SCHOOL SHOP INSTALLATION AND MAINTENANCE

GREENE

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PREFACE

THE author has observed that among teachers of shop subjects there is a noticeable lack of ability when it becomes their duty to solve problems of school shop planning, installation and maintenance.

The fundamental reason for this deficiency is, perhaps, that, altho there are numerous technical books and magazine articles dealing with such problems, they are written primarily for the engineer and do not provide readily the comparatively simple, yet essential information needed by the shop teacher when it becomes his duty and privilege to plan, install and keep in order school shop equipment.

The purpose of this book is therefore two-fold. An attempt has been made to present in simple language and readily usable form, information, rules and methods that (1) will constitute a handbook for teachers for use in solving these problems of equipment and maintenance, and (2) will be a text for use in normal courses in which manual arts and vocational teachers are trained.

While the material presented in these notes may be of greatest use to shop teachers as a handbook and to teachers of vocational teacher-training classes, these two purposes do not limit its use. For instance, pupils in many vocational classes should know how to take care of belting properly, how to babbitt a bearing, how to fit circular saws, braze bandsaws, etc., and in this sense this book can be used as a text and reference book by the students. Because of the direct method of presenting the subject matter, the book should also prove valuable to apprentices and mechanics.

The author wishes to express his indebtedness to Prof. F. D. Crawshaw for timely suggestions. The author's wife and associate teachers have also been of much assistance.

The illustrations are the work of the author.

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PART ONE—INSTALLATION

CHAPTER I

Power Transmission in a School Shop

1. Individual vs. Group Drive.—There are two common methods of driving machines. One consists in connecting the source of power to a line shaft from which the individual machines receive their power by means of belting and pulleys. This system is called *group drive.* The other method consists in connecting a machine directly to a source of power and is called *individual drive.* In the second case, an electric motor is generally used for the power and, in the following discussion of individual drive, such power will be assumed.

It is not necessary, of course, that the machines be driven by either method alone for the nature of the work to be done or the equipment to be used may make it desirable to combine these two methods in the same shop so that part of the equipment is run as group and part as individual drive. Determination of the method to be used should come only after careful consideration has has been given to the advantage of each type and after a thoughtful survey has been made of the machines to be driven, the work to be done on them, and the comparative amount of time that each will be in use.

2. Advantages of Individual Drive.—In the individual drive type of power transmission, there is often obtained a decided saving in the amount of floor space necessary for different machines. It is not necessary to locate the machines in a line or in a certain order or so that they will face the same way. This often permits of better aisle arrangements and better use of daylight for the operation of the machines. The absence of complex overhead shafting, pulleys and speeding belts allows of better lighting, avoids collections of dust and oil which fall down on the machines and the work, and removes much of the dangers attendant upon an industrial shop because of fast turning belts and pulleys.

If the work being done is intermittent in nature and the machines are not all running all the time or at full capacity all the time, as is the case in nearly all school shops, then there is a saving in the cost of operation and upkeep of machines, shafting and belting. There are fewer delays of all machines by breakdown of belts, loosening of pulleys, etc. In a wood shop or a metal shop, it is often desirable to run the band-saw, drill-press or some other machine without necessitating the running of a complete line shaft, and possibly other machines with it, and this is not necessary if the individual type of transmission is used. Machines are made more portable by individual drive and more variation of speed for the work to be done is possible. Some machines can function properly with the motor connected direct to the main shaft, as in the case of the band-saw or small circular-saw, and thus the annoyances obtained from the slipping of belts is avoided. The energy of the teacher is conserved because of the fewer repairs necessary with the result that more efficient instruction should obtain.

The following reasons why individual motor driven machines are preferable in schools are given by The Oliver Machinery Co., Grand Rapids, Mich.

