?

271. Just how may a hook or lock joint be easily made with common tools?

272. (*a*) What is the best way of punching holes in sheet metal for rivets? (*b*) What other methods may be used? (*c*) What kind of blows should be used in hammering down the end of a rivet after it is in place? (*d*) How may a smooth round head be formed on a rivet?

273. (*a*) What kind of fuel is best for use in a gasoline blowtorch? (*b*) Why should gasoline that has been treated with lead not be used? (*c*) What troubles may arise from using too low a grade of motor fuel?

274. (*a*) What are the steps in filling and lighting a blowtorch? (*b*) How may gasoline leaks around threaded joints be stopped? (*c*) How many strokes of the pump are usually required to pump up pressure in the air chamber after filling with gasoline? (*d*) Just where should the match be held in lighting a torch after it is generated? (*e*) How tight should the shutoff valve be closed when the torch is turned out? (*f*) What difficulties may arise if this precation is not observed? Why?

275. (*a*) What troubles might prevent the air pump on a blowtorch from pumping air? (*b*) What might cause a pulsating red and blue flame? (*c*) What conditions might cause the torch to burn with a weak flame? (*d*) How may the passages in a torch be cleaned?

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PART VI

FARM BLACKSMITHING

CHAPTER XVIII

BLACKSMITHING EQUIPMENT; FORGE FIRES

Whether a farmer can afford a forge and anvil will depend upon the distance to a blacksmith shop, the amount of machinery repair work he needs to do or have done, and his ability as a mechanic. Although not every farmer can profitably own blacksmithing equipment, many farmers can. If a farmer cannot, he should remember that a great deal of repair work can be done with cold metal, if he has a few simple tools like a vise, a hack saw, files, cold chisels, and drills.

Although blacksmithing under many conditions should occupy a minor place in a farm shop course, no such course can be considered complete without at least some instruction in this work. Blacksmithing is generally more difficult than woodwork. Almost any high school boy with average mechanical ability, however, can soon learn to do simple blacksmithing and feel well repaid for his efforts, if he will set himself diligently to the task. In all mechanical work, much more rapid and satisfactory progress can be made if the student will carefully study the theory and principles along with his practice. This is particularly true of blacksmithing.

276. The Forge.—The forge for the farm shop should have a gear-driven blower operated by a crank, and it should have a hearth at least 18 in. wide, preferably somewhat larger. Probably the cheapest way of providing a good forge is to buy a good blower and tuyere (that part in the bottom of the hearth through which the blast comes) and make a hearth and stand of concrete, brick, or other masonry. The forge should be provided with a hood and pipe connection for taking away the smoke.

277. The Anvil.—Anvils are of two general grades: cast iron and steel. Steel anvils are much better and should be used if they can be afforded. The two kinds can be distinguished by striking with a hammer. A cast anvil has a dead sound while a steel one has a clear ring.

Anvils are commonly available in sizes ranging from 50 to 200 lb. An anvil weighing 100 or 125 lb. would be quite satisfactory for the average farm shop. A piece of railroad iron 20 to 30 in. long, mounted on a suitable block or stand, will serve fairly well for light hammering and riveting, although a much greater variety of work can be done on a regular anvil.

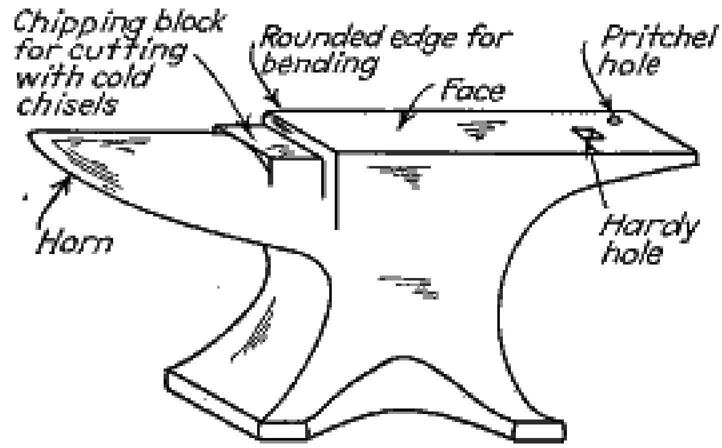


FIG. 243.—Parts of the anvil.

Use of Different Parts of Anvil.—The horn of the anvil is used for making bends and shaping curved pieces; and the flat face is used for general hammering. The flat depressed surface near the horn is the chipping block, and here all cutting with cold chisels and similar tools should be done, rather than on the face of the anvil. The chipping block is soft and will not damage the chisel if it cuts through. The face is hardened and cutting into it with a chisel would damage both the chisel and the face, which should be kept smooth for good blacksmithing.

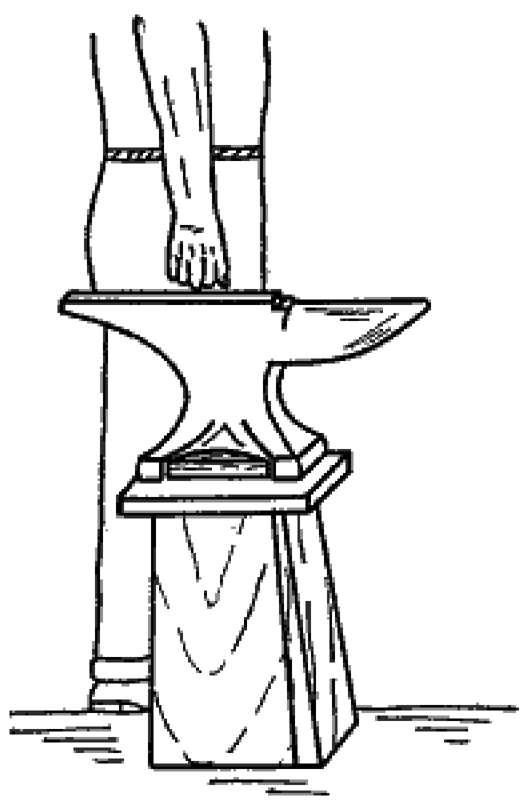


FIG. 244.—The anvil should be mounted on a solid block and at such a height that the face of the anvil can just be reached with the knuckles of the clenched fist when standing erect.

The better anvils have a corner of the face next to the horn slightly rounded, so that sharp bends may be made in rods and bars without unduly marring or galling the iron.

The round hole in the face of the anvil is used for punching holes. It is called the *pritchel hole*, taking its name from the sharp punch used by smiths in punching nail holes in horseshoes. The square hole in the face is called the *hardy hole* and is used for holding the hardy and other tools, such as swages and fullers.

Mounting the Anvil.—The anvil should be mounted on a solid block, preferably of wood. It should be so located in front of the forge that the workman can take the irons from the fire and place them on the anvil by making a short turn and without the necessity of taking even a full step. The horn should be to the workman's left (unless he is left-handed, in which case it should be to his right). The face of the anvil should be at such a height that it can be touched with the knuckles of the clenched fist when standing erect and swinging the arm straight down.

278. Tongs.—At least one or two pairs of tongs will be needed. Various types are available, but the hollow-bit, curved-lip bolt tongs are probably the most useful. Flat bars as well as round rods and bolts can be held in them, and the curved part back of the tip makes it possible to reshape them easily to fit different sizes of stock. By grinding, filing, or sawing a groove crosswise in each of the lips, the tongs can be made to

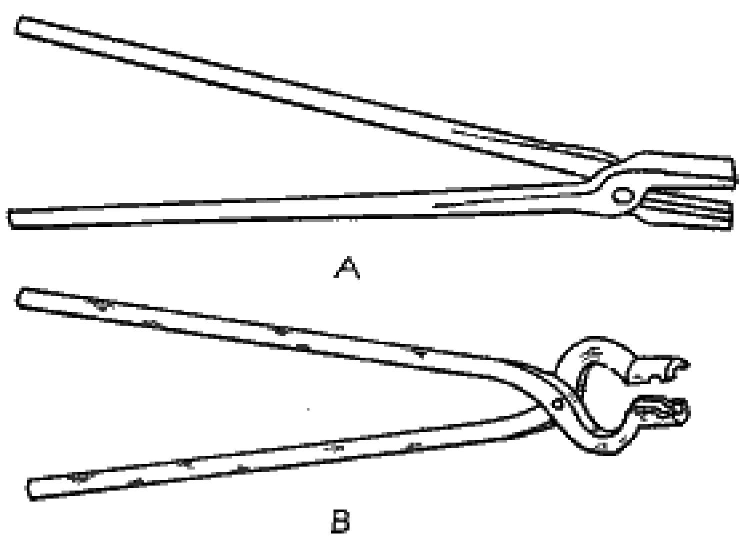


Fig. 245.—Types of tongs.
A. Flat-jawed hollow-bit tongs.
B. Hollow-bit curved-lip tongs. This style is very good for the farm shop. Flat bars as well as round rods and bolts can be held in them.

hold links practically as well as regular link tongs (see Fig. 245). Tongs 18 to 20 in. long are a good size for average work.

279. Hammers.—A blacksmith's hand hammer weighing 1½ or 2 lb. and another weighing 3 or 3½ lb. will handle all ordinary work very satisfactorily.

280. Hardy, Chisels, Punches.—There should be a hardy to fit the hole in the anvil, and there should be a fair assortment of hand cold chisels and punches. The chisels and punches may be made in the shop. If considerable blacksmithing is to be done, it would be well to have a hot cutter and a cold cutter (simply large chisels with handles on them) for heavy cutting with a sledge hammer. It would be well, also to have one or two large punches with handles on them for punching holes in hot metal. Punches for making holes ⅜ in. and ½ in. in diameter are probably most useful.

281. Vise.—One vise can well serve for all metal work in the farm shop, including blacksmithing if it is heavy and strong enough. A heavy blacksmith's steel-leg vise with jaws 4 to 5 in. wide is generally preferred as an all-purpose vise in the farm shop. A leg vise is one that has one leg extending down to be anchored or fastened into the floor. Such a vise can be used for heavy hammering and bending better than other types.

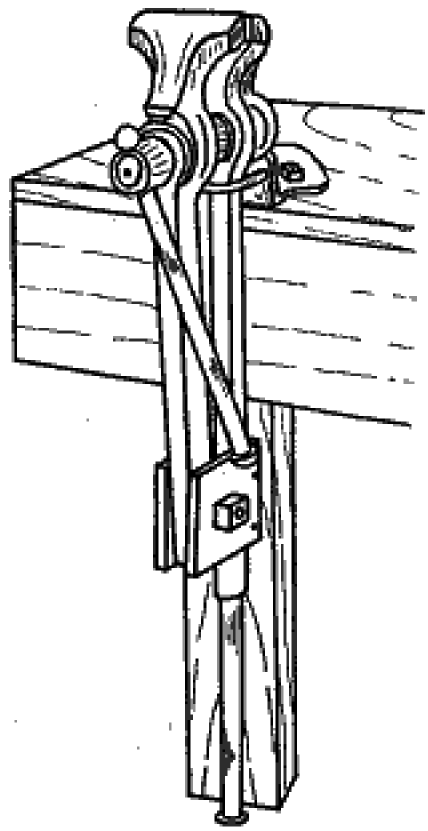


FIG. 246.—A heavy blacksmith's steel-leg vise is a good type of vise for the farm shop.

If there is a strong steel machinist's box vise in the shop, it can be used for blacksmithing work if care is used not to do too heavy hammering or bending with it.

282. Fire Tools.—A small shovel and poker or rake will be needed for use on the forge fire. These can easily be made in the shop. A flat

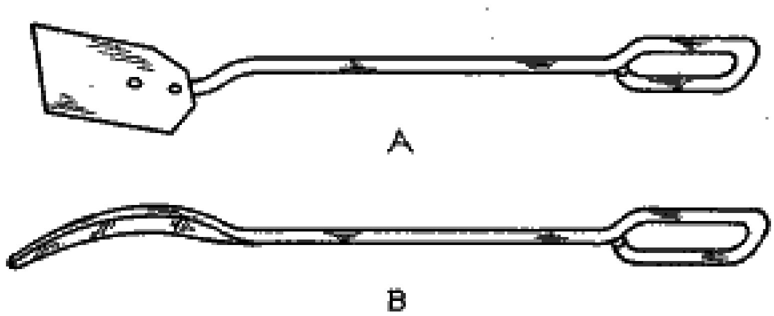


FIG. 247.—Homemade forge fire tools. *A*, shovel; *B*, poker.

piece of heavy sheet iron about 3 or 4 in. wide by 4 or 5 in. long, riveted to a bar or rod for a handle, makes a good shovel. A ½-in. round rod, with an oblong eye in one end to serve as a handle and the other end flattened and curved, makes a good combination poker and rake.

283. Measuring Tools.—Some kind of metal rule will be needed for measuring and checking pieces being forged. A small steel square is very good for both measuring lengths and checking angles and bends. A wooden rule should not be used to measure hot iron. A caliper, or a caliper rule, for measuring diameter of rods and thickness of parts, although not a necessity, will be found very convenient.

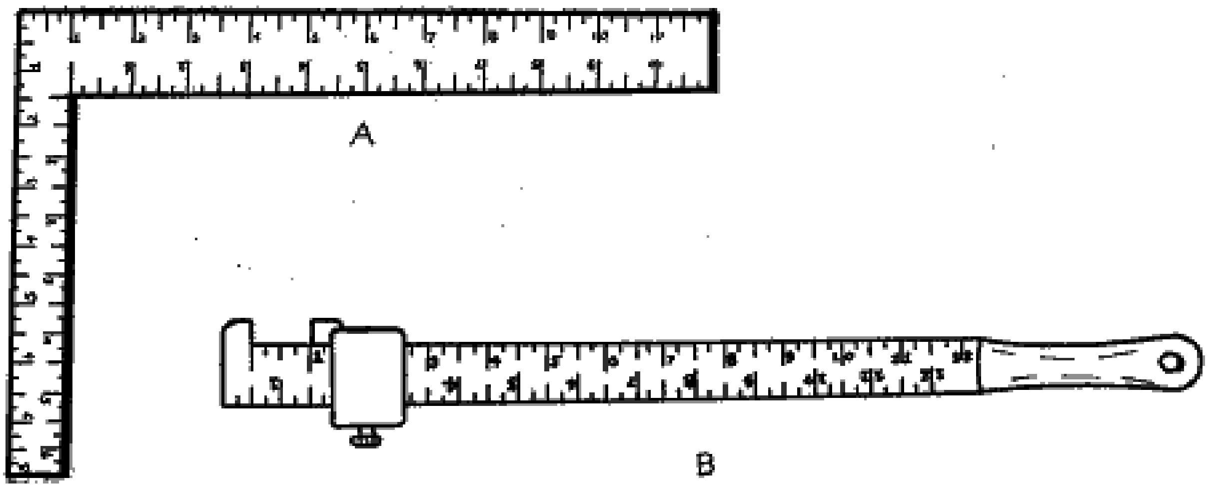


FIG. 248.—Metal measuring tools should be used in blacksmithing.

A. The small steel square is very useful for checking bends and angles as well as for measuring.

B. The caliper rule is especially good for measuring the diameter or thickness of bolts, rods, and bars; as well as for general measuring.

THE FORGE FIRE

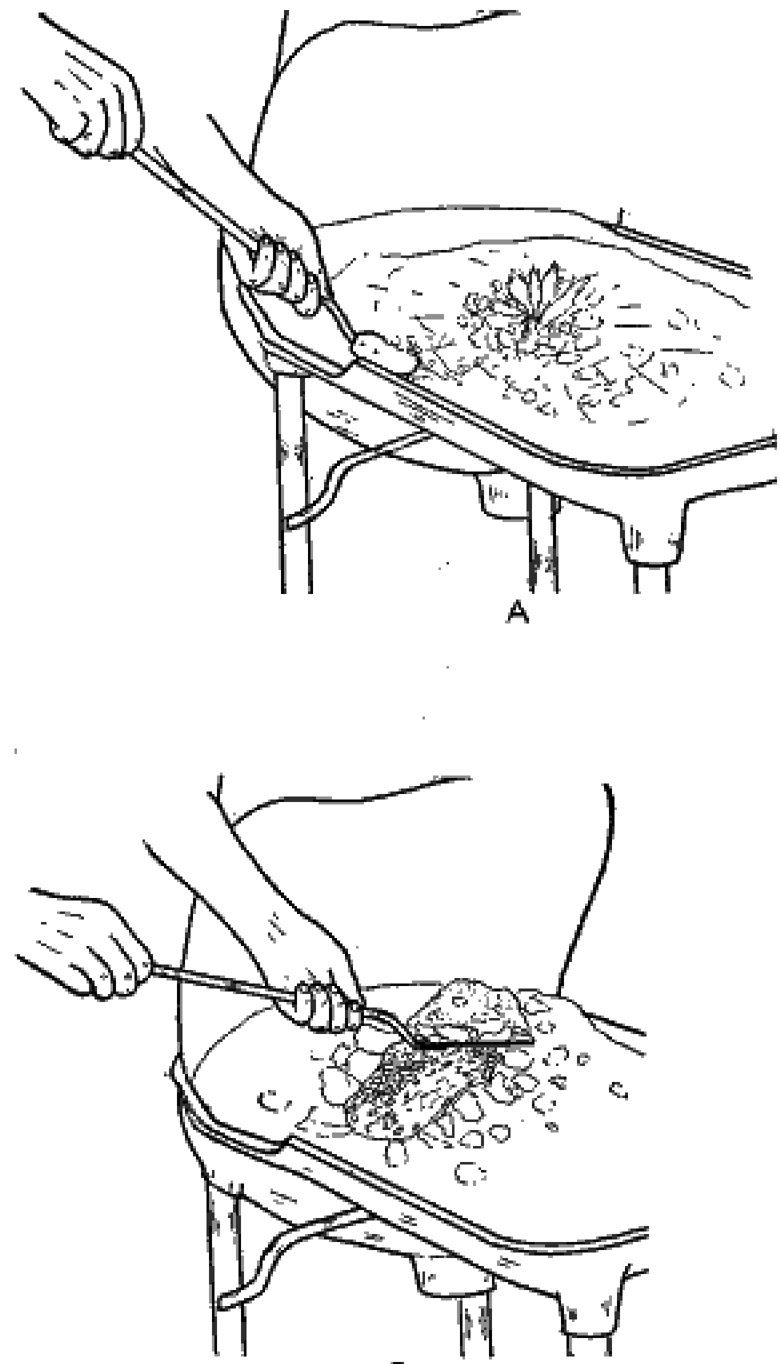
A good fire is the first requirement for good blacksmithing. Many beginners do poor work simply because they do not recognize the importance of a good fire.

A good forge fire has three characteristics. *It is clean*, that is, free from clinkers, cinders, etc. *It is deep*, with a big center of live burning coke. And *it is compact*, being well-banked with dampened coal.

284. Fuel for the Forge Fire.—Blacksmithing coal is used in the forge. It is a high-quality soft coal that is practically free from sulphur, phosphorus, and other objectionable impurities. When dampened and packed down around the fire, it readily cakes and changes to coke, which is a lightweight material that burns with a clean, intense flame. Ordinary stove or furnace coal will not work satisfactorily in a forge.

285. Building the Fire.—To start a fire, first clean the fire bowl with the hands, pushing all coal and coke back on the hearth and throwing out all clinkers. Clinkers are heavy and metallic and have sharp, hard corners or projections and are therefore easily distinguished from the coke, which is light in weight and easily crumbled. Fine cinders and ashes are easily shaken through the grate into the ashpit.

After cleaning the fire bowl, dump the ashpit below the tuyere and then try the blower and make sure a good strong blast comes through. Sometimes ashes work back into the blower pipe and obstruct the blast.



A

B

FIG. 249.—The forge fire should be cleaned by pushing the shovel along the bottom of the hearth to the center of the fire, as at *A*, and then lifting it straight up, as at *B*. The clinker and ashes, if any, will be exposed and can be easily removed.

Next light a small handful of shavings or kindling *from the bottom* and drop onto the tuyere. Give the blower a gentle turn and rake fuel, preferably coke left from the previous fire, onto the burning kindling. Once the fire is burning well, rake more coke onto it, and bank the fire on both sides and on the back with dampened coal. This forms a mound with burning coke at the center, and the heat is concentrated in the center by the dampened coal on the outside. In a little while this dampened coal, sometimes called *green coal,* has gases driven off and it changes to coke.

286. Maintaining the Fire.—When the coke at the center of the fire burns up, additional coke from the hearth or the underside of the mound is forced into the center, and from time to time green coal is added to the outer parts of the mound to keep the fire well banked. Do not continually poke at the fire; simply keep the center well supplied with coke and the outside packed down with dampened coal.

If the fire tends to spread too much or becomes open and loose, throw or sprinkle water on the edges and pack it down with the shovel. Only a gentle blast of air should be used. Excessive air makes an oxidizing fire and causes the iron to scale badly.

287. Cleaning the Fire.—From time to time—usually every half hour when welding—the clinkers and cinders that accumulate over the tuyere should be removed. This can be done by passing the shovel along the bottom of the hearth to the center of the fire and then raising it straight up through the fire. The clinkers can then be easily seen and removed. Most of them will stay on the shovel. The burning coke is then raked back into the center and the outside packed down, using green coal on the outer edges if needed.

288. Heating the Irons.—To heat irons in a forge, they should be placed in the fire in a *horizontal position,* not pointing down. There

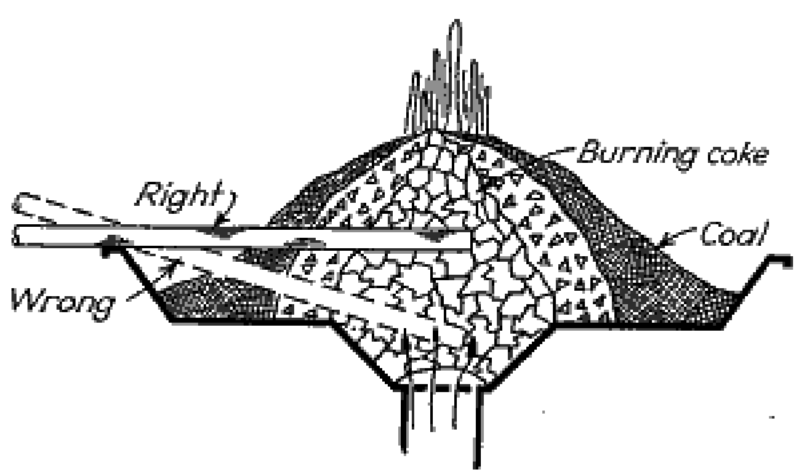


FIG. 250.—In heating irons in the forge, they should be placed level—never pointed down. There should be burning coke below them, on top of them, and on all sides of them.

should be burning coke *below the irons, on both sides of them, and on top of them.* Irons heated in a deep, compact fire heat much more rapidly and oxidize or scale off less than when heated in a shallow, burned-out fire. Some scale will form in spite of a good fire, but it should be kept to a minimum. A good blacksmith keeps the scale brushed from the face of the anvil with his hands.

Small thin parts heat much more rapidly than heavier and thicker parts. To prevent burning the thinner parts, they may be pushed on through the fire to a cooler place, or the position of the irons otherwise changed to make all parts heat uniformly.

Mild steel should be heated to a good, bright-red heat for forging. It should not be allowed to get white hot and sparkle, as it is then burning.

289. Fitting Tongs; Holding the Work.—If tongs cannot be found to fit the work, a pair should be reshaped by heating and hammering the

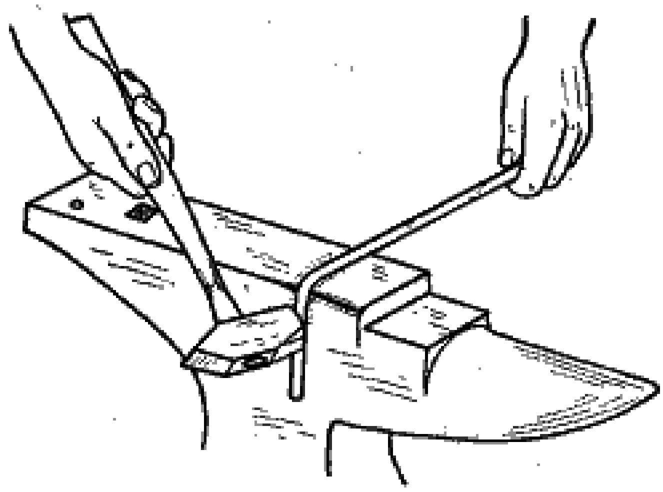


Fig. 251.—By careful planning, many blacksmithing jobs can be done almost, if not altogether, without the use of tongs.

jaws over the piece to be held. Poorly fitting tongs are a source of continual trouble and should not be used.

Some Work Done without Tongs.—A considerable amount of work can be done without tongs. An eyebolt, for instance, can be made on the end of a rod 20 or 30 in. long and then cut off when finished.

Questions

276. (*a*) What is the cheapest way of providing a good forge for the farm shop? (*b*) What kind of blower would you recommend? (*c*) How large a hearth should the farm forge have?

277. (*a*) What different kinds of anvils are available? (*b*) What kind is best, and how may the different kinds be readily distinguished? (*c*) What size of anvil is best for the farm shop? (*d*) Can a piece of railroad iron or rail be used satisfactorily in the farm shop? (*e*) What is the chipping block and what is it for? (*f*) Why is one corner of the anvil face rounded? (*g*) What is the purpose of the holes in the face? (*h*) In what position should the anvil be mounted with respect to the forge? (*i*) How high should it be mounted?

278. (*a*) What kind or kinds of tongs would you recommend for the farm shop? (*b*) What size?

279. What sizes of hand hammers would you recommend for blacksmithing?

280. What other tools, like hardies, chisels, and punches, would be needed?

281. What kind and type of vise is best for blacksmithing?

282. (*a*) What fire tools will be needed? (*b*) What materials would be needed to make these in the shop?

283. (*a*) What measuring tools would you recommend for blacksmithing? (*b*) In what respects is a small steel square better than a rule? (*c*) Why are wooden rules not satisfactory?

284. (*a*) What are the characteristics of a good forge fire? (*b*) What kind of fuel is used in the forge? (*c*) What are its characteristics or properties?

285. (*a*) Just how would you go about building a fire in a forge? (*b*) Why should the fire be well banked with green coal?

286. (*a*) What attention should the fire have to keep it in good condition? (*b*) How may it be kept from spreading or becoming open and loose?

287. (*a*) How often should the fire be cleaned? (*b*) Just how is the fire cleaned?

288. (*a*) Just how should the irons be placed in the fire? Why? (*b*) How may light or thin parts be kept from overheating? (*c*) How hot should irons be heated for forging?

289. (*a*) How may tongs be reshaped to fit the work? (*b*) Under what conditions may work be done without tongs?

References

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CHAPTER XIX

FUNDAMENTAL FORGING OPERATIONS

Forging may be defined as changing the shape of a piece of metal by heating and hammering. All the various operations that a blacksmith performs in forging iron may be classified into a surprisingly small number of fundamental or basic processes. Once these are mastered, the beginner is well on his way to success, and he can do practically any ordinary piece of forge work. These fundamental operations are (1) bending and straightening; (2) drawing, or making a piece longer and thinner; (3) upsetting, the opposite of drawing, or making a piece shorter and thicker; (4) twisting; and (5) punching. Other operations commonly done by a blacksmith, but which are not strictly forging, are welding, tempering, drilling, threading, filing, etc.

290. Bending and Straightening.—In bending at the anvil, two things are most important:

1. Heat the iron to a good bright-red heat, almost but not quite white hot, throughout the section to be bent.
2. Use bending or leverage blows—not mashing blows.

The iron should be so placed on the anvil and so struck that it can bend down under the hammer blow without being forced against the anvil and mashed. If the iron is struck at a place where it is resting firmly on the anvil, it will be mashed instead of bent. A few moderately sharp blows are better than several lighter blows.

Abrupt square bends can be made over the face of the anvil near the chipping block where the corner of the anvil is rounded to prevent marring or galling the iron.

Care should be taken to keep the iron at the proper bending heat. If it gets below a red heat, it should be put back in the fire and heated again. To bend a piece at a certain point, without bending the adjacent section, the piece may be heated to a high red heat and then quickly cooled up to the point of bending by dipping in water. Bending is then done quickly by hammering, or other suitable methods.

Bending may be accomplished in several ways besides hammering over the anvil. The iron may be heated and then put in the pritchel or hardy hole and bent by pulling; or it may be clamped in a vise and bent.

Straightening can usually best be done on the face of the anvil. The stock should always be firmly held and then struck with the hammer at points where it does not touch the face. Sighting is the best way to test for straightness and to locate the high points that need striking.

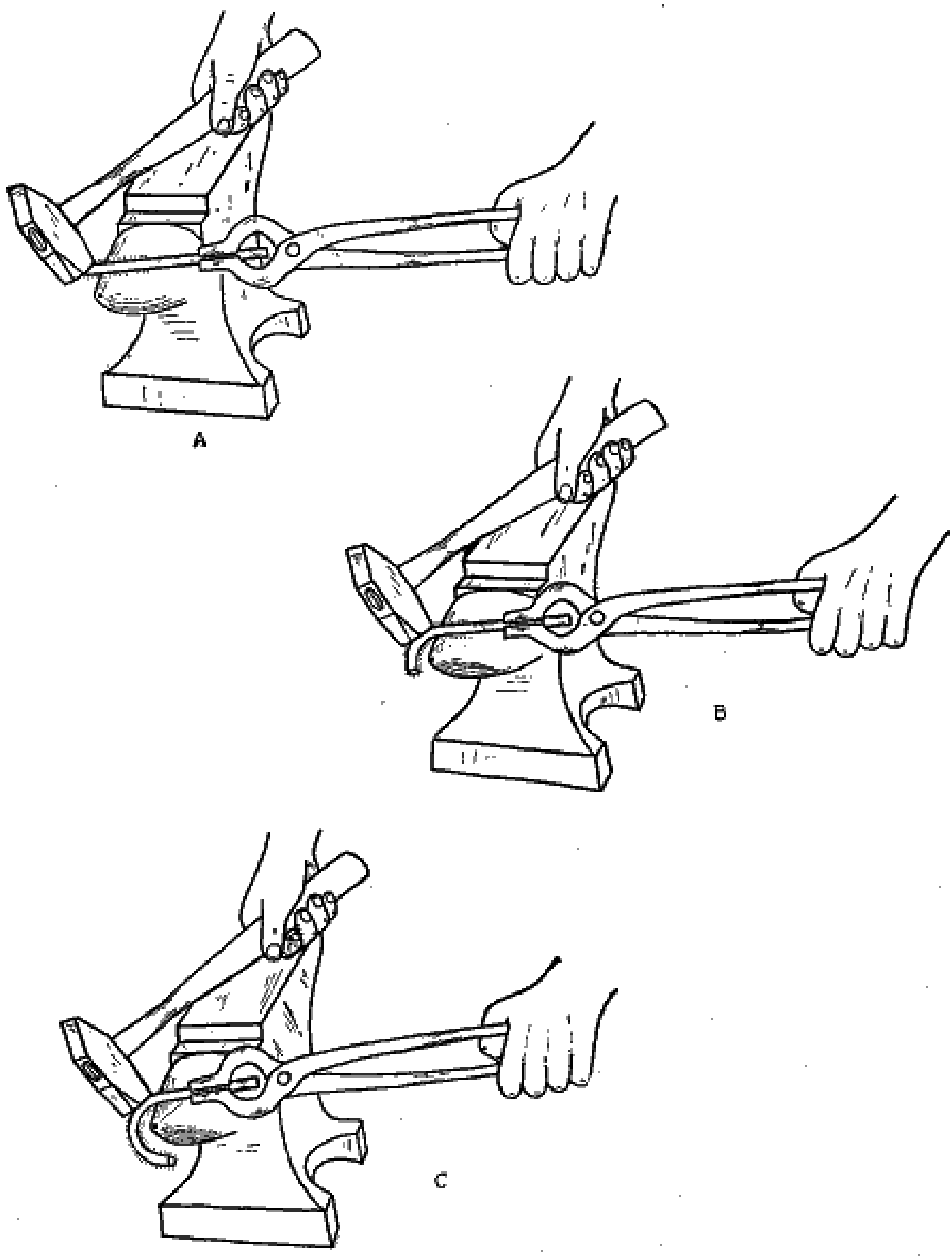

Fig. 252.—To make a uniform bend in the end of a rod, strike the part that projects beyond the horn and keep feeding the rod forward with the tongs as the bending progresses. Keep the iron at a good working heat and do not strike the rod where it rests on the horn.

Bending Flat Bars Edgeways.—A flat bar can usually be easily bent edgeways by heating and placing over the horn and bending the two ends

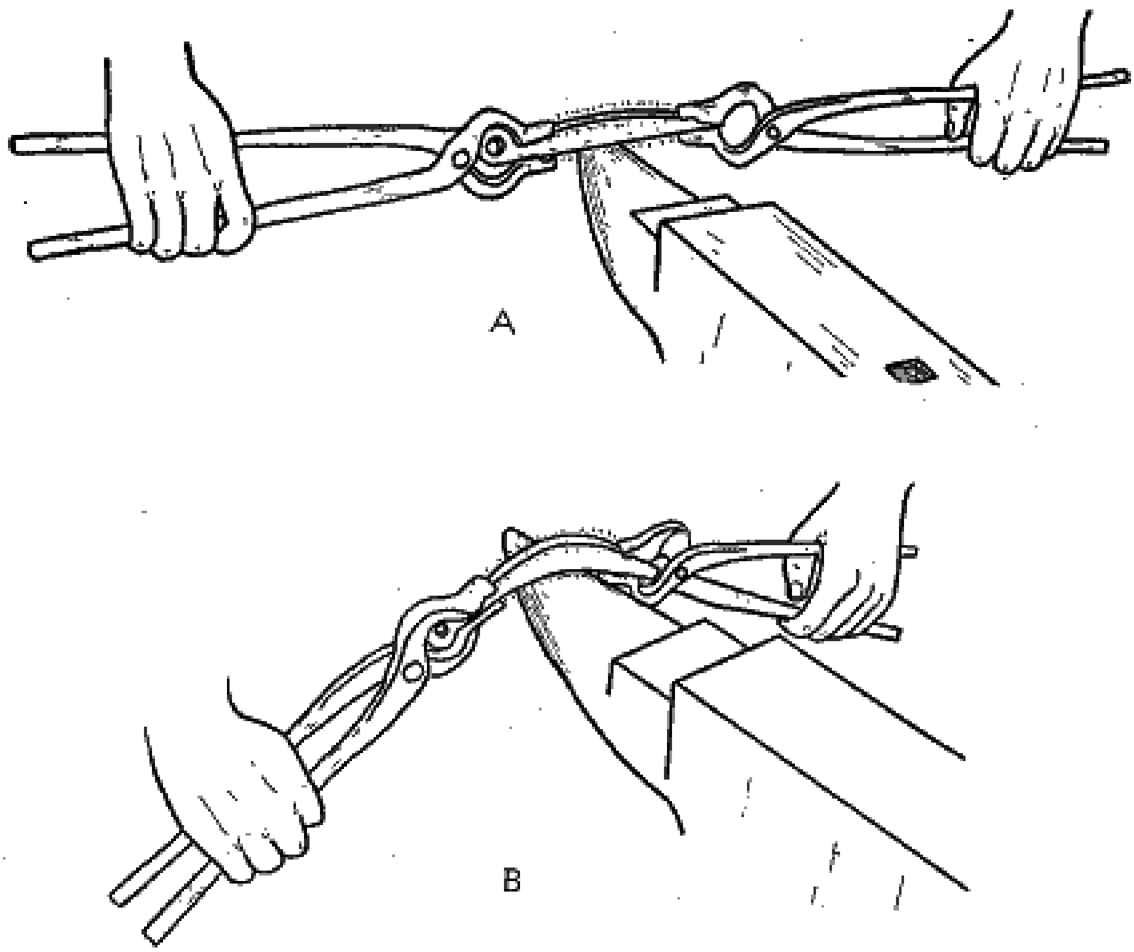

Fig. 253.—Flat iron may be bent edgewise by heating to nearly a white heat and bending slowly with tongs. This method is good in making flat chain hooks.

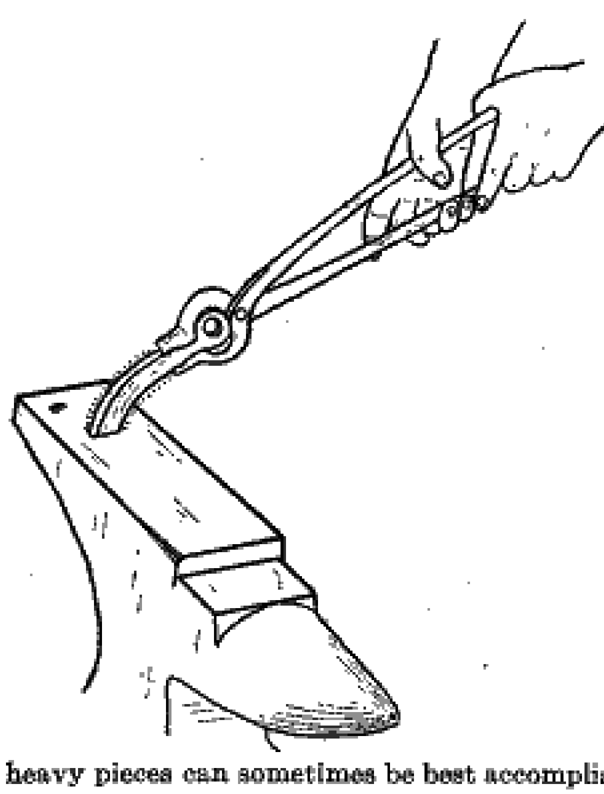

Fig. 254.—Bending of heavy pieces can sometimes be best accomplished in the hardy hole.

down slowly, using the hands if the piece is long enough, or two pairs of tongs in the case of short pieces (see Fig. 253). Sometimes the bending can be done easily by putting one end of the piece in the hardy hole and pulling on the other end (see Fig. 254). If the stock starts to buckle, it should be laid flat on the anvil and straightened. Hammering the outside edge of the iron when laid flat will tend to stretch it and therefore help with the bending. Once the bend is well started, hammering the piece on edge around the horn is not so difficult. The stock should always be firmly held, either by hands or with tongs, and the parts to be bent should be at a high red heat. Places not to be bent should be comparatively cold.

291. Bending and Forming an Eye.—One of the most common bending jobs in the blacksmith shop is that of forming an eye on the end of a rod. The following is a good method of making such an eye:

1. Heat the rod to a good red heat back for a distance of about 5 to 8 in., depending on the size of the eye.
2. Quickly place the rod across the face of the anvil with just enough of the heated end projecting beyond the edge of the anvil to form the eye. For exact work the length of hot iron that is to project over may be quickly measured with a metal rule. The iron should be placed across the anvil well up near the horn where the edge is rounded.
3. Bend the end down, forming a square bend, with a few well-directed blows. Work rapidly before the iron cools.
4. Heat the end of the stock and start bending the tip end around the horn. Work from the tip back toward the stem. Keep the iron hot throughout the part being bent; otherwise the bending will be slow and difficult, and the iron will not bend at just the places desired. If the square bend at the juncture of the stem and eye tends to straighten out, it is an indication that the end of the stock is not being kept hot enough while being bent.
5. Round the eye by driving it back over the point of the horn, noting carefully where it does not rest against the horn and striking down lightly in these places. Keep the iron well heated.
6. Center the eye on the stem, if necessary, by placing the stem flat on the anvil face with the eye projecting over the edge, and striking the eye. The stock should be well heated at the juncture of the stem and eye, but the eye itself should be practically cold. Such a condition can be produced by heating the whole eye and then quickly cooling most of the rounded part by dipping in water.

292. Drawing.—Drawing is the process of making a piece longer and thinner. Two important points should be kept in mind while drawing:

1. The iron must be kept at a good forging heat, a high red or nearly white.
2. *Heavy, straight-down, square* blows should be struck.

Many beginners make the mistake of striking a combination down-and-forward pushing blow, thinking that the pushing helps to stretch the metal.

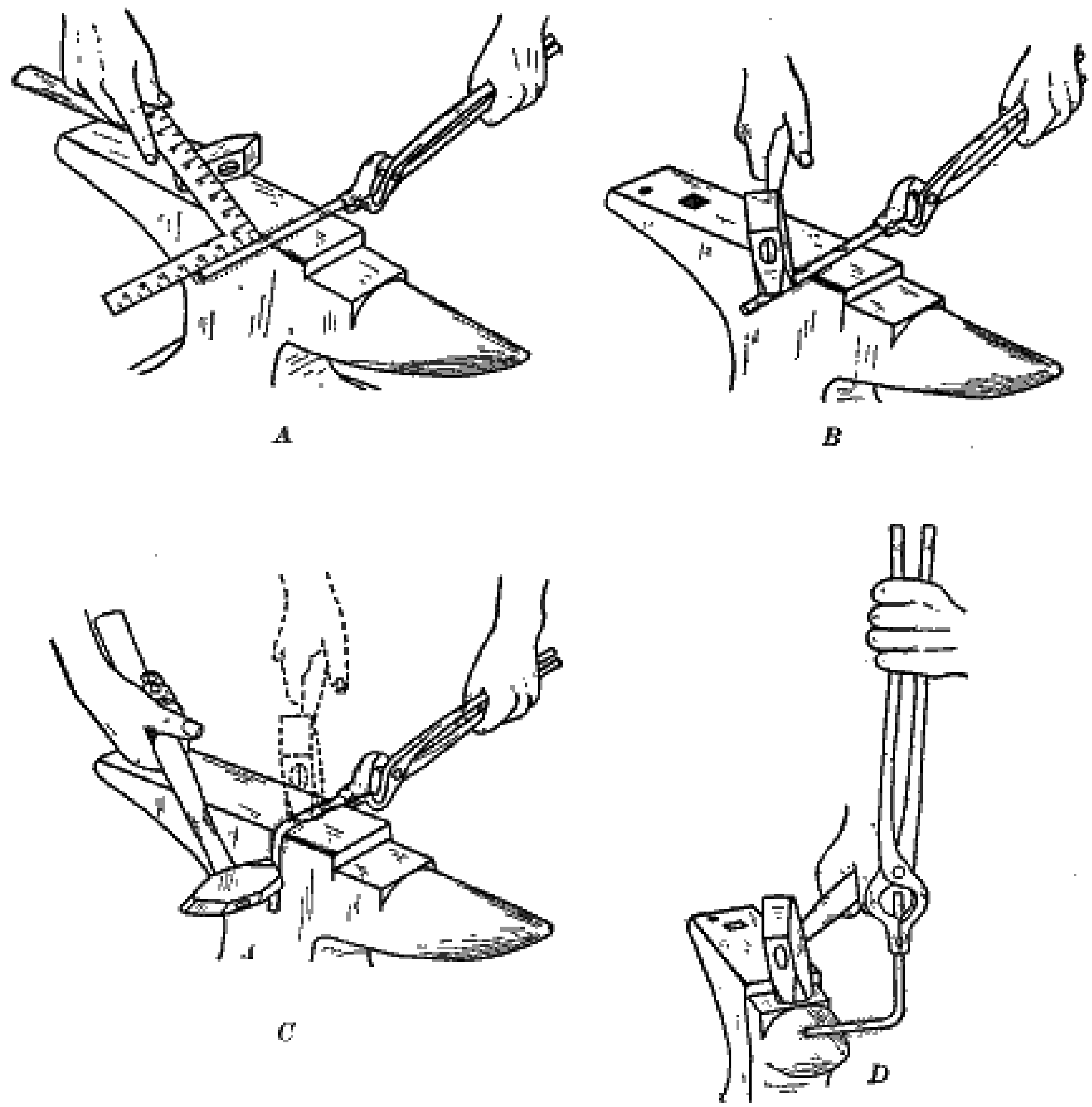

Fig. 255.—Steps in making an eye.

A. Place a well-heated iron across the anvil with enough stock projecting over to form the eye. Where the eye must be made accurately to size, use a metal rule or square for measuring. Work rapidly.

B. Bend the projecting portion down, forming a right angle.

C. Finish the right angle bend by striking alternately on top and on the side, keeping the iron at a good working heat all the while.