1. **Because they are more sanitary.**
    a. Less belting causes less dust.
    b. Less belting affords more light.
    c. No oil drippings from overhead bearings.
2. **Because they are safer.**
    a. No belting to get tangled in.
    b. No belts to break and fall down.
    c. No overhead shafting or other material to be pulled down.
3. **Because they are less noisy.**
    a. No belts or shafting to create noise.
    b. Only machines in actual use make any noise at all.
4. **Because they require less attention from instructor, assuring better instruction.**
    a. Less parts to adjust.
    b. Fewer bearings to lubricate.
    c. Fewer belts to keep tight and in shape.

   d. Fewer disputes with students because they have less chance for mischief.
5. **Because they individualize each student's operations.**
   a. Students become masters of their own realm.
   b. No time lost because of another's carelessness.
   c. Better discipline is possible because of less opportunity for intercommunication.
6. **Because of less wear and tear—upkeep is cheaper.**
   a. No unnecessary running parts—belts, shafts, bearings—hence fewer repairs.
   b. Machines will last longer because:
      (1) During class hours, only machines in actual use are running.
      (2) At odd times such as after school and on Saturdays, only machines needed are run.
7. **Because operating cost is less.**
   a. Less oil, waste and belting is used.
   b. Less current used because power required merely when doing actual work.
8. **Because the sytem is more flexible—saves room.**
   a. Machines may be located as suits the room and utility, without regard to direction of shafting.
   b. Future additions or alterations are more easily performed.

3. **Advantages of Group Drive.**—The initial cost of group drive is often much less than that of individual drive and with certain machines or groups of machines this method might be more acceptable as far as cost of operation is concerned. This is plain in the case of a number of wood lathes, driven from one line shaft, where the total horse-power needed at any one time is less than the sum total of the maximum horse-power of the several machines. While each machine needs, under certain conditions, its maximum horse-power, yet very seldom, and perhaps never, would conditions be such that all machines would be using their maximum horse-power at the same time. It is safe to assume that the power necessary to drive this line shaft under these conditions would be from 40 per cent. to 80 per cent. of the sum total of the maximum horse-power of all lathes on the shaft. If these lathes were driven by individual motors, a greater total amount of horse-power would have to be provided to drive them. In the case of machines, like the lathes mentioned above, where nearly all, or all, are driven at the same time, there is economy in the group drive. Wherever the machines are small and require little power, or where the initial cost of individual drive might over-balance the operative

economies of the same drive, it might be advisable to install group drive transmission.

4. **Selection of Shafting.**—Cold-rolled steel is generally used for shafting up to 3″ in diameter and is considered to be about 15% stronger than turned steel shafting. It is round and straight and needs no turning unless key-ways are to be cut in it, in which case the tension on the surface is relieved, and it may take a form not perfectly round.

In selecting shafting, one should consider not only immediate needs but also possible needs of the future; such as adding to the amount or the size of the machinery that is to be driven by the shafting, increasing the size of the driving motor, or the erection of secondary shafting, (i. e., another shaft to be driven by the shaft receiving the power by being belted to it), for the choice of the size of a shaft should depend upon two things (1) its ability to withstand twisting forces when it receives and transmits power, and (2) its ability to remain stiff or to resist bending forces due to the weight of the shaft itself, weight of pulleys, pull of belts and distance apart of hangers. Should more demands upon the shafting be expected in the future, then it is wise to consider these probable demands when making a choice of shafting, for thus a saving in time, annoyance and money may often be effected.

As it is not possible to know exactly what additional pulleys, machines and power will be needed in the future or what shifting and changing of machines and pulleys will take place, it is impossible to determine exactly the size of the shaft. Undoubtedly the best policy would be to play safe by choosing a shaft slightly larger than apparently seems necessary, according to tables that will follow, for the extra cost will be justified as a precaution against a possibility of adding extra hangers, new bearings, or even a larger shaft at a later date, any of which would probably cost more than an extra size of shafting when first installed.