D. Start bending the tip end around the horn, being careful to strike "overhanging" or bending blows.

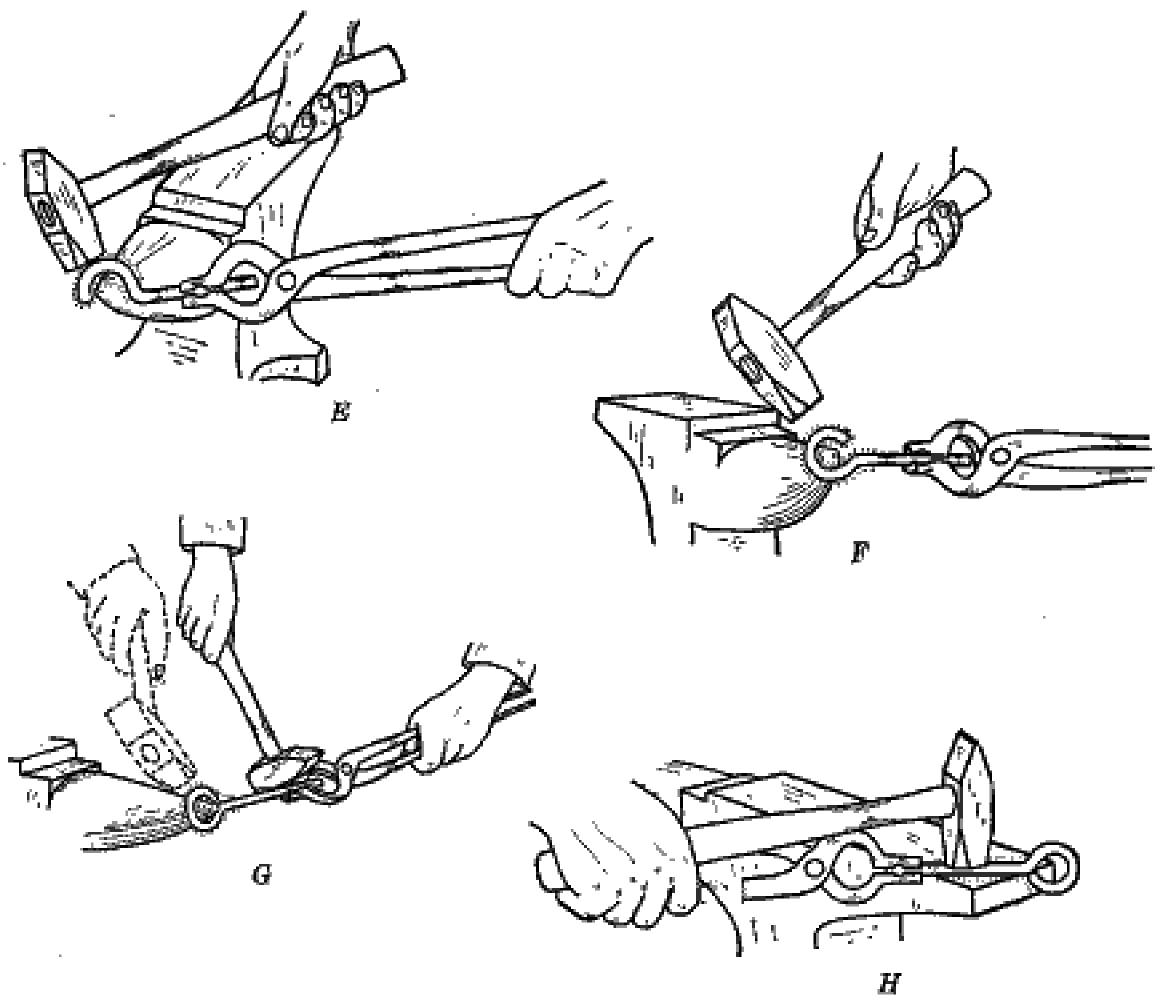

FIG. 255a. Steps in making an eye (*continued*).

E. Gradually work back from the end to the square bend.

F. Turn the eye over and close it up. Exert considerable back pull on the tongs to keep the upper part of the eye up off the horn. In this position the hammer can strike bending blows instead of flattening or mashing blows.

G. Round the eye by driving it back over the point of the horn. Carefully note where the eye does not touch the horn, and strike down lightly in these places.

H. To straighten the stem of an eye, place it across the corner of the anvil face and strike the high points while the iron is at a good working heat.

Drawing can be done more rapidly over the horn than on the face of the anvil, as the round horn wedges up into the metal and lengthens it, and there is less tendency for it to stretch in all directions. If a piece tends to get too wide it may be placed on edge and hammered.

Hammering after the red heat leaves is hard work and accomplishes little. Also, the iron is apt to split or crack if hammered too cold.

Drawing Round Rods.—To make a round rod smaller, the following steps should be carefully followed.

1. Make it four-sided, or square in cross section.
2. Draw it to approximately the desired size *while it is square.*
3. Make it *distinctly eight-sided* by hammering on the corners *after it is drawn* sufficiently.
4. Make it round again by rolling it *slowly* on the anvil and hammering *rapidly* with *light* blows or taps.

An attempt to draw round rods without first going to the square section not only requires a lot of extra work but usually results in a badly distorted and misshaped piece.

Pointing a Rod.—If a round point is desired on a rod, a square tapered point should first be made. It is then easy to make it eight-sided and finally round.

In making a point the rod should not be held flat on the anvil, but the back end should be raised somewhat. Also, the hammering should be

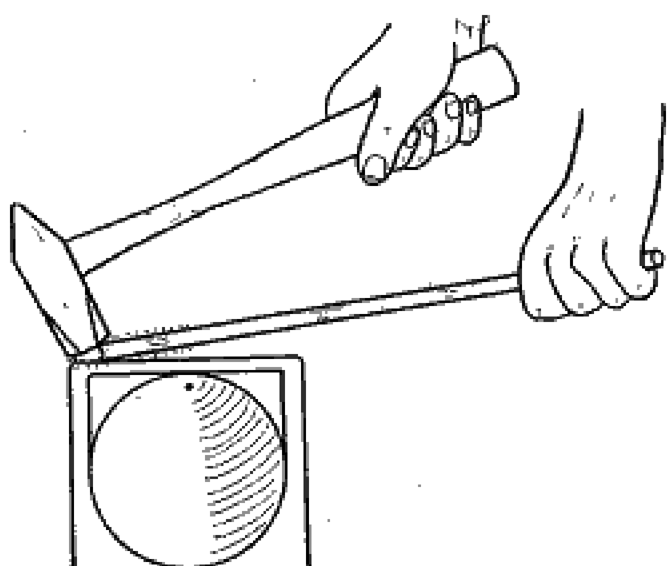

FIG. 256.—In pointing a rod or bar, raise the back end, tilt the toe of the hammer down, and work on the far edge of the anvil. Round points should be made square first, then eight-sided, and finally round.

done with the toe of the hammer lower than the heel, so that the desired angle for the point is formed between the hammer face and the anvil. The hammering should be done on the far edge of the anvil, so that the toe of the hammer will not leave marks in the anvil face.

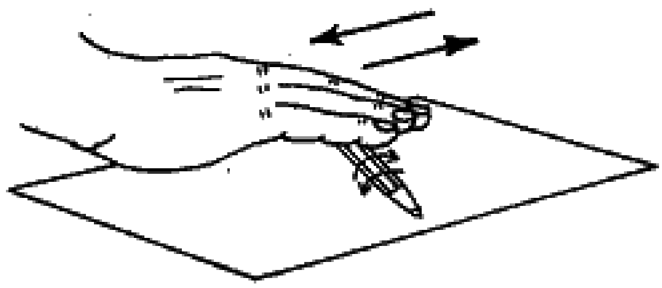

Fig. 257.—Rolling a punch or pointed round rod on a flat surface and watching the point will tell whether it is straight and the point is centered. If the point wobbles, it is off center.

293. Upsetting.—Upsetting is simply the reverse of drawing, or the process of making a piece shorter and thicker. It is done when more metal is needed to give extra strength, as when a hole is to be punched for an eye. There are two main points to be observed in upsetting:

1. Heat the bar or rod to a high red or nearly white heat throughout the section to be upset.
2. Strike *extremely heavy* well-directed blows.

Light blows simply flatten and burr the end instead of upsetting the piece throughout the heated section. The extra-heavy blows needed for upsetting can best be struck by first striking a light blow or two to get the direction of striking and then following with an extra-hard blow.

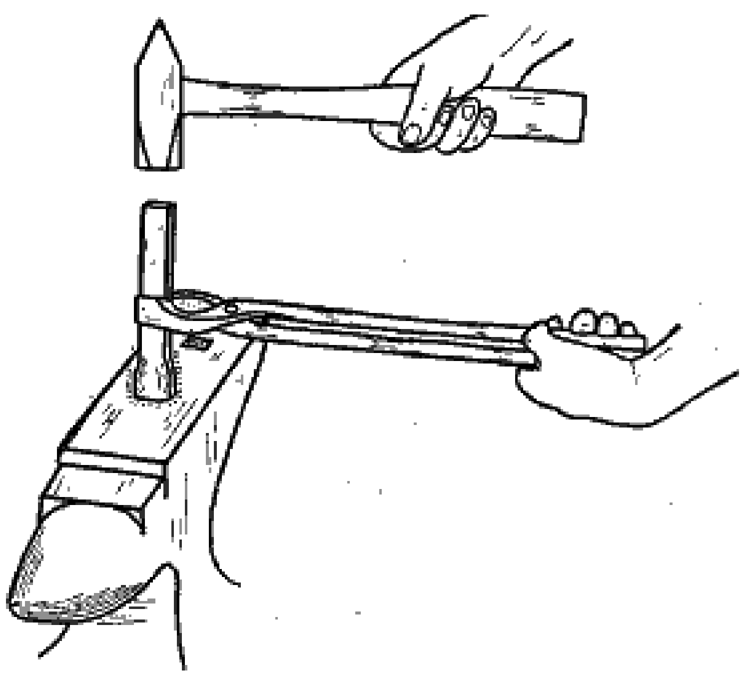

Fig. 258.—To insure success in upsetting, work the iron just under a white heat and strike tremendously heavy blows. Light blows simply flare the end without upsetting very far back from the end.

Probably the best way to upset a short piece is to place the hot end down on the anvil and strike the cold end. The hot end, of course, may be up, but it is usually easier to upset without bending if the hot end is down. If the bar starts to bend it should be straightened at once. Further hammering will simply bend it more instead of upsetting it.

In order to heat thoroughly the part to be upset, and yet confine the heat to this part, it is sometimes better to heat the work somewhat further than the upsetting is to go and then cool it quickly back to the line of upsetting by dipping in the water.

The end of a long bar may be upset by laying it on the anvil face with the hot end projecting beyond the edge, and striking heavy blows endways with the hammer. If the bar is long and heavy enough, it

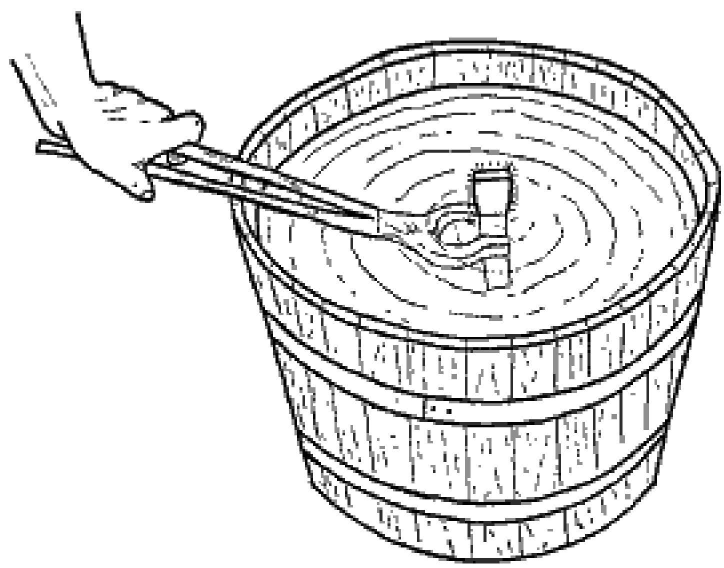

Fig. 259.—When it is desired to heat only a small portion of an iron, as in upsetting only the end of a piece, it is sometimes necessary to heat a larger portion, and then cool back to the desired point by dipping in water.

may be upset easily by ramming the hot end against the face or the side of the anvil.

294. Twisting.—Twisting is really a form of bending. Small pieces may be twisted by heating the section to be twisted to a uniform red heat, clamping a pair of tongs at each end of the section and applying a turning or twisting force. If the piece is too large to be twisted this way (say more than about 1/4 in. thick by 1 in. wide), it may be clamped in a vise and twisted with a pair of tongs or a monkey wrench, the jaws of the vise and the wrench being carefully placed at the ends of the section to be twisted. It is important that the work be done rapidly before the iron cools too much. For a uniform twist, the iron must be at a uniform temperature.

If the twist must be confined to a very definite section of the stock, it is a good plan to place center-punch marks at the ends of the section before the iron is heated.

Care must be exercised in twisting so as not to get the piece out of alignment. If it becomes necessary to straighten the bar after twisting, it may be done by striking with a wooden mallet, rather than a hammer, in order to prevent marring the sharp corners of the twisted part.

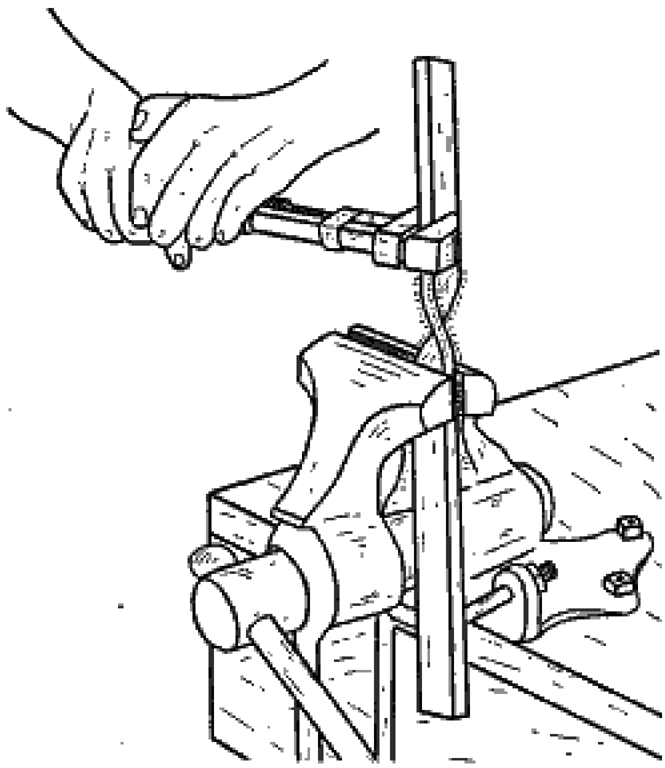

FIG. 260.—Heavy bars may be twisted by heating to a good working heat, clamping in a vise, and twisting with a wrench or pair of tongs.

295. Punching Holes.—It is sometimes easier to punch a hole in a piece of iron than to drill it; and for some purposes a punched hole is better. For instance, in forming an eye on the end of a bar in making a hook or a clevis, punching makes a stronger eye. A small or medium-size hole is first punched and then expanded by driving the tapered punch on further through the hole, first from one side and then the other. Thus less material is wasted than if the hole were drilled, and a stronger eye results.

The steps in punching a hole in hot iron are as follows:

1. Heat the iron to a good working temperature, a high red or nearly white heat.
2. Place the hot iron quickly on the flat face of the anvil—*not over the pritchel hole or hardy hole*. Punching over a hole would stretch and bulge the iron.
3. Carefully place the punch where the hole is to be and drive it straight down into the metal with heavy blows until it is about two-thirds of the way through.
4. Turn the iron over and drive the punch back through from the other side. Reheat the iron and cool the punch if needed. The punch should be carefully located so as to line up with the hole punched on the other side.
5. Just as the punch is about to go through, move the piece over the pritchel hole or hardy hole to allow the small pellet or slug to be punched out.
6. Enlarge the hole to the desired size by driving the punch through the hole first from one side and then the other. Always keep the metal at a good working temperature, reheating as may be necessary.

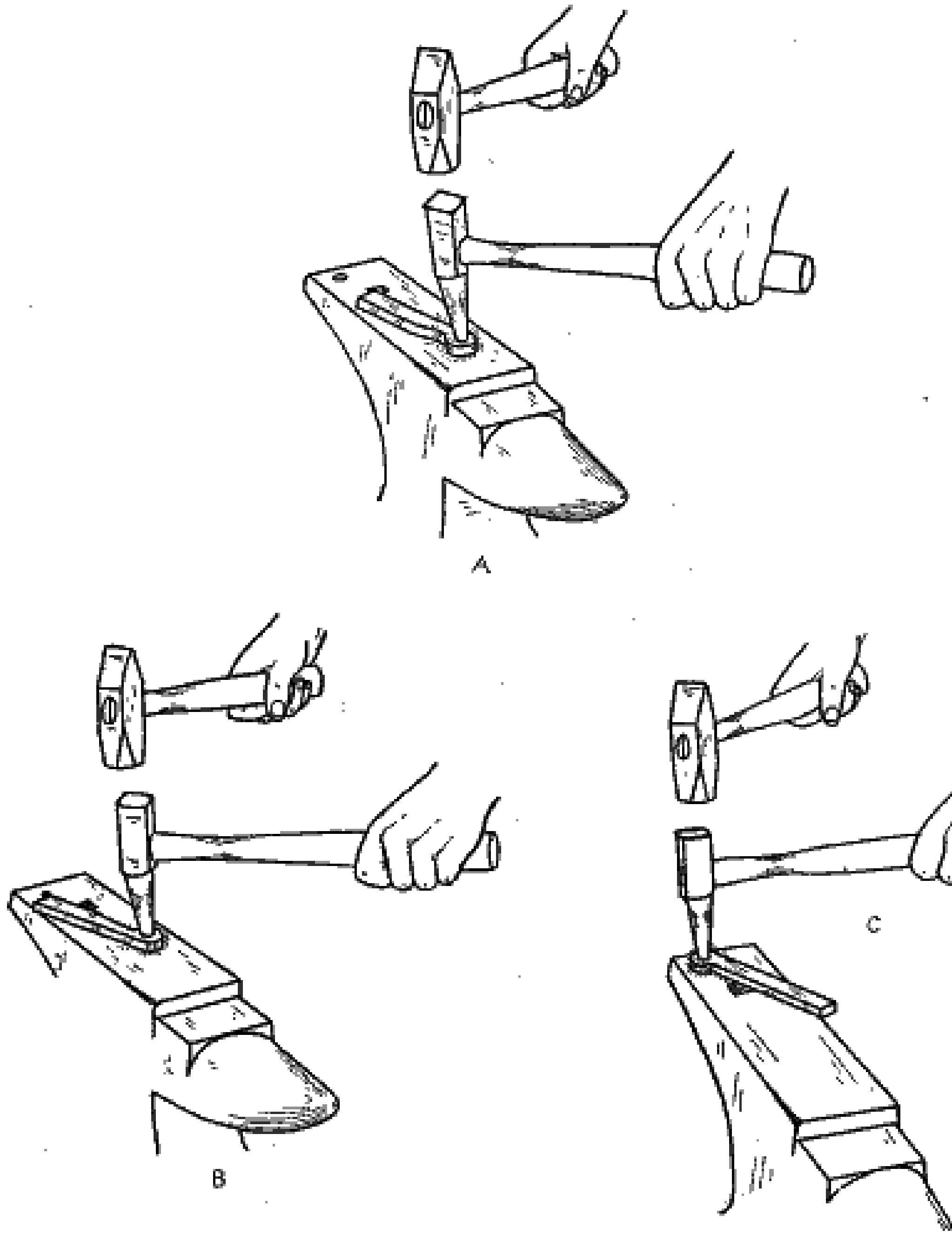

FIG. 261.—In punching holes in hot iron, work it just under a white heat.

A. Carefully locate the punch and drive it about two-thirds of the way through.

B. Then turn the iron over and drive it back through from the other side.

C. Finally move the piece over the pritchel hole or hardy hole to allow the slug or pellet to be driven through.

The end of the punch should be dipped in water frequently to keep it from getting too hot. A little powdered dry coal dropped into the hole will help to keep the punch from sticking.

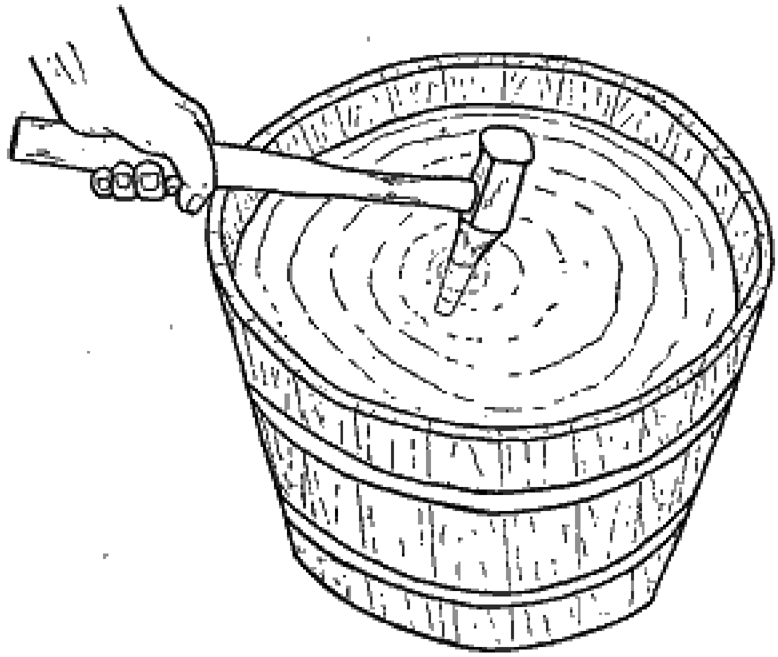

FIG. 262.—In punching hot iron, the punch should be cooled frequently by dipping into water.

Most beginners have difficulty in placing the punch so as to get the hole centered in a bar. If, in placing the punch, it is found to be off center, it may be leaned and twisted slightly until it is in the correct position.

In punching hot iron, it is much better to use a punch with a handle in it, as it is uncomfortable to hold a short punch on a red-hot bar.

296. Forming Punched Eyes.—Usually, although not always, when a hole is to be punched for an eye, as in a chain hook or a clevis, it is best to upset the stock first so as to give more metal and make a stronger eye.

After upsetting, the end is shaped and the corners are rounded before punching. This can best be done by forming a neck or shoulder just back of the eye by hammering over the far edge of the anvil, as shown in Fig. 263*A*. The end is then further shaped and the corners rounded by working over the anvil as suggested in the various other views of Fig. 263. Having the end thus shaped, the hole may be punched in the usual fashion.

In a clevis, the holes are punched with straight sides to fit the clevis pin. For holes in chain hooks, however, it is desirable to have the edges and corners rounded. This can be done by placing the eye at an angle on the end of the horn and making the stock approximately eight-sided and then finally round by rolling slowly while striking light, rapid blows (see Fig. 264).

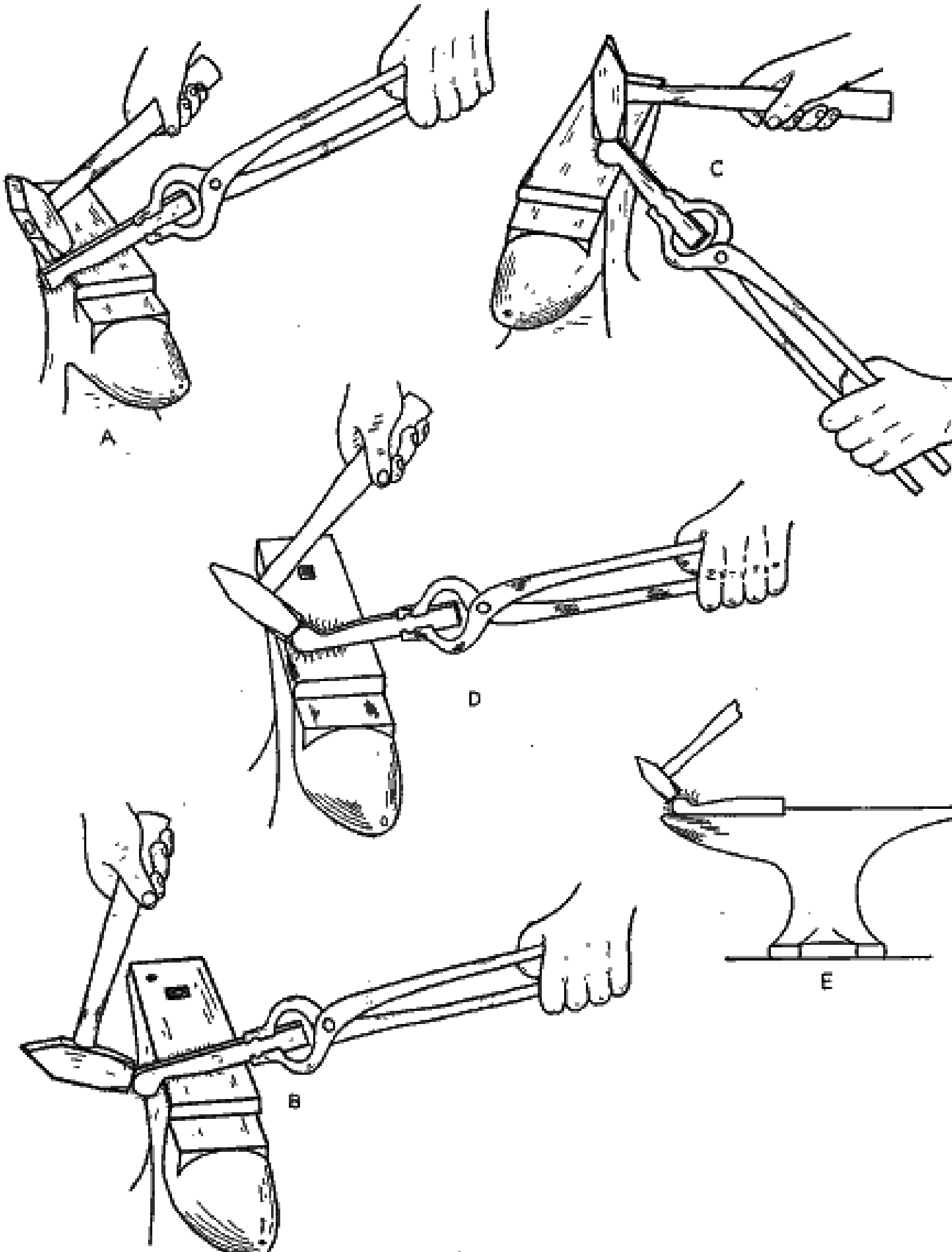

Fig. 263.—Forming a shoulder or neck, preparatory to punching a hole for an eye. The iron is first driven down against a corner of the anvil, as shown at *A*. The end of the piece is then shaped and rounded by working over the corners and the horn of the anvil, as suggested in the various other views.

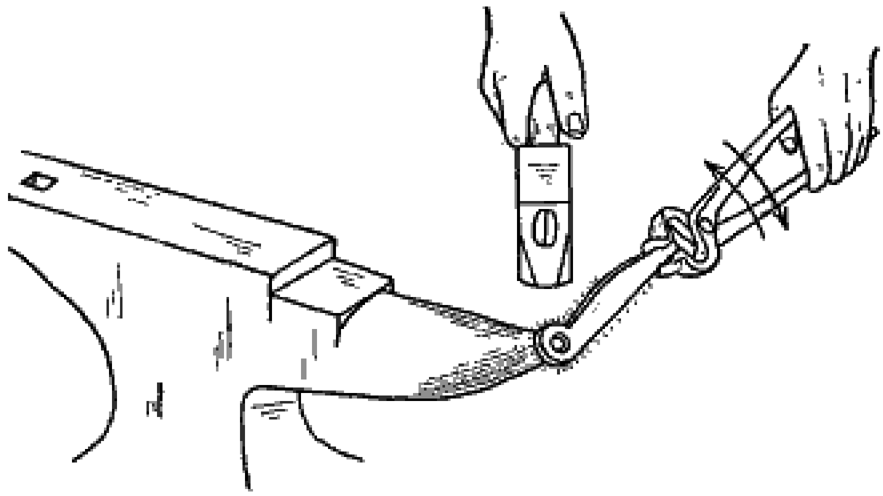

FIG. 264.—Smoothing both the inside and the outside edges of a punched eye. The eye is placed on the horn at an angle and the stock made approximately eight-sided. It is then rounded by rolling it slowly on the horn and striking fast light blows.

297. Cutting with the Hardy.—The blacksmith does most of his cutting of iron and steel on the hardy rather than with a hack saw. Although the hardy does not leave quite so smooth a cut as a saw, it is quite satisfactory for most work. It cuts faster and easier than a saw and is less expensive to use, as there are no blades to wear out or break.

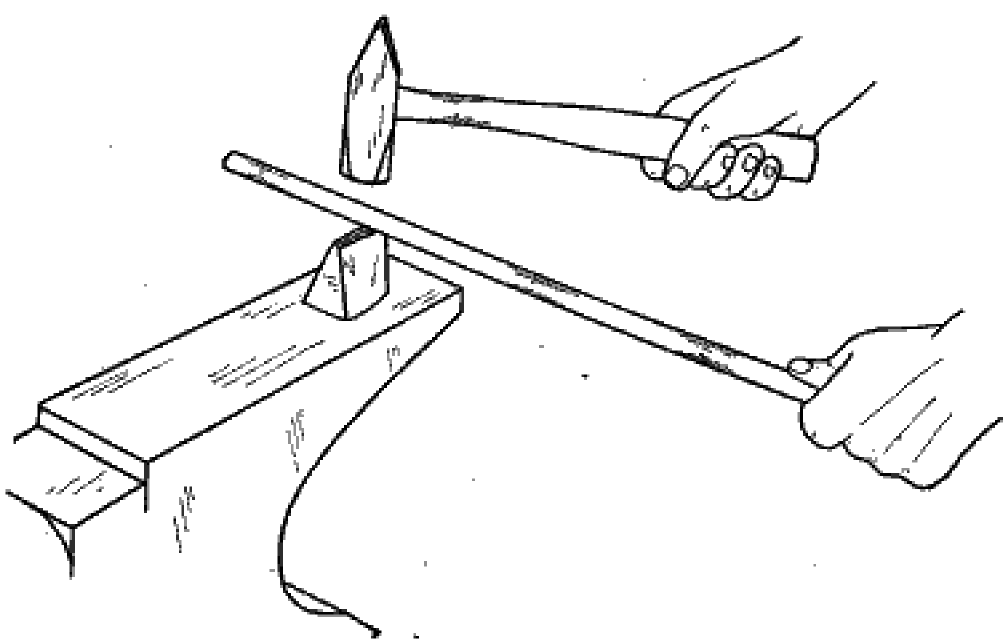

FIG. 265.—Iron may be cut either hot or cold on the hardy. Cold iron may be nicked deeply on two or three sides and broken by bending. In cutting hot iron, cut all the way through from one side, being careful to strike overhanging blows at the last to prevent the hammer from striking the cutting edge.

To use a hardy, the rod or bar to be cut is simply placed on it and hammered down against the sharp edge. Hardies may be used for either hot or cold cutting. Some smiths prefer to keep two hardies, one that is thick and stocky and tempered for cutting cold iron and one that is thin for cutting hot iron. The hardy, like any other cutting tool, works much better if kept sharp. It may be ground like a cold chisel.

In cutting cold iron, the bar may be deeply nicked on two or more sides and then broken off by bending. In cutting hot iron, it is common practice to cut clear through from one side. Care must be taken, of course, not to let the hammer strike the cutting edge of the hardy, or else both the hammer and the hardy may be damaged. In finishing a cut, the last two or three blows should be struck just beyond the cutting edge and not directly over it.

Cutting Tool Steel.—No attempt should be made to cut tool steel in the hardened state. It should always be annealed or softened. To cut it on the hardy, it should be cut hot—not cold—and handled just like other iron or steel.

Where it is important to have a smooth cut, a bar of tool steel may be sawed about a quarter of the way through and then broken by clamping in a vise at the sawing line and hammering (see Art. 212, page 146).

298. Estimating Amount of Stock Required.—To estimate the amount of stock required for bends and curves, estimate the length of the center line. For example, suppose it is desired to know how much will be needed for making a ring of ½-inch round stock and of 3 in. inside diameter. The length needed will be the length of the mid-line, halfway between the inside and the outside edges. Its length is equal to the mid-diameter, 3½ in. times 3.1416, or 11 in.

To determine the length required for pieces of irregular shape, small wire can be bent into the desired shape and then straightened out and measured.

299. Striking with the Hammer.—Success in blacksmithing depends largely upon ability to strike effectively with the hammer. Most blacksmithing requires heavy, well-directed blows. Where light blows are better, however, they should be used.

Light blows are struck mostly with motion from the wrist; while heavier blows require both wrist and elbow action; and very heavy blows require action from the shoulder in addition to wrist and elbow motion.

To direct hammer blows accurately, strike one or two light taps first, to get the proper direction and feel of the hammer, and then follow with quick, sharp blows of appropriate force or strength. It is also important to use a hammer of appropriate size. A heavy hammer on light work is awkward, and blows cannot be accurately placed. And using a light hammer on heavy work is very slow and tedious.

300. Blacking.—After forging a piece of iron it is a good plan to black it by heating it slightly and rubbing with an oily rag. The iron should not be red, yet it should be hot enough to burn the oil off and prevent a greasy appearance. Blacking the piece gives a better appearance and provides some protection against rusting. Tempered tools, of course, should not be blacked in this manner, as heating will draw the temper.

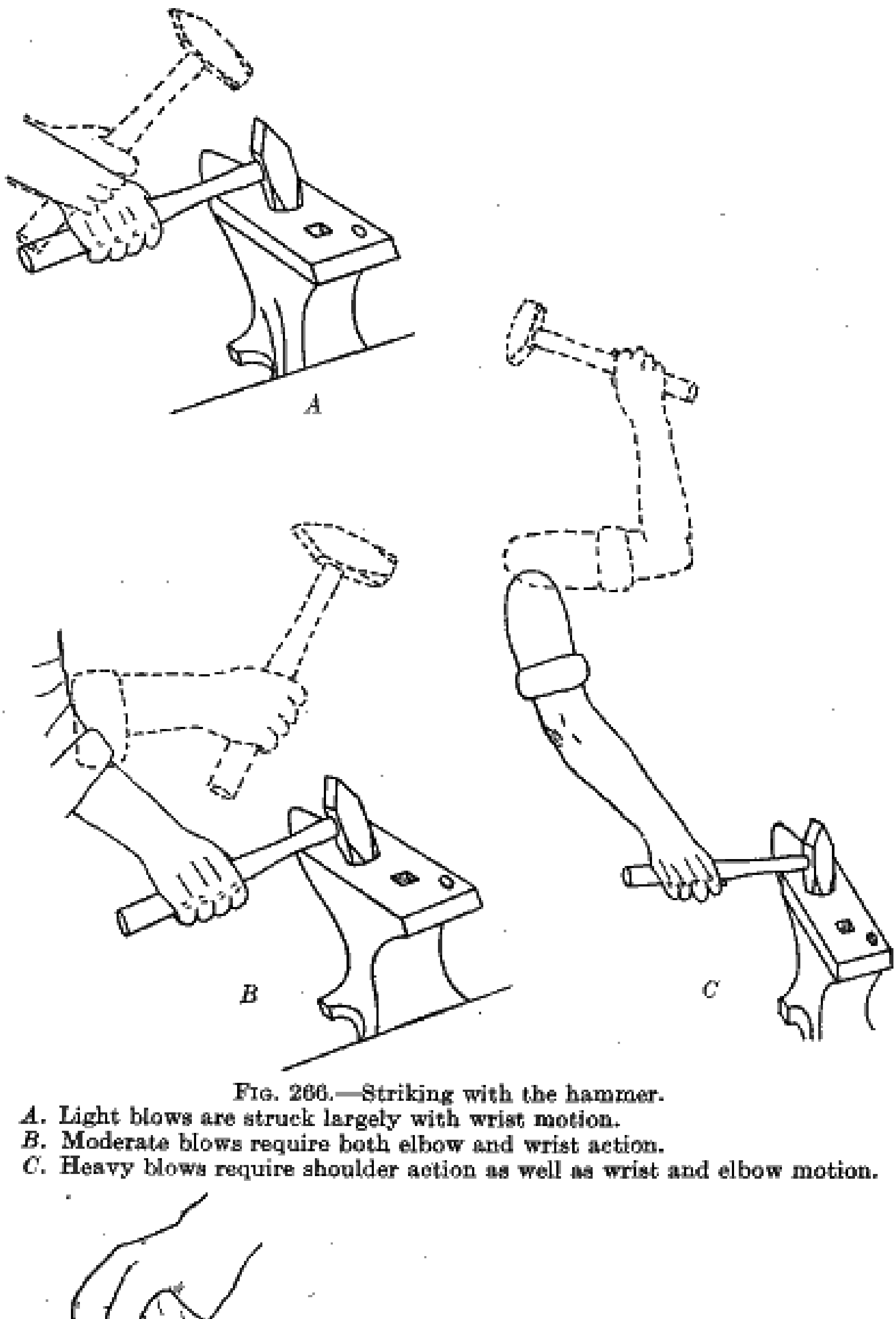

FIG. 266.—Striking with the hammer.
A. Light blows are struck largely with wrist motion.
B. Moderate blows require both elbow and wrist action.
C. Heavy blows require shoulder action as well as wrist and elbow motion.

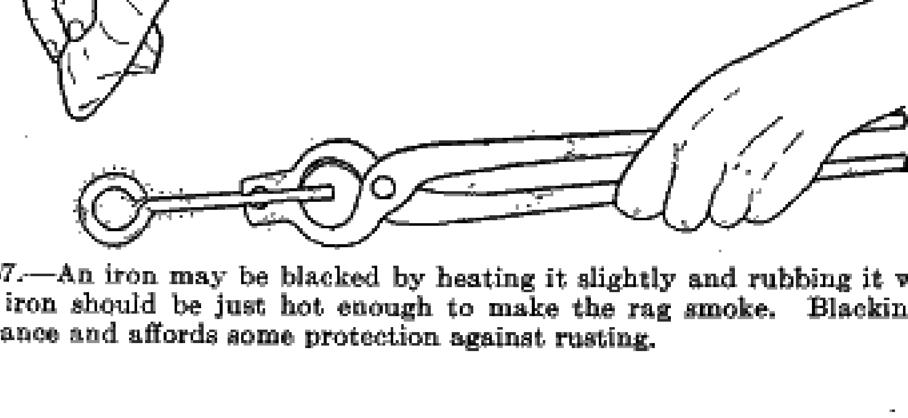

FIG. 267.—An iron may be blacked by heating it slightly and rubbing it with an oily rag. The iron should be just hot enough to make the rag smoke. Blacking improves the appearance and affords some protection against rusting.

Points on Blacksmithing

1. A clean, deep, compact fire is the first requirement for good blacksmithing.
2. Put the irons in the fire in a horizontal position—never point them down into the fire.
3. Use tongs that fit the work. If they do not fit, heat them and reshape the jaws over the piece to be held.
4. Always work the irons at a good forging heat—a bright red or nearly white heat for mild steel.
5. Never allow the irons to get hot enough to sparkle, except in welding, and even then very little.
6. In bending, use bending or leverage blows—not mashing blows.
7. In drawing, strike square, direct blows straight down—not forward-pushing, or glancing blows.
8. In drawing round rods, always make them square first and do the drawing while square. When drawn sufficiently, make them eight-sided and finally round.
9. To smooth up a round rod, roll it *slowly* on the anvil while striking a series of light, quick blows.
10. In pointing rods, work on the far edge of the anvil. Raise the back end of the rod and strike with the toe of the hammer tilted down.
11. In upsetting use a high heat, and strike *extra-heavy* blows.
12. To make a good twist, have the section to be twisted at a uniform temperature.
13. To punch a hole in a hot iron, start in on the flat face of the anvil. Then turn it over and drive the punch back from the other side. Move the iron over a hole in the anvil face for finally driving out the pellet.
14. In cutting on the hardy, be careful not to let the hammer strike the cutting edge.
15. Use the chipping block for cutting with the cold chisel—not the flat face of the anvil.
16. To estimate the amount of stock required for curved pieces, estimate the length of the mid-line.
17. Strike light hammer blows with wrist motion only; medium blows with motion from both the wrist and the elbow; and heavy blows with motion from the shoulder, wrist, and elbow.
18. Blacking a forging gives it a better appearance and provides some protection against rust. To black, simply rub the piece with an oily rag when it is just hot enough to make the rag smoke.

Questions

290. (*a*) What are the main fundamental forging operations? (*b*) Why is it important to master them thoroughly? (*c*) What are the main important points to observe in bending iron at the anvil? (*d*) How may irons be bent without mashing them? (*e*) How may square bends be made without marring or galling the iron? (*f*) How may irons be straightened? (*g*) What procedure would you use for bending flat irons edgeways?

291. (*a*) Explain and be able to demonstrate the procedure for making an eye on the end of a rod. (*b*) If an eye is somewhat oval in shape, how may it best be rounded? (*c*) Why is it important to keep the iron at a high forging heat?

292. (*a*) What is drawing? (*b*) What are the main important points to be observed in drawing? (*c*) When, if ever, should forward pushing blows be used in drawing? (*d*) What difficulties may arise from hammering the iron too cold? (*e*) What are the steps in the process of drawing round rods? (*f*) In making a tapered point, why should the iron not be laid flat on the anvil? (*g*) Why should the hammering be done on the far edge of the anvil face? (*h*) Why should the toe of the hammer be lower than the heel?

293. (*a*) What is upsetting and for what purposes is it done? (*b*) Why should very heavy blows be used in upsetting? (*c*) How may a very high heat be used and yet confined to only the portion to be upset? (*d*) What special ways may be used for upsetting the end of a long heavy bar?

294. (*a*) How may a twist be neatly made in a bar and confined to a definite part of the bar? (*b*) Why is a uniform heat especially desirable for twisting? (*c*) Why is it important to work rapidly in twisting?

295. (*a*) What advantage is there to be gained by punching a hole rather than drilling it? (*b*) Just what procedure should be used in punching a hole? (*c*) Why should the hole be started on the flat face of the anvil rather than over the pritchel hole or hardy hole? (*d*) How may the punch be kept from sticking in the hole? (*e*) How may a punch be maneuvered to get it located exactly in the desired position for punching?

296. (*a*) Just how can a head or shoulder be formed on the end of a bar preparatory to making a punched eye? (*b*) How may the eye for a chain hook have the corners and edges rounded after the hole is punched?

297. (*a*) What advantages does cutting with a hardy have over hacksawing? (*b*) What points should be observed in cutting with a hardy? (*c*) Can tool steel be cut on a hardy? If so, just how?

298. (*a*) How may the amount of stock required for a ring be closely estimated? (*b*) How may the amount of stock required for irregular bends and curves be estimated?

299. (*a*) Explain and be able to demonstrate just how to hold the hammer and strike light blows; also medium blows and heavy blows. (*b*) What difficulties may arise from using a hammer that is too heavy or too light for the work at hand?

300. (*a*) How may irons be blacked after forging? (*b*) How hot should they be for blacking? (*c*) What are the purposes of blacking? (*d*) May tempered tools be blackened in the same manner as ordinary mild steel?

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CHAPTER XX

FORGING AND TEMPERING TOOL STEEL

One of the main advantages of having a forge in the farm shop is to be able to redress and make and temper tools like cold chisels, punches, screw drivers, picks, wrecking bars, etc. Tool steel for making cold chisels and punches and similar tools may be bought from a blacksmith or ordered through a hardware store; or it may be secured from parts of old machines, such as hay rake teeth, pitchfork tines, axles and drive shafts from old automobiles.

301. Nature of Tool Steel.—Tool steel contains more carbon than mild steel, and it is granular, while mild steel is fibrous or stringy (see Art. 328, page 242). The smaller the size of the grains or particles in tool steel, the tougher and stronger it is. When tool steel is heated above a certain temperature, called the *critical temperature*, the grain size increases. (The critical temperature is usually between 1300 and 1600°F., depending upon the carbon content, and for practical purposes is indicated by a dark-red color.) If the steel is heated only slightly above the critical temperature, the fine grain size may be restored by allowing it to cool slowly and then reheating it to just the critical temperature. If the steel is heated to a white heat, however, the grain size will be permanently enlarged and the steel damaged or possibly ruined. If tool steel is hammered with heavy blows while it is just above the critical temperature, the grain size will be made smaller, and the steel thereby refined and improved. It is evident, therefore, that a piece of steel may be improved or damaged or even ruined, depending upon how it is heated and forged.

302. Heating Tool Steel.—Tool steel should be heated slowly and evenly in a good, clean, deep, coke fire. Uneven heating, which is usually caused by heating in poor shallow fire or by too rapid heating, results in unequal expansion, which in turn may cause internal cracks and flaws.

Tool steel should not be heated above a bright-red or low-orange heat, and to this temperature only for heavy hammering. Heating higher is likely to ruin the grain structure. In case a piece of steel is accidentally heated a little too hot, the grain size may be restored by (1) allowing it to cool slowly and then reheating, being careful not to overheat it again, or (2) by heavy hammering at a bright-red or low-orange heat. The damage done by overheating will depend upon the temperature to which it was heated, and upon how carefully it is subsequently heated and handled.

303. Forging Tool Steel.—Since the making of a satisfactory tool depends so largely upon the proper heating and handling of the steel, the following points should be kept in mind when forging with it.

1. Tool steel has a much narrower range of forging temperatures than mild steel. Hammering below a red heat may cause cracking or splitting, while temperatures above a bright red or dark orange may damage the grain structure.
2. Tool steel should always be uniformly heated throughout before it is hammered. Otherwise the outside parts, which are hotter, may stretch away from the inside parts, which are colder, and thus cause internal flaws.
3. Very light hammering should be avoided, even when the steel is well heated, because this may likewise draw the outer surface without affecting the inner parts.
4. As much of the forging as possible should be done by heavy hammering at a bright-red or dark-orange heat—slightly above the critical temperature—as this will make the grain size smaller and thus refine and improve the steel.
5. When a piece is being finished and smoothed by moderate blows, it should not be above a dark-red heat.

304. Annealing Tool Steel.—After a tool has been forged, it is best to anneal it, or soften it, before hardening and tempering. This is to relieve any strains that may have been set up by alternate heating and cooling and by hammering. Annealing is done by heating the tool to a uniform dark-red heat and placing it somewhere out of drafts, as in dry ashes, or lime, and allowing it to cool very slowly. (Copper and brass may be softened by heating to a red heat and plunging quickly into water.)

305. Hardening and Tempering Tool Steel.—If tool steel is heated to a dark red, or the critical temperature, and then quenched (cooled quickly by dipping in water or other solution), it will be made very hard, the degree of hardness depending upon the carbon content of the steel and the rapidity of cooling. The higher the carbon content, the harder it will be; and the more rapid the cooling, the harder it will be.

A tool thus hardened is too hard and brittle and must be tempered, or softened somewhat. This is done by reheating the tool to a certain temperature (always below the hardening temperature) and quickly cooling it again. The amount of softening accomplished will depend upon the temperature to which the tool is reheated. For practical purposes in the farm shop, these temperatures are judged by the color of the oxide or scale on the steel as it is being reheated. A straw color, for example, indicates that the tool has been reheated to a comparatively low temperature, and if quenched on a straw color, it will be rather hard. A blue color, on the other hand, indicates that the tool has been reheated considerably higher, and, if quenched on a blue, it will be softer.

306. Hardening and Tempering a Cold Chisel.—After a cold chisel is forged and annealed, it may be hardened and tempered as follows:

1. Heat the end to a dark red, back 2 or 3 in. from the cutting edge.

2. Cool about half of this heated part by dipping in clean water and moving it about quickly up and down and sideways, until the end is cold enough to hold in the hands.

3. Quickly polish one side of the cutting end by rubbing with emery cloth, a piece of an old grinding wheel, a piece of brick, or an old file.

4. Carefully watch the colors pass toward the cutting end. The first color to pass down will be yellow, followed in turn by straw, brown, purple, dark blue, and light blue.

5. When the dark blue reaches the cutting edge, dip the end quickly into water and move it about rapidly. If much heat is left in the shank above the cutting edge, *cool this part slowly* so as not to harden the shank and make it brittle. This is done by simply dipping only the cutting end and keeping it cool while the heat in the shank above slowly dissipates into the air.

6. When all redness has left the shank, drop the tool into the bucket or tub until it is entirely cool.

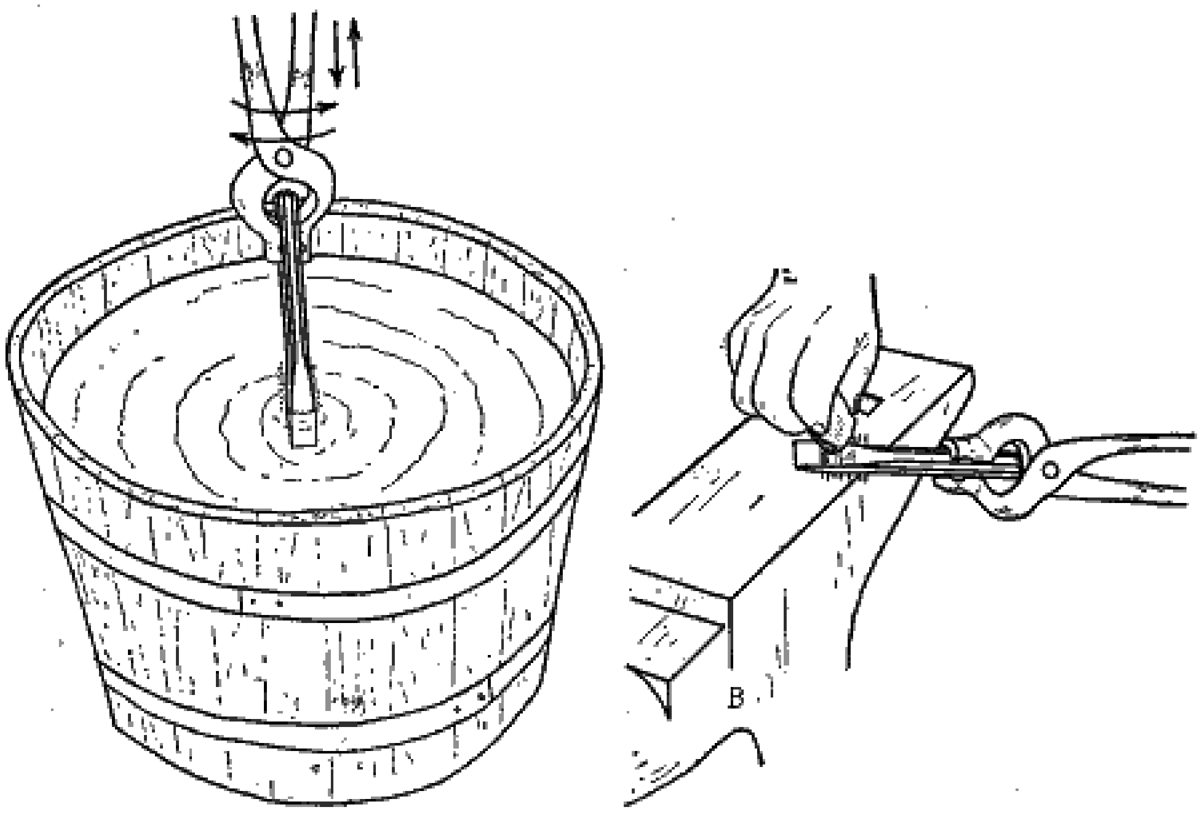

FIG. 268.—Tempering a cold chisel.

A. The end is heated to cherry red back about 3 in. from the cutting edge. Then about half the heated portion is cooled in clean water, moving the tool about rapidly, up and down and sideways, to prevent too sharp demarcation between the hot and cold parts.

B. The end is then quickly polished by vigorous rubbing with emery cloth or other abrasive to enable the colors to be seen as they pass down. When a dark blue appears at the cutting edge, the *end* of the tool—and only the end—is again dipped, working it up and down and around, and keeping it cold while any heat in the shank of the tool is slowly given up to the air.

When the tool is first dipped, it is important that it be moved up and down to prevent the formation of a sharp line between the hardened and unhardened parts, as such a line might cause the tool to break at this point sometime later when in use.

If the colors come down too rapidly, the tool may be dipped into the water and out again quickly to retard their movement. When they move down slowly it is easier to watch them and do a good job of tempering.

Dipping the end at the first of the hardening and tempering process makes it very hard. The heat left up in the shank of the tool, however, gradually moves down to the cutting end and softens it; and when it is softened to the desired degree of hardness, as indicated by the color, the tool is then quickly quenched to prevent any further softening. The various colors are simply indications of different temperatures.

If a tool is tried and found to be too soft, as indicated by denting, it should be retempered and the final quenching made before the colors have gone out quite as far as they did originally—that is, before the end has been softened quite as much. In case a tool proves to be too hard and the edge chips or crumbles, it should be retempered and the colors allowed to go out a little further.

307. Tempering Punches, Screw Drivers, and Similar Tools.—Tools like punches, screw drivers, scratch awls, etc., may be tempered in the same manner as a cold chisel, but may be made harder or softer according to the requirements of the tool. A scratch awl should be made somewhat harder than a cold chisel, a rock drill somewhat harder, a center punch just a little harder, a punch for lining up holes somewhat softer, a screw driver somewhat softer, etc.

Different grades of tool steel will have different degrees of hardness when quenched at the same color. Therefore, it may be necessary to experiment a little with the first piece of a new lot of steel in order to secure the desired degree of hardness.

308. Tempering Knives.—Knives and tools with delicate parts are usually hardened and tempered in a manner slightly different from that used for cold chisels, in order to avoid the danger of overheating and warping and to insure uniform hardening and tempering of the cutting edges.

After a knife is forged, it should be annealed. It is then heated slowly and uniformly to a dark red, or the critical temperature. It is then quickly cooled by dipping edgeways in clean tepid water or oil, *thick edge first*. This method of dipping helps to insure uniform cooling and therefore uniform hardening and freedom from warping. It is then polished and reheated by drawing it back and forth through a flame, or by laying it against a large piece of red hot iron and turning it frequently to insure uniform heating. When the desired color, usually blue, appears, it is again quickly cooled.

Another method of heating knives and similar tools for hardening and tempering is to draw them slowly back and forth inside a pipe in the forge fire. The pipe should first be uniformly heated in a big fire and then turned frequently to keep it uniformly heated on all sides. The knife should not be allowed to touch the pipe.

Points on Forging and Tempering Tool Steel

1. Use a good, clean, deep, coke fire for heating tool steel and heat it slowly and evenly.

2. Heating in a poor shallow fire, or heating too rapidly, is likely to cause uneven heating, which results in unequal expansion, which in turn may cause internal flaws or cracks.

3. Proper hammering of tool steel at the proper temperature refines it, making the grain size smaller.

4. Do not hammer tool steel unless it is at least at a dark-red heat, and heated uniformly clear through.

5. Hammering below a red heat is likely to cause cracking and splitting.

6. Hammering when not heated clear through may cause the outer parts to stretch away from the inner parts and cause internal flaws or cracks.

7. Light hammering should be avoided even when the steel is well heated, because of danger of drawing the outer surface without affecting the inner parts.

8. Never heat tool steel above a bright-red or low-orange heat, and then only for heavy hammering.

9. For moderate hammering, as in finishing and smoothing a job, do not heat above a dark red.

10. Tool steel is ruined if it gets white hot.

11. In case tool steel is accidently overheated somewhat, allow it to cool slowly and then reheat, being careful not to overheat it again; or heat it to a bright-red or low-orange heat and forge by heavy hammering to restore the fine grain size.

12. After a tool is forged, it should be annealed by heating to a uniform low red and placing it in dry ashes or similar material to cool slowly.

13. In quenching a tool like a cold chisel, move it about rapidly—up and down and around—to prevent a sharp line of demarcation between the hot and cold parts.

14. Tempering colors should move slowly so they may be easily seen. If they move too fast, dip the tool quickly into water for an instant.

15. In the final quenching of a tool like a cold chisel, cool the end quickly but dissipate any heat left in the shank very slowly. Otherwise the shank may be hard and brittle.

16. In case a tool is found to be too hard, retemper it and allow the temper colors to go out a little further before final quenching.

17. In case the tool is too soft, quench before the colors go so far.

Questions

301. (*a*) What materials may usually be obtained about the farm for making tools like cold chisels, punches, and screw drivers? (*b*) What are the chief differences, in chemical composition and physical properties, between tool steel and mild steel? (*c*) What is the critical temperature of tool steel? (*d*) How may the smith recognize it? (*e*) How may tool steel be so hammered as to refine it?

302. (*a*) Why should tool steel not be heated too rapidly? (*b*) What is the highest safe forging heat for tool steel? (*c*) What trouble will occur if tool steel is overheated? (*d*) What should be done in case tool steel is accidentally overheated?

303. (*a*) What troubles may develop from hammering tool steel below a red heat? (*b*) What trouble may develop from hammering when it is not uniformly heated throughout, or from hammering with very light blows? (*c*) What is the best heat for heavy hammering of tool steel? For moderate or finish hammering?

304. (*a*) What is annealing? (*b*) Why should a piece of tool steel be annealed after it is forged? (*c*) Just what is the procedure for annealing?

305. (*a*) How may tool steel be hardened? (*b*) What determines the degree of hardness to which a piece of tool steel may be hardened? (*c*) What is tempering? (*d*) How may tool steel be tempered?

306. (*a*) Explain and be able to demonstrate the process of hardening and tempering a cold chisel. (*b*) Name the colors in the order in which they appear at the end of the chisel. (*c*) Why is it important that the end of the chisel be moved about rapidly in the water at the first quenching? (*d*) Why is it important that only the cutting end be cooled quickly at the second quenching, and that the shank be cooled slowly? (*e*) Why is it desirable to have the colors move down slowly? (*f*) What would you recommend, if upon trial it is found that a cold chisel has been tempered too hard? If too soft?

307. (*a*) In what respects are tools, like punches, scratch awls, and screw drivers, tempered differently from cold chisels? (*b*) How should the hardness of the following tools compare with that of a cold chisel? Scratch awl? Screw driver? Rock drill? Center punch?

308. (*a*) Why are knives and similar tools not hardened and tempered in the same manner as cold chisels? (*b*) Outline, step by step, a good method of hardening and tempering a knife. (*c*) In quenching a knife, which part is immersed first? Why?

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CHAPTER XXI

WELDING; PLOW SHARPENING; KINDS OF IRON AND STEEL

WELDING

309. The Welding Fire.—A good fire is the first requirement for welding. It is important for any blacksmithing work, but for welding it is indispensable.

The fire must be *clean*, that is, free from clinkers, brass, babbitt, etc., as such impurities tend to make the irons slippery instead of sticky at the welding temperature. Lots of good coke is needed, as fresh coal not only makes a smoky fire but may also introduce some sulphur, which will make welding difficult, if not impossible.

The fire should be *deep*, with at least 4 in. of burning coke below the irons. There should also be burning coke on both sides and above the irons. Thus enough heat can be provided for thorough heating of the irons before the fire burns down.

The fire should be *compact* and well banked with dampened coal so as to confine and concentrate the heat and to prevent too much air from going through the fire and causing the irons to oxidize or scale unduly.

The fire should be thoroughly cleaned about every half hour while welding.

310. Scarfing the Irons.—Ends to be welded together should first be properly shaped or scarfed. Scarfed ends should be short, usually not over 1½ times the thickness of the stock; and they should have rounded or convex surfaces, so that when they come together any slag or impurities will be squeezed out rather than trapped in the weld. Long, thin, tapering scarfs are to be avoided because they are easily burnt in the fire and because they cool and lose their welding heat very rapidly when removed from the fire, thus making welding exceedingly difficult.

In order to counteract the wasting away of the irons by scaling and the tendency to draw out from hammering when they are welded, the ends are commonly upset before scarfing. Scarfs on the ends of bars are made by working on the far edge of the anvil, striking backing-up or semi-upsetting blows with the toe of the hammer lower than the heel. (See Art. 314, page 235, for instructions on the link scarf.)

311. Welding Flux.—Borax or clean sand, or a mixture of the two, may be used as a welding flux. Commercial welding flux, however, such as may be bought from hardware stores, is usually more satisfactory; and since but a little is needed, it is probably best to buy a small package for the farm shop.

Flux is applied to the pieces to be welded after they are at a red or white heat and just before the welding heat is to be taken. It covers the irons and causes the oxide to melt at a lower temperature. The oxide must be melted before the irons can be welded.

Flux is not needed in welding wrought iron, as it may be heated above the melting temperature of the oxide without danger of burning. Although it is possible to weld mild steel without flux, it is much easier to do a good job with it. Tool steel cannot be welded without flux.

312. Heating the Irons.—The irons should be heated slowly at first, so they will heat thoroughly and uniformly throughout. The irons should be turned over once or twice during the heating to insure equal heating of all sides and parts.

After the irons reach a bright-red heat, remove them and dip the scarfed ends into flux, or sprinkle the flux on them with the fingers. Replace the irons in the fire and continue to heat, being careful not to brush the flux off the irons before it melts. Pull a few lumps of coke on top of the irons and raise the coke occasionally with the poker to see how the heating is progressing.

Care must be taken to see that both irons reach the welding heat at the same time. If one heats faster, pull it back into the edge of the fire for a few seconds. During the last part of the heating, have the scarfed sides of the irons down so they will be fully as hot as the other parts of the pieces.

313. The Welding Heat.—When the irons reach the welding temperature, they will be a brilliant, dazzling white; their surfaces will appear molten, much like a melting snowball; and a few explosive sparks will be given off. When the sparks start to come from the fire a little more violently, it is time to remove them and weld them together.

314. Welding a Link or Ring.—To make a link or ring, the stock is first heated and bent into a horseshoe or U-shape. The ends are then scarfed

FIG. 269.—Steps in making a link.

by placing on the anvil, with one end diagonally across the shoulder between the anvil face and the chipping block, and with the other end against the vertical side of the anvil. A series of three or four medium or light blows are struck on the end on the shoulder, swinging the tongs a little between each blow. In this manner the end of the U is given a short, blunt, angling taper with a slightly roughened surface. The piece is then turned over and the other end scarfed in the same manner. The scarfs may be finished by striking lightly with the cross peen of the hammer.

The legs of the U are next bent over the horn, lapped together, and hammered shut. It is important that the link or ring be somewhat egg-shaped at this stage—not round. The ends should cross each other at an angle of about 90 deg. This insures plenty of material at the joint for finishing the link and prevents a thin, weak section at the weld.

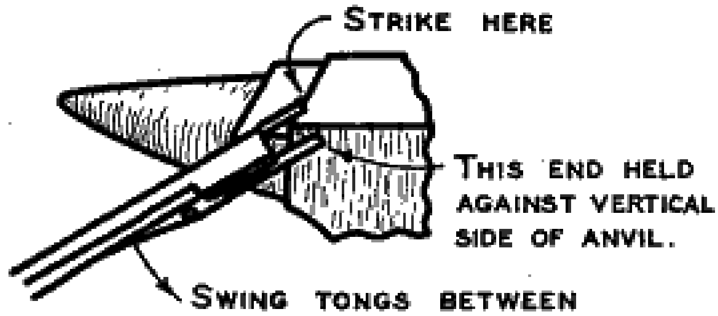

FIG. 270.—A good method of scarfing links.

The link is then placed in a good welding fire and heated, flux being applied after a red heat is reached. The link may need to be turned over in the fire a time or two in order to insure even heating.

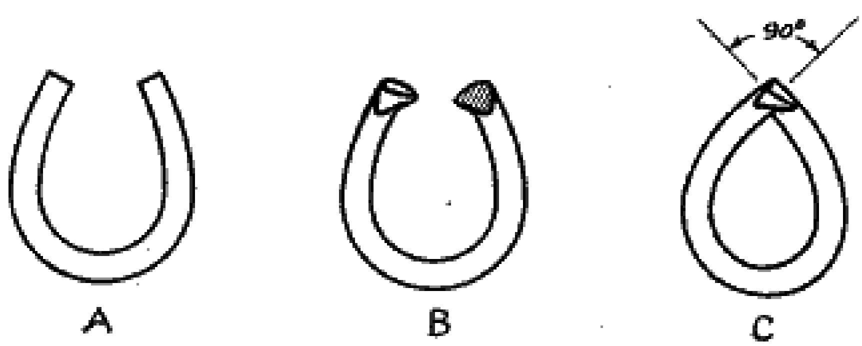

FIG. 271.—Steps in making a ring.
A. Bend to horseshoe shape.
B. Scarf same as chain link.
C. Bend egg-shaped and weld.

When the welding heat is reached, the work is quickly removed from the fire, given a quick rap over the anvil to shake off any slag or impurities, and then put in place on the face of the anvil and the ends hammered together. The link is struck two or three quick, *medium* blows on one side, then turned over and struck on the other side.

Medium blows are used because the iron at welding heat is soft, and heavy blows would mash it out of shape. Forcing the parts firmly together is all that is required. It is essential to work fast before the iron loses the welding heat. A second or even a third welding heat may be taken if necessary to completely weld the ends down.

After the ends are welded together, the link is finished by rolling it slowly on the horn (by twisting or swinging the tongs back and forth) while hammering rapidly with light blows. In case of a large ring, the weld can best be finished by making the stock square, then eight-sided and finally round as in drawing round rods.

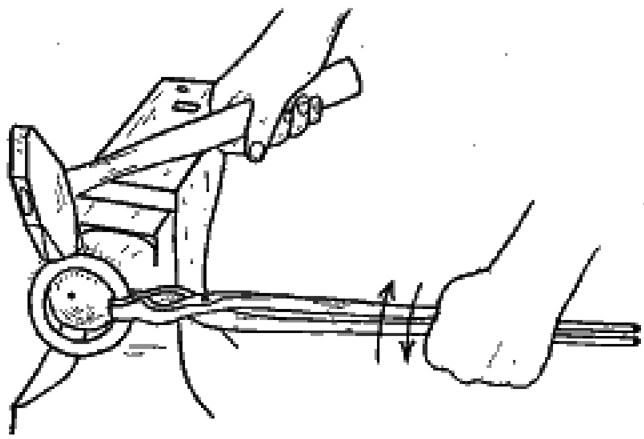

FIG. 272.—The weld on a link or ring should be finished by rolling it slowly on the horn while hammering with a series of rapid, light blows. Large rings may be finished by making the stock square, then eight-sided, and finally round.

315. Welding Rods or Bars.—To weld rods or bars, it is best to upset the ends somewhat before scarfing. The scarfs should be short and thick and with rounded convex surfaces (see Fig. 273). The irons are fluxed and brought up to the welding heat in the usual manner. When they reach the welding heat, they are removed from the fire, struck quickly over the edge of the anvil to shake off any slag or impurities, put in place on the anvil and hammered together first on one side and then the other with

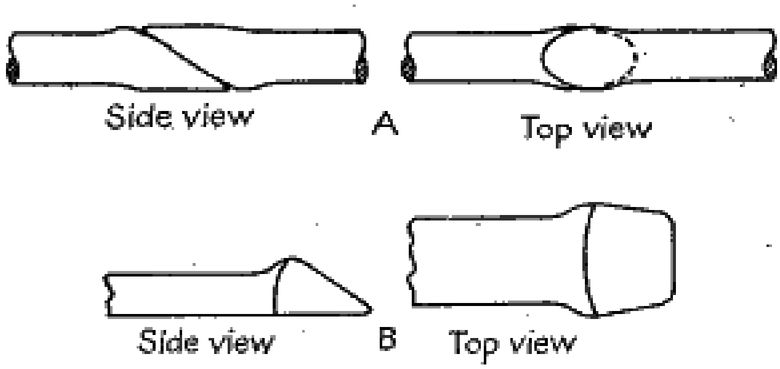

FIG. 273.—*A*. Round rods upset, scarfed, and in position for welding. *B*. Flat bar upset and scarfed for welding.

light or medium blows, followed by heavier ones. After the first blow or two to stick the irons, the ends of the scarfs should be welded down next because they are thin and lose their welding temperature rapidly.

Getting Irons in Place on Anvil.—The irons are put in place on the anvil face with the scarfed surfaces together, and with *the left-hand piece on top.* The pieces can thus be held together with only one hand, leaving the right hand free to use the hammer. Steadying the pieces over the edges of the anvil will help get them accurately and quickly placed together (see Fig. 275).

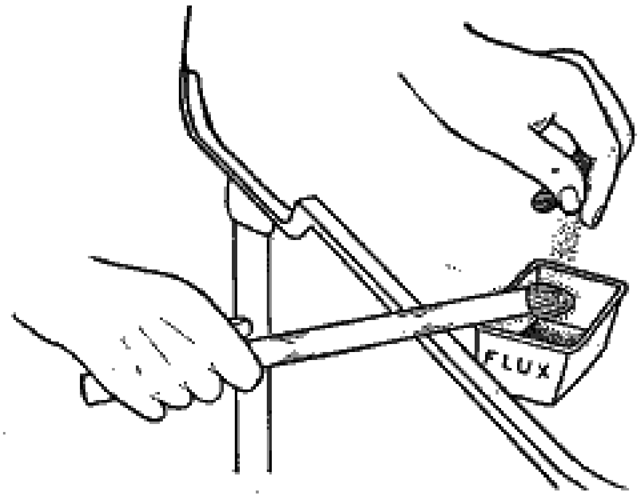

FIG. 274.—Apply welding flux with irons at a red heat, and just before the welding heat is taken.

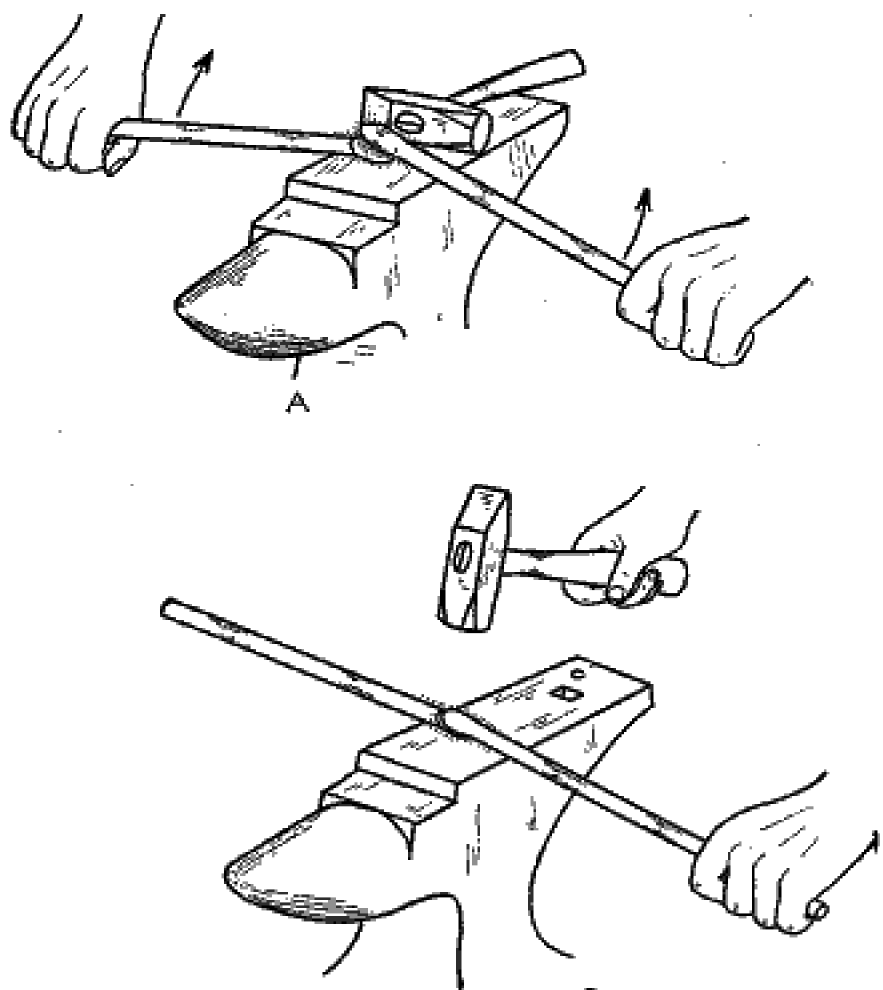

FIG. 275.—Placing irons together and welding. Steady the irons over the edges of the anvil, the one in the left hand being on top, as at *A*. Gradually raise the hands until the iron in the left hand holds the other one against the anvil, as at *B*, while the right hand strikes with the hammer.

It is a good plan for the beginner to practice bringing the irons out of the fire and placing them together a few times before taking the welding heat. Pieces that are long enough to be held in the hands without tongs are more easily handled than short pieces.

Finishing the Weld.—If it is not possible to get all parts welded down at the first heat, then flux is reapplied and another heat taken. Once the pieces are stuck well enough to hold together, however, they are much more easily handled. In welding small pieces, it is frequently necessary to take two extra heats, one on each side of the irons. In taking an extra heat to weld down a lap, the lap should be on the underside in the fire just before removing. This insures thorough heating.

After the weld is completed in a round rod, the welded section should then be smoothed and brought to size by first making the section square, as in drawing round rods, and keeping it square until drawn down to size. It is then finished by making it eight-sided, and finally round by rolling it slowly on the anvil while striking a series of light, rapid blows.

316. In Case of Failure.—If the irons do not stick at the first attempt, do not continue hammering but reshape the scarfs and try again, being sure that the fire is clean and that it is deep and compact. Irons will not stick if there is clinker in the fire, or if it has burnt low and hollow. Be sure, also, that the irons are brought well up to the welding temperature. It is generally not possible to make irons stick after two or three unsuccessful attempts because they will most likely be burnt somewhat, and burnt irons are difficult or impossible to weld. In such cases the ends should be cut off and rescarfed.

317. Welding an Eyebolt.—To make a welded eyebolt, a short, blunt, square-pointed scarf is made as shown in Fig. 276. The welding heat is

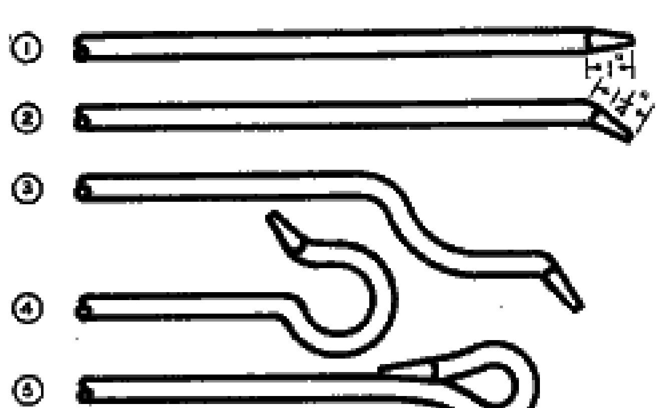

FIG. 276.—Steps in scarfing and preparing to weld an eye on the end of a rod.

taken in the usual manner, having the scarfed end down in the fire just before removing and hammering. By doing the hammering over the horn instead of the flat surface of the anvil, there will be less danger of marring and drawing the stem of the bolt next to the eye and thus making it weak at this point.

Points on Welding

1. Use a clean, deep, compact coke fire.
2. Clean the fire every half hour.
3. Make the scarfs short and thick, rather than long and thin. Scarfs should not be longer than $1\frac{1}{2}$ times the thickness of the stock.
4. Round the surfaces of scarfs so slag will be squeezed out rather than trapped in the weld.
5. Heat the irons to a good welding heat, yet do not burn them.
6. Bring both irons up to the welding heat at the same time.
7. Have the scarfed sides of the irons down in the fire just before removing them.
8. Before welding the irons together, shake off any slag or impurities by quickly rapping the tongs against the edge of the anvil.
9. Steadying the pieces over the edges of the anvil will help get them accurately and quickly placed.
10. Strike light or medium blows when irons are at the welding heat. Simply forcing the parts together is all that is necessary. Heavy blows mash the irons.
11. Work fast; keep the hammer on the anvil within easy reach.
12. In case of failure to stick, do not continue hammering. Reflux and try again, being sure the fire is in good shape, and that you heat the irons hot enough.

PLOW SHARPENING

318. Drawing and Shaping Steel Shares.—Steel plowshares are sharpened by heating and drawing the edge. The share should be placed in the fire so that only the portion to be drawn is heated. This is best done by placing the share flat with the edge over the center of the fire, and by banking up under the share with green coal. The share should not be placed in a vertical position with the edge down.

The share should be hammered on top, beginning at the point and working back toward the heel, heating and hammering only a small section at a time. The share should not be heated above a cherry red, and care should be exercised not to dent the top side of the share with hammer marks any more than necessary.

It is important in sharpening a share to get the point shaped so that it will have the proper suction. It should slope downward until the tip end is about $\frac{1}{4}$ to $\frac{3}{8}$ in. below the lower edge of the landside. The point should also be bent out toward the land slightly, usually about $\frac{1}{8}$ to $\frac{1}{4}$ in., to give the plow what is known as *land suction*. In case of a walking plow, the outer corner or wing of the share should have a small flat surface that bears on the ground and helps to support the outer side of the plow. Sulky or tractor plowshares require little or no such wing bearing.

319. Hardening the Share.—A soft-center steel share may be hardened by heating about 2 in. along the cutting edge to a dull red and then dipping it in water, cutting edge straight down. Some smiths heat the whole share to a dull red before dipping.

Solid crucible-steel shares should be hardened very little if at all. There is danger of breaking during hardening. Also, it is easy to get them too hard and brittle, which may result in breakage in use.

320. Sharpening Chilled Shares.—Chilled iron shares cannot be forged. They must be sharpened by grinding or chipping on the top side. Chilled iron shares are comparatively cheap and are commonly discarded after they are sharpened once or twice.

321. Sharpening Harrow Teeth.—Spike-tooth harrow teeth that have sharp points and sharp square edges are much more effective than teeth that have become blunt and rounded from long use. Harrow teeth are easily sharpened by forging at a cherry-red heat.

They will stay sharp longer if hardened by heating the points back from 1 to 3 in. to a dull red and dipping in water. There is some danger, however, of making them so hard and brittle that they may break in use.

KINDS OF IRON AND STEEL

There are many different kinds and grades of iron and steel used in implements and other farm equipment. To be better enabled to repair such equipment, a mechanic should know something about the different kinds of iron and steel and their properties and uses.

322. Pig Iron.—The first step in the manufacture of iron and steel is to extract the iron from the iron ore, which is mined in various parts of the world. This is done by means of the modern blast furnace. The molten iron accumulates at the bottom of the furnace and is drawn off into sand molds and allowed to cool and form short, thick bars known as *pig iron*. Pig iron is then used as the source from which other kinds of iron and steel are made.

323. Cast Iron.—To make castings, the pig iron is remelted, together with small amounts of scrap iron, and poured into molds of the desired shape and then allowed to solidify. Cast iron is used extensively because it is cheap and can be readily molded into complicated shapes. It is hard and brittle and cannot be bent. It cannot be forged or welded in the forge fire, but it can be welded with the oxyacetylene torch. It crumbles when it is heated to a bright red or white heat. It can be drilled and sawed easily and also filed easily after the hard outer shell is removed. The quality of cast iron can be controlled by varying the amounts of scrap iron and steel mixed with pig iron when it is melted.

324. Chilled Iron.—Chilled iron is cast iron that has been made in special molds, sometimes water-cooled molds, that cool the outer portions of the casting rapidly, thus making the surface of the casting very hard and wear resistant. Chilled iron is used for bearings on certain farm machines and for shares and moldboards of plows that are to be used in gravelly or stony soils.

325. Malleable Iron.—Malleable iron is cast iron of special composition that has been treated, after casting, by heating for a long period. This prolonged heating removes some of the carbon from the surface of the casting and reduces its brittleness. Malleable castings are softer and tougher than plain castings and can be bent a certain amount without breaking. They are also more shock resistant.

326. Wrought Iron.—Wrought iron is practically pure iron with only very small amounts of carbon or impurities. It is made by removing the carbon and impurities from pig iron. The best grade of wrought iron comes from Norway and Sweden where the purest iron ores are mined. Wrought iron was formerly used extensively by blacksmiths, but, because of its high price, its use at present is quite limited. Wrought iron has about 0.04 per cent carbon.

327. Mild Steel.—Mild steel, also known variously as *machine steel, low-carbon steel, soft steel,* and *blacksmith iron*, is the common material used by blacksmiths. It is made by removing practically, but not quite, all the carbon from pig iron. To remove it all would be much more expensive. It contains from about 0.1 to 0.3 per cent carbon, not enough to enable it to be hardened to any appreciable extent by heating and quenching in water. It can be bent and hammered cold to some extent and can be forged and welded in the forge. It is a little more difficult to weld than wrought iron.

328. Tool Steel.—Tool steel is made from pig iron by first removing all the carbon and practically all the impurities and then adding a definite, known amount of carbon. Tool steel contains from about 0.5 to about 1.5 per cent carbon. It is granular in structure instead of fibrous or stringy. It must not be heated higher than a bright-red or low-orange heat, or it will become honeycombed and therefore weak and brittle. The higher the percentage of carbon the harder the steel may be tempered, and the more difficult it is to weld. Blacksmiths' tools, such as hammers and cold chisels, are commonly made of steel having from 0.5 to 0.9 per cent carbon. Taps and dies and such tools are made of steel having 1 to 1.25 per cent carbon. The carbon content of iron and steel is designated by points, one point being one-hundredth of 1 per cent of carbon. Thus a 50-point carbon steel contains $^{50}/_{100}$ or one-half of 1 per cent of carbon.

329. Distinguishing between Grades of Steel.—A good way to distinguish between the various grades of steel is to grind them on a grinding wheel and note the sparks that are given off. Sparks from wrought iron are light yellow or red and follow straight lines. Sparks from mild steel are similar but more explosive or sprangled. Tool steel gives off sparks that are lighter in color and still more explosive. The higher the percentage of carbon in steel the brighter and more explosive are the sparks.

330. Soft-center steel consists of a layer of mild steel welded between two layers of high-carbon steel. The outside surfaces can therefore be hardened, while the center remains comparatively soft and tough. It is used in moldboards of plows and in cultivator shovels where it is desired to have a very hard outer wearing surface combined with toughness and strength.

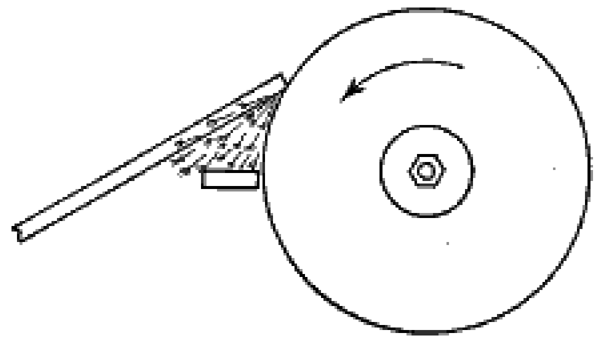

FIG. 277.—Different grades of iron and steel may be distinguished by the sparks produced when ground on a grinding wheel. The higher the carbon content of the steel, the brighter and more explosive are the sparks.

331. Alloy Steels.—Small amounts of one or more other metals, such as tungsten, nickel, chromium, silicon, vanadium, etc., are commonly mixed with steel to form alloy steels. These metals are used in steel to give certain desirable properties, such as great strength, resistance to corrosion, toughness, and resistance to shock.

Questions

309. (*a*) Why should the welding fire be deep, clean, and compact? (*b*) How often should the fire be cleaned when welding?

310. (*a*) What is meant by scarfing? (*b*) What are the characteristics of a good scarf? (*c*) Why are long thin pieces hard to weld? (*d*) Why are irons usually upset before scarfing?

311. (*a*) What materials may be used for welding flux? (*b*) When and how is it applied? (*c*) Just how does a flux assist in welding? (*d*) What kinds of iron and steel, if any, may be welded without flux?

312. (*a*) What precautions should be observed in heating irons for welding? (*b*) What should be done in case one iron heats faster than the other? (*c*) Why should the scarfs be down instead of up just before the irons are removed from the fire for welding?

313. How may the welding heat be recognized?

314. (*a*) Outline the process of making a welded chain link or a ring. (*b*) What is the general shape of the link scarf? (*c*) Why is it important to have the ends lapped at about 90 deg. when they are being welded? (*d*) Why is the link given a sharp rap over the edge of the anvil just after it is taken from the fire and before the ends are welded together? (*e*) Why should the weld be started with only medium and not heavy blows? (*f*) How may the welded part of a link or a ring be neatly and smoothly finished?

315. (*a*) Explain and be able to demonstrate how to quickly take two irons out of the fire and place them accurately on the anvil for welding. (*b*) Should the thin edges of the scarfs be welded down first or last or at some other time? Why? (*c*) After a weld is completed in a round rod, just how should the welded section be neatly smoothed and brought to size?

316. (*a*) What are common causes of failure in welding? (*b*) What procedure would you recommend in case irons do not stick at the first attempt to weld? At the second or third attempt?

317. (*a*) Just how would you proceed to make a welded eyebolt? (*b*) How may the work be done to prevent marring and drawing the stem next to the eye?

318. (*a*) Just how should a steel plowshare be placed in the fire for heating? (*b*) How much of the share should be heated at a time? (*c*) What is the proper forging heat for steel plowshares? (*d*) Should the share be hammered on the top or on the bottom side? (*e*) What important points should be observed in shaping the share?

319. (*a*) How may plowshares be hardened? (*b*) What kind of shares should be hardened very little if at all? Why?

320. How are chilled iron shares sharpened?

321. (*a*) How are spike-tooth harrow teeth sharpened? (*b*) Should they be hardened? If so, how?

322. (*a*) What is pig iron? (*b*) How is it made? (*c*) For what is it used?

323. (*a*) How are castings made? (*b*) What are some of the important properties or characteristics of cast iron?

324. (*a*) What is chilled iron, and how is it made? (*b*) What are the main uses of chilled iron in farm machines?

325. (*a*) What special property does malleable iron have? (*b*) How are malleable castings made?

326. (*a*) What is wrought iron? (*b*) How is it made?

327. (*a*) How is mild steel made? (*b*) By what other names is mild steel commonly known? (*c*) What are its important properties or characteristics?

328. (*a*) How is tool steel made? (*b*) What are the chief differences between tool steel and mild steel? (*c*) How is the amount of carbon in tool steel commonly designated? (*d*) How much carbon is contained in steel used for making blacksmithing tools like hammers and cold chisels?

329. Just how may one distinguish between the various grades of steel?

330. (*a*) What is soft-center steel, and how is it made? (*b*) What are its particular advantages over other kinds of steel? (*c*) In what parts of farm machines is it commonly used?

331. (*a*) What is an alloy steel? (*b*) What materials or metals are commonly used in making alloy steels? (*c*) In what respects may allow steels be better than plain steels?

References

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PART VII

CHAPTER XXII

FARM CONCRETE WORK[1]

Concrete is an ideal material for foundation walls, floors, walks, steps, water tanks, and countless other jobs on the farm. It is economical, strong, durable, sanitary, and attractive in appearance. To insure most satisfactory results, however, a working knowledge of how to make good concrete is essential. The principles outlined in the following pages are easily understood and can be readily mastered.

332. Action of Cement.—In a concrete mixture, the cement and water form a paste that, upon hardening, binds or cements the particles of sand and pebbles or crushed rock together into a permanent mass. (The hardening is caused by chemical action between the water and the cement.) The use of too much water thins or dilutes the paste and weakens it. Consequently, it is very important that the proper proportions of cement and water be used.

333. Specifying Mixtures.—Until the recent discovery that the strength, durability, and watertightness of concrete are dependent upon the proportions of water to cement, it was customary to specify mixtures as 1 part of cement to a certain number of parts of sand and pebbles. Modern practice is to specify the amount of mixing water for each sack of cement, the amount varying according to the class of work. For example, the recommended mixture, for tanks, cisterns, and similar work, is 5 gal. of water per sack of cement for sand and pebbles of average dampness. Six gallons would be used for dry sand and pebbles (see Table VI).

334. Determining the Proportions of Sand and Pebbles.—Table VI gives recommended quantities of mixing water for different classes of concrete work and also suggests proportions of cement to sand and pebbles to use for trial batches. It may be found that these trial proportions give a mix that is too wet, or a mix that is too stiff, or one that lacks smoothness and workability. If the mix proves to be too wet, add sand and pebbles slowly until the right degree of wetness is obtained. On the other hand, if the mix proves to be too stiff, use less sand and pebbles in the next batch. In this way the best proportions for a given job can

[1] The material in this section is compiled largely from publications of the Portland Cement Association.