Another point to think about and investigate is whether the immediate demands upon the shaft are what might be called normal or usual demands, i. e., hangers a usual distance apart, the pull of the belts in such a direction as to offset one another, pulleys close to hangers, etc. If the condition as regards these points is such as to increase the bending tendency of the shaft then the shafting should be larger to make up for this tendency even if the power to be received or transmitted does not seem to require a larger shaft. The tables which follow are guides only and not hard and fast rules and one should bear this in mind when using them.

Where there is a long stretch of shafting and where the demands upon the shaft, at the far end away from where the power is received or transmitted to secondary shafting, are not so heavy as at the other end, there is some economy in reducing the size of the shafting at this far end. This can be done at a coupling by reducing the size of the larger shaft to that of the smaller shaft so that both of them fit the same coupling.

Weight for weight a hollow shaft is stronger than a solid one, but where the diameters are the same the solid one is the stronger. A shaft will deliver more power at fast speed than at slow, and the diameter required to deliver a certain horse-power at fast speed is less than that required for the same horse-power at slow speed. A shaft, equal in diameter to another but running twice as fast, will transmit twice as much power, or in other words, the horse-power is directly proportional to the number of revolutions per minute of the shaft.

5. **Speeds of Line Shafts.**—For machine shops, 120 to 240 R. P. M.

For woodworking shops, 250 to 300 R. P. M.

(R. P. M. means revolutions per minute.)

6. **Rules for Determining Horse-Power.**—A shaft which carries a receiving pulley or a transmitting pulley for driving another line should be considered a prime mover or head shaft when the rules which are to follow are used.

To determine the horse-power (H. P.) transmitted by cold-rolled steel shafting at different speeds as prime movers or head shafts carrying the main driving pulley and well supported by bearings use the following formula:

H. P. $= \frac{d^3 R}{100}$ where d = diameter of shaft in inches, R = R. P. M. of the shaft and H. P. = horse-power transmitted.

As an example, determine the horse-power transmitted by a shaft 2″ in dia. running 300 R. P. M. Using the formula above and substituting for the letters the figures given in the example we get H. P. $= \frac{2 \times 2 \times 2 \times 300}{100} = 24$.

Below is a table giving various combinations of H. P., R. P. M., and diameters.

Applications of the Above Formula

Dia. of Shaft	Horse Power		
	100 R. P. M.	200 R. P. M.	300 R. P. M.
1½	3.4	6.7	10.1
1⁹⁄₁₆	3.8	7.6	11.4
1⅝	4.3	8.6	12.8
1¹¹⁄₁₆	4.8	9.6	14.4
1¾	5.4	10.7	16.1
1¹³⁄₁₆	5.9	11.9	17.8
1⅞	6.6	13.1	19.7
1¹⁵⁄₁₆	7.3	14.5	22
2	8.0	16.0	24
2¹⁄₁₆	8.8	17.6	26
2⅛	9.6	19.2	29
2³⁄₁₆	10.5	21	31
2¼	11.4	23	34
2⁵⁄₁₆	12.4	25	37
2⅜	13.4	27	40
2⁷⁄₁₆	14.5	29	43
2½	15.6	31	47
2⁹⁄₁₆	16.8	34	50
2⅝	18.1	36	54
2¹¹⁄₁₆	19.4	39	58

Dia. of Shaft	Horse Power		
	100 R. P. M.	200 R. P. M.	300 R. P. M.
$2\frac{3}{4}$	21	41	62
$2\frac{13}{16}$	22	44	67
$2\frac{7}{8}$	24	48	72
$2\frac{15}{16}$	25	51	76
3	27	54	81