TABLE VI.—RECOMMENDED PROPORTIONS OF WATER TO CEMENT AND SUGGESTED TRIAL MIXES

Kind of work	Add U.S. gallon, of water to each one-sack batch if sand is			Suggested mixture for trial batch			Maximum aggregate size, in.
	Very wet	Wet (average)	Damp	Portland cement, sacks	Sand, cu. ft.	Pebbles, cu. ft.	
5-Gal. Paste for Concrete Subjected to Severe Wear, Weather, or Weak Acid and Alkali Solutions							
Colored or plain topping for heavy wearing surfaces; all two-course work such as pavements, walks, residence floors, etc.	4¼	4½	4¾	1	1	1¾	⅜
Fence posts, flower boxes, garden furniture; work of very thin sections; all concrete in contact with weak acid or alkali solutions	3¾	4	4½	1	1¾	2	¾
6-Gal. Paste for Concrete to Be Watertight or Subjected to Moderate Wear and Weather							
Watertight floors such as basement, dairy barn, milk houses, etc. Watertight basement walls and pits, walls above ground, grain bins, silos, manure pits, scale pits, dipping vats, dams, lawn rollers, hotbeds, cold frames, storage cellars, etc. Water storage tanks, cisterns, septic tanks, sidewalks, feeding floors, barnyard pavements, driveways, barn approaches, steps, porch floors, corner posts, gate posts, piers, columns, sills, lintels, chimney caps, etc.	4¼	5	5½	1	2¼	3	1½
7-Gal. Paste for Concrete Not Subjected to Wear, Weather, or Water							
Foundation walls, footings, retaining walls, engine bases, mass concrete, etc., not subjected to weather, water pressure, or other exposure	4¾	5½	6¼	1	2¾	4	1½

NOTE.—It may be necessary to use a richer paste than is shown in the table because the concrete may be subjected to more severe conditions than are usual for a structure of that type. For example, a water storage tank ordinarily is made with a 6-gal. paste. However, the tank may be built in a place where the soil water is strongly alkaline, in which case a 5-gal. paste is required.

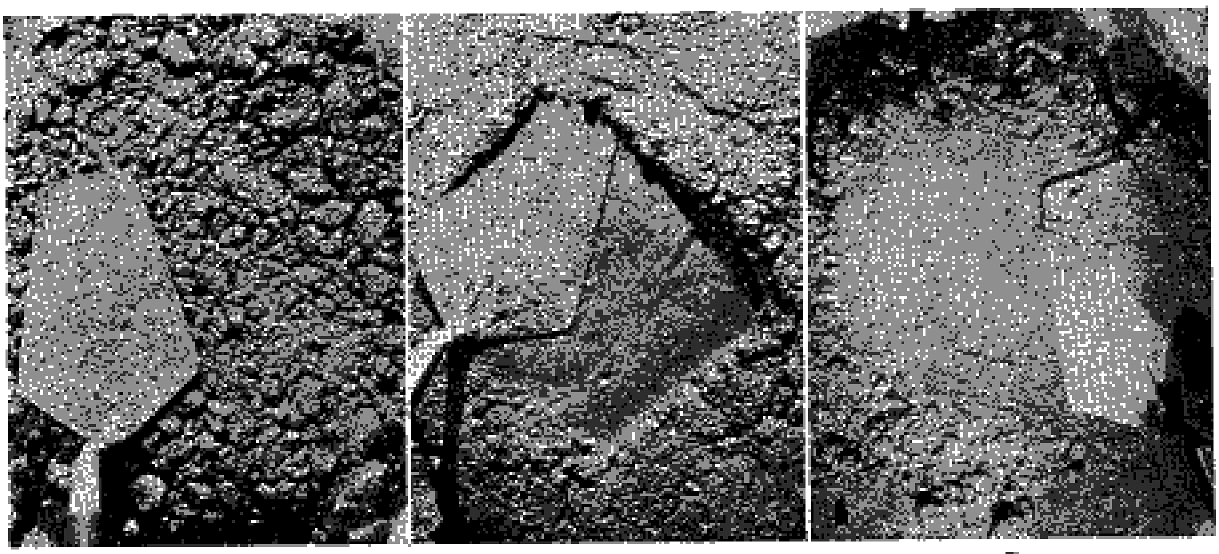
be determined. In general the following rules for proportioning may be given. These are based on damp sand. If the sand is absolutely dry, a condition seldom encountered, use 25 per cent less.

1. For coarse aggregate ranging from ¼ up to ½ in., use approximately equal parts of sand and pebbles.

2. For coarse aggregate ranging from ¼ up to ¾ in., use about three-quarters as much sand as pebbles.

3. For coarse aggregate ranging from ¼ up to 1½ in., use about half as much sand as pebbles.

335. Workability of Mixtures.—A workable mixture is one of such plasticity and wetness that it can be placed in the forms readily, and when spaded or tamped will result in a dense concrete. In a workable mixture



A B C

Fig. 278.—*A*. The mix on the left is one that does not contain enough cement-sand mortar to fill the spaces between pebbles. This mix is hard to work, rough, and porous.

B. The mix in the center has an excess of mortar. It is plastic and workable but is expensive owing to the small yield of concrete per bag of cement. It is also likely to be porous.

C. The mix on the right contains the correct amount of mortar. With light troweling the spaces between pebbles are filled. Note how it hangs together on the edges of the pile. This mix gives maximum yield of concrete and produces smooth, dense surfaces.

there is sufficient cement-sand mortar to give good smooth surfaces free from rough spots, called *honeycombing*, and to bind the pieces of coarse aggregate into the mass so they will not separate out in handling. In other words there should be just enough cement-sand mortar to fill completely the spaces between the pebbles and to insure a smooth, plastic mix. Mixtures lacking sufficient mortar will be harsh, hard to work, and difficult to finish. On the other hand, the use of too much sand should be avoided as it increases porosity and reduces the amount of concrete that can be produced with a sack of cement.

A workable mixture for one class of construction may be too stiff for another. Concrete to be deposited in thin sections, like fence posts, tank

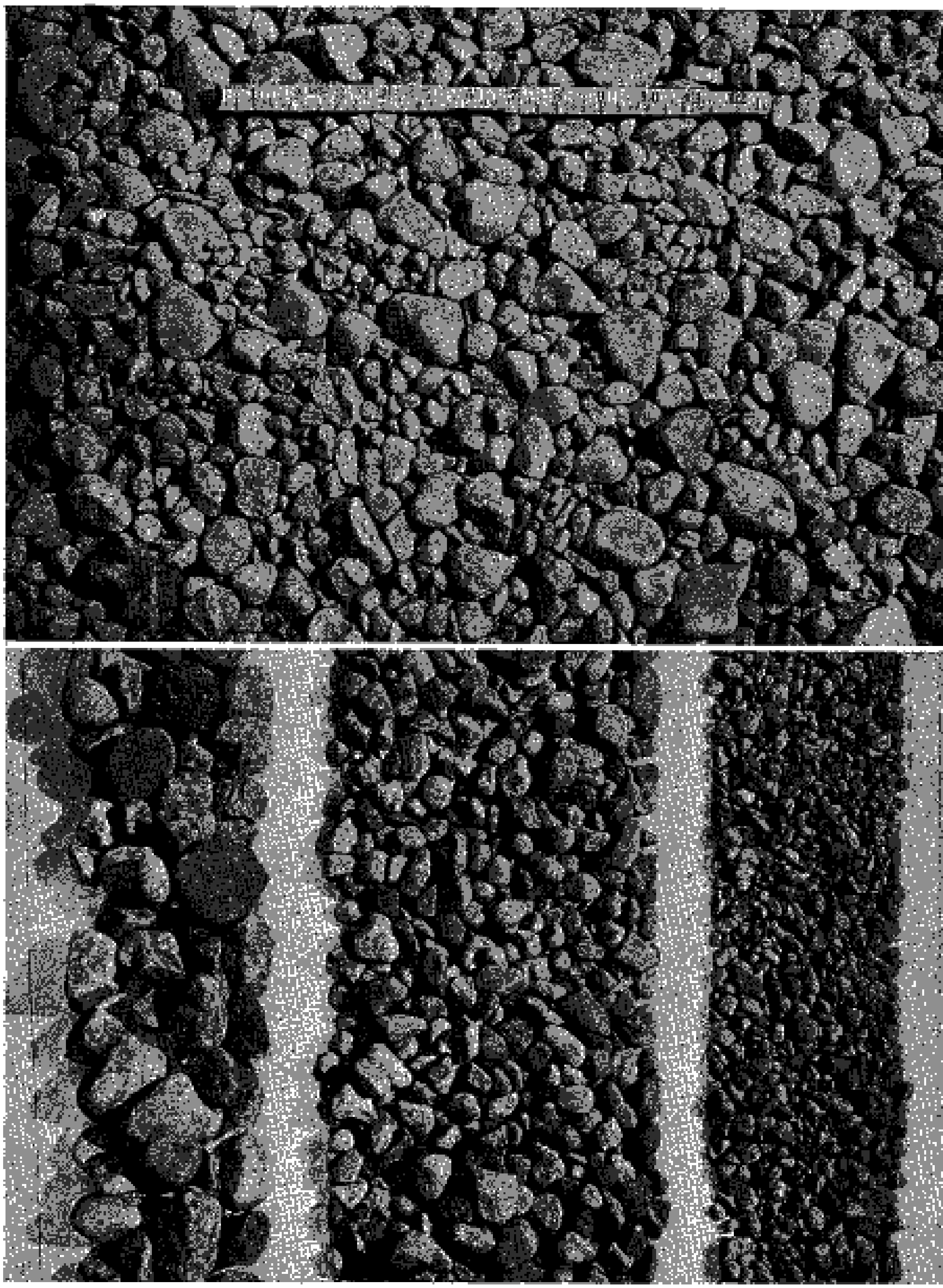


FIG. 279.—This is how a well-graded coarse aggregate appears before and after being separated in three sizes. Reading from left to right, in the separated aggregate, ¾ to 1½-in size, ⅜ to ¾-in. size, and ¼ to ⅜ in. Note how the smaller pieces fit in between the larger ones in the mixed aggregate, thus producing a dense mixture.

walls, etc., must be more plastic than if used in heavier work like foundation walls, footings, and floors. Very wet, sloppy mixtures are to be avoided as they result in weak, porous concrete.

A good rule to follow is to so proportion the amounts of sand to pebbles as to obtain the greatest volume of concrete of plasticity suitable to the character of the work. Under no circumstances should the ratio of water to cement be varied from the quantities given in Table VI.

336. Watertight Concrete.—The ratio of water to cement governs the watertightness or impermeability of the concrete, as well as its strength. A workable mixture in which not more than 6 gal. of water have been used for each sack of cement will usually produce watertight concrete. The addition of more water increases permeability. Sloppy mixtures, unless they contain a high cement content, are generally quite porous. Proper curing is also essential to obtain watertight concrete (see Art. 349, page 255).

337. Aggregates.—Sand and pebbles or broken stone are usually spoken of as *aggregate*. Sand is called *fine aggregate*, and pebbles or crushed stone, *coarse aggregate*. Fine aggregate, such as sand or rock screenings, includes all particles from very fine (exclusive of dust) up to those which will just pass through a screen having meshes ¼ in. square. Coarse aggregate includes all pebbles or broken stone ranging from ¼ up to 1½ or 2 in. The maximum size of coarse aggregate to be used is governed by the nature of the work. In thin slabs or walls the largest pieces of aggregate should never exceed one-third the thickness of the section of concrete being placed.

338. Sand.—Sand should be clean, hard, and free from fine dust, loam, clay, and vegetable matter. These materials are objectionable because they prevent a good bond between the cement and the particles of sand, thereby reducing the strength of the concrete and increasing its porosity.

Sand should be well graded, that is, the particles should not all be fine nor all coarse, but should vary from fine up to those particles that will just pass a screen having meshes ¼ in. square. If the sand is well graded, the finer particles help to fill the spaces (voids) between the larger particles, thus resulting in a denser concrete and permitting the most economical use of cement in filling the remainder of the spaces and binding the sand particles together.

339. Coarse Aggregate.—Pebbles or crushed stone to be used in a concrete mixture should be tough, fairly hard, and free from any of the impurities that would be objectionable in sand. Stone containing a considerable quantity of soft, flat, or elongated particles should not be used.

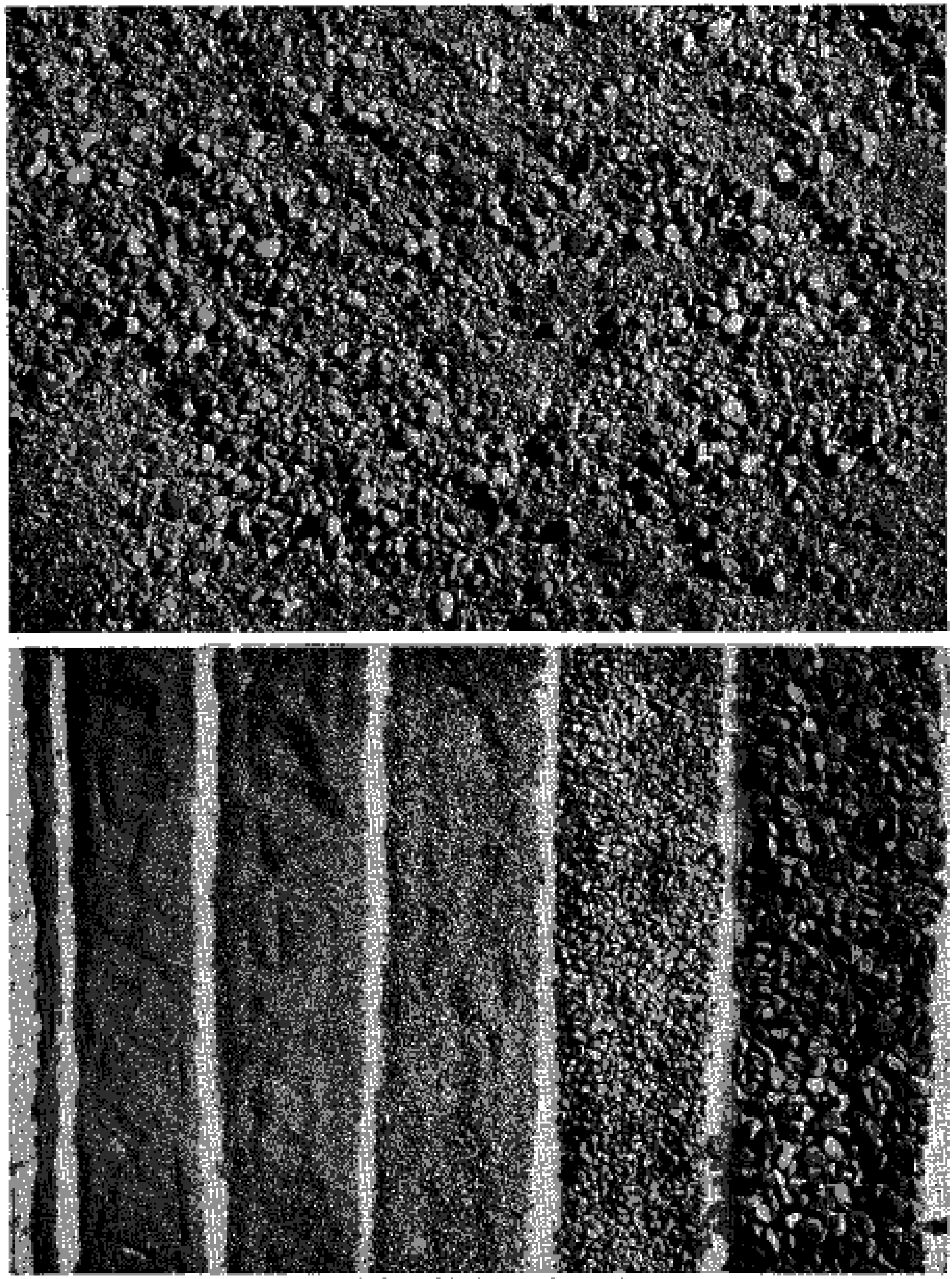


FIG. 280.—Sample of well-graded sand before and after it has been separated in various sizes. Particles vary from fine up to ¼ in. in size. Width of strips indicates amounts of each size. This is a good sand for concrete work.

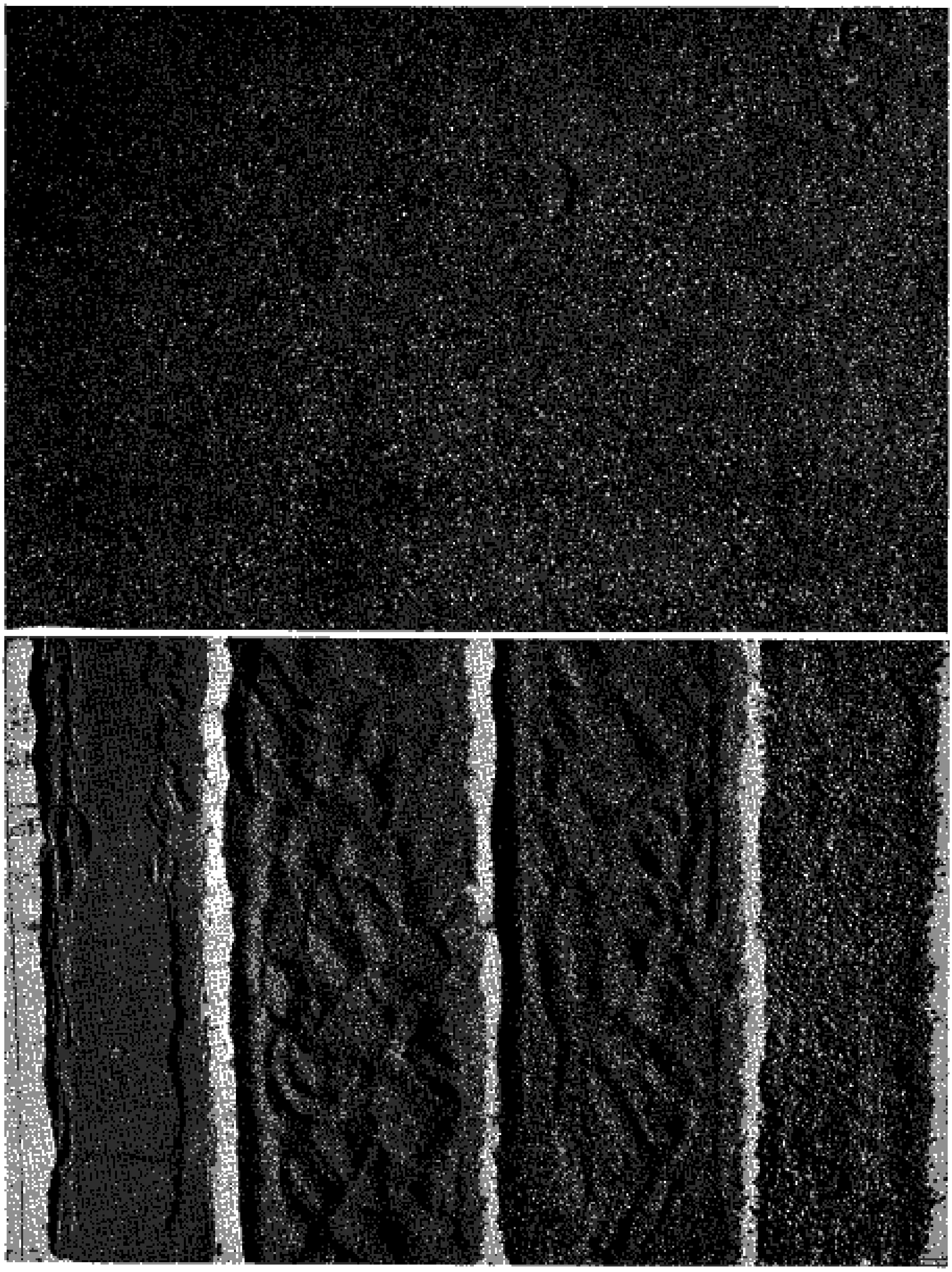


FIG. 281.—Sample of sand that lacks particles above $\frac{1}{16}$ in. in size and how it looks when separated into four sizes. More cement is required when sand is fine. This is not a good concrete sand.

340. Bank-run Gravel.—The natural mixture of sand and pebbles as taken from a gravel bank is usually referred to as *bank-run material.* In bank-run material, fine and coarse aggregates are seldom present in the right proportion to produce a good mixture. Most gravel banks contain either more sand or more pebbles than desirable. Usually there is too much sand. Money can usually be saved by screening out the sand and then recombining the materials in the correct proportions.

341. The Silt Test.—To determine if sand has so much silt or fine material in it that it is objectionable for use in concrete, a silt test may be made as follows, using an ordinary quart milk bottle or quart fruit jar. Fill the jar to a depth of 2 in. with a representative sample of the sand to be tested. Add water until the jar or bottle is about three-fourths full and shake vigorously for 1 min., the last few shakes being in a sidewise direction to level off the sand. Allow the jar to stand for an hour, during which time any silt will be deposited in a layer above the sand. If this layer is more than ⅛ in. thick, the sand is not suitable for concrete work unless excess silt is removed by washing.

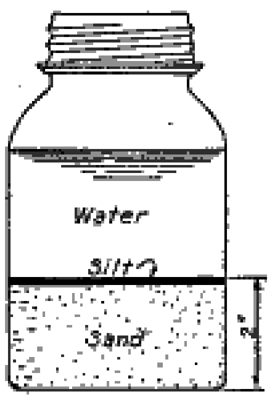


Fig. 282.—If a 2-in. sample of sand contains more than ⅛-in. of silt, the sand should be washed or rejected.

342. The Colorimetric Test for Organic Impurities. The colorimetric test is a reliable indicator of the presence of harmful organic matter except in areas where there are deposits of lignite. To make this test, an ordinary 12-oz. prescription bottle is filled to the 4½-oz. mark with a sample of the sand. To this is added a 3 per cent solution of caustic soda[1] (sodium hydroxide) until the 7-oz. mark is reached. The contents are thoroughly shaken and then allowed to stand for 24 hr.

At the end of this time the color of the liquid will indicate whether the sand contains dangerous amounts of organic matter. A clear liquid indicates absence of organic matter. A straw-colored solution indicates some organic matter, but not sufficient to be seriously objectionable. Darker colors indicate that the sand contains injurious amounts and should not be used without washing. After washing a retest should be made to see if it is then satisfactory.

[1] A 3 per cent solution of caustic soda is made by dissolving 1 oz. of sodium hydroxide in 1 qt. of water, preferably distilled. Sodium hydroxide may be purchased at any drug store at nominal cost. The solution should be kept in a glass bottle tightly stoppered. Handling sodium hydroxide with moist hands may result in serious burns. Care should be taken not to spill the solution, which is highly injurious to clothing, leather, and most other materials.

If preferred, the testing solution may be made by dissolving a heaping teaspoonful of lye in ½ pt. of clear water. Any household lye that contains as much as 94 per cent sodium hydroxide may be used.

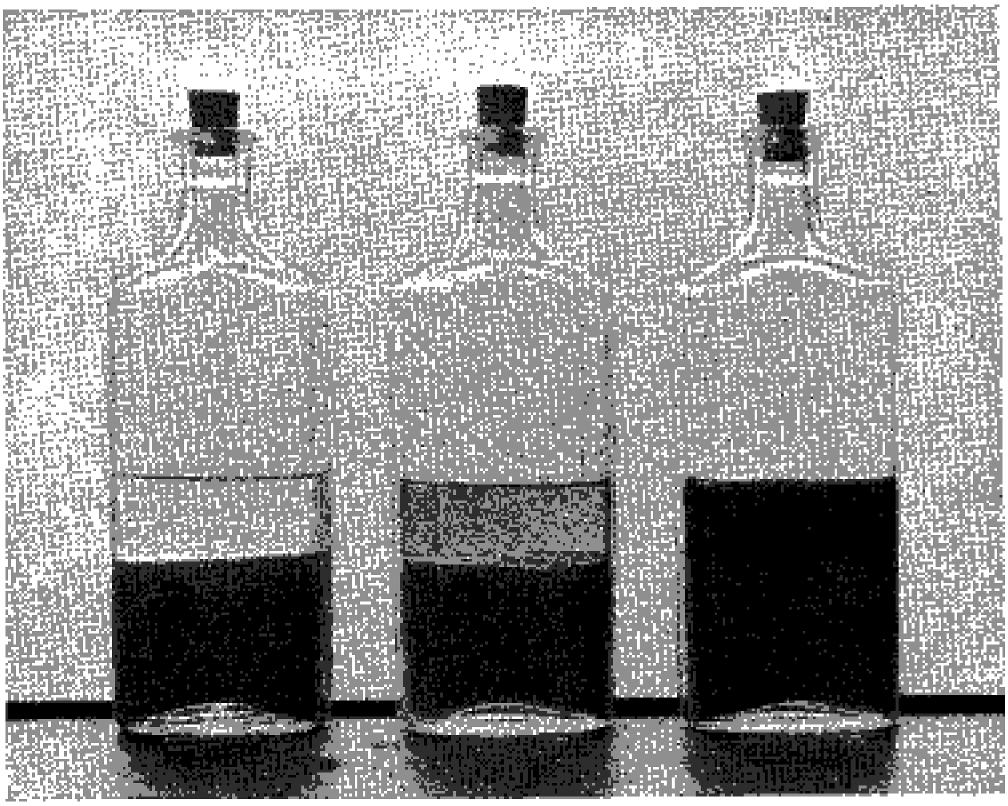


FIG. 283.—The colorimetric test is used to detect the presence of harmful amounts of organic matter in aggregates. A clear liquid as shown in the bottle on the left indicates that the aggregate is free from organic matter. The slightly colored liquid in the center bottle indicates the presence of some organic matter but not enough to prove injurious. The dark liquid in the right-hand bottle shows that the aggregate is unsatisfactory for concrete work unless the organic matter is washed out.

343. Washing Aggregates.—Sand or pebbles containing injurious amounts of silt or organic matter should be washed. A simple washing device is shown in Fig. 284. The materials to be washed are piled on the

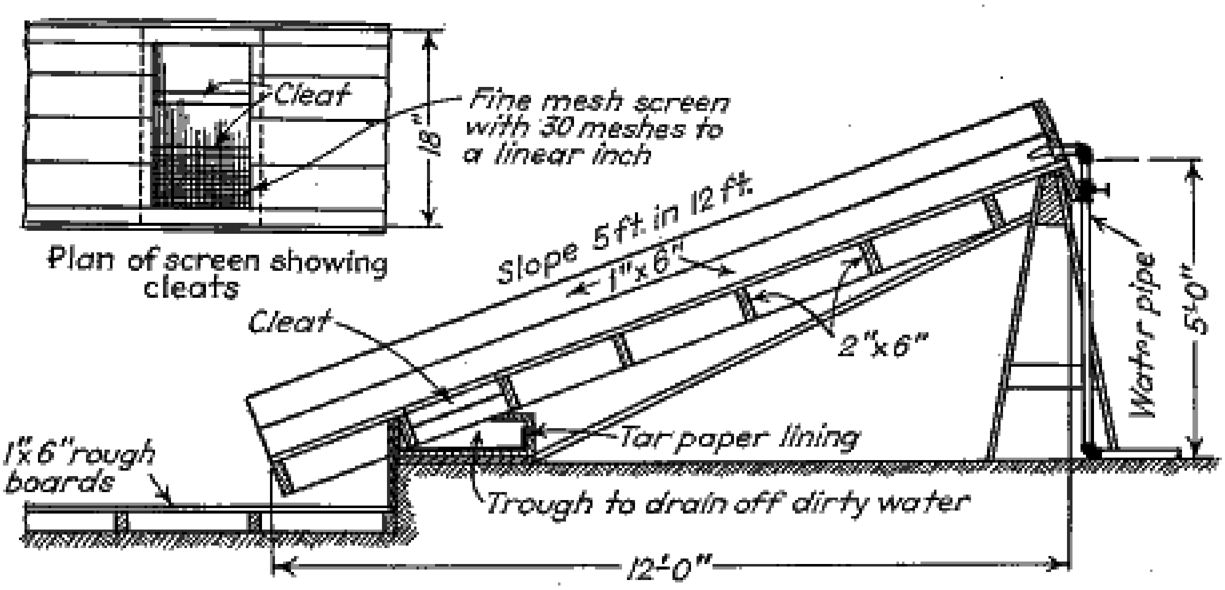
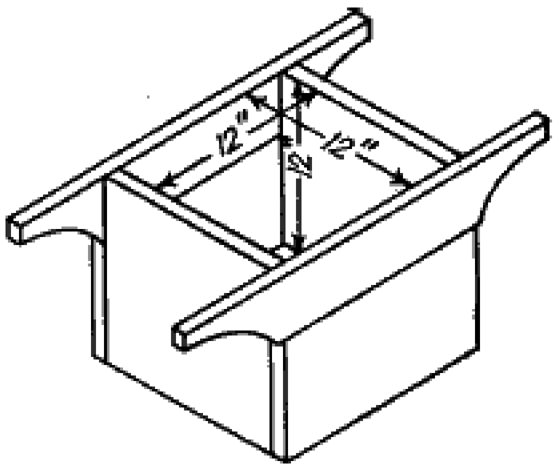


FIG. 284.—Design for a simple device for washing aggregates.

higher end. Water is applied by means of a garden hose, pail, or other convenient method. As the materials are washed down the incline, silt, dust, and organic matter separate out and are carried away in the water. It is a good plan to run check tests to see whether washing has been thoroughly done.

344. Water.—Water used to mix concrete should be clean and free from oil, alkali, and acid. In general, water that is fit to drink is good for concrete.



DIMENSIONS FOR BOTTOMLESS MEASURING BOXES OF VARIOUS CAPACITIES

Capacity in cu. ft.	Inside measurements in inches		
	Length	Width	Height
1	12	12	12
1¼	15	15	9⅝
1½	15	15	11½
1¾	15	15	13½
2	18	18	10⅝
2¼	18	18	12
2½	18	18	13⅜
2¾	18	18	14⅝
3	18	18	16

FIG. 285.—A bottomless box holding 1 cu. ft., 2 cu. ft., or any other desired amount makes a convenient measure for proportioning sand and pebbles.

345. Measure All Materials Accurately.—All materials, particularly water, should be accurately measured. A pail marked on the inside to indicate gallons and quarts is handy for measuring mixing water. Aggregates can easily be measured by using a box or bottomless frame made to hold exactly 1 cu. ft., 2 cu. ft., or any other volume desired (see Fig. 285). To measure the materials, the frame is placed on the mixing platform and filled. When the required amount of material has been placed in it, it is lifted, and the material remains on the platform. In mixing one-sack batches, it is not necessary to provide a measure for cement as one sack holds one cubic foot. A pail may also be used in proportioning materials. For example, a 1–2¼–3 batch of concrete would be measured by taking 1 pail of Portland cement, 2¼ pails of sand, and 3 pails of pebbles or stone.

346. Mixing the Materials.—Concrete may be mixed either by machine or by hand. Machine mixing is preferred. It is recommended that the mixer be run for at least 2 min. after all materials, including water, are placed in the mixer drum. First-class concrete can be mixed by hand. Whichever way mixing is done, it should continue until every pebble or stone is completely coated with a thoroughly mixed mortar of sand and cement.

A tight barn floor or some paved area like a feeding floor provides a satisfactory surface on which to mix concrete by hand. If such floors are not available, a watertight mixing platform at least 7 ft. wide and 12 ft. long should be made. A platform of this size is large enough for two men using shovels to work upon at one time. Such a platform should be made of matched lumber so that joints will be tight. Strips should be nailed along three sides of the platform to prevent materials from being washed or shoveled off while mixing.

The usual procedure in mixing concrete by hand is as follows: The measured quantity of sand is spread out evenly on the platform. On this the required amount of cement is dumped and evenly distributed. The cement and sand are then turned over thoroughly with square-pointed shovels enough times to produce a mass of uniform color, free from streaks of brown and gray. Such streaks indicate that the sand and cement have not been thoroughly mixed. The required quantity of pebbles or broken stone is then measured and spread in a layer on top of the cement-sand mixture, and all of the materials again mixed by turning with shovels until the pebbles have been uniformly distributed. At least three turnings are necessary. A depression or hollow is then formed in the center of the pile and the correct amount of water added slowly while the materials are turned with square-pointed shovels, this turning being continued until the cement, sand, and pebbles have been thoroughly and uniformly combined.

347. Placing Concrete.—Concrete should be placed in the forms as soon as possible, in no case more than 45 min. after mixing. It should be deposited in layers of uniform depth, usually not exceeding 6 in. When placed in the forms it should be tamped and spaded so as to cause it to settle thoroughly everywhere in the forms and produce a dense mass. By "spading" is meant the working of a spade or chisel-edged board in the concrete and between it and the side of the forms, moving the spading tool to and fro and up and down.

This working of the concrete next to the forms forces the large pebbles or stone particles away from the forms into the mass of the concrete, and insures an even, dense surface when forms are removed.

348. Finishing Concrete.—The surface of walks, and floors in barns, hog houses, and most other farm buildings, should be finished with a wood float to give a smooth, yet gritty, nonskid surface. A steel trowel should be used sparingly, if at all, as its use is likely to result in an oversmooth surface that will be slippery when wet.

Where a smooth surface is desired, however, as in a poultry house floor, most of the smoothing is done with the wood float, and, after the concrete has stiffened somewhat, the final finishing is done with a steel trowel. The steel trowel should be used sparingly and only in the final finishing, since excessive trowelling draws the fine material to the surface, which may cause hair checking and dusting after hardening.

349. Protecting Newly Placed Concrete; Curing.—Do not permit the newly placed concrete to dry out. Protect it from sun and drying winds for 1 week or 10 days; otherwise the water necessary for the proper hardening will evaporate, resulting in a loss of strength. Floors, walks, and similar surfaces can be protected by covering with moist earth, or hay or straw as soon as the concrete has hardened sufficiently so that the surface will not be injured. This covering should remain on for 1 week or 10 days and be kept moist by occasional sprinkling.

Walls or other sections that cannot conveniently be covered in the manner suggested can be protected by hanging moist canvas or burlap

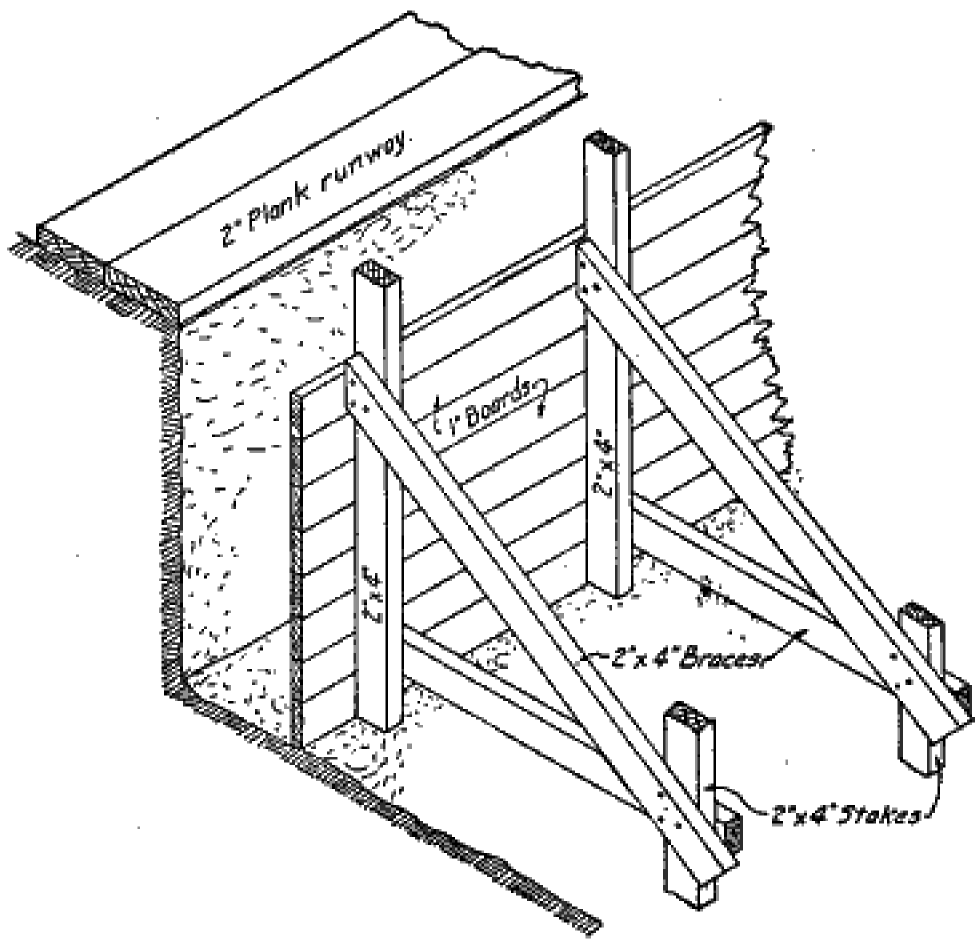


FIG. 286.—Forms for foundation walls where the embankment serves as the outer form.

over them and wetting down the work often enough to keep it moist for 10 days after placing. In cold weather, work should be protected by a layer of straw, but need not be kept moist, as evaporation is not rapid.

350. Forms.—Forms, generally made of wood, hold the concrete in place until it hardens. Rough lumber may be used where appearance is not important, but where a smooth finish is desired, the forms should be carefully built of good planed lumber. Tongue-and-grooved lumber or shiplap is commonly used to give tight joints. Forms should be built so they can be easily removed without damage to the fresh concrete and with the least possible damage to the form lumber. Where forms are to be used again, they may be built in sections to facilitate removal. It is important that forms be built tight and strong and that they be wellbraced in position to prevent bulging when the wet concrete is tamped into place. Wood forms are commonly oiled with crude oil or crankcase drainings to prevent warping and to prevent concrete from sticking to them.

For foundation work below ground, forms are not necessary if the sides of the excavation will stand without caving.

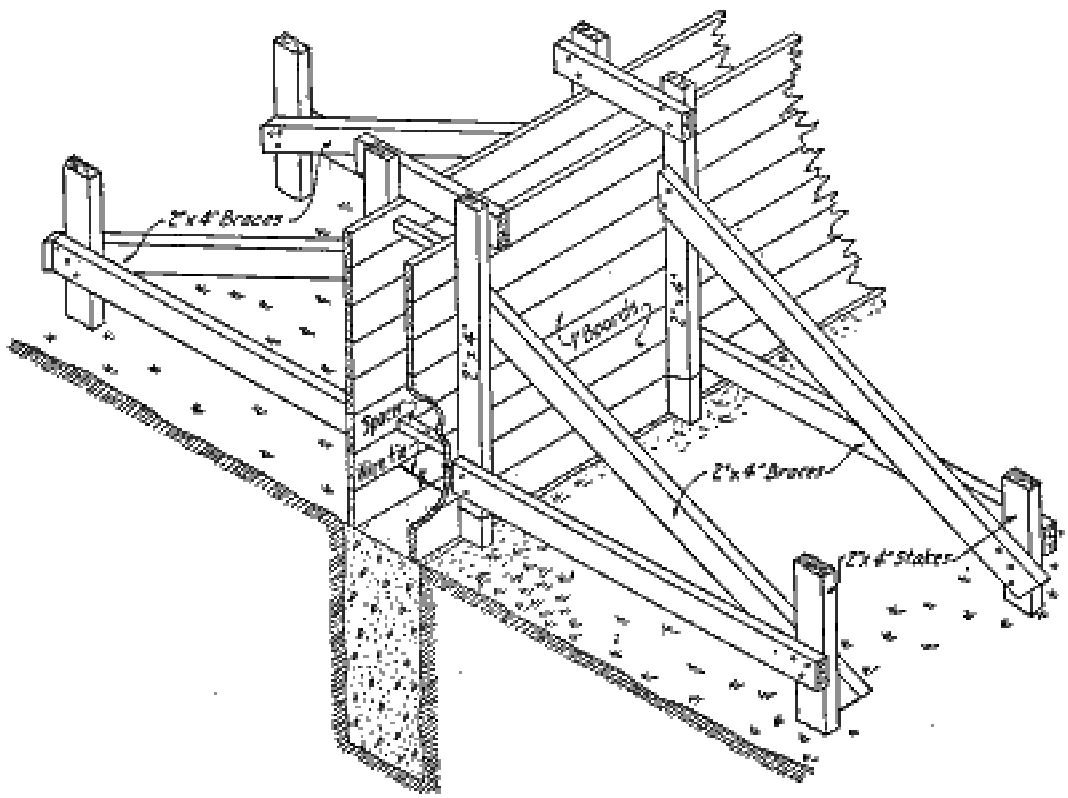


FIG. 287.—Forms for foundation walls above grade. Concrete may be placed directly into the earth trench below grade if care is taken to keep the side walls firm and straight.

351. Removal of Forms.—Forms should not be removed until the concrete has hardened sufficiently to be self-supporting and until there is no danger of damage to the concrete in removing the forms. The time required will vary from 1 day to 2 weeks or more, depending upon the weather, the nature of the work, etc. In summer, wall forms may generally be removed after 1 or 2 days, and in colder weather in from 4 to 7 days. Forms for roofs and floors over basements should not be removed in less than 7 days in summer and 14 days in colder weather.

352. Reinforcing Concrete.—Concrete, like stone, is strong in compression. It can support very heavy loads that tend to mash or crush it. Steel rods or other forms of reinforcing should be used in concrete, however, where loads or forces tend to pull it apart. It is important that the reinforcement be placed where it will do the most good in helping the concrete to resist the stretching or pulling forces. For example, in a concrete lintel or beam, the reinforcement should be placed near the lower side, as that is the side that tends to stretch or pull apart when the beam is loaded. Important or elaborate structures, as floors above ground, beams, columns, and retaining walls, should be designed by an experienced engineer.

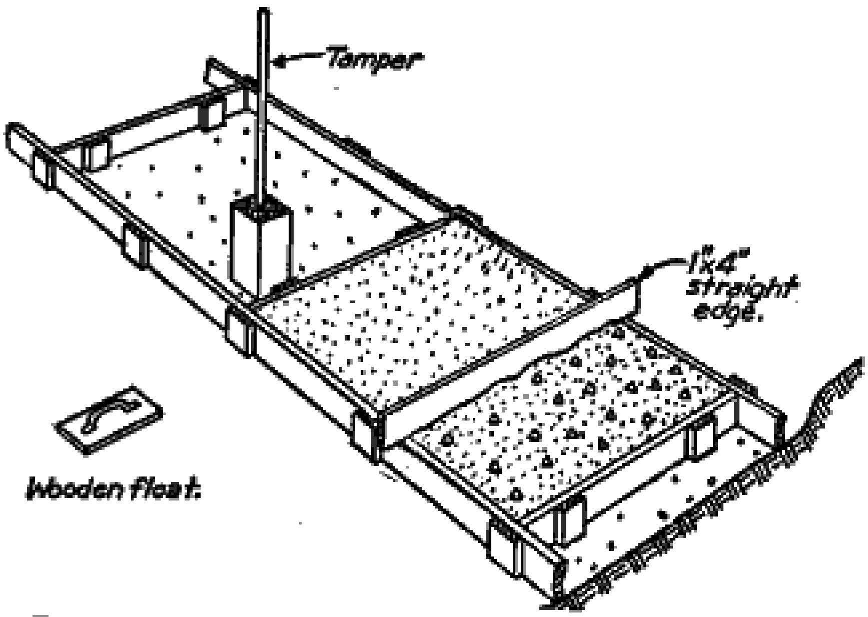


FIG. 288.—Forms for sidewalks usually consist of two by fours set on edge. These serve as guides in striking off the surface. For convenience, sidewalks are generally built in sections.

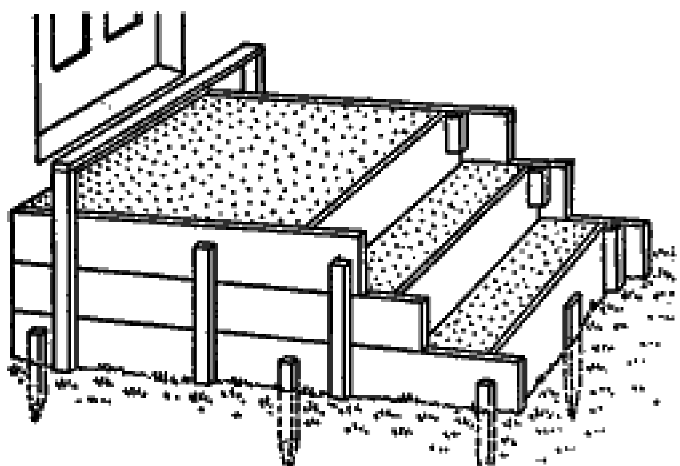


FIG. 289.—Simple forms for building steps.