To illustrate the use of the above table, let us assume it is desired to know the H. P. transmitted by a 2″ cold-rolled steel shaft running at 200 R. P. M. as a prime mover. By running the finger down the 200 column to a point opposite the figure 2 in the dia. column we find 16 as the H. P. given. Similarily, if it is desired to know the proper size of cold-rolled steel shafting to run at 300 R. P. M. as a prime mover to deliver 25 H. P., we run the finger down the 300 column in search of figure 25 and find that the nearest figure would be 24 or 26 and we choose the latter to be safe and find that the figure in the dia. column opposite is $2\frac{1}{16}$″, the dia. required. Or, let us find the H. P. for cold-rolled steel shafting $2\frac{3}{16}$″ in dia. to run 250 R. P. M. as a prime mover. Reference to the table will show that no 250 column is given but, in the 200 column for this dia. we find 21 as the horse-power and in the 300 column we find 31 as the horse-power and as 250 R. P. M. is half way between 200 and 300 R. P. M. we accept the figure 26, which is half way between 21 and 31, as the H. P. required.

The above table is accurate only for *cold rolled steel* shafting. In order to make it of more use the following rules are given.

1—For H. P. transmitted by *turned steel* shafts as prime movers, multiply the figures in the table above that represent H. P. by 0.8.

2—For shafts as *second movers* or line shafts with bearings 8 ft. apart, multiply by 1.43 for cold-rolled and by 1.11 for turned steel shafts to get the H. P. safely transmitted.

3—For simply transmitting power (short counter-shafts, etc.) with bearings 8 ft. apart or less, multiply by 2.0 for cold-rolled and by 2.5 for turned steel shafting.

As an example of the above let us assume that we wish to know the H. P. that is safely transmitted by a 2½" *turned steel line shaft* with bearings 8 ft. apart running at 200 R. P. M. Referring to the table, we run the finger down the 200 column of figures to the number in this column opposite 2½" dia. and we find that 31 is the horse-power given. This 31 H. P. represents the H. P. permissible with *cold rolled steel shafting* as a *prime mover* but as we wish to know what H. P. is advisable with *turned steel* shafting as a line shaft we refer to rule 2 above. This rule reads to multiply the 31 H. P., gained from the table, by 1.11 which gives us 31x1.11 =34 H. P. Rules 1 and 3 can be used similarly.

7. **Position of Shafting.**—Shafting may be fastened to the wall, to the ceiling or to the floor. The greatest economy of space is obtained in most cases by fastening it to the ceiling. When fastened to the wall or floor the arrangement of the belts and pulleys makes them inconvenient and dangerous if an attempt is made to use the floor space close to them. Shafting on the floor should be well guarded by fences or railings. The number of machines that can be driven from shafting elsewhere than on the ceiling is limited. The belts from lathes, for instance, must run to pulleys above the lathes.

The distance apart of shafts, counter-shafts, and connected pulleys will depend upon (1) physical limitations and those of convenience, and (2) width of the belt to be used and the corresponding work expected of it. The necessary arrangement of the shafting and machinery may be such as to make other considerations quite dependent upon their arrangement but, if possible, the distance between the pulleys should be such as to allow of a gentle sag to the belt when in motion. This allows a belt to have better contact with the pulleys and requires less tension on the belt for the same amount of horse-power. Increased tension means increased strains in the belt and added wear and friction in the bearings. About 2″ of sag in narrow belts and from 3 to 4″ in wide belts is sufficient.

Where it can be avoided, connected pulleys should not be placed one directly above the other for then only a minimum contact with the belt is obtained, and more tension in the belt is required to deliver a certain amount of horse-power than if the pulleys connected more nearly horizontal.

8. Hangers.—There are three common types of hangers employed for the suspension of shafting, viz.: drop, post and wall extension hangers. Each type varies in that some are rigid and not easily adjusted while others have varying methods of adjustment.

The best types of drop hangers are those which have screw adjustments. Two screws adjust the up and down movement and two others adjust the lateral or side movement. These screws aid materially in securing a quick and accurate aligning of the shafts. Other types have screws for adjusting the vertical movement of the bearing only. A refinement of the former type is the substituting of a roller bearing which minimizes the friction and wear, is light, being made of pressed steel, and in the end pays for the added cost. This type, as well as some types without roller bearings, has an advantage in having bearings of different sizes interchangeable in the same hanger.