353. Concrete Work in Cold Weather.—Concrete can be made during cold weather if a few simple precautions are observed. In early winter, when freezing occurs only at night, it is necessary merely to protect the concrete after it has been placed in the forms. As the weather grows colder and freezing temperatures prevail, the mixing water and aggregate should be heated and the work protected after it is poured by covering with straw, manure, paper, or canvas, or by building enclosures around the new work and heating with stoves. Aggregate may be heated by building a fire inside an old smokestack, metal culvert, or steel barrel laid on its side, and piling the aggregate over it. Cement should not be heated, nor should water hotter than 150°F. be mixed with the cement.

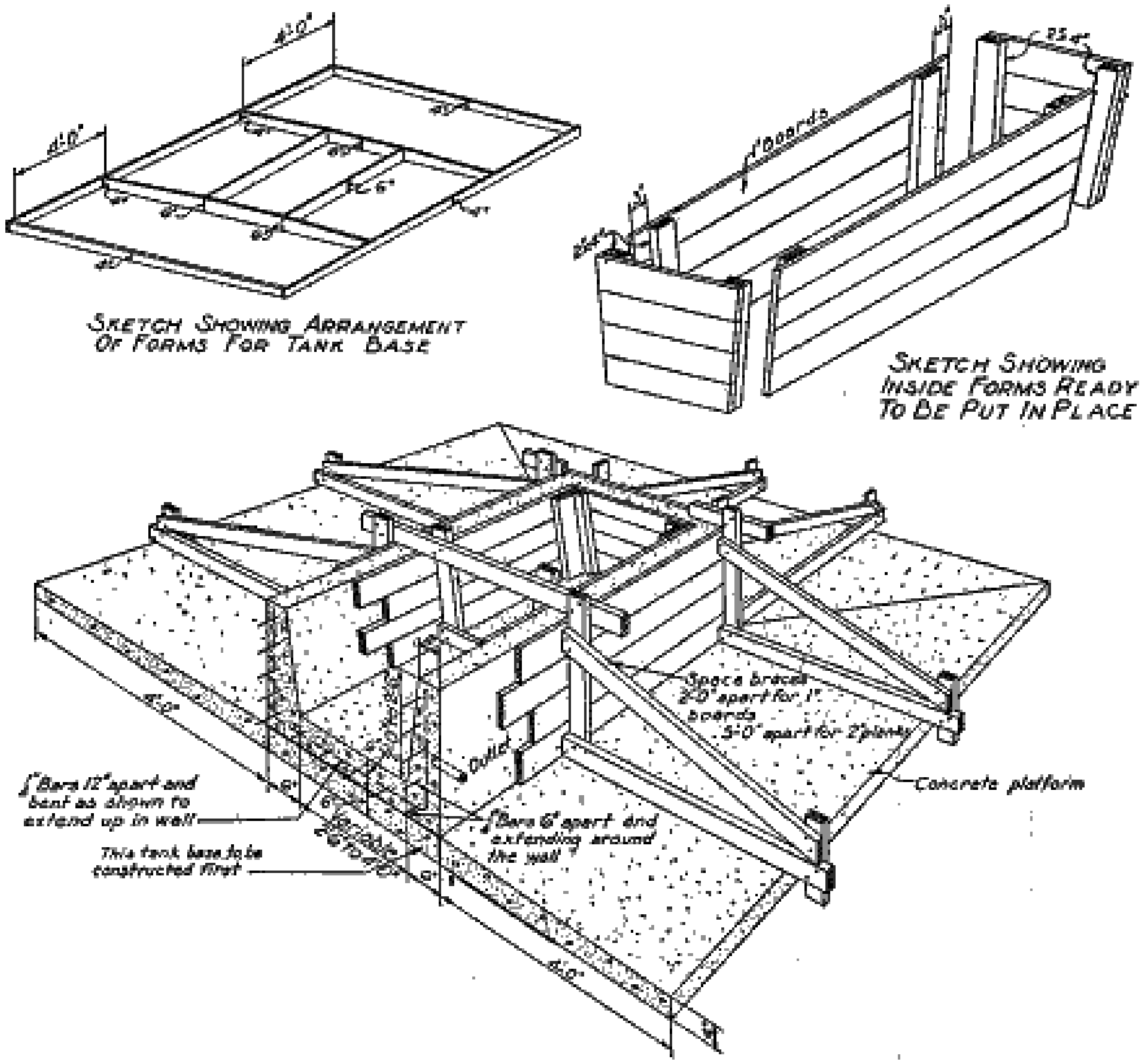


FIG. 290.—Forms for building a stock watering tank, platform, and base.

354. Mortar for Masonry Walls.—Portland cement mortar is recommended for laying concrete blocks, building tiles, rocks, or bricks. For ordinary work a mortar composed of 1 part of cement, 1 part of hydrated lime or well-slaked lime, and not more than 6 parts of clean well-graded sand, all measured by volume, is considered satisfactory.

Where extra strength and density are desired, as in building water storage tanks, silos, and similar structures, a mortar consisting of 1 sack of cement, 3 cu. ft. of sand, and 10 lb. of lime, is recommended.

Mortar should be mixed thoroughly with just enough water to give the desired plasticity and workability. Thorough mixing improves the plasticity of mortar, and less mixing water is required to obtain a workable consistency when the time of mixing is increased. The lime is used in mortar to make it more plastic or "fat."

355. Quantities of Materials Required.—The amounts of cement and aggregate required for a given job may be closely figured by first determining the total volume of concrete required and then referring to a table such as Table VII or VIII.

Table VII.—Quantities of Cement, Fine Aggregate, and Coarse Aggregate Required for 1 Cu. Yd. of Compact Mortar or Concrete[1]

Mixtures			Quantities of Materials				
Cement	Fine aggregate	Coarse aggregate	Cement, sacks	Fine aggregate		Coarse aggregate	
				Cu. ft.	Cu. yd.	Cu. ft.	Cu. yd.
1	2	...	12	24	0.9		
1	3	...	9	27	1.0		
1	1	1¾	10	10	0.37	17	0.63
1	1¾	2	8	14	0.52	16	0.59
1	2¼	3	6¼	14	0.52	19	0.70
1	2¾	4	5	14	0.52	20	0.74

[1] Quantities may vary 10 per cent either way, depending upon character of aggregate used.

Table VIII.—Materials Required for 100 Sq. Ft. of Surface for Varying Thicknesses of Concrete or Mortar[1]

Thickness of mortar or concrete, in.	Amount of mortar or concrete, cu. yd.	Proportions								
		1–2			1–3			1–1–1¾		
		Cement, sacks	Fine aggregate, cu. ft.	Coarse aggregate, cu. ft.	Cement, sacks	Fine aggregate, cu. ft.	Coarse aggregate, cu. ft.	Cement, sacks	Fine aggregate, cu. ft.	Coarse aggregate, cu. ft.
⅜	0.115	1.4	2.8	....	1.0	3.0				
½	0.15	1.8	3.6	....	1.3	4.0				
¾	0.23	2.7	5.4	....	2.0	6.0	....	2.3	2.3	3.9
1	0.31	3.7	7.4	....	2.7	8.1	....	3.1	3.1	5.3
1¼	0.38	4.5	9.0	....	3.3	10.0	....	3.8	3.8	6.5
1½	0.46	5.4	10.8	....	4.0	12.0	....	4.6	4.6	7.8
1¾	0.54	6.4	12.8	....	4.7	14.1	....	5.4	5.4	9.2
2	0.62	7.3	14.6	....	5.4	16.2	....	6.2	6.2	10.5
		1–1¾–2			1–2¼–3			1–2¾–4		
3	0.92	7.5	12.9	14.7	5.8	12.9	17.5	4.6	12.9	18.4
4	1.24	10.0	17.3	19.9	7.8	17.3	23.6	6.2	17.3	24.8
5	1.56	....	....	....	9.8	21.7	29.6	7.8	21.8	31.2
6	1.85	....	....	....	11.5	26.0	35.2	9.3	26.0	37.0
8	2.46	....	....	....	15.4	34.4	46.8	12.3	34.4	49.3
10	3.08	....	....	....	19.3	43.2	58.5	15.4	43.2	61.6
12	3.70	....	....	....	23.1	51.8	70.4	18.5	51.8	74.0

[1] Quantities may vary 10 per cent either way, depending upon character of aggregate used.

The required quantities of materials may also be estimated by using the following formula:

$$C = \frac{42}{c + s + g}$$

where C = the number of sacks of cement to make a cubic yard of concrete.

c = 1, or the proportions of cement in the mixture.

s = the proportions of sand in the mixture.

g = the proportions of gravel or coarse aggregate in the mixture.

For example, suppose it is desired to know the materials required to make 1 cu. yd. of concrete (27 cu. ft.) with a 1–2¼–3 mixture. Substituting in the formula,

$$C = \frac{42}{1 + 2\frac{1}{4} + 3} = \frac{42}{6\frac{1}{4}} = 6.7 \text{ sacks}$$

The amount of sand required is 2¼ times the cement required, or 15 cu. ft. ($2\frac{1}{4} \times 6.7 = 15$). The amount of gravel or coarse aggregate is three times the amount of cement, or 20.1 cu. ft. ($3 \times 6.7 = 20.1$).

A simple, easy method of very roughly estimating quantities of materials required for small jobs is to assume that the amount of coarse aggregate required will be the same as the total volume of the forms; and that the amounts of sand and cement required will be in the same proportion to the coarse aggregate, as they are in the mix. For example, suppose 10 cu. ft. of concrete is to be made, and the mixture is to be a 1–2¼–3. According to this method, 10 cu. ft. of coarse aggregate will be needed; and the amount of sand needed will be to 10 as 2¼ is to 3, or 7½ cu. ft. (Sand:10 = 2¼:3, or, Sand = $(10 \times 2\frac{1}{4}) \div 3 = 7\frac{1}{2}$). From the proportions it is evident that one-third as much cement is required as coarse aggregate, or 3.3 cu. ft. (sacks). It is obvious that this method indicates more materials than will be needed, but it is valuable for making a quick rough estimate on small jobs when no table is at hand, and where a little surplus is preferable to taking a chance on having to reorder or make a second trip for extra materials.

Questions

332. (*a*) Just what takes place when concrete hardens into a permanent mass? (*b*) Why is it important that too much water not be used in mixing concrete?

333. How should mixtures for concrete be specified? Why?

334. (*a*) How should the proper proportions of sand and pebbles to cement be determined? (*b*) In case a mixture is too stiff and harsh, what would you recommend? (*c*) What are some general rules governing the proportions of sand to pebbles?

335. (*a*) What is a workable mixture? (*b*) What condition may result from the use of insufficient mortar in a mixture? (*c*) From the use of too much sand? (*d*) Give examples of construction where the mixture should be more plastic than in other cases?

336. (*a*) Upon what factor does watertightness depend principally? (*b*) What other factors are also important?

337. (*a*) What is meant by aggregate? (*b*) What is fine aggregate? (*c*) What is the maximum size of particles of coarse aggregate that should be used in thin slabs or in walls?

338. (*a*) What are the desirable properties of sand? (*b*) What is meant when it is said that sand should be well graded? (*c*) Why should it be well graded?

339. What are the desirable properties of coarse aggregate?

340. (*a*) What is bank-run gravel? (*b*) Why is it seldom suited for concrete work as it is found? (*c*) What is the recommended practice where bank-run material is to be used?

341. (*a*) What is the purpose of the silt test? (*b*) Just how is it made? (*c*) What is the maximum allowable amount of silt in a sample? (*d*) How may the amount of silt in sand be reduced?

342. (*a*) What test can be made to determine the amount of organic matter in sand? (*b*) Is the test always reliable? (*c*) Just how is the test made? (*d*) Just how may the testing solution be made from common household materials?

343. (*a*) Describe a simple washing device that may be used for washing sand and gravel. (*b*) Is it necessary to run tests after washing to determine if the silt or organic matter has been reduced to safe limits?

344. What requirements should be met by water that is to be used in mixing concrete?

345. Describe different convenient methods that may be used to accurately measure the materials used in concrete.

346. (*a*) What important point or points should be observed in mixing concrete with a machine mixer? (*b*) How large a floor or mixing platform is needed for hand mixing? (*c*) Describe, step by step, a good method of mixing materials by hand.

347. (*a*) How long after mixing may concrete be left before placing in the forms? (*b*) What treatment should the fresh concrete receive as it is placed in forms? Why?

348. (*a*) Why is a steel trowel not generally used for smoothing the surface of walks and floors in farm buildings? (*b*) What tool is commonly used for such purposes? (*c*) How may a floor, like a poultry house floor, be given a very smooth finish? (*d*) What may result from excessive troweling of a surface?

349. (*a*) Why should fresh concrete be protected against too rapid drying while curing? (*b*) How may walks and floors be properly protected? (*c*) How long should new concrete be kept moist?

350. (*a*) What important points should be observed in the construction of forms? (*b*) Why are wood forms commonly oiled? (*c*) What kind of oil may be used?

351. (*a*) In general, how long should forms be left in place after the concrete is poured? (*b*) What conditions affect the length of time forms should remain in place?

352. (*a*) Under what conditions should concrete be reinforced? (*b*) In what part of a concrete beam or lintel should the reinforcing be placed?

353. (*a*) What precautions should be taken in making concrete in cold weather? (*b*) How may aggregate be heated?

354. (*a*) What materials are commonly used for mortar in laying tile, brick, or concrete block walls? (*b*) In what proportions should they be mixed? (*c*) What materials and what proportions should be used for mortar where extra strength and density are desired, as in water tanks? (*d*) Just what property does lime impart to a mortar? (*e*) Why is thorough mixing especially important?

355. (*a*) What is the first step in estimating the amounts of materials needed for a concrete job? (*b*) Explain how tables may be used in estimating quantities.

(*c*) Estimate the amount of cement, sand, and gravel required for a floor 12 ft. wide, 20 ft. long, and 4 in. thick, if made of a 1–2¼–3 mixture. Use the tables. (*d*) By use of a different method, estimate the quantities required for the job. (*e*) Explain a simple, easy rule for roughly estimating quantities, particularly on very small jobs.

References

Various bulletins of the Portland Cement Association, Chicago, Ill.
Boss, Dent, and White: "Mechanical Training."
McMillan: "Basic Principles of Concrete."
U.S. Dept. Agric., Farmers' Bull. 1772, Use of Concrete on the Farm.

PART VIII

HARNESS, BELT, AND ROPE WORK

CHAPTER XXIII

HARNESS REPAIR; BELTING; BELT LACING

Repairing of harness is not difficult for one with a moderate amount of mechanical ability or one who commonly does shopwork in wood or metal.

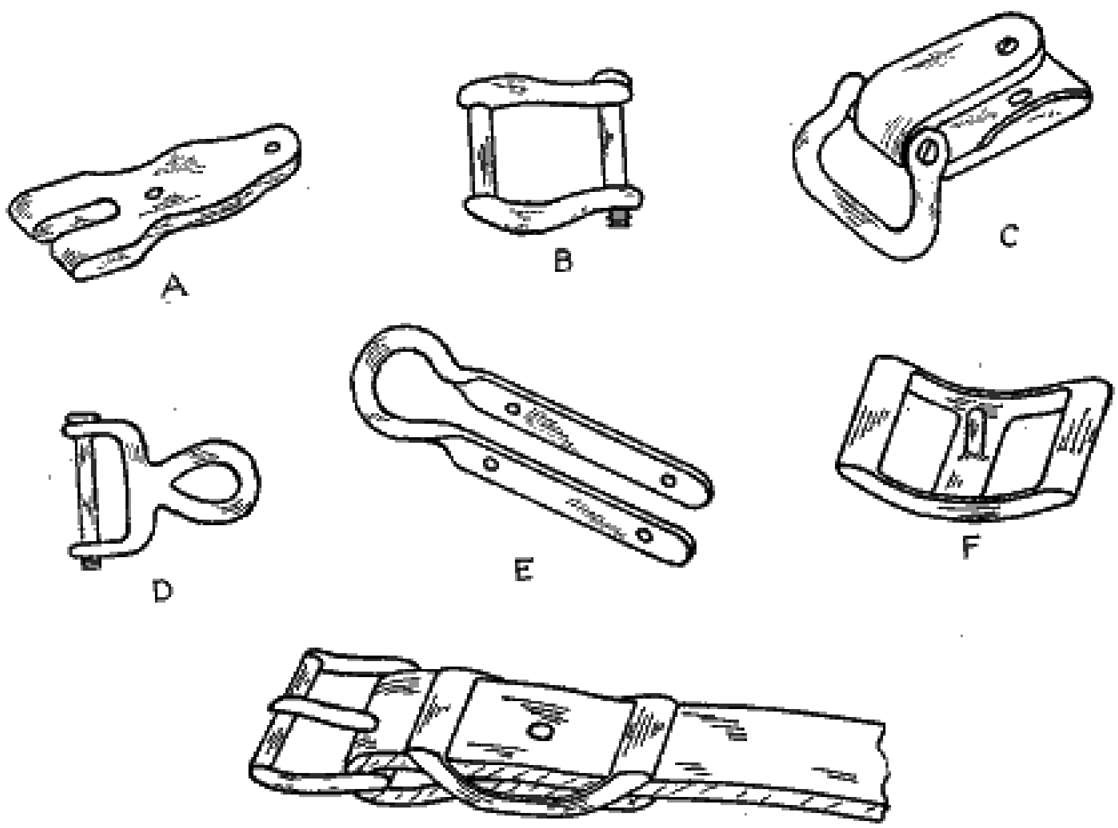


FIG. 291.—Harness repair hardware.
A. Buckle repair clip.
B. Screw hame loop.
C. Bottom hame clip.
D. Screw cockeye.
E. Hame clip.
F. Conway loop.
G. Buckle attached with conway loop.

There is available on the market a rather wide range of harness hardware, such as buckles, loops, hame staples, repair links, etc., which may be installed on a harness with the use of only such tools as a hammer, vise, file, cold chisel, and punches. With such pieces of harness equipment, and with a knowledge of harness riveting and leather sewing, a farm boy can easily keep harness in good repair.

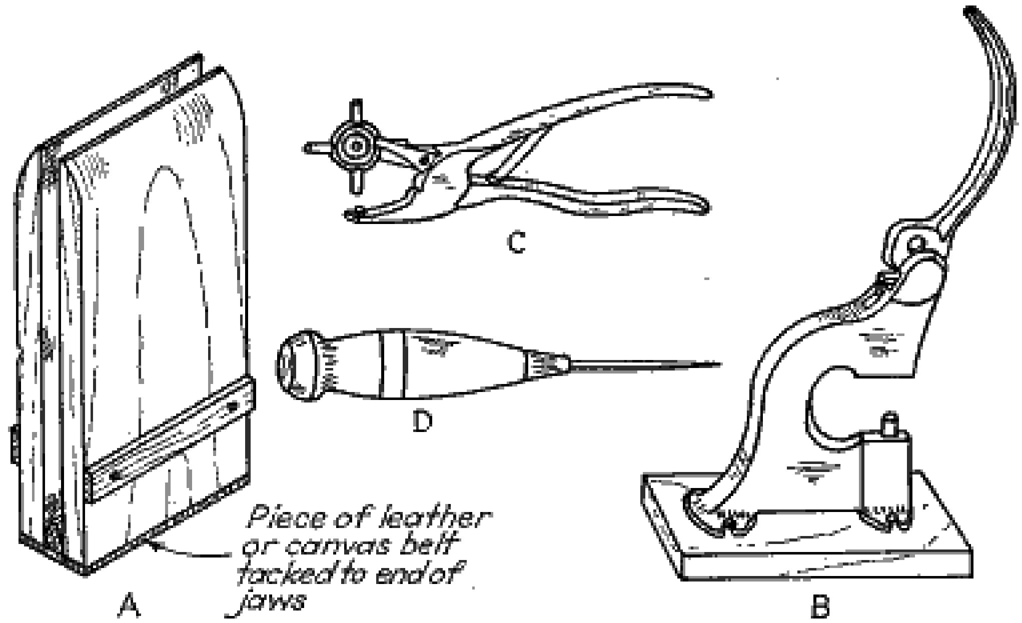


FIG. 292.—Harness repair tools.
A. Homemade harness sewing clamp for use in a vise.
B. Hand machine for using tubular rivets.
C. Leather punch.
D. Harness sewing awl.

356. Tools and Equipment for Harness Repairing.—Very little special equipment is required for harness repairing. The following list would ordinarily be quite adequate for the farm shop.

1 riveting machine for using tubular rivets.
1 harness sewing awl.
1 package assorted harness sewing needles.
1 ball No. 10 linen thread.
1 harness punch.
1 harness sewing clamp (may be homemade).
1 piece harness maker's wax.
Assortment of solid copper rivets and burrs.
Assortment of tubular rivets.

357. Riveting Leather.—The most secure kind of riveting is done by punching holes in the leather with a hollow-bit leather punch, inserting a solid rivet, and then placing a burr (washer) on the end and riveting it in place. This kind of riveting is recommended when permanent repairs are being made.

Hollow or tubular rivets are quickly and easily used with the aid of a small hand riveting machine. Such rivets are commonly used for temporary repairs and are excellent for this purpose. Another type of rivet sometimes used is the split rivet, which has two prongs. It is hammered through the leather, and the prongs are bent over and clinched to hold the rivet in place.

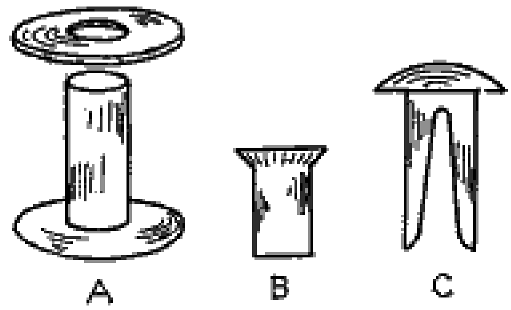


FIG. 293.—Styles of harness rivets. *A*, solid rivet with burr; *B*, tubular rivet; *C*, split rivet.

358. Making a Waxed Sewing Thread.—To make a sewed splice, it is first necessary to make a waxed sewing thread. From three to five strands of No. 10 linen thread are used.

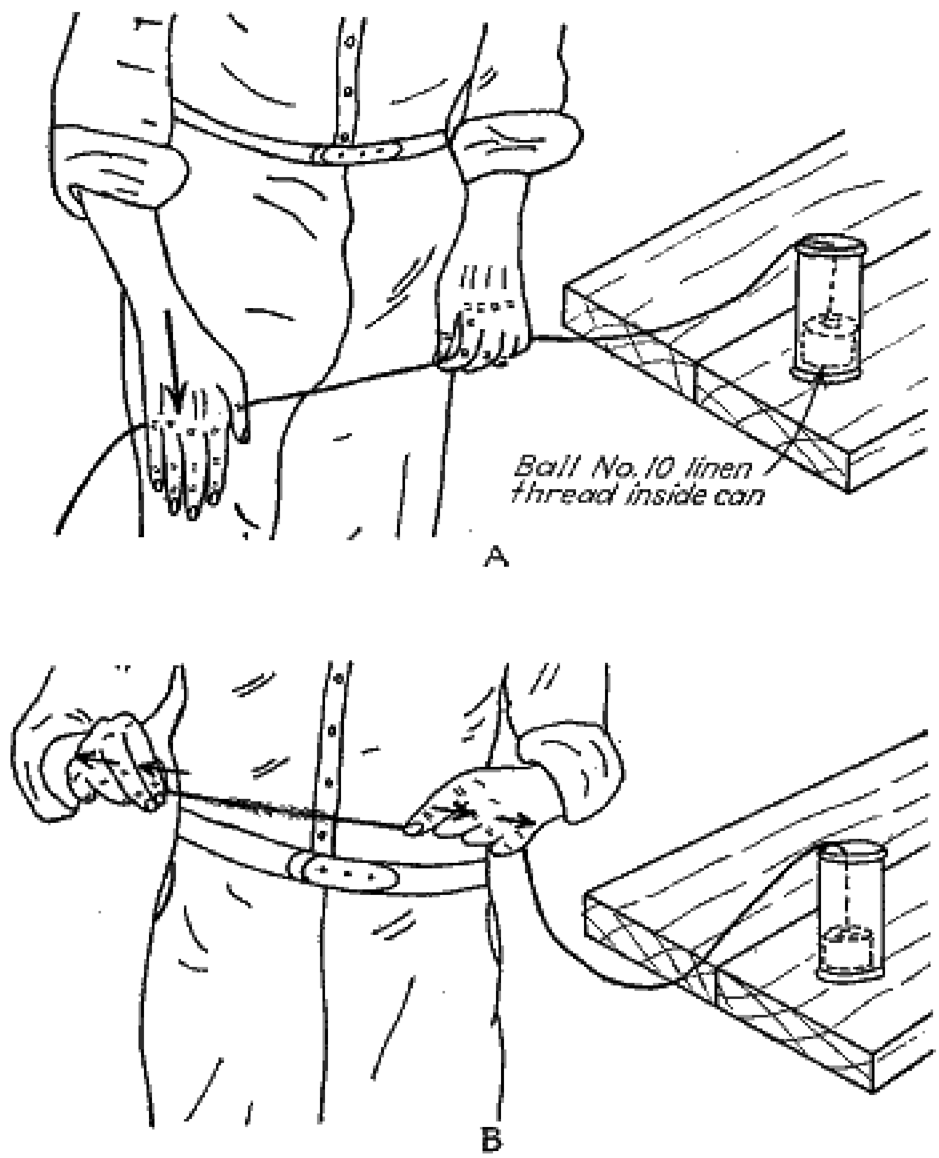


FIG. 294.—Harness thread should be torn, not cut. After the desired length is withdrawn from the ball, it is untwisted by rolling over the thigh, as at *A*, and then torn apart by a series of short, quick jerks, as at *B*.

Tearing the Thread.—The desired length of thread, usually about 5 ft., is drawn from the ball and torn rather than cut off. To tear it, the thread is untwisted over an 8- or 10-in. length, and then jerked. It will tear apart at about the middle of the untwisted section. To untwist the thread for tearing, roll it between the palm and right thigh, while holding with the left hand at a point about 8 in. back from the thigh.

To keep the supply of thread from becoming tangled, the ball may be kept in a small can, such as an empty baking powder can, with a small hole punched in the lid for the thread to be drawn through.

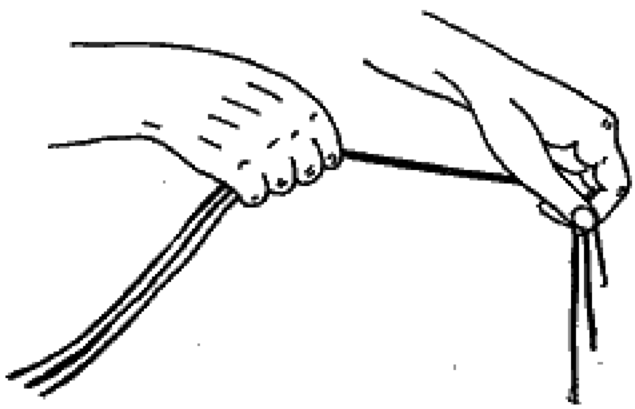


FIG. 295.—To give a fine tapering point to the finished thread, the individual strands are assembled with ends offset or staggered.

Assembling the Threads.—When the desired number of strands, usually three or four, have been withdrawn from the ball and broken off the same length, they are then assembled with the ends offset or staggered. The end of the first strand should extend about 1½ in. beyond the end of the second, and the second about 1½ in. beyond the end of the third, and so on.

Waxing the Ends.—After the strands have been thus assembled, the ends are brought together and waxed by rubbing with a small piece of

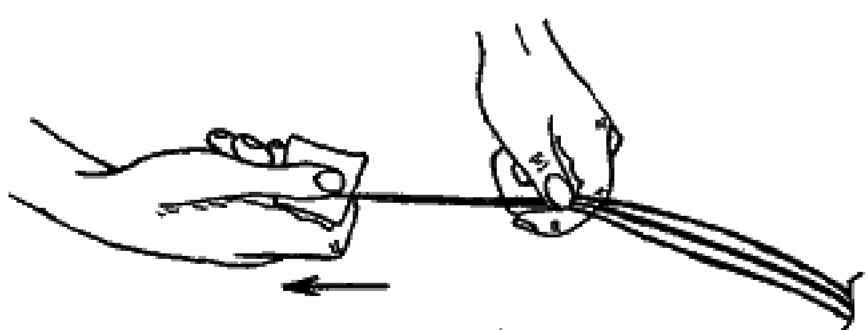


FIG. 296.—After assembling the strands, the ends are next waxed.

harness maker's wax. The wax is usually kept on a pad of scrap leather for convenience. In cold weather it may be well to warm the wax a little.

Twisting and Waxing the Threads.—After the ends are waxed, the thread is stretched tightly over a nail or hook and twisted, one end at a time, by rolling over the right thigh with the palm of the right hand. The left hand holds one end of the thread tight and catches and holds the twist made in the other end by rolling. When both ends are twisted, the thread is pulled back and forth over the hook to even the twist in the two ends. A little practice will indicate how much to twist the thread. Too much twist will cause kinking, and too little twist will cause the thread to be flat instead of round.

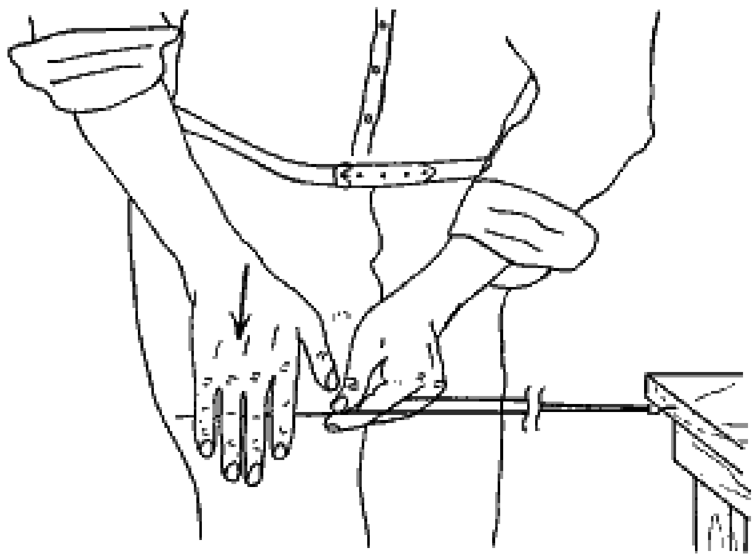


FIG. 297.—The thread is twisted by running it around a nail or hook and then rolling it over the thigh, one end at a time.

After the thread is twisted, it is waxed by rubbing the wax back and forth along the thread a few times. The thread is then rubbed with a piece of leather or the thumb and fingers, to work the wax in and distribute it evenly. Too much wax should not be used, for it will cause the thread to bind in sewing; yet there should be enough used to make the

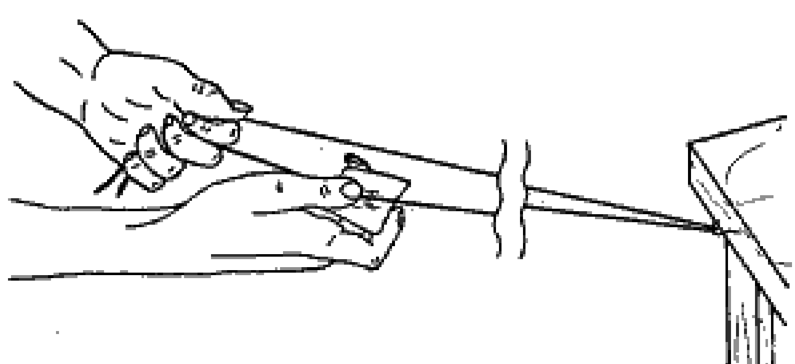


FIG. 298.—After twisting, the thread is waxed. Do not apply too much wax, but work it in well.

thread black all over after the wax is well distributed. In case the thread is sticky, it may be rubbed with a piece of beeswax.

Attaching the Needles.—A blunt-pointed harness sewing needle is fastened on each end of the waxed thread in the following manner: The needle is threaded onto the pointed end as far as it will go without pushing back the wax or ruffling up the fibers of the thread, usually about 2 or 3 in.

The pointed end of the thread is then folded back alongside the main thread and the doubled thread held close to the needle with the thumb and first finger of the left hand. The needle is then twisted clockwise by rolling between the right thumb and finger while the left thumb and finger move slowly down the thread from the needle. The end of the

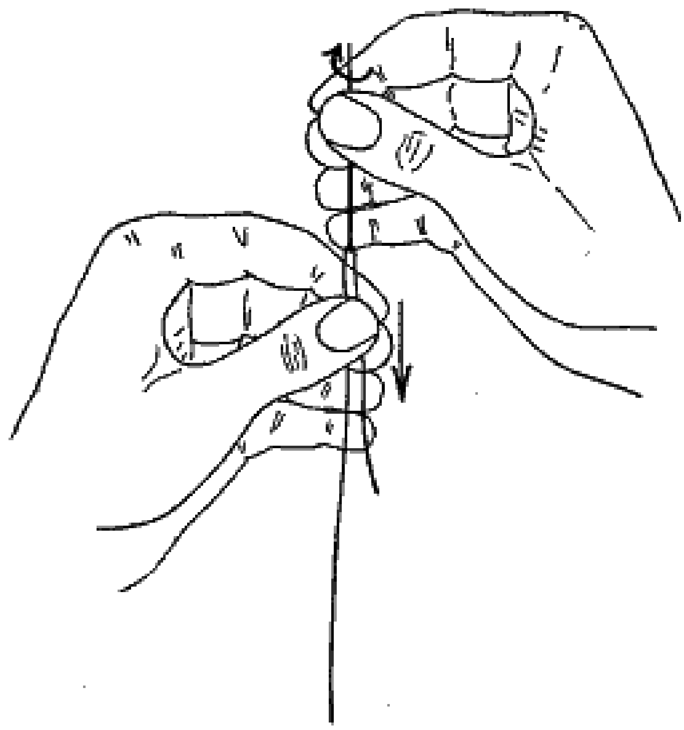


FIG. 299.—Fastening a needle to the end of the thread. Roll the needle in a clockwise direction and slowly move the left thumb and finger down the thread.

thread is thus twisted around and worked into the main thread, and the wax holds it in place. When carefully done, the end of the thread is then about the same size as the needle.

359. Preparing Ends to Be Spliced.—The ends of the leather to be spliced should be cut off square and beveled or skived back about 2 in.

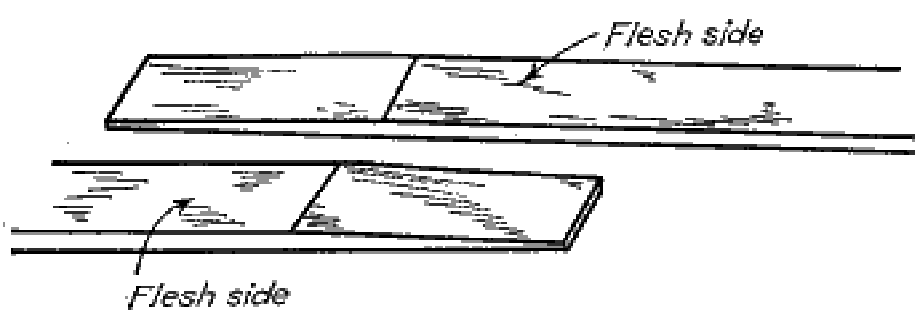


FIG. 300.—Ends of straps beveled or skived ready for sewing.

from the ends, using a sharp knife or plane and beveling on the rough or flesh side of the leather. The hair or smooth side of the leather is tougher and stronger and should not be cut away in beveling. The ends of the straps should not be made too thin, but should be left about half the normal thickness of the leather.

360. Stitching the Splice.—After the ends are beveled they are lapped together about 3½ to 4 in. and placed in a harness-stitching vise or clamp with the hair side of both pieces to the right, and with the strap nearest you to the right. A homemade clamp used in a woodworking or a metal-

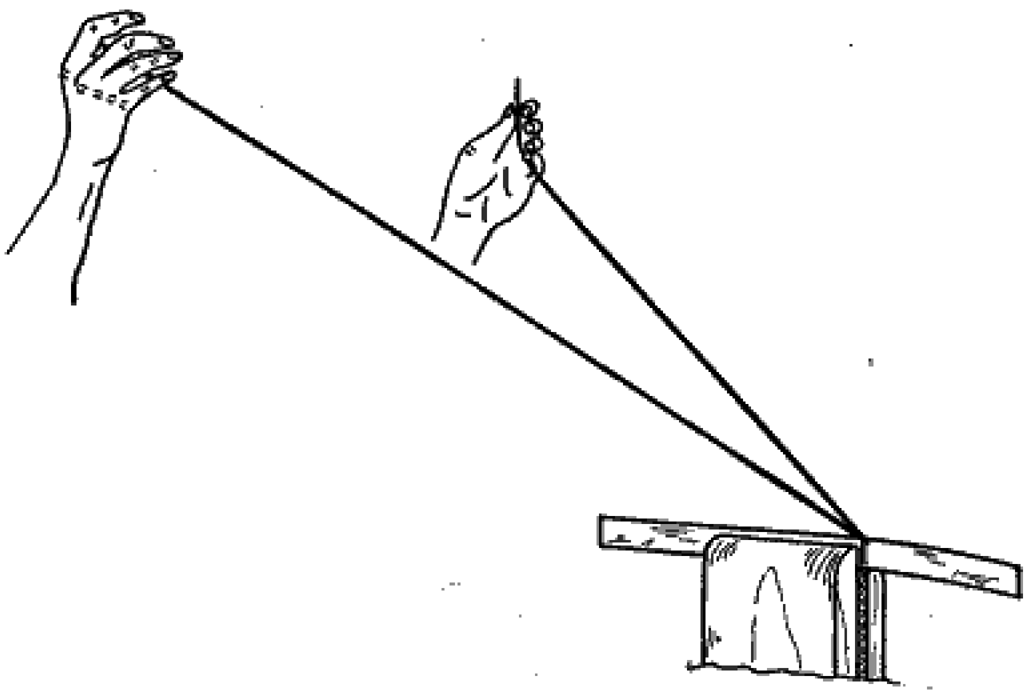


FIG. 301.—Starting the stitching. Hair sides of both pieces are to the right, and the piece nearest the worker is to the right. The first hole is punched in the single strap beyond the splice, one needle is inserted, and the thread is drawn halfway through.

working vise is quite satisfactory, although a harness-stitching horse might be justified where considerable leather sewing is done.

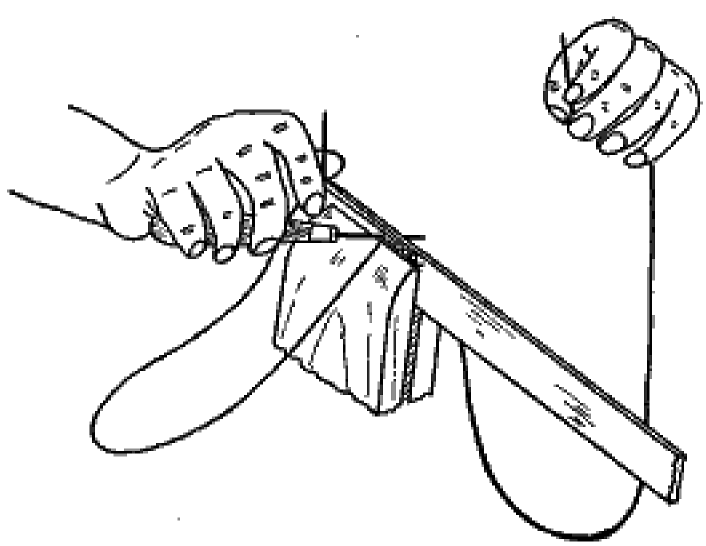


FIG. 302.—Keep the awl in the right hand all the time while sewing.

The top edges of the pieces should project above the jaws of the clamp about ¼ in. The stitching begins by punching an awl hole in the single strap beyond the splice, placing one needle through the hole and drawing the thread halfway through (see Fig. 301). Punch the second hole through both pieces and about $\frac{3}{16}$ in. from the first. Insert the left needle and pull the thread through a little way; then insert the right needle and pull both threads up tight, keeping the awl in the right hand all the time. In a similar manner continue the stitching to the end of the splice.

Punching the Awl Holes.—If desired, a line may be marked or creased in the leather about $\frac{3}{16}$ in. from the edge to serve as a guide line for the

FIG. 303.—The awl makes a diamond-shaped hole. The long axis should be neither lengthwise of the strap nor crosswise, but about halfway between.

awl holes. This line may be marked with a creasing tool, or a pencil, or one leg of a pair of dividers drawn along a straightedge. The spacing of the stitches may be marked off with a stitching wheel, or with a pair of dividers set for about a $\frac{3}{16}$-in. spacing, although, with a little practice, one will be able to space the awl holes evenly by eye without first marking them off.

The awl makes a diamond-shaped hole, and the long axis of the diamond should be about halfway between vertical and horizontal (see Fig. 303).

Making the Crossover.—When the stitching has proceeded across the splice, an awl hole is punched through the single strap just beyond the lap.

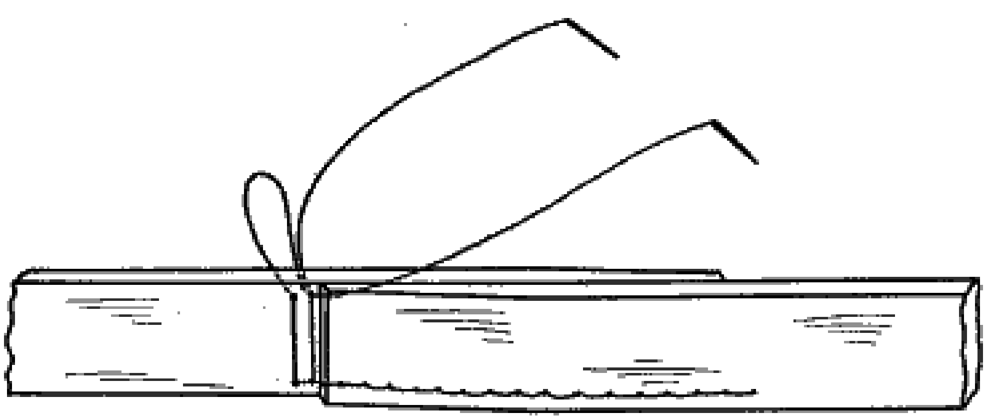


FIG. 304.—The crossover just being finished preparatory to sewing the second side.

Both needles are put through in the usual manner. A second hole is then punched in the single strap and the right needle placed through. This brings both threads out on the left side or flesh side of the leather.

The splice is then turned end for end in the clamp, and two holes punched in the single strap just beyond the lap. A needle is placed through each of these holes, bringing both threads to the right side or hair side of the leather. The needle coming through the farthest hole is placed back through the hole nearest the lap, which leaves a thread on each side of the leather. The second edge of the splice is then sewed in exactly the same manner as the first.

Anchoring the Threads.—To prevent the stitching from loosening, the threads may be anchored as follows: As the stitching is being finished, take one regular stitch through the single strap just beyond the splice, and then make an anchor stitch back in the double part in line with the last stitch in the double part, but about 3⁄16 in. in toward the center of the straps (see Fig. 305). To make this anchor stitch, place both threads

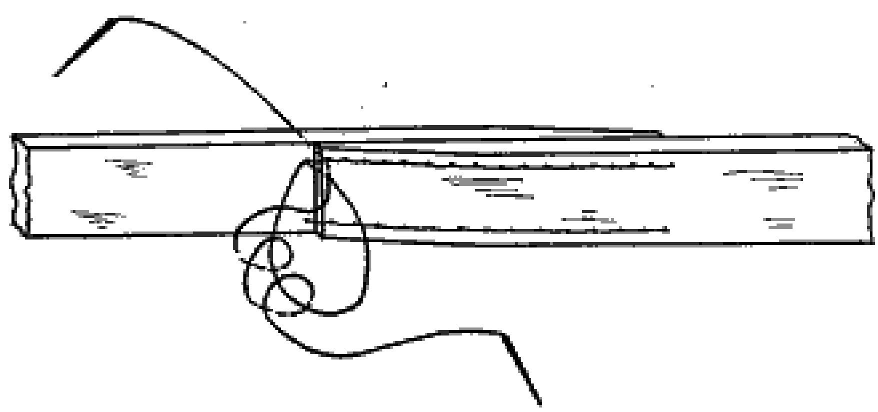


Fig. 305.—Making the lock stitch to prevent the sewing from loosening.

through the hole in the usual manner, but draw only one thread, say the one coming through from the left side, up tight. This left thread is then wrapped twice in a counterclockwise direction through the loop made by the other thread. Tension is kept on the thread coming through from the left while the other thread is carefully drawn up tight. This wraps the threads around each other in the hole. The threads are then cut off.

Some prefer not to make the crossover at all but prefer to stitch each side of the splice independently and anchor the threads at the end of each side.

After the sewing is done, the splice may be hammered lightly with a smooth-faced hammer or rubbed with a piece of leather to work the stitches in and smooth the wax.

361. Fastening a Buckle or Snap to a Strap.—A good method of attaching a buckle or snap is by sewing, although it might be attached by riveting or by the use of such harness hardware as the conway loop or buckle repair clip. When attaching a buckle by sewing, the slot for the tongue may be made by punching two holes about 1 in. apart with a leather punch and then cutting out between the holes with a sharp knife. The end of the strap should be cut off square or have the corners slightly rounded, and it should be beveled back about ½ to ¾ in. from the end.

If desired, a leather loop or keeper may be sewed into place by careful work.

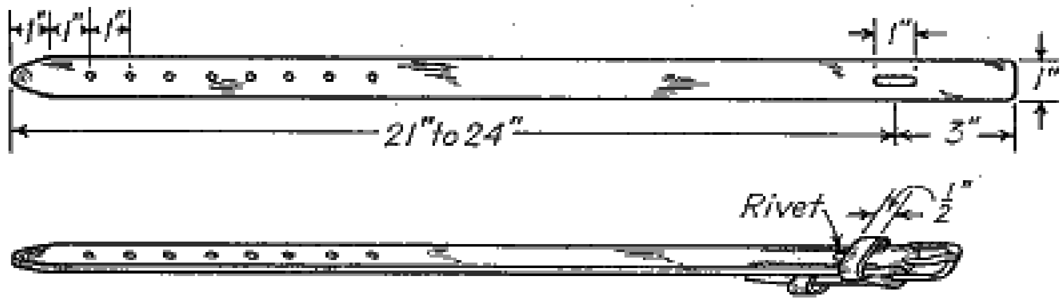


FIG. 306.—A homemade hame strap. The buckle is attached by sewing reinforced with a rivet.

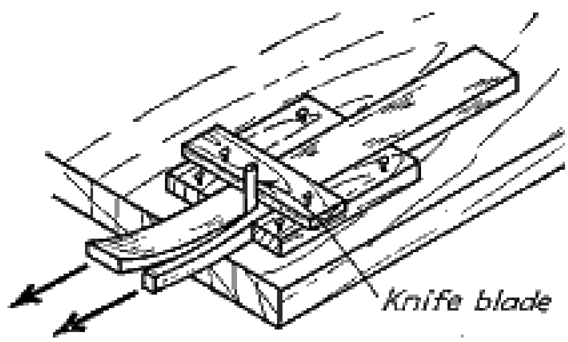


FIG. 307.—A convenient method of splitting leather. A knife blade stuck into the bench top does the cutting, and a few strips of thin wood tacked to the bench guide the strap as it is pulled through.

362. Cleaning and Oiling Harness.—Harness may be cleaned by washing with warm water and mild soap, or warm water and sal soda. A good plan is to take the harness apart and soak in a tub of warm water into which a small handful of sal soda has been dissolved, and then to scrub with a stiff brush.

The harness should then be hung in a warm place to dry, and, while still slightly damp, a good grade of harness oil should be applied by rubbing with a sponge or cloth. As the moisture dries out, the oil penetrates into the leather.

Only a good harness oil or a compound of animal oils, such as neat's-foot oil and tallow, should be used in oiling leather. Motor oil or machine oil should never be used because of its detrimental effect on leather.

BELTING

363. Kinds of Belting.—*Leather belts* are usually considered superior to other kinds under conditions favorable to their use. They are more expensive, however, and they should be used only where they will be protected against moisture, steam, and oil. Their use is therefore somewhat limited on farms. The best grades of leather belts are made from the backs of hides.

Rubber belts are made of alternate layers of canvas and rubber vulcanized together. They are cheaper than leather belts, are not injured by moisture or heat, and are therefore more widely used on farms.

Canvas belts are made of layers of canvas folded and stitched together. They are treated with materials to make them waterproof. They will stand considerable abuse and are widely used as drive belts for machines like threshers and corn shellers. They are not recommended for use over pulleys a fixed distance apart, because of their tendency to stretch. As a drive belt on portable machines, however, this is not objectionable, since the tractor can be "backed into the belt" tighter to compensate for stretching.

364. Care of Belting.—Belts should be kept clean and free from machine oil and grease. If they become dry and hard after a period of use, they should be cleaned and then treated with a suitable belt dressing. A dressing recommended by the maker of the belt should be used if possible. Neat's-foot oil makes a good dressing for leather belts. A dressing made of two parts of edible beef tallow and one part of cod-liver oil is also good for leather belts. The tallow is melted and allowed to cool a little. The cod-liver oil is then added, and the mixture stirred until cold.

Rubber belts will usually need no dressing. Washing with soap and water will generally keep them in good condition. In case the surface of a rubber belt does become hard and dry, however, a very light dressing of castor oil may be applied, after the belt has first been cleaned.

Canvas belts should be treated occasionally with a light application of castor oil or raw linseed oil.

The object of applying dressing to a belt is to keep it soft and pliable. In this condition it can better conform to the surface of pulleys, and transmit power with the least slippage. The use of sticky materials like rosin or tar is not recommended for belt dressings.

Leather belts should be run with the hair or smooth side next to the pulleys. Rubber belts should be run with the seam on the outside of the pulleys.

365. Large Pulleys Are Preferred.—The larger the area of contact between a pulley and a belt, the less the chance for slippage. For this reason it is desirable to use as large a size pulley as practical. Large pulleys are desired also because belts have to bend less abruptly and are strained less in going around them.

366. Open and Crossed-belt Drives.—Belts are crossed between pulleys sometimes to give a greater area of contact, and sometimes to give a desired direction of rotation to the driven pulley. Where an open type of belt drive is used—that is, where the belt is not crossed—it is preferable to have the slack side of the belt on top. This gives a greater area of contact.

Vertical drives where one pulley is directly above the other are to be avoided if possible because of the difficulty of keeping the belt tight on the lower pulley. Where a vertical drive must be used, some convenient and effective means of tightening the belt should be provided. Idler pulleys are frequently used for such purposes.

367. V-Belts and Pulleys.—The V-belt and pulley drive is the most practical for many small-size farm machines. A V-belt can run with considerable slack without slipping because the pull on the belt wedges it tighter into the V-shaped groove on the pulley. V-belts do not slip off the pulleys like flat belts, and the driving and driven pulleys do not have to be in such perfect alignment as with flat belts and pulleys. This type of drive is especially good for machines driven by electric motors.

368. Speed and Sizes of Pulleys.—Pulley speeds are designated in revolutions per minute (abbreviated r.p.m.). For most efficient service a driven machine usually needs to be operated at a definite speed; likewise, the tractor or motor used to drive it should run at a definite speed. Therefore, a problem frequently arises as to what size of pulley should be put on a driven machine to make it run at the desired speed; or just what the speed of the driven machine will be if a certain size of pulley is used on it. The following very simple rule is used for such purposes:

The r.p.m. of the driving pulley × its diameter =
the r.p.m. of the driven pulley × its diameter

When any three of the factors are known, the fourth is easily found. For example, suppose a tractor pulley is 15 in. in diameter and runs 650 r.p.m. and it is desired to know the speed it will drive an ensilage cutter if the cutter pulley is 18 in. in diameter. Substituting in the formula,

$$600 \times 15 = 18 \times \text{r.p.m. of cutter}$$

Solving by simple algebra,

$$\text{R.p.m. of cutter} = \frac{600 \times 15}{18} = 500$$

The rule may also be stated in other forms, two of which are as follows:

(1) R.p.m. of driven pulley =
(r.p.m. of driving pulley × its diameter) ÷ diameter of driven pulley

(2) Diameter of driven pulley =
(r.p.m. of driving pulley × its diameter) ÷ r.p.m. of driven pulley.

BELT LACING

369. Types of Belt Laces.—Where many belts are used on the farm, it will probably pay to buy and use commercial metal belt laces rather than leather-thong laces. Some metal belt laces may be applied with a

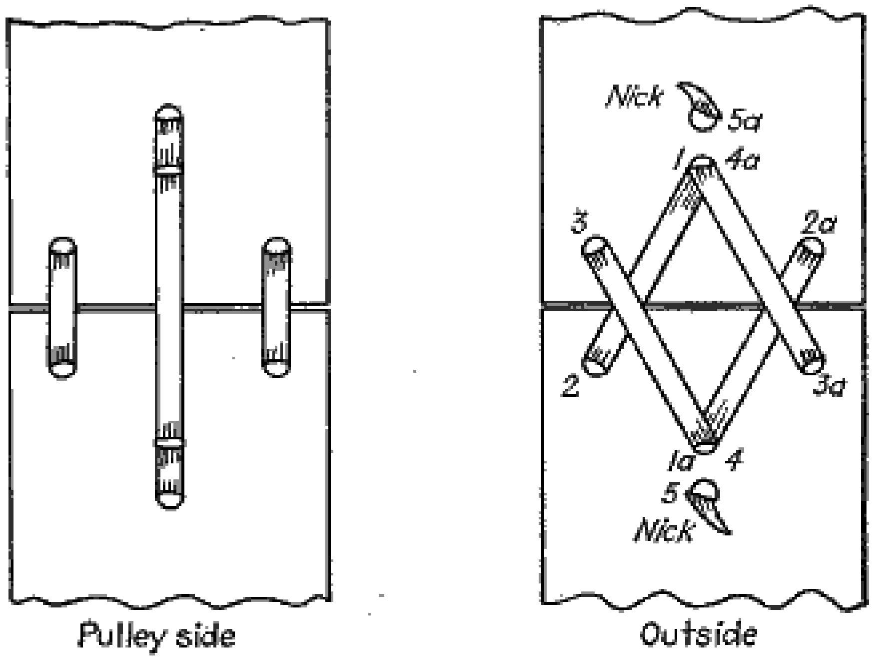


FIG. 308.—The single straight lace for thin, narrow belts. (The numbers at the holes indicate the order of placing the thong through the holes.)

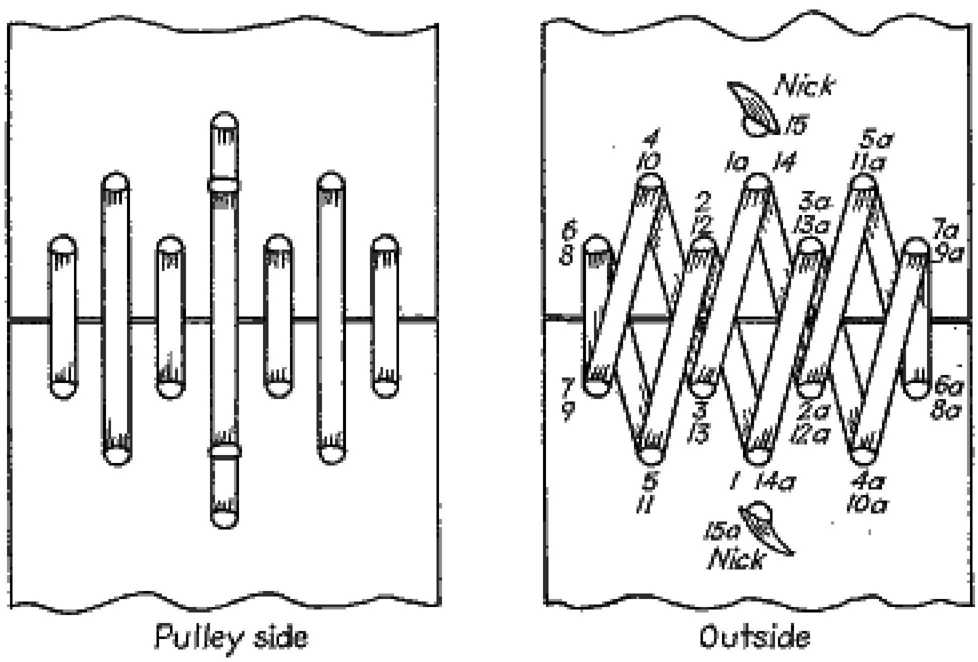


FIG. 309.—The double straight lace. This style is most commonly used on farm belts.

hammer, while others require a small machine that may be used in an ordinary vise. Leather laces are satisfactory for moderate service, and even where metal laces are commonly used it is well to be able to lace a belt with leather laces in an emergency. The process, although requiring careful work, is not at all difficult.

Various types of leather-thong laces may be used. For very light belts, the single straight lace (Fig. 308) is good. The double straight lace (Fig. 309) is probably the most generally used type for moderate duty. For belts that work around small pulleys, the double hinge lace (Fig. 310) is recommended; and for heavy duty, the double lock lace (Fig. 311).

370. Punching Holes for Laces.—In preparing a belt for lacing, the ends are first cut off square, and the locations of the holes carefully marked out. Figure 312 gives suggested spacing of holes for a few common widths of belts. Holes should be no larger than necessary on account of the weakening effect on the belt. Holes 3/16 in. in diameter are large enough for 1/4-in. laces. Oval holes with the long axis parallel with the edges of the belt are better than round holes.

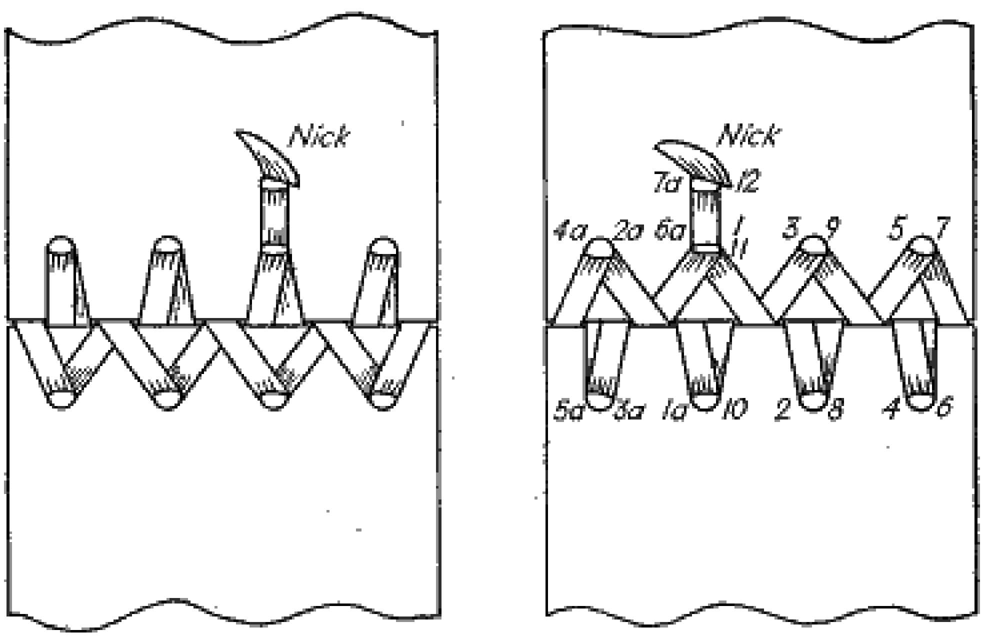


FIG. 310.—The double hinge lace. This lace is recommended where belts work over small pulleys.

371. Threading the Laces.—With most styles of lacing, the thong is started in one of the middle holes of the belt. One end is then threaded to one edge of the belt and back to the center; and the other end is threaded to the other edge and back. The order of lacing through the various holes is indicated by the numbers in Figs. 308 to 311. In making the hinge lace, the thong is threaded through the holes in exactly the same manner as the other types, except that it is always passed through the joint instead of directly across.

372. Fastening the Ends of the Laces.—The ends of the laces must be fastened to prevent them from pulling back out of the holes. Where no idlers are used and the outside of the belt does not run against a pulley, the ends may be tied together with a square knot. A good method that may be used regardless of idlers is to draw the end of the lace through a very small hole and then cut a small diagonal nick along the edge of the lace to form a small fish-hook type of barb. As the lace tends to pull back through the hole, this barb flares out and prevents it from going farther.

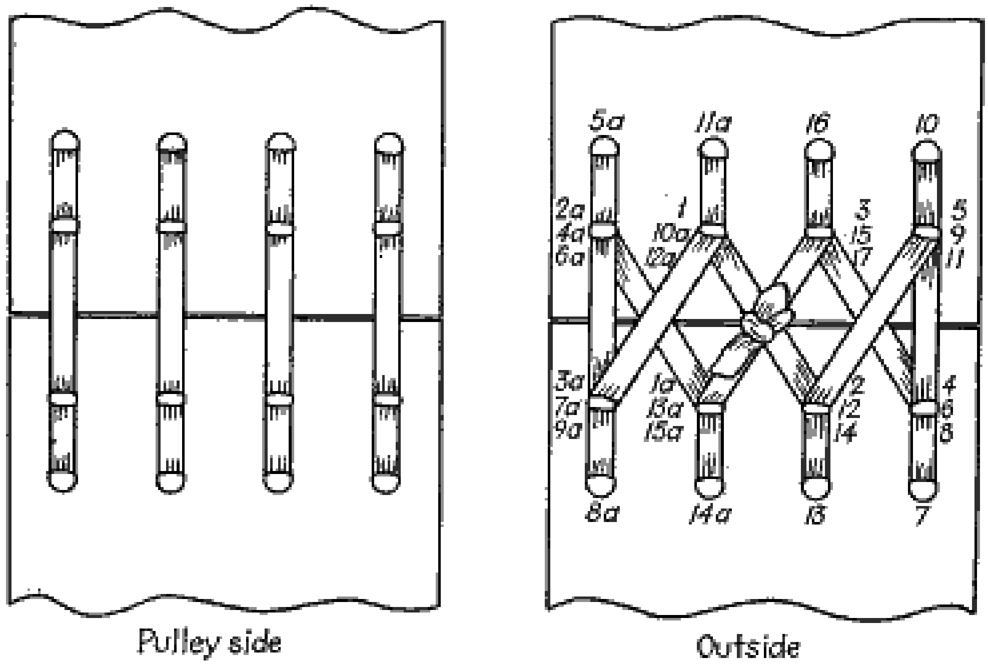


FIG. 311.—The double lock lace is good for heavy duty.

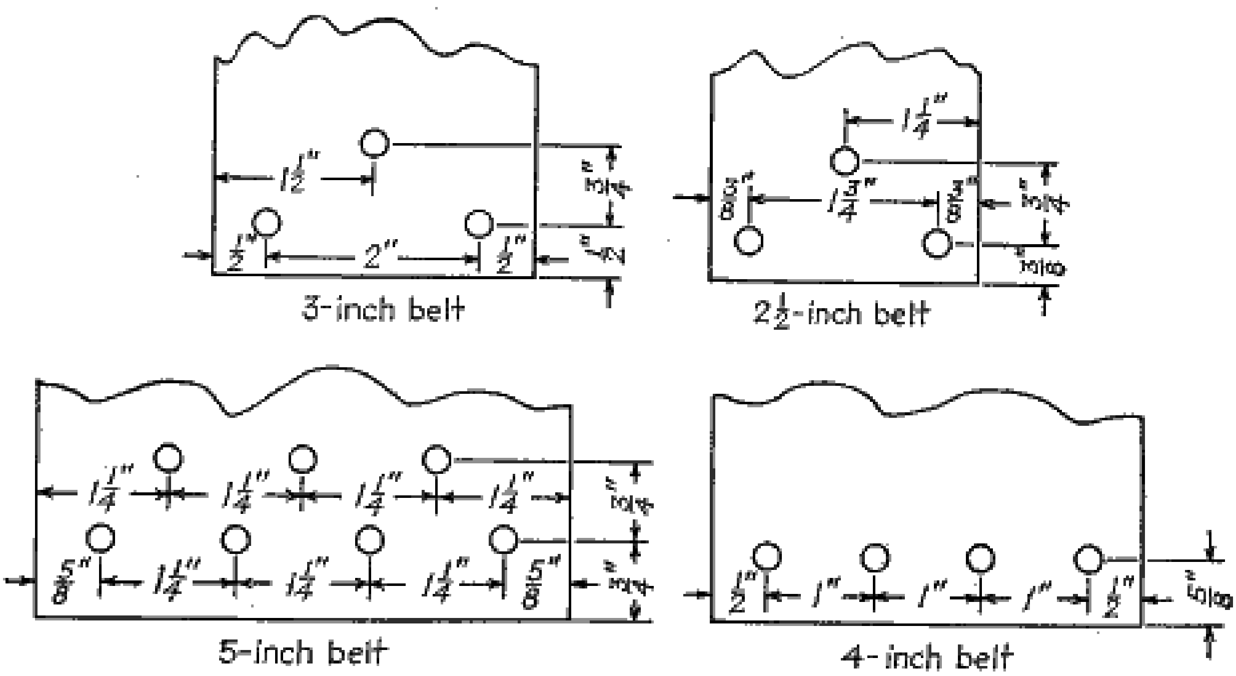


FIG. 312.—Suggested spacing of holes for common belt laces.

Questions

356. What tools and supplies would you recommend for a harness repair kit on the farm?

357. (*a*) What kinds of harness rivets are available? (*b*) What are the particular advantages of each kind?

358. (*a*) What are the steps of the process of making a waxed sewing thread? (*b*) What kind and size of thread is used? (*c*) How many strands are needed for making a waxed thread, and about how long should they be? (*d*) Why is the thread torn rather than cut? (*e*) Just how may it be torn easily? (*f*) How may thread be kept or stored so as not to become tangled? (*g*) Why should the strands be assembled with the ends offset or staggered? (*h*) Should all strands be the same length? (*i*) Should the ends be waxed before the threads are twisted? (*j*) How may wax be kept for convenience in handling? (*k*) Just how are the threads twisted? (*l*) What are indications of too much twist? Of insufficient twist? (*m*) Just how are the needles fastened to the ends of the thread? (*n*) What remedy may be used in case the thread is too sticky?

359. (*a*) Which side of a piece of leather should be skived or beveled preparatory to splicing? Why? (*b*) What tools are used for skiving?

360. (*a*) How much should the ends of two pieces be lapped for a sewed splice? (*b*) Explain and be able to demonstrate just how the pieces should be placed in the clamp. (*c*) Describe a simple stitching clamp or vise that can easily be made in the shop. (*d*) How far should the top edges of the splice project above the jaws of the clamp? (*e*) Describe the process of punching the holes and threading the needles through them. (*f*) Where should the awl be kept while the stitching is being done? (*g*) How many holes should be punched with the awl at one time? (*h*) How far should the stitches be from the edge of the leather, and how long should they be? (*i*) Should the long way of the diamond-shaped awl hole be vertical or horizontal or some other way? (*j*) Explain and be able to demonstrate just how to make the crossover when the splice is half stitched. (*k*) Explain and be able to demonstrate just how to anchor the threads when the stitching is completed. (*l*) What procedure may be used in sewing a splice to avoid the crossover?

361. (*a*) What different ways may be used in fastening a buckle to a strap? (*b*) Just how would you prepare the strap for sewing the buckle on?

362. (*a*) What procedure would you use for thoroughly washing a harness? (*b*) What kind of soap or other material would you use, and how much? (*c*) How may a harness be oiled? (*d*) Should the leather be thoroughly dry before oiling? Why? (*e*) What kind of oil is recommended?

363. (*a*) Under what conditions are leather belts usually preferred to other kinds? (*b*) How are rubber belts made? Canvas belts? (*c*) What are the particular advantages and disadvantages of rubber and canvas belts?

364. (*a*) What are the main important points to be observed in the care of belts? (*b*) What kinds of belt dressing, if any, should be used on leather belts? On rubber belts? On canvas belts? (*c*) What is the object of applying belt dressings? (*d*) What materials should be avoided in belt dressings? (*e*) Which side of a leather belt should run next to the pulley? Which side of a rubber belt?

365. For what two main reasons are large pulleys preferred over small ones?

366. (*a*) What is meant by open and by crossed-belt drives? (*b*) Which type is preferred? (*c*) Why is it not always used? (*d*) Why are vertical belt drives not desirable?

367. What particular advantages have V-belts and pulleys over flat belts and pulleys?

368. (*a*) State a simple rule that may be used in problems involving pulley sizes and speeds. (*b*) Give one or two other forms of this rule or formula. (*c*) Assume a problem of your own and demonstrate its solution by the application of this rule.

369. (*a*) Under what conditions would you recommend the use of metal belt laces and under what conditions leather laces? (*b*) What are the most commonly used types of leather laces, and under what conditions would each be recommended?

370. (*a*) What procedure should be followed in preparing the ends of a belt for lacing with leather thong? (*b*) What size holes should be punched? (*c*) What kind of holes is preferred? Why?

371. What is the general system of threading the thong through the holes?

372. In what ways may the ends of the thong be fastened to prevent them from becoming unlaced?

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CHAPTER XXIV

ROPE WORK

Every farmer has occasion to use rope, and it will be well worth his time to master some of the more useful knots, hitches, and splices so that he can make them easily and quickly. It is better to learn a few of the more useful ones thoroughly than to acquire only a superficial knowledge of many and be unable to use them when needed.

373. How Rope Is Made.—Rope is made of fibers of certain vegetable plants. The fibers *A* (Fig. 313) are twisted together in a right-hand[1]

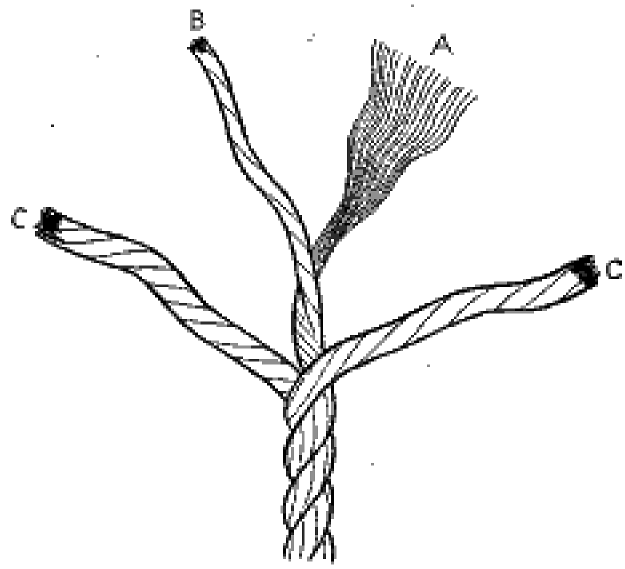


Fig. 313.—Parts of rope. *A*, fibers; *B*, yarn; *C*, strand; *D*, whole rope.

direction to form the yarns *B*. The yarns are then twisted together in a left-hand direction to form the strands *C*; and the strands are twisted together in a right-hand direction to form the rope. It is this opposite or alternate twisting of fibers, yarns, and strands that keeps a rope in shape. When a weight is hung on the end of a rope, it tends to untwist and become longer. In untwisting, however, the yarns are twisted tighter. The weight will revolve until the twists in the fibers, yarns, and strands are equalized.

[1] If a rope is pointed toward a clock, and the twist of the fibers, yarns, or strands is the same direction as the hands move, the twist is said to be *right-hand*. If the twist is counterclockwise, it is said to be *left-hand*.

374. Rope Terms and Definitions.

Fiber. Threadlike material obtained from the plant.
Yarn. Fibers twisted together.
Thread. Two or more small yarns twisted together.
String. The same as thread but made of larger yarns.
Cord. Several threads twisted together.
Strand. Two or more large yarns twisted together.
Rope. Several strands twisted together.
Hawser. Three-strand rope laid up right-handed.
Cable. Three hawsers twisted together left-handed.
Bight. A U made by turning the rope back on itself.
Loop. A complete turn in the rope (see Fig. 314).
Standing Part. The main part or long part of the rope as distinguished from the end being knotted, tied, or spliced.

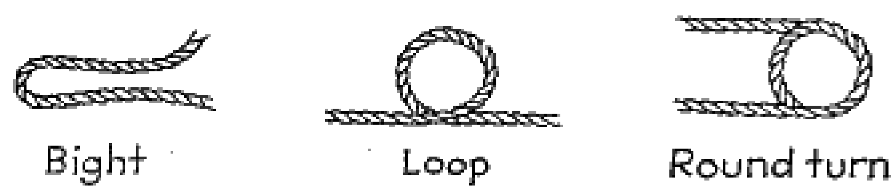


FIG. 314.—Elements of a knot.

375. Rope Materials.—Rope is made from a number of different vegetable fibers, including manila, sisal, and cotton. Most of the rope used on the farm is made from manila or sisal fiber, or a combination of the two.

Manila fiber is made from the outer portions of the abaca plant, which resembles the banana plant and is grown in the Philippine Islands. The best grade of manila fiber is light buff in color, has a silky or lustrous appearance, is fine, uniform in size, flexible, and from 6 to 12 ft. in length.

Sisal fiber, which comes from a plant grown in Central America and Mexico, is somewhat coarser, stiffer, shorter, lighter in color, and weaker than manila fiber.

CARE OF ROPE

376. Relieving Kinks.—A new rope frequently causes trouble on account of kinking. This is because the right and left-hand twists of the fibers, yarns, and strands have not been equalized. The trouble can be remedied in the case of a short rope by fastening one end to an overhead beam or support and tying a weight to the free end. A long rope may be dragged slowly over a pasture or other reasonably smooth surface, thus allowing the free end to revolve and to equalize the twists in the parts of the rope.

377. Coiling and Uncoiling a Rope.—Rope should be coiled in a clockwise direction so as to untwist the strands and prevent kinking. It may be coiled on the ground or floor (Fig. 315) or in a loose coil around the flexed left forearm, winding between the thumb and fingers of the open hand and over and around the elbow (see Fig. 316). In taking a rope out

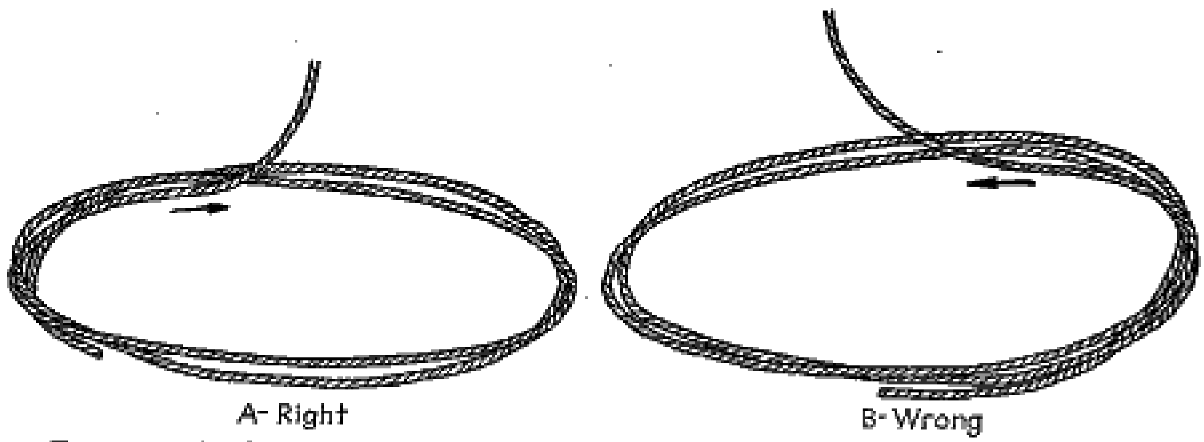


FIG. 315.—Right and wrong methods of coiling a rope. To prevent kinking and tangling, the rope should be coiled in a clockwise direction. (It should be uncoiled in a counterclockwise direction.)

of a coil, it should be unwound in a counterclockwise direction. If it starts to uncoil in a clockwise direction, turn the coil over and pull the end up through the center from the other side.

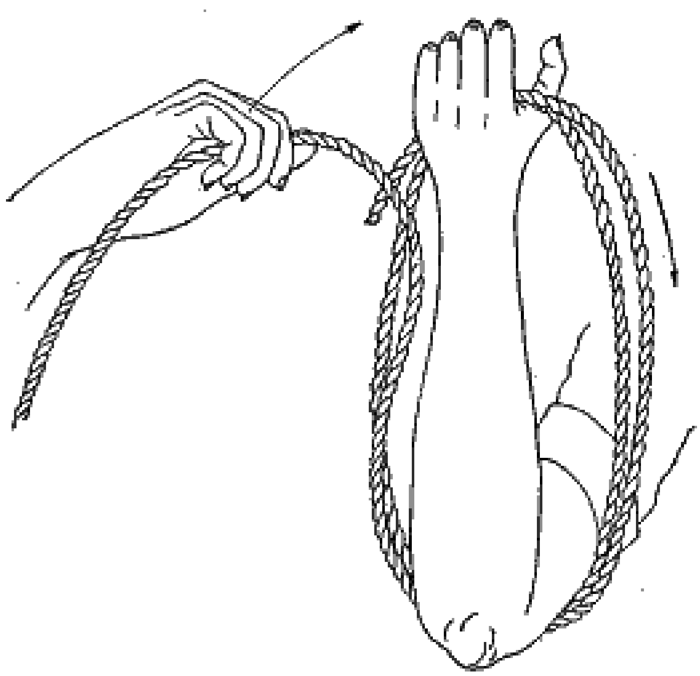


FIG. 316.—A good way to coil a small rope is to wrap it loosely around the flexed left forearm in a right-hand direction.

378. Avoid Abuse and Keep Rope Dry.—Care should be exercised not to draw a rope over sharp or rough objects that might wear or break the outer fibers. Nor should a rope be used over a pulley that is too small in diameter. The diameter of the pulley should be at least eight times the diameter of the rope.

Ropes should not be exposed to dampness or moisture more than necessary, nor should they be left damp under poor conditions for drying, as dampness tends to rot the fibers.

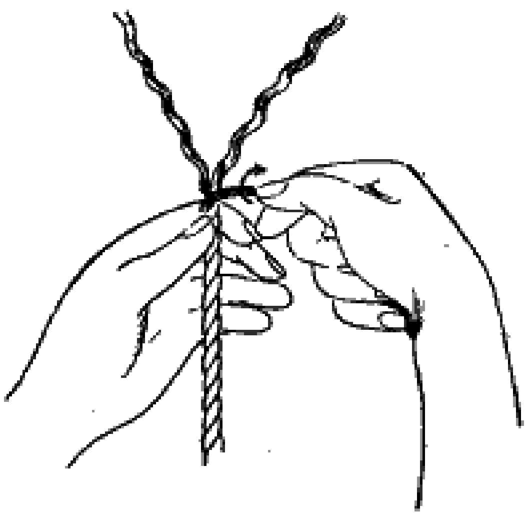


FIG. 317.—Re-laying strands.

379. Re-laying Strands.—If the end of a rope becomes untwisted, and the strands stay in good condition, they may be easily re-laid. The rope is held in the left hand while the right hand twists one strand tightly to the right (see Fig. 317). The left thumb is moved up the rope to hold the twist in the strand. In like manner the other two strands are twisted in turn, and the process continued until all the loose strands are re-laid. It is best not to rotate the rope in the left hand, but to simply move the hand straight up the rope.

FINISHING THE ENDS OF A ROPE

380. Whipping.—This is a neat and effective method of preventing the ends of a rope from untwisting and is recommended when the rope must pass through small holes.

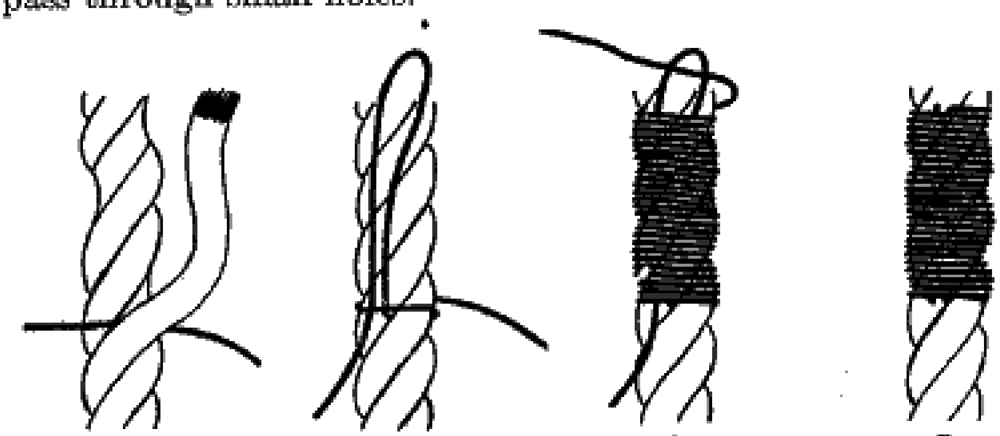


FIG. 318.—Whipping an end of a rope is an effective way to prevent fraying.

There are various methods of whipping a rope end. One of the best methods is as follows:

1. Unlay one strand of the rope back an inch or two from the end (see Fig. 318).
2. Place one end of a stout cord, 2½ to 3 ft. long, under the raised strand, leaving the short end of the cord 6 or 8 in. long; and then re-lay the strand.
3. Hold the end of the rope up, letting the short end of the cord hang down.
4. Wrap the long end of the cord once around the rope, just above the short end.
5. Pull the short end of the cord towards the end of the rope and turn it back, forming a bight. It is best to lay the sides of this bight in a groove in the rope.
6. Wind the long end of the cord around the rope and the bight, keeping the turns tight and close together.

7. When the wrapping has progressed as far as desired, pass the long end of the cord through the bight, keeping it tight.

8. Pull on the short end of the cord, drawing the bight back under the wrapping to about the center. Cut off the loose ends.

381. The crown knot is used principally as the first step in making the crown splice. It is made as follows:

1. Unlay the end of the rope about five turns.
2. Bring strand 1 down between strands 2 and 3, forming a bight (see Fig. 319).
3. Place strand 2 around behind the bight and in front of strand 3.
4. Pass strand 3 through the bight and draw the strands down even and tight.

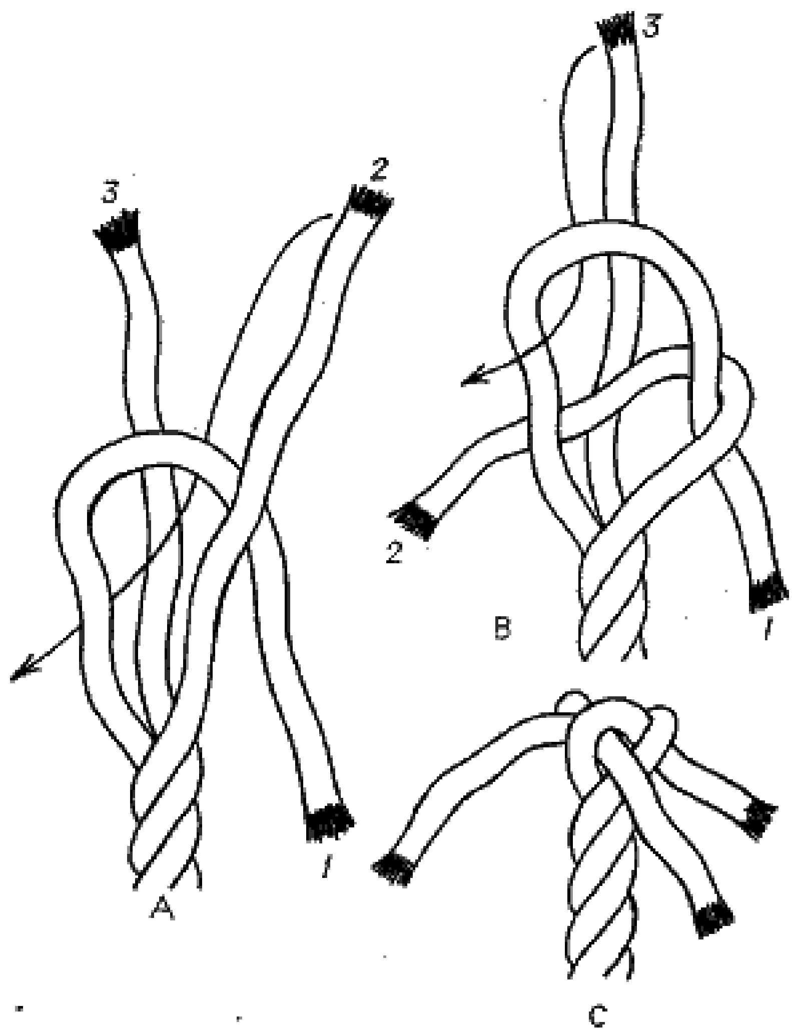


Fig. 319.—The crown knot.

382. The crown or end splice is one of the most useful and permanent end fastenings for a rope. It is made by first making a crown knot and then proceeding as follows:

1. Place strand 1 over the first adjacent strand in the main part of the rope, and under the next strand (see Fig. 320).

2. In a similar manner pass strand 2 over the strand of the main part that is adjacent to strand 2 and under the next.

3. Strand 3 is then passed over the strand of the main part that is adjacent to it and under the next. *Strand 3 should come out at the same place strand 1 went in*, and

when properly done the three strands will come out of the main part equally spaced and no two in the same place.

4. In the same manner, each of the three strands is tucked under strands of the main rope about three more times. A strand is tucked under but one strand of the main rope at a time. The strands, as they are woven in place, keep almost at right angles to the strands of the main part and work diagonally around the rope, not straight down it.

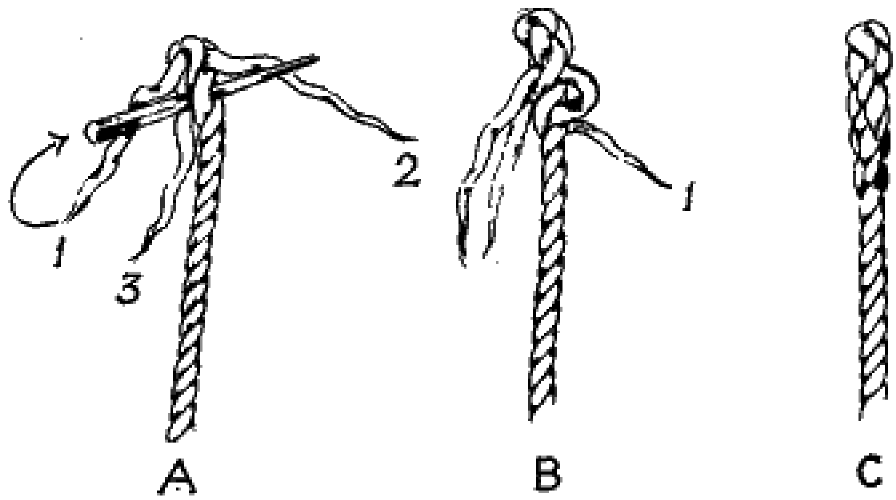


FIG. 320.—The crown splice.

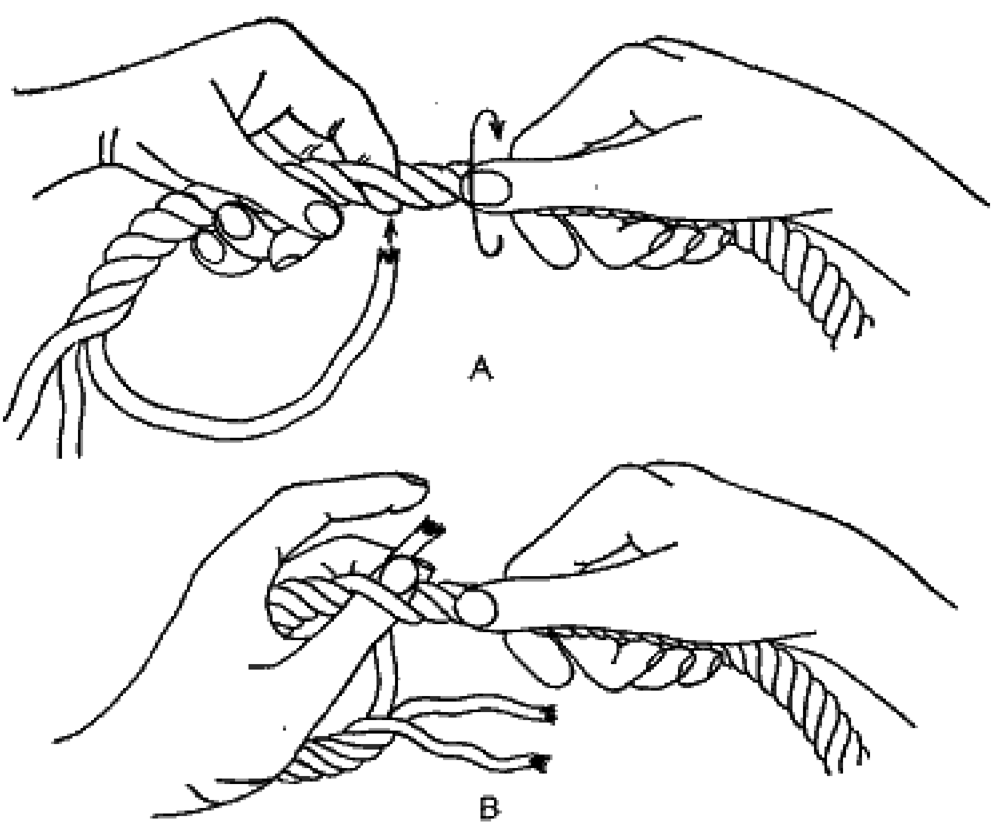


FIG. 321.—An easy method of tucking.