The rigid types are more difficult to adjust and require the wedging or moving of the whole hanger in order to change the alignment. The drop hangers are intended for over-head use but can be used on the floor. The size of a hanger depends upon the duty to be imposed upon it and the size of the pulleys to be used on the shaft. Hangers vary in size according to the distance from the wall, or other support, to the center of the shaft opening.

Wall hangers are for use on side walls although they can be used on posts. Their design is such that they are more rigid for side wall use than are drop hangers. A post hanger has much less distance from its base to the center of the shaft opening than a wall hanger because it is designed for use on posts where, ordinarily, no allowance need be made for pulley clearance. The matter of adjustment, as explained in connection with drop hangers, also applies to wall and post hangers.

Hangers should be of sufficient size to allow of plenty of freedom for pulleys and belts, and the possibility of adding larger pulleys in the future should be considered. The distance apart that hangers should be placed depends upon the size of the shafting, the number and sizes of pulleys the latter will carry, the amount of power to be delivered or taken at certain points in the shaft, and the direction and pull of the belting. In the best practice and in order to obtain stiffness, hangers are placed each side of the receiving pulley, the pulley connecting with the secondary shafting and any pulleys upon which there are extra demands, like those to which a large planer is connected. Where convenient, belting should be distributed alternately to one side and then to the opposite side of a shaft in order to balance the pulling forces as much as possible and save wear on the bearings. It is evident that if successive belts run to one side of the shafting with none running to the opposite side there will be excessive wear upon the bearings. The same principle would hold in regard to belting from above and below the shaft.

The following table and formulas can be used as a guide in determining the distance apart of hangers. This table is good for normal conditions only as regards number, size, and weight of pulleys, pull of belts, work to be done, etc. Where the work to be done is excessive the hangers should be closer together than is indicated in the table.

Kimball and Barr say that the allowable distance between hangers can be determined by the formula $L=7\sqrt[3]{d^2}$ for shafting without pulleys, and $L=5\sqrt[3]{d^2}$ for a shaft carrying the usual amount of pulleys. $L=$ the distance in feet, $d=$ the diameter of the shaft in inches. As an example, find the distance apart of bearings for a 2″ shaft carrying the usual amount of pulleys. Substituting 2 for d in the second formula, we get $L=5\sqrt[3]{2\times 2}=7.93$ ft. or practically 8 ft. apart. The larger the shaft the farther apart may the bearings be.

TABLE OF DISTANCES OF HANGERS APART

CENTER TO CENTER—NORMAL CONDITIONS

Diameter of Shaft Inches	Distance between Hangers Feet	Distance between Hangers Inches
1	5	0
1¼	5	9
1½	6	6
1¾	7	3
2	8	0
2¼	8	6
2½	9	3
2¾	9	9
3	10	3
3¼	11	0
3½	11	6

9. First Alignment; Hangers and Shafting.—The first alignment of shafting, preparatory to locating the hangers, may be obtained in several ways. In the first way, having marked for the two extremities of the proposed line, the transit is placed directly under the point where one extremity is to be. A plumb line can be used for this determination. The transit is then accurately leveled and sighted at the point at the other extremity. Then, if the movement of the transit in the horizontal plane is prevented by adjustments, as many intervening points may be sighted and marked as is wished. A very similar procedure is followed when aligning for hangers on the side wall, only in this case the vertical movement of the transit is prevented so that it will always sight in a level plane. Targets are used in connection with the transit in this method of aligning.

In using a stretched line method, two points, near the extremities of the position that the shaft is to take, must be known. A line is stretched tight exactly thru these points, and by it can be determined any intervening points. A cord is not desirable as it can not be stretched as taut as it should be. A piano wire is very good for this purpose.