A. The rope is untwisted slightly and then the first finger of the left hand is placed under a strand, opening up a hole.

B. As the finger is withdrawn the thumb pushes the strand through the hole.

5. When the strands have been woven far enough, the loose ends are cut off about ¼ in. long and the splice is smoothed by rolling it under the foot on the floor.

If it is desired to make a tapered splice, part of each strand may be cut out before taking the last one or two tucks.

In order to facilitate tucking, the strands of the main part of the rope may be untwisted slightly, with the right hand, and the end of the first finger of the left hand started back through under a strand of the standing part to raise it (see Fig. 321). The end of the loose strand to be tucked under is then placed against the end of the first finger and made to follow it back out by pushing the loose strand with the end of the left thumb.

383. The wall knot is used most as the first part of a Matthew Walker knot. It is sometimes used alone, however, as an end fastening for a rope.

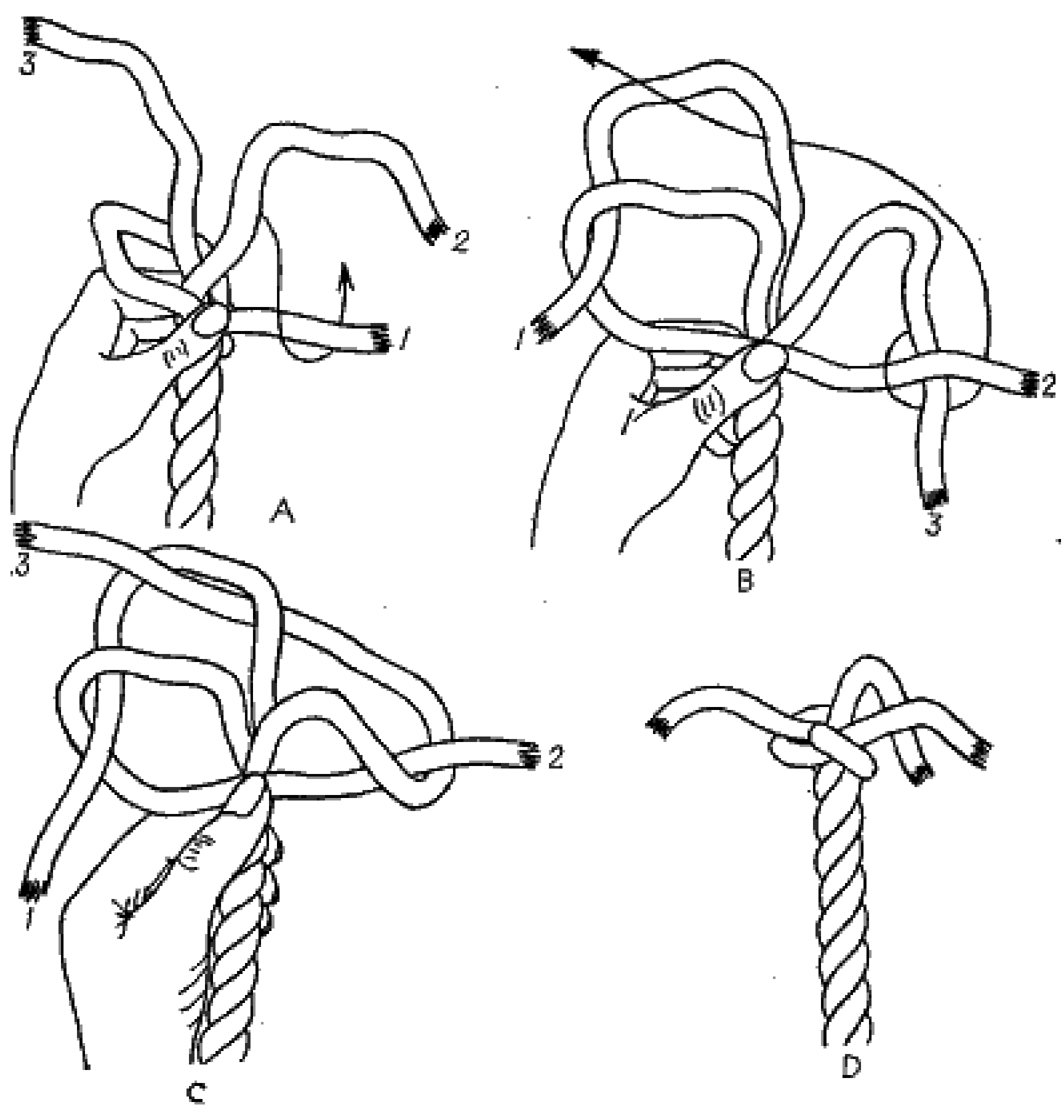


FIG. 322.—The wall knot.

To make the wall knot:

1. Unlay the strands about 3 or 4 in. and hold the rope in the left hand, loose ends up.

2. Bring strand 1 halfway around and across in front of the rope, holding it in place with the left thumb (see Fig. 322).

3. Pull strand 2 down and around the end of strand 1, releasing strand 1 from under the left thumb and placing the thumb on strand 2 to hold it in place.

4. In a similar manner, pull the end of strand 3 down and around the end of strand 2 and pass the end of strand 3 up through the loop of strand 1.

5. Draw the strands up evenly and tightly.

384. Matthew Walker knot is one of the most useful and permanent end knots. It is made as follows:

1. First make a wall knot, leaving it loosely constructed (see Fig. 323*A*).
2. Then pass end 1 up through loop *a* ahead of it; end 2 up through loop *b* and end 3 up through loop *c*.
3. Draw the strands up even and tight.

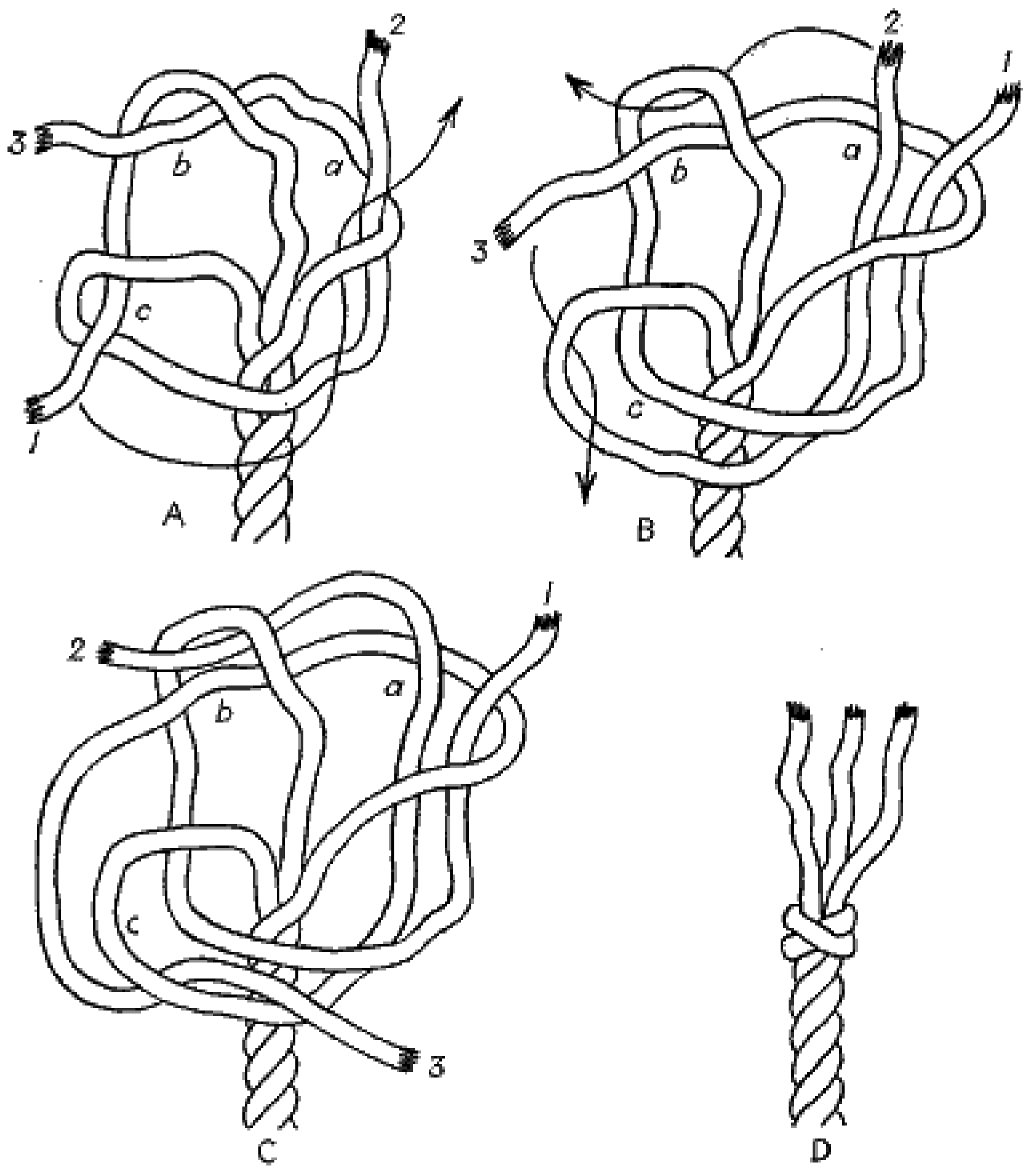


FIG. 323.—The Matthew Walker knot.

KNOTS[1]

385. The overhand knot (Fig. 324) is used sometimes as an end knot in a rope but more frequently as a part of other knots and hitches.

[1] For discussion of the crown knot and the wall knot, see Arts. 381 and 383, respectively.

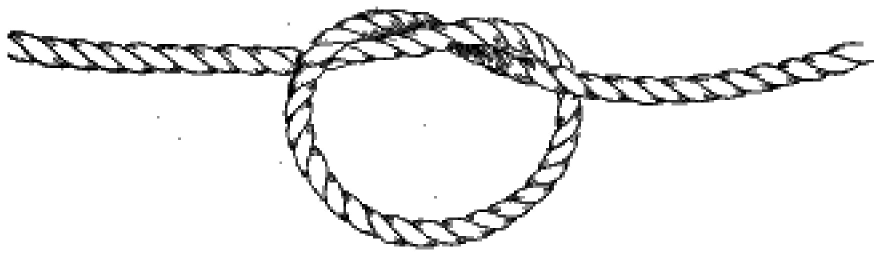
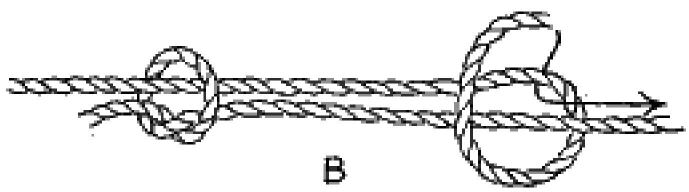


FIG. 324.—The overhand knot.

386. The fisherman's knot (Fig. 325) is used for joining silk lines or guts on fish tackle. It may be used also for tying two ropes together. It is made by placing the two ends to be joined side by side, and then tying each end around the other, using an overhand knot.

A



B

C

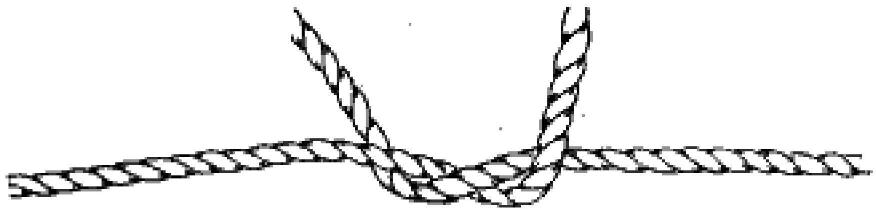
FIG. 325.—The fisherman's knot.

387. The square knot (Fig. 326) is one of the most useful knots for joining the ends of twine, string, or rope.

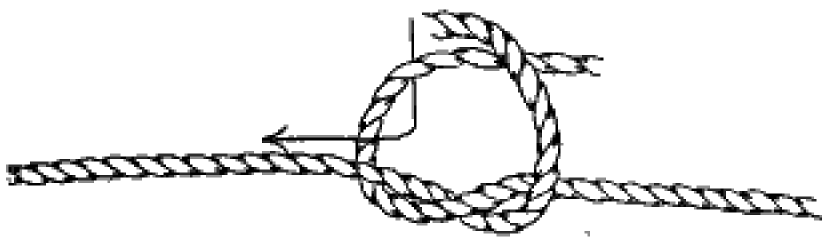
388. The granny knot (Fig. 327) has much the same appearance of the square knot, but it will slip under strain and should not be used. It should be studied carefully so that it will not be mistakenly tied for the very useful square knot.

389. The slip knot (Fig. 328) is used for tying a tight loop around an object. It is made by forming a bight in the end of the rope, and tying the end around the standing part, using an overhand knot.

390. The Tom fool's or double-bow knot (Fig. 329) is sometimes called a trick knot, although it is very useful. It is often used for holding hogs while ringing. One loop is slipped over the hog's upper jaw, and the standing end of that loop is fastened to a post. The knot is untied, and



A



B

C

FIG. 326.—The square knot is a very useful knot and should not be confused with the granny knot.

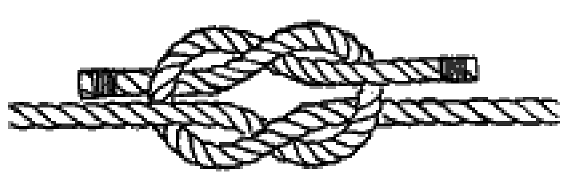


FIG. 327.—The granny knot slips under load and should usually be avoided.

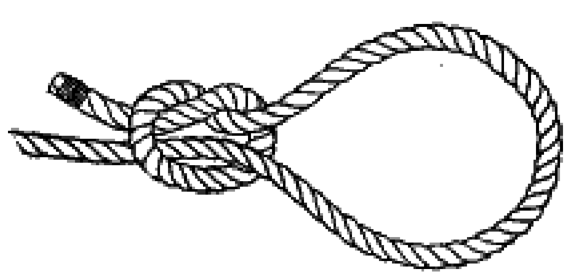


FIG. 328.—The slip knot.

the hog released by simply pulling on the opposite end of the rope. It may be tied by tying a slip knot, leaving the end of the rope long, and then putting the end back through the knot and tightening.

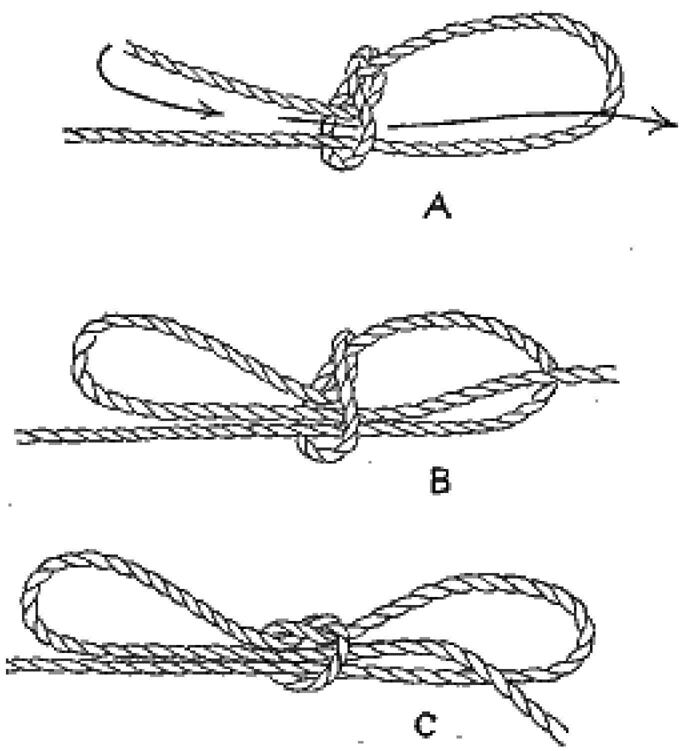


Fig. 329.—The Tom fool's or double-bow knot.

391. The hitching or manger knot (Fig. 330) is started like a slip knot. Instead of drawing the rope entirely through and completing the slip knot, however, a bight is left, and the end of the rope passed through this bight.

392. The bowline knot (Fig. 331) is one of the most useful of knots. It holds securely and will not slip nor draw up tight. It is made by forming a loop near the end of the rope and then passing the end through the loop, around the standing part, and back through the loop again.

393. The anchor bend (Fig. 332) is particularly good for fastening a rope into a ring or clevis or around a beam. It is secure, does not draw tight like many other knots, and does not wear the rope excessively.

394. The miller's knot (Fig. 333) is by far the best knot for tying grain sacks. It is easily tightened by pulling on the ends of the completed knot, holds securely, and is easily untied. The end of the bag is gathered and held tight between the thumb and first finger of the right hand. The tie string is placed across the front of the bag, under the last three fingers, but over the first finger of the right hand. The string is then taken around the neck of the sack, under the heel of the right hand and under all fingers, but over the end of the string. The string is then wound around the neck of the sack a second time in the same manner. The first finger of the right hand then pulls the end of the tie up under the loop which was formed over the finger when the knot was started. The knot is completed by drawing the ends tight.

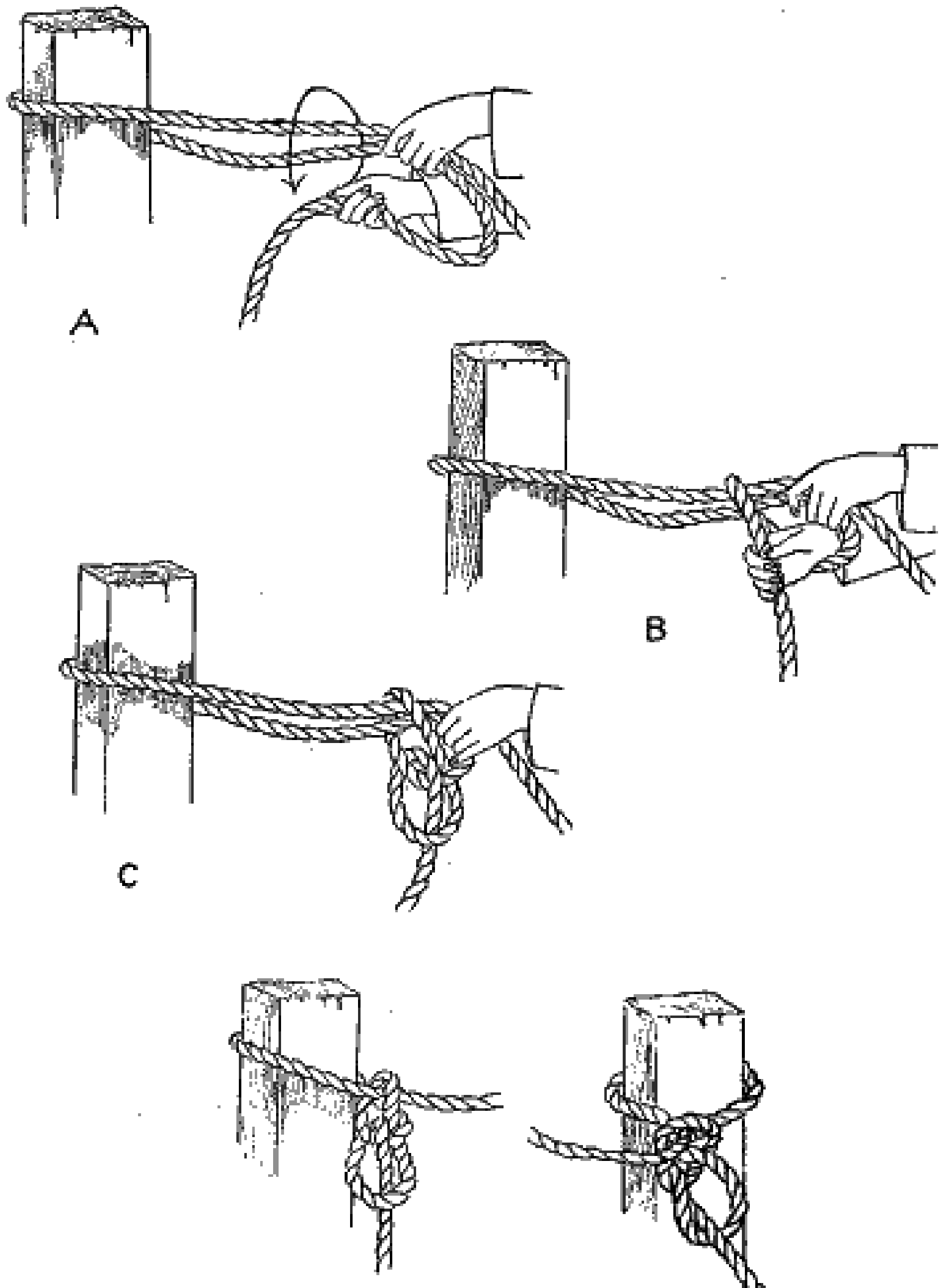


FIG. 330.—The hitching or manger knot.

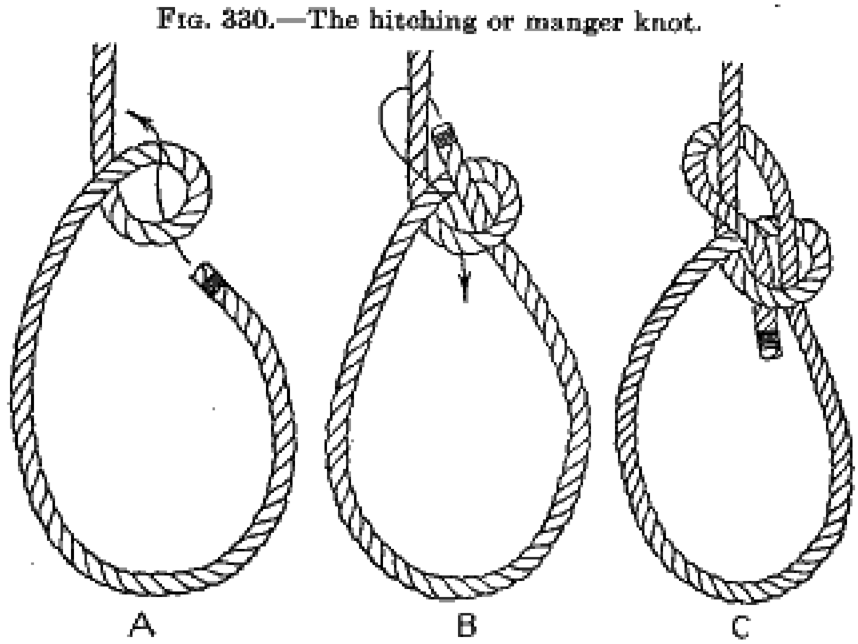


FIG. 331.—The bowline knot.

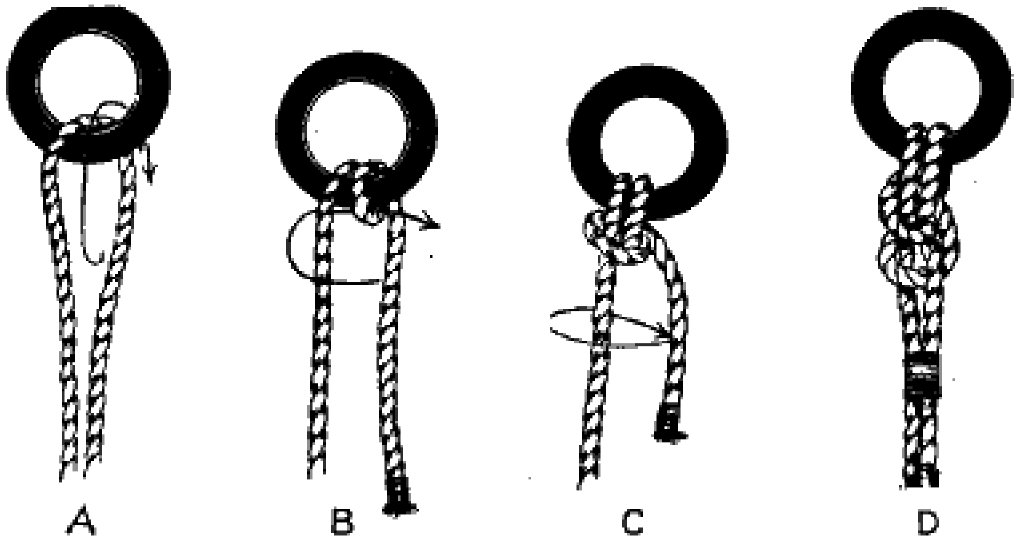


FIG. 332.—The anchor bend.

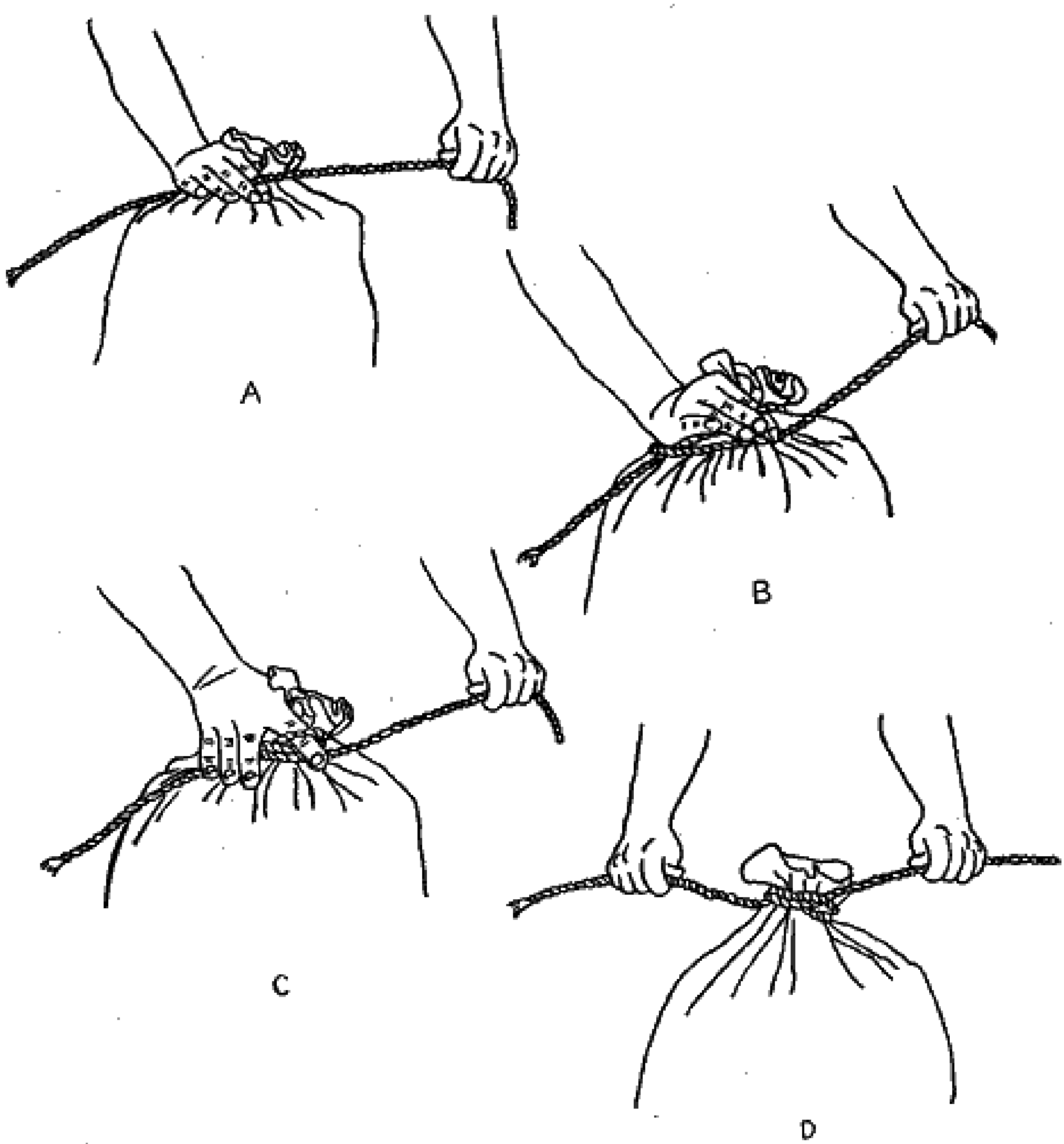


FIG. 333.—The miller's or grain-sack knot.

Some prefer not to draw the end of the tie completely through under the loop, but to leave a bight as in the double bow knot. The knot is then very quickly and easily untied by pulling on the end.

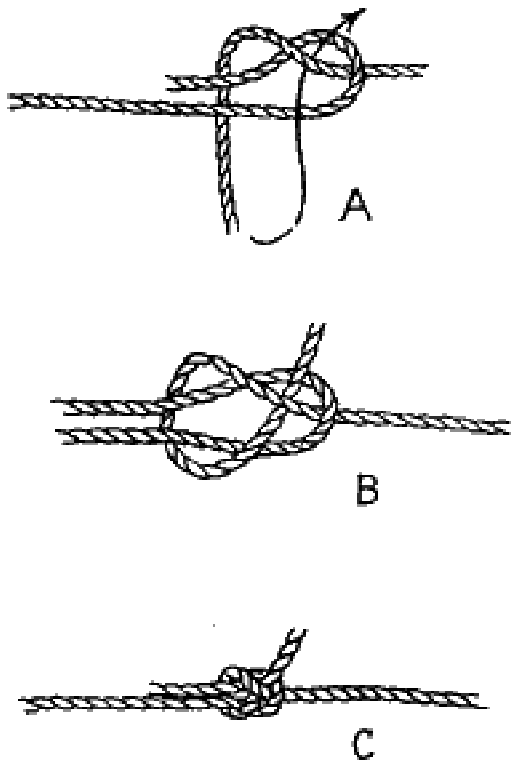


FIG. 334.—The weaver's knot.

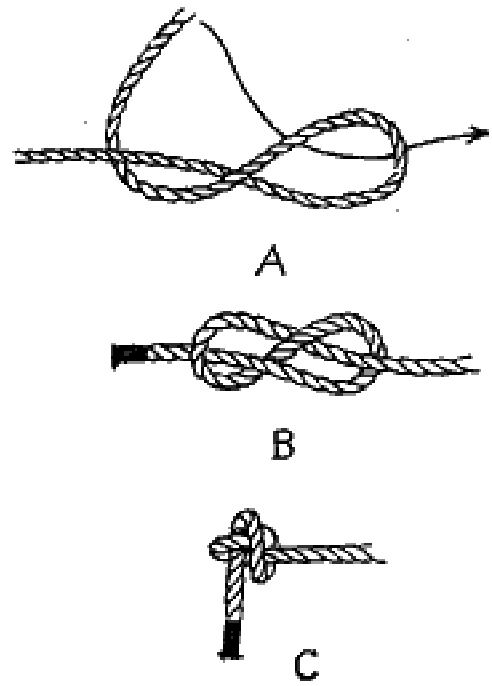


FIG. 335.—The figure-8 knot.

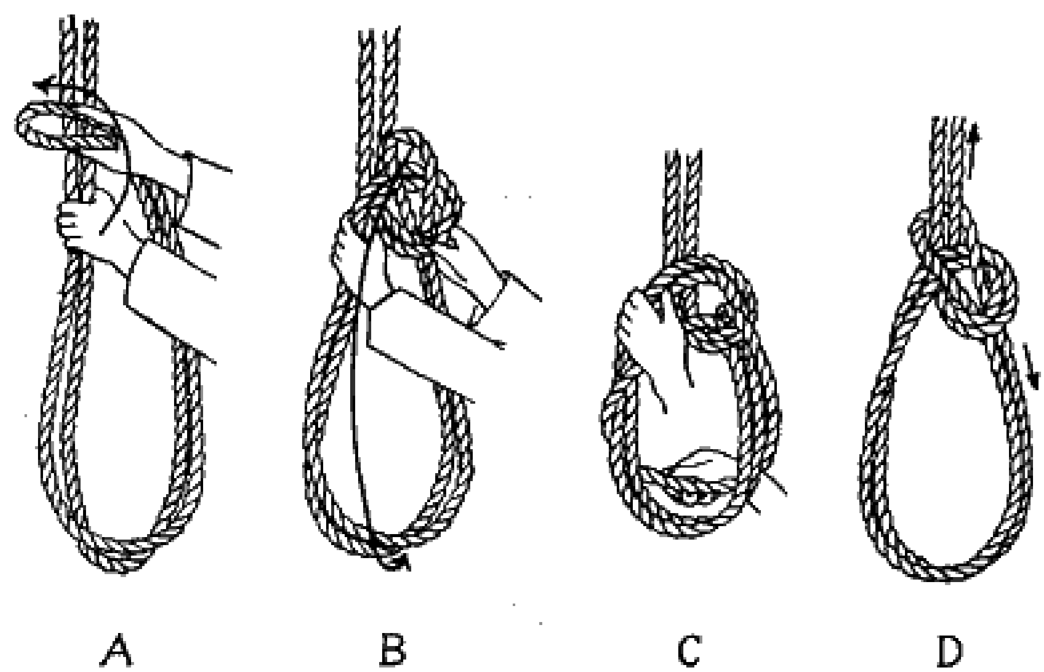


FIG. 336.—The bowline on the bight.

395. The weaver's knot or sheet bend (Fig. 334) is good for joining two ropes. It remains secure without drawing up tight and is easily untied.

396. The figure-8 knot (Fig. 335) may be used where a large bulky knot is needed on the end of a rope to keep it from drawing through a hole or through a pulley.

397. The bowline on the bight (Fig. 336) is used for forming a loop in the middle of a rope or near the end where it has been doubled. It is used as part of the tackle in casting horses. It is tied by forming a loop in the doubled rope and passing the doubled end of the rope through the loop. The doubled end, or bight, is then brought down and slipped over and back up around the loop and standing parts.

398. The lariat knot (Fig. 337) is made by first tying two overhand knots—one at the end of the rope and drawn up tight, and the other back

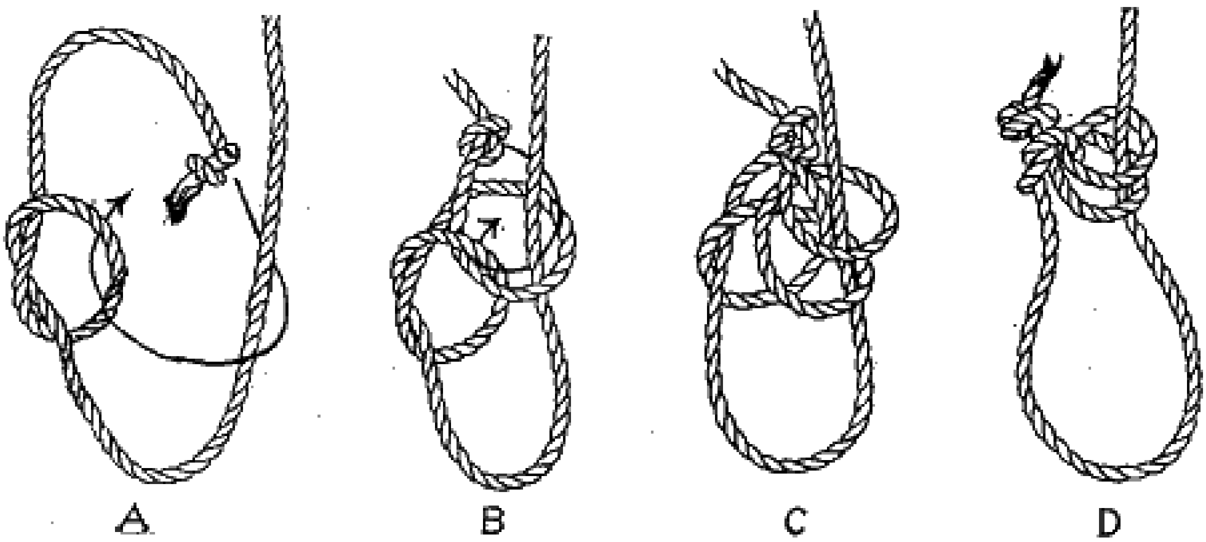


Fig. 337.—The lariat knot.

from the end about a foot, and drawn up loosely. The end of the rope is then passed around the standing part and through the loop and a second time around the standing part and through the loop. The knot is then finished by drawing the parts tight.

HITCHES

Hitches are, in the main, quickly made temporary fastenings that depend upon the pull on the rope to keep them secure.

399. The half hitch is generally used in connection with other knots and hitches. A half hitch ready to be put over an object such as the end of a post is shown at *A* (Fig. 338). A half hitch in the end of a rope is shown at *C* (Fig. 338).

400. The timber hitch (Fig. 339) is similar to the half hitch but is made more secure by wrapping the loose end once or twice through the loop. The timber hitch and half hitch are often used in combination for holding or moving logs.

401. The clove hitch is one of the most useful ways of fastening a rope to a post or stake. Two methods of making the hitch are illustrated in Fig. 341.

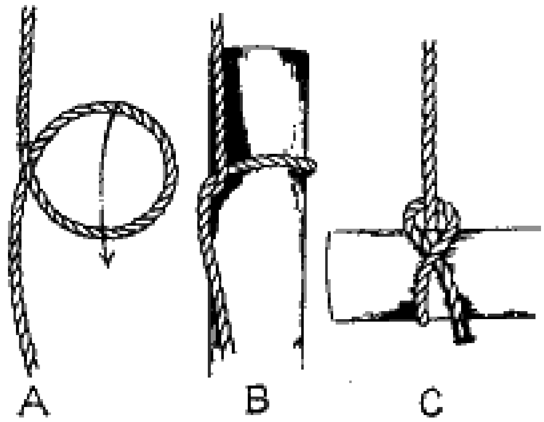


FIG. 338.—The half hitch.

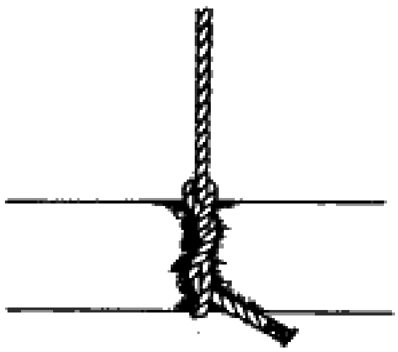


FIG. 339.—The timber hitch.

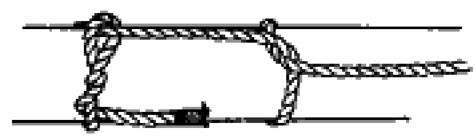


FIG. 340.—The timber hitch and half hitch combined.

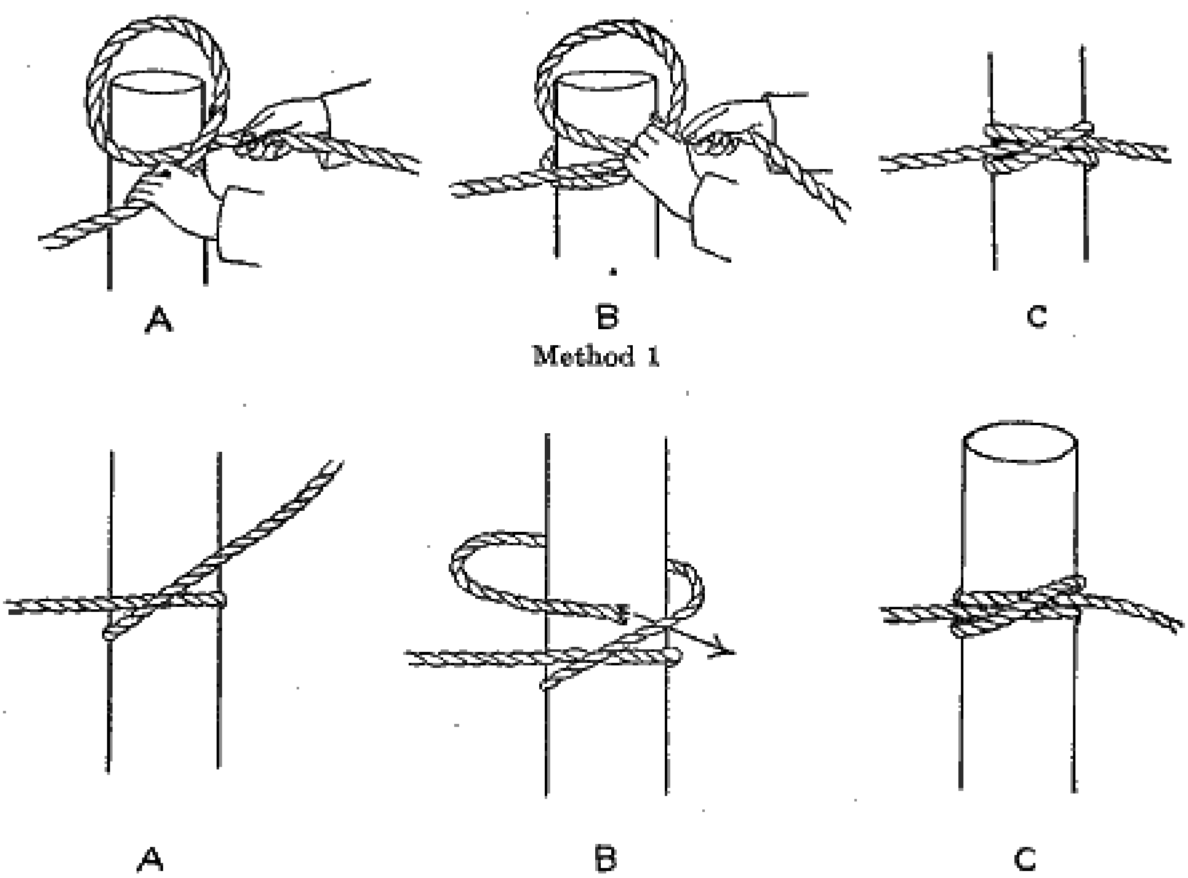


FIG. 341.—Two methods of making the clove hitch.

402. The Blackwall hitch (Fig. 342) is used for fastening a rope temporarily to a hook.

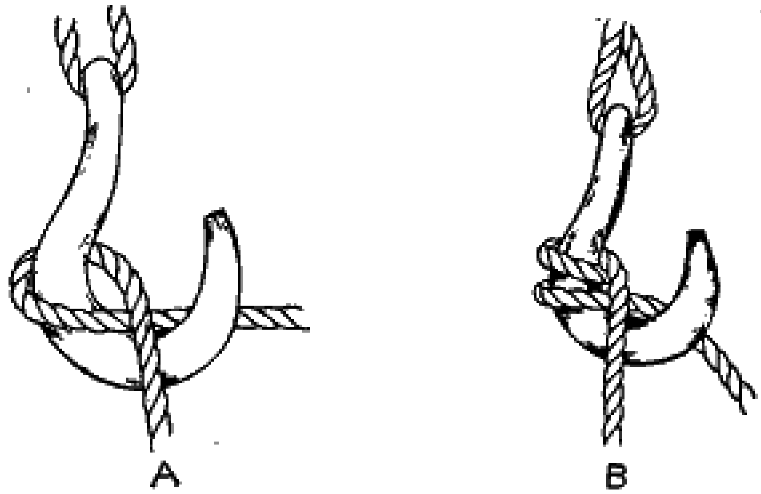


FIG. 342.—Two forms of the Blackwall hitch.

403. The scaffold hitch is made by wrapping the rope around the board as indicated in Fig. 343 and then fastening the end to the standing part by use of a bowline knot.