In a new shop, alignment may be effected by nailing blocks on the floor directly under where the shaft is to be. By using a straight edge and level, and planing the blocks when desired, they can be made exactly level. A chalk line should then be stretched across the blocks and a mark on them made. Over these marks and by means of a plumb line, a center point for each hanger can be obtained. By using a template having a center hole and bolt holes for the hanger, and putting this center hole on the point located by the plumb line, the points for the hanger bolt holes can be located. The shafting can be located as to distance above these leveling blocks by using a stick cut to a length equal to the distance from the blocks to the position that the bottom of the shafting should have.

By using a stick of the desired length, counter-shafts on the ceiling may also be located parallel to the line shaft and at a certain distance from it. Counter-shafts on the floor may be located by dropping a plumb line at two points from the main shaft, chalking a line thru these points and making the counter-shaft parallel to this line.

10. **Fastening Hangers.**—Where it is known that a building, which is to be built of concrete, must support shafting hangers, provision should be made in the plans for the fastening of the hangers. A more satisfactory job of installation can be performed if materials are imbedded in the green concrete when the building is being constructed. Where it is necessary to put up shafting on old concrete, the hangers must be bolted to the concrete. Expansion bolts are useful for this purpose. Shaft hangers on wooden buildings may be fastened by lag screws or bolts.

11. **Second Alignment.**—The second alignment of shafting in the vertical plane can be performed by tightly stretching piano wire horizontally opposite the center of the extremities of the shaft and equidistant from the shaft at each end. The bearings can then be so adjusted that, by measurement, it is found that the shaft is exactly parallel to the wire thruout its length.

To align the shaft in the horizontal plane or make it level, hangers or hooks, similar to those shown in *C*, Fig. 1 are hung over the shaft *A* to support on their lower ends a straight edge *B*. Nuts *E* on the hanger raise or lower the straight edge to make it parallel to the shaft. The gauge *F* will aid in making the distance between each end of the straight edge and the shaft equal. The straight edge should be made of pine and should be at least 1″ thick. The upper edge should be planed perfectly straight. The level *D* is put on this edge and from it one can tell when the boxes have been so

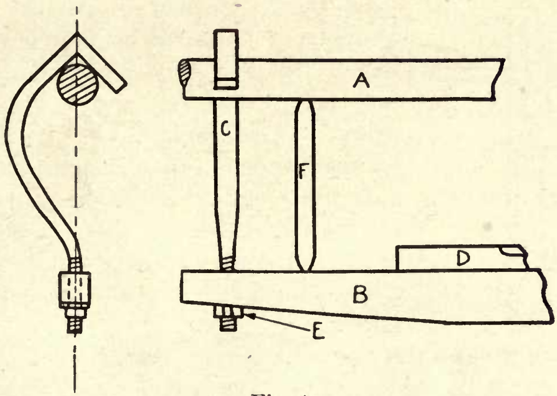


Fig. 1

adjusted that the shaft is level. This is an efficient and simple method.

12. **Set Collars.**—Every shaft should have two set collars to limit the end play. They should never be placed, however, so as to allow of no end play, for any shaft will run better and the bearings wear longer if a small amount of end play is allowed. The collars are sometimes placed, one at each end of the shaft. This plan is not so good as that of putting them one at each side of a centrally located bearing, as, in the first case, variations in temperature, especially in a long shaft, will change the amount of end play and either permit of too much play or so little play as to cause undue friction. The second method will cause neither of these troubles.

13. Aligning Pulleys.—In order to have belts run true on pulleys of parallel shafting, it is necessary to have the two shafts in line vertically and horizontally. They can be placed in parallel horizontal planes by getting each one level. If they are not to be very far apart, they can be located in parallel vertical planes by using a stick, cut to the desired length, as a means for making them equidistant from one another at all points.