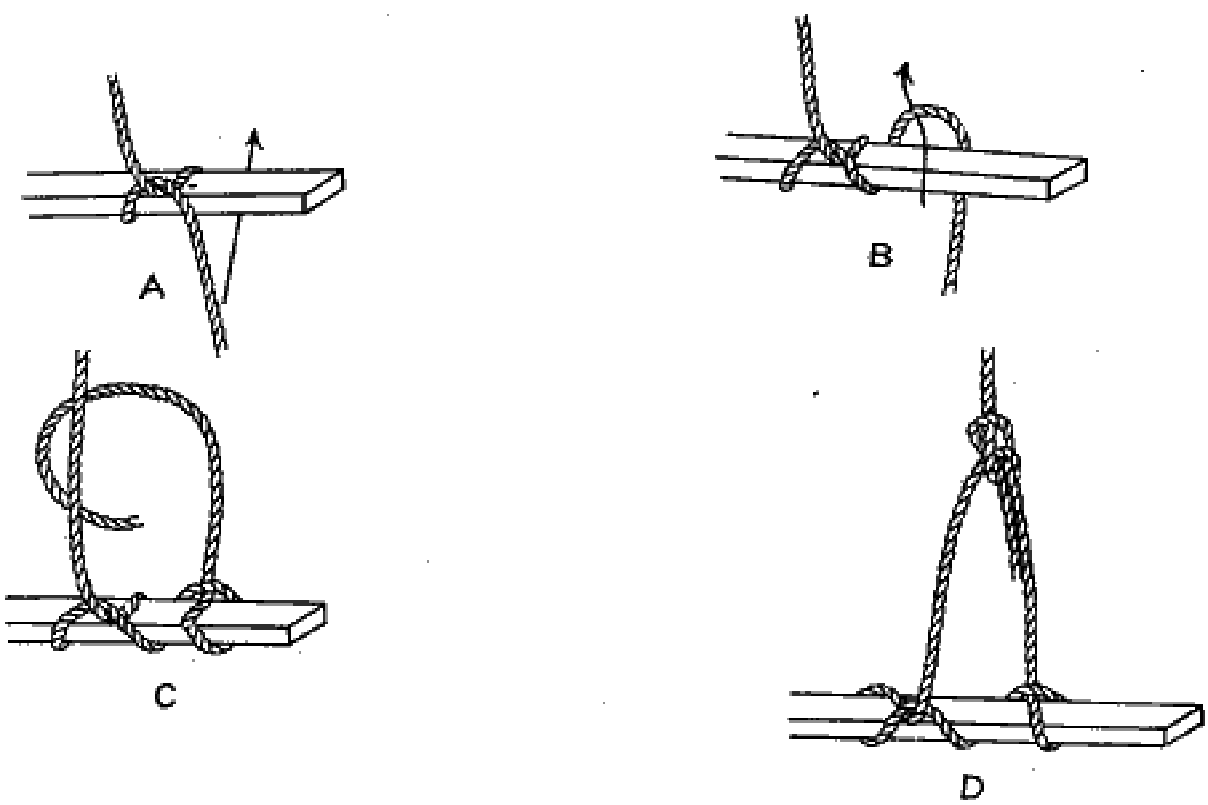


FIG. 343.—The scaffold hitch.

404. The sheepshank (Fig. 344) is used for shortening the rope. It is made by gathering up the rope, forming two bights of the desired length. The standing parts are then looped around the end of each bight, using half hitches.

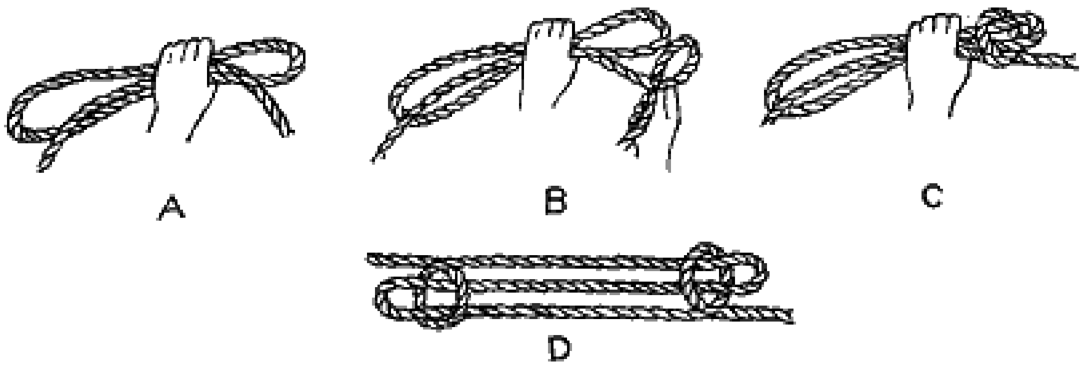


FIG. 344.—The sheepshank.

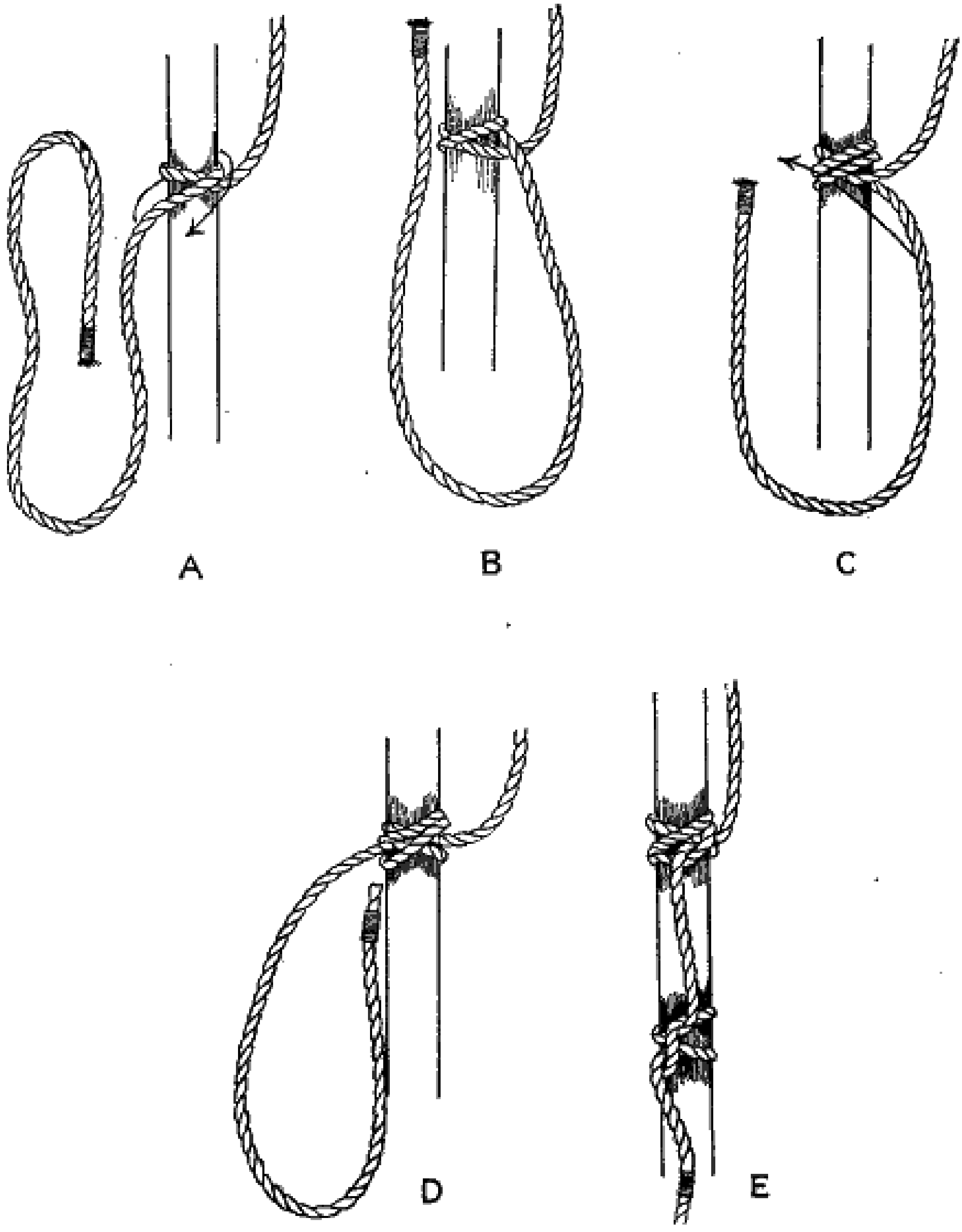


FIG. 345.—The well-pipe hitch.

405. The well-pipe hitch (Fig. 345) is made by wrapping the end of the rope around the pipe, making a half hitch. A second wrap is made, wrapping downward and over the standing part. A third wrap is made, this time going under the standing part and up between the last two turns. The hitch is completed by making a clove hitch with the end of the rope. The pull on the standing part of the rope should be parallel with the pipe.

SPLICES[1]

406. The short splice is made where a considerable enlargement in the size of the rope would not be objectionable, or where only a short length of rope can be spared for making the splice. It should not be used where the rope has to pass through pulleys. It is made as follows:

1. Unlay the strands for six or seven turns on the ends to be joined.
2. Place the two ends together so that the strands from one end alternate with the strands from the other. Be sure that every strand branches outward from the main rope directly and without crossing over the center of the rope (see Fig. 346).

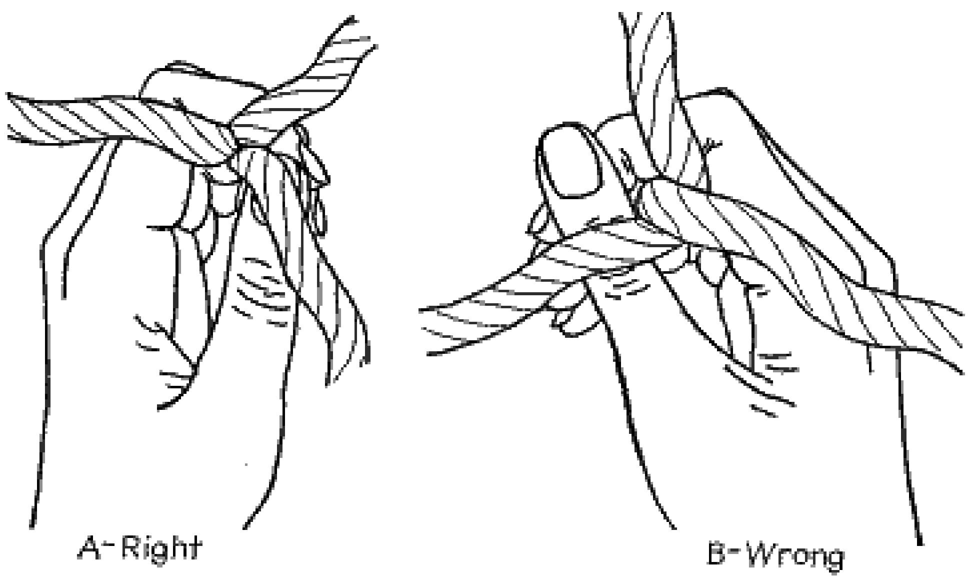


FIG. 346.—Strands spread out preparatory to placing two ropes together for splicing.

3. Tie each strand from one rope with the corresponding strand from the other rope, using a simple overhand knot. When all three strands are thus tied, draw them all up even and tight (see Fig. 347).
4. Tuck the strands from each rope under the strands of the other, using the method outlined for the crown or end splice (Fig. 320) page 286. Tuck the strands alternately, making a single tuck on one strand, then a single tuck on the next strand, etc. Each strand should be tucked ultimately three or four times under strands of the other rope.

407. The long splice should be made if the rope is to pass through pulleys or if a neat splice is desired that will not appreciably increase the size of the rope. The following directions are for making the long splice in a three-strand rope. Four strand ropes are spliced in a similar manner.

[1] For discussion of the crown or end splice, see Art. 382.

1. Unlay the strands of each rope about 15 turns.

2. Place the two ends tightly together in exactly the same manner as for the short splice.

3. Keeping the two ends tightly together, unlay any strand from the right end, and lay in its groove the corresponding strand from the left end. Be careful to keep the strand tightly twisted as it is re-laid in the groove. Continue until all but about 6 in. of the re-laid strand is used (see Fig. 348*B*).

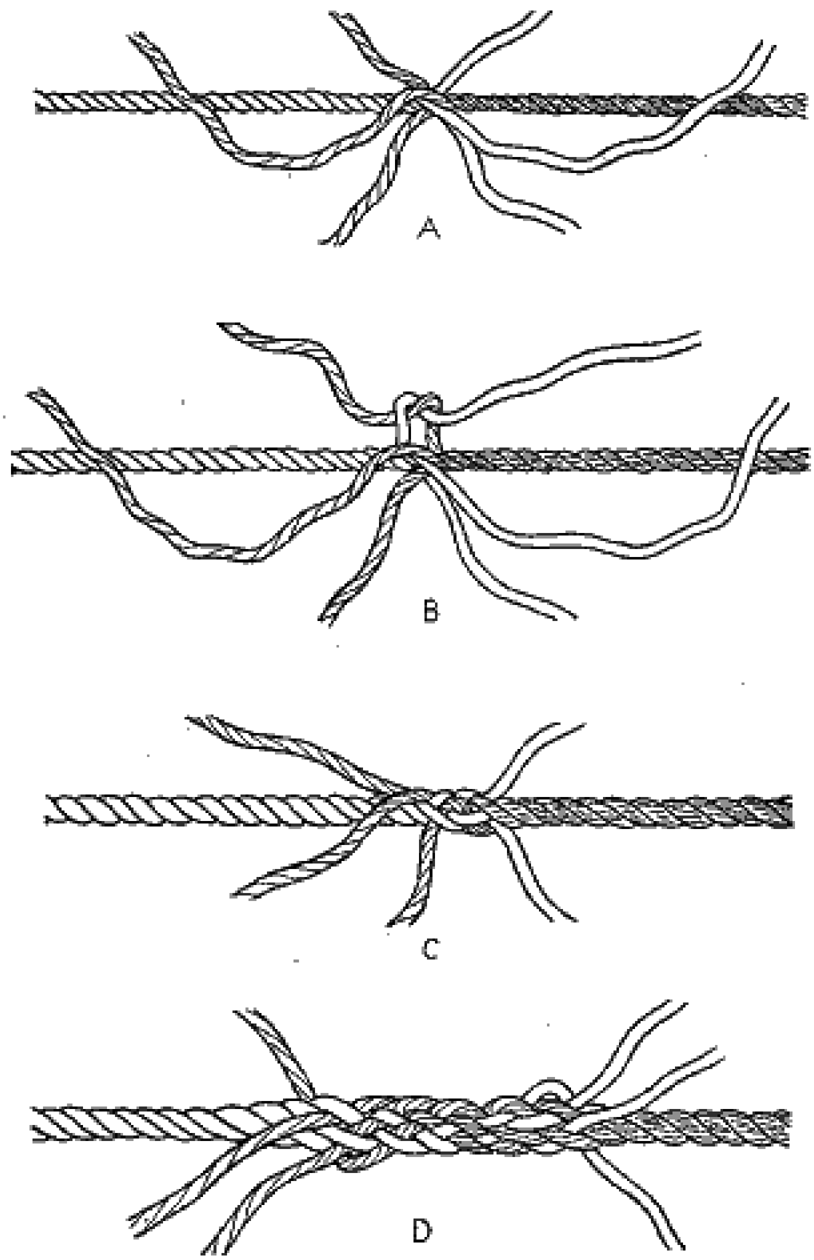


Fig. 347.—The short splice.

4. In the same manner, unlay a strand from the left end and lay in its place the corresponding strand from the right end.

5. The third pair of strands are left side by side in the center of the splice (see Fig. 348*C*).

6. All strands are then cut off to about 6 in. long, and all are woven or tucked into the rope as follows: Each strand is placed diagonally across the first strand of the standing part and tucked under the next (see Fig. 349). This is then repeated at least twice more, making at least three tucks for each strand.

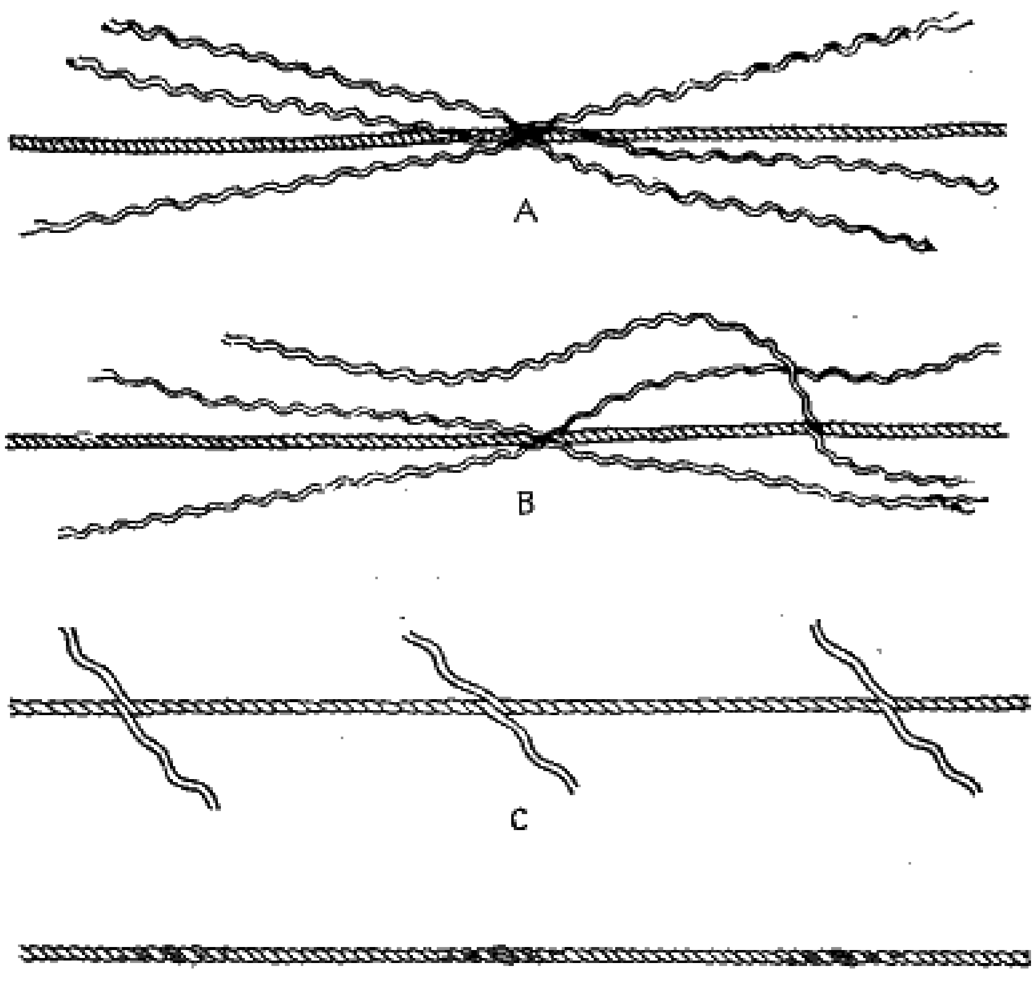


FIG. 348.—The long splice.

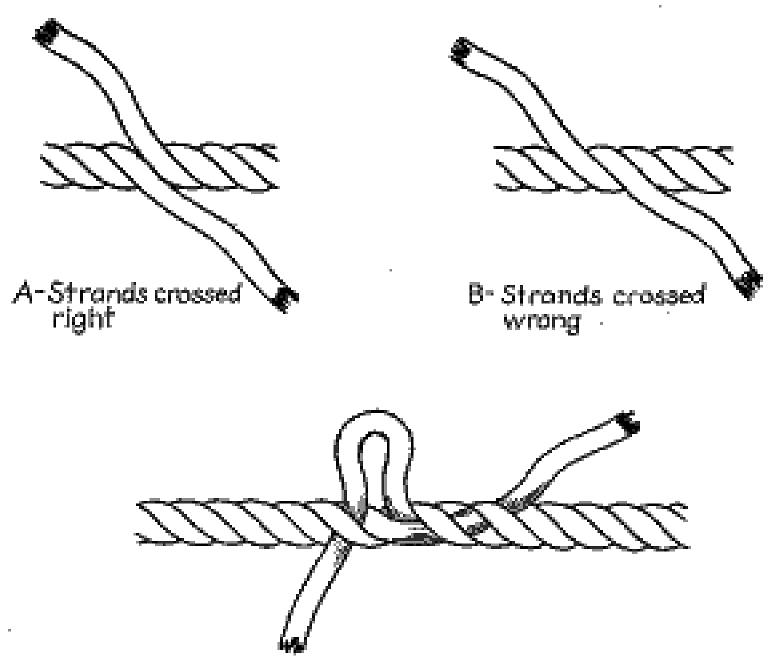


FIG. 349.—Method of tucking ends in finishing the long splice. Be sure the strands are crossed as shown at *A* and not as shown at *B*. Each strand is then placed over the first strand of the main rope and under the next. In the same manner the end is tucked twice more, making at least three tucks in all.

408. Replacing a Broken Strand.—A rope with one broken strand may be repaired by unlaying the broken strand 5 or 6 turns each way from the break, and then laying in its place a good strand from a rope of the same size. The ends of the new strand are joined to the ends of the broken strand and tucked in the same way as outlined for the long splice.

409. The eye splice is used in many places where a permanent loop is to be made on the end of a rope. It is made as follows:

1. Unlay the strands about five turns.
2. Place strand 1 under a strand of the standing part (see Fig. 350).

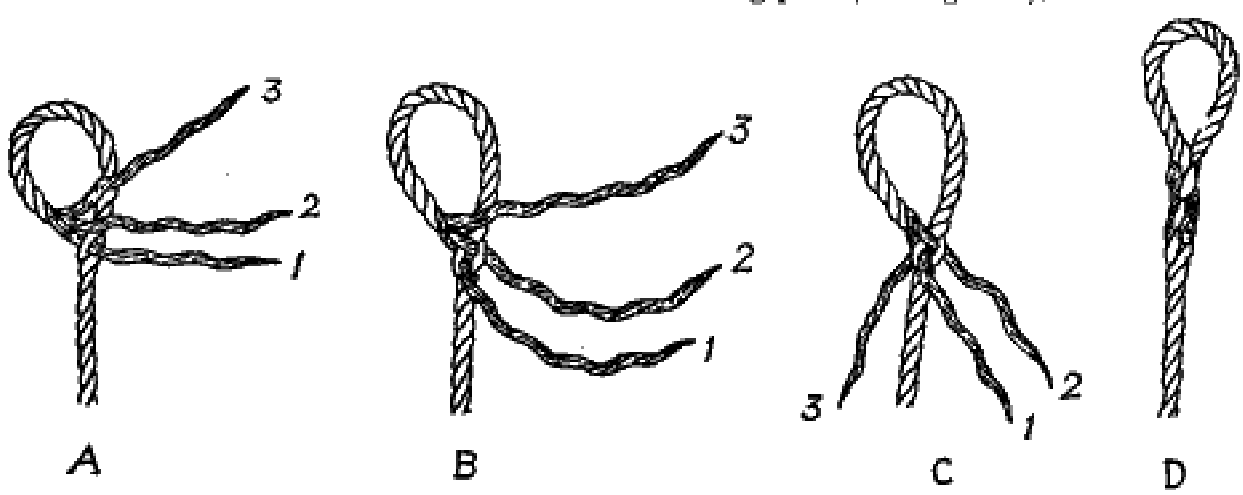


Fig. 350.—The eye splice.

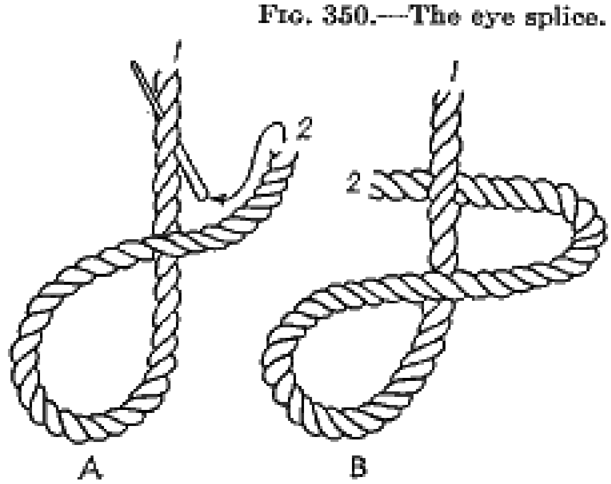


Fig. 351.—The loop splice.

3. Place strand 2 over the strand under which 1 was placed, and under the next.
4. Place strand 3 over the strand under which 2 was placed, and under the next. Strand 3 should come out of the standing part at the same point that strand 1 went in.
5. Continue weaving and tucking the strands as in the crown splice and the short splice.

A modification of the eye splice, called the *side splice,* is used in splicing the end of one rope into the standing part of another rope.

410. The loop splice is used for making a loop or eye in a rope at a point not at the end. It is used principally in making rope halters. It is made as follows:

1. Raise two strands of part 2 and pass part 1 through (see Fig. 351).

2. Raise two strands in part 1, *at a point that will give the desired size of finished loop, and pass part 2 through.*
3. Draw up tight.

ROPE HALTERS

411. A nonadjustable halter is illustrated in Fig. 352. It is made by making a loop splice, a side splice, and an end splice.

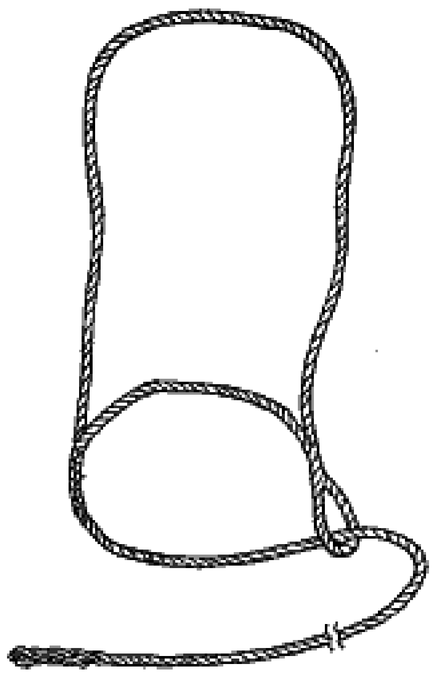


FIG. 352.—A nonadjustable halter.

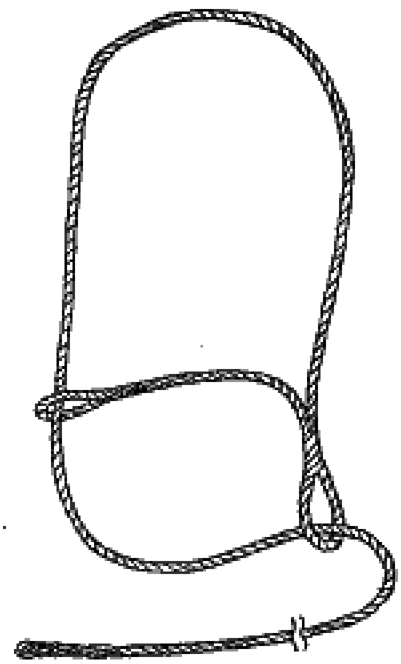


FIG. 353.—An adjustable halter.

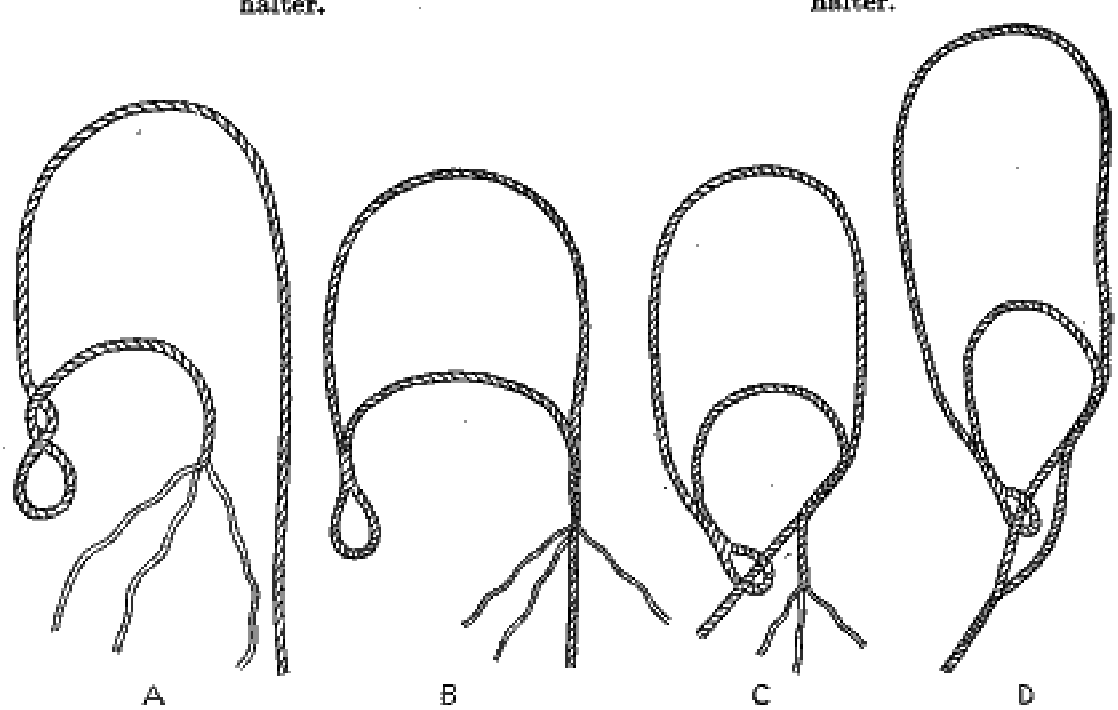


FIG. 354.—A nonadjustable halter with guard loop.

412. An adjustable halter, illustrated in Fig. 353, involves making only a loop splice, an eye splice, and an end splice. It is a good plan to make both the loop and the eye quite small.

413. A nonadjustable halter with guard loop, illustrated in Fig. 354, is a good type of permanent halter. The guard loop prevents the halter from loosening or tightening beyond a certain amount. After the first side splice is made (*B*, Fig. 354) the strands are re-laid for a distance of 5 or 6 in., and a final side splice is made.

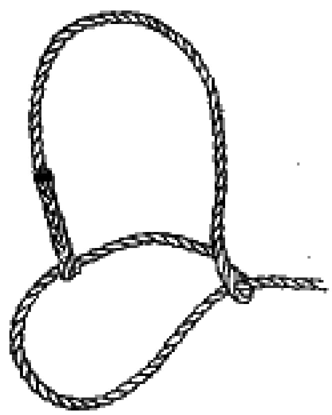


Fig. 355.—A calf halter.

414. A calf halter, popular with calf club members, is illustrated in Fig. 355. A loop splice is first made, and then the end of the headpiece fastened to the standing part with a special, tight-fitting, adjustable loop. To make this special loop, the strands are unlaid back about 7 in. from the end. They are then wrapped around the standing part as shown in Fig. 356, and then woven back into the headpiece in the same manner as in making an end splice or a side splice.

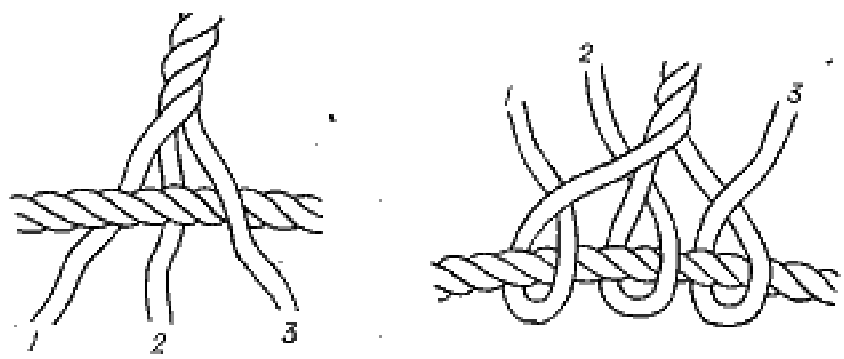


Fig. 356.—Detail of halter splice used on calf halter, Fig. 355.

415. An emergency or temporary halter is easily and quickly made, as illustrated in Fig. 357. The end of the rope is turned back on itself forming a bight, and then an overhand knot is tied in the bight as at 1. The end of the nosepiece is then secured to the standing part with a bowline as at 2.

Table IX.—Approximate Dimensions for Rope Halters

Kind of halter	Diameter of rope, in.	Total length of rope, ft.	Length of parts, in.	
			Nosepiece	Headpiece
Horse	½ or ⅝	14	8	16
Cow	½	12	7	14

SPECIAL TACKLES FOR LEADING AND CASTING

416. The leading or tying tackle, shown in Fig. 358, is effective in breaking a colt to lead. The loop around the body should be made so that it will loosen promptly when the tie rope is slackened.

This tackle is also good for breaking horses from pulling back when tied. In case the manger or hitching rack is low, the tie rope should be

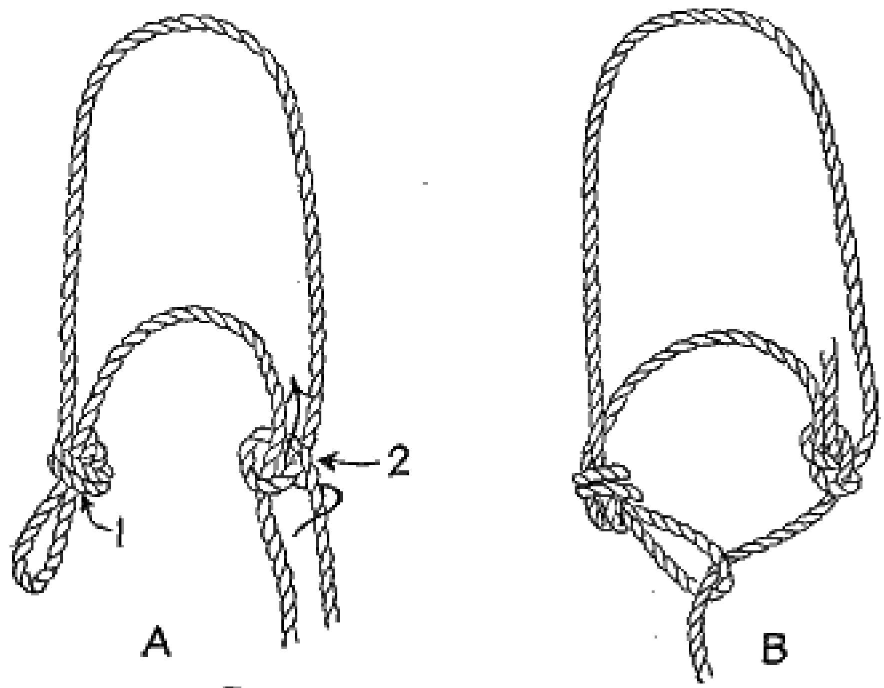


FIG. 357.—An emergency halter.

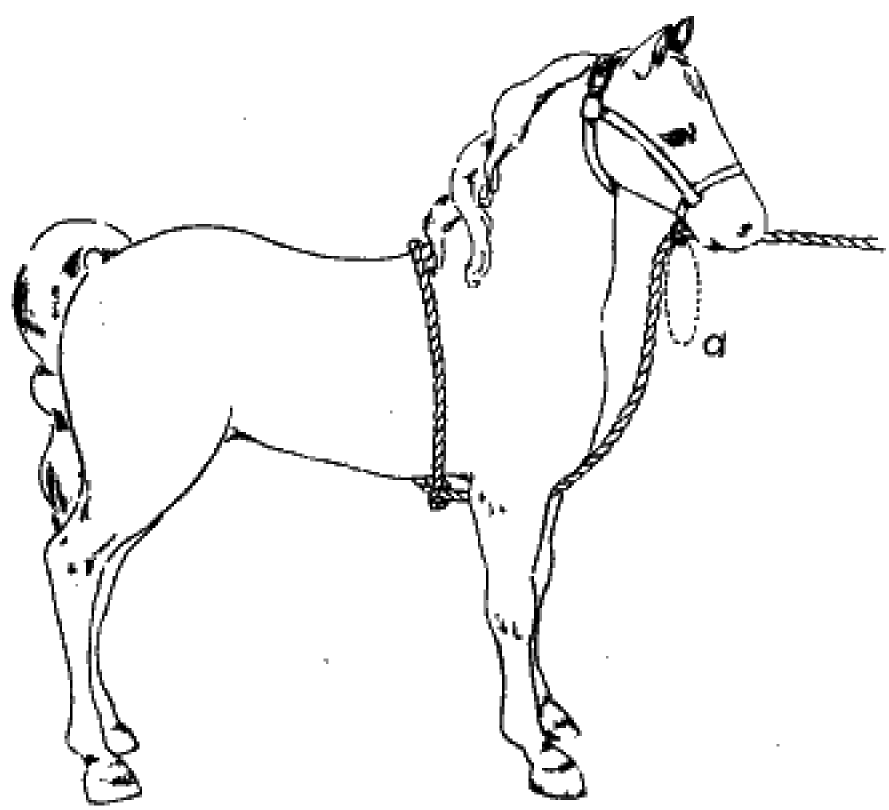


FIG. 358.—A leading or tying tackle.

run through a loop or strap in the halter ring *a* (Fig. 358) and not through the halter ring itself.

417. Casting Horses.—The tackle illustrated in Fig. 359 is recommended for throwing horses, with safety both to the animal and the workman. A bowline on the bight (see Art. 397, page 295) is tied and placed over the animal's head, fitting much like a horse collar. The ends are then run between the front legs to rings in ankle bands on the hind feet. After leaving the rings, each rope is wrapped once around itself and

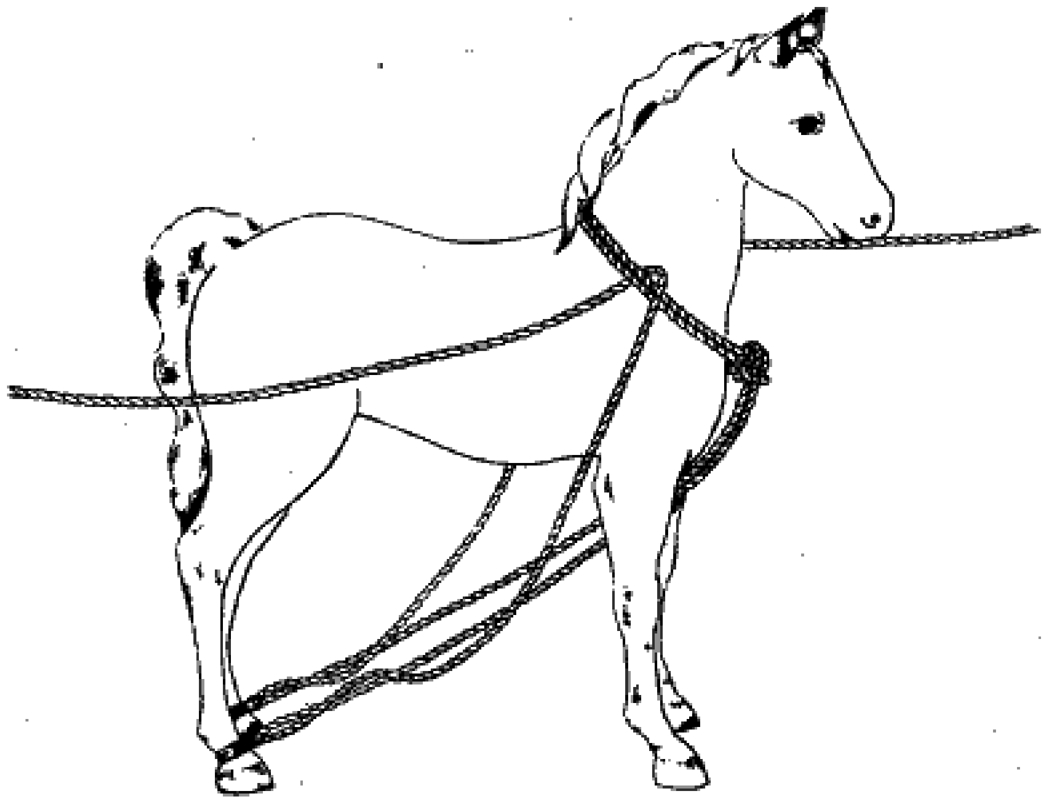


FIG. 359.—A casting tackle for horses.

passed under the double loop around the neck, one end extending to the rear and the other forward. The horse is then backed and the ropes tightened.

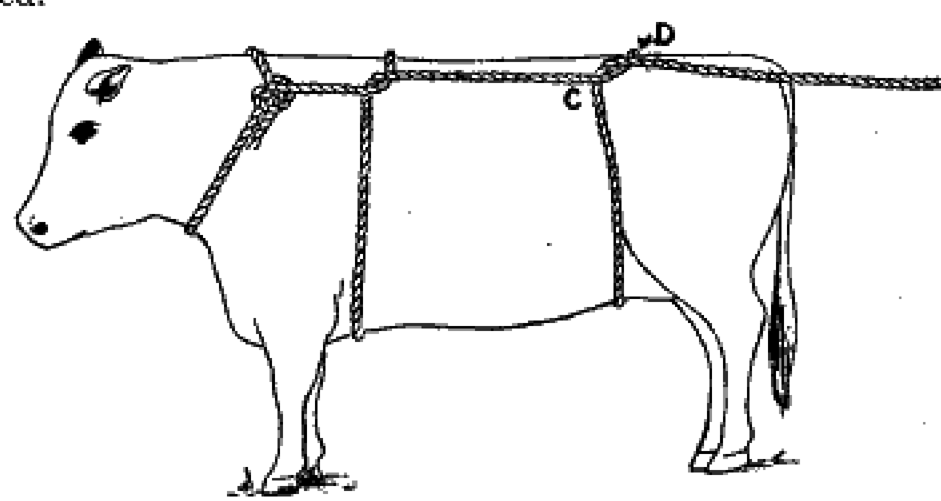


FIG. 360.—A casting tackle for cattle.

418. Casting Cattle.—A simple method of casting cattle is shown in Fig. 360. The rope is tied around the animal's neck by means of a bowline. Two half hitches are then taken, one at the front of the body and the other at the rear. The rope at *C* should come in front of the hipbone, and behind the other hipbone at *D*. The animal is thrown by pulling backward and toward the side upon which it is to be thrown.

Questions

373. Explain how the twist in the various parts of a rope keeps it in shape.

374. (*a*) What is a bight? (*b*) What is the standing part of a rope? (*c*) Name and define several other terms used in connection with ropes.

375. (*a*) What two kinds of fiber are most commonly used in ropes for the farm? (*b*) Which is best, and how may it be distinguished from the other? (*c*) What kinds of plants produce these fibers, and where are they grown?

376. (*a*) What causes kinking in a new rope? (*b*) How may the trouble be remedied?

377. (*a*) How should a rope be coiled and uncoiled to avoid kinking and tangling? (*b*) How should rope be wound around the left forearm?

378. (*a*) What damage may be done to a rope by using it in pulleys that are too small? (*b*) How large should the pulleys be? (*c*) In case a rope becomes wet, what should be done?

379. Explain and be able to demonstrate just how to re-lay strands.

380–384. *Finishing Rope Ends.* (*a*) What different methods may be used for keeping the ends of a rope from untwisting and becoming frayed? (*b*) Compare these different methods as to advantages, disadvantages, ease of making, etc. (*c*) Learn and be able to demonstrate whipping, the end or crown splice, and the Matthew Walker knot.

385–398. *Knots.* (*a*) Learn and be able to demonstrate the overhand knot, the square knot, the bowline knot, and the miller's or grain-sack knot. (*b*) How is the granny knot different from the square knot? Why should the granny knot not be used? (*c*) What other knots do you believe a farm boy should learn and be able to tie at any time?

399–405. *Hitches.* (*a*) What are hitches? (*b*) Learn to make and be able to demonstrate the half hitch, the timber hitch, and two methods for making the clove hitch. (*c*) What other hitches, if any, do you believe a farm boy should know well?

406–410. *Splices* (*a*) Under what conditions would you recommend the short splice, and under what conditions the long splice? (*b*) What is the difference between the eye splice and the loop splice? (*c*) Learn and be able to demonstrate the short splice, the long splice, the eye splice, and the loop splice. (*d*) How may a broken strand be repaired?

411–415. *Rope Halters.* (*a*) What knots, hitches, or splices should one know in order to make good rope halters? (*b*) What features of the various halters illustrated in the text do you believe to be particularly good? What features do you believe are not good? (*c*) Learn to make one or two halters, possibly including one of your own design, which you believe to be particularly good.

416–418. *Special Tackles.* (*a*) Describe a leading or tying tackle that is good for breaking a colt to lead, or for breaking animals from pulling back when tied. (*b*) Describe a tackle that may be used for casting or throwing horses. (*c*) Describe one that may be used for throwing cattle.

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