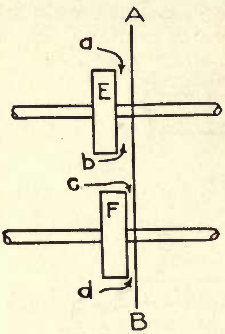


Fig. 2

Where shafts are a considerable distance apart their alignment in parallel vertical planes may be tested by dropping plumb lines to the floor, from which points on the floor may be located and a chalk mark struck. These marks will be directly under the shaft and by careful measurement with a steel tape one can determine whether they are the same distance apart at all points or not. If they are not far out of line they can be adjusted by means of the bolts in the hanger.

Not only must the shafts be aligned properly but it is also necessary that the centres of the pulleys be in line. Referring to Fig. 2 and assuming that the shafts are in line, the pulley *F* is fixed, and it is desired to bring pulley *E* in line with pulley *F*, a string *A-B* is drawn taut across the pulleys close to the shaft and at a distance of ½″ or so from pulley *F*. The pulley *E* is then moved until the distances *a*, *b*, *c*, *d*, between the rims and the string are all equal. In case one pulley is wider than the other, due allowance should be made so that the centres of the pulleys are fixed in line.

14. Pulleys.—The pulleys commonly used are of the following kinds: cast-iron solid, cast-iron split, wood split, pressed steel, and paper. Those types which are held in place on the shafts by means of keys or set-screws are not as desirable as those that can be clamped tight. A key weakens a shaft and when it is necessary to change a pulley, it is often also necessary to cut a new key-way. Pulleys with set screws do not hold as well as is often wished. Key-ways in cold-rolled steel shafting often release the tension in the surface of the shaft, putting it out of form.

The cast-iron solid pulley is the poorest type because it is not easily taken off or put on, is not adjustable to various sizes of shafting, is easily broken and requires a key or set-screw to hold it.

Cast-iron split pulleys are better, for they are more easily taken off or put on and have bushings which make them adjustable to shafts of different sizes. They are easily broken, however.

Wood split pulleys are fairly good, but they loosen rather easily, squeak, and are affected by atmospheric conditions. They have bushings of various sizes and make good belt contact.

Paper pulleys are light, cheap, non-breakable and give good belt contact, but they require keys and are not adjustable to shafts of varying sizes.

Pressed steel pulleys are the best and latest development. They are light, durable, fasten tightly, are easily changed, do not break and have interchangeable bushings.

Pulleys on which a belt is not shifted should have a crown. This crown aids materially in keeping the belt in the center of the pulley. If it were not for this crown, arms would be necessary to keep the belt in place and they wear the edge of the belt. Tight and loose pulleys, upon which a belt is shifted, do not ordinarily have crowns.

15. **Placing Pulleys.**—Pulleys should be placed as near bearings as possible to prevent undue deflection of the shafting and corresponding friction. Tightening or guide pulleys, when used, should be on the slack side of belt near the smaller pulley. Pulleys should be a trifle wider than the belts to be used on them to prevent over-hang of the belt.

16. **Shaft Couplings.**—There are several good styles of shaft couplings. Those which require no keys and which have no bolt heads or other projections to catch things and cause damage are preferable.

17. Rules for Finding Sizes and Speeds of Pulleys.—Of the two pulleys, the driving pulley is the one nearest the source of power.

1. *To Find the Size of Driving Pulley* multiply the diameter of the driven pulley by the revolutions it should make and divide the product by the revolutions of the driver.

Example: The dia. of the driven pulley is 12″ and it should make 240 R. P. M. The R. P. M. of the driving pulley is 160. What should its diameter be?

Answer: 12 × 240 = 2,880 and 2,880 divided by 160 = 18″, dia. of the driving pulley.

2. *To Find the Size of Driven Pulley* multiply the dia. of the driver by its R. P. M. and divide the product by the R. P. M. of the driven.

Example: A driving pulley 18″ in dia. makes 160 R. P. M. and the driven pulley should make 240 R. P. M. What should be its diameter?

Answer: 18 × 160 = 2,880, and 2,880 divided by 240 = 12″, dia. of the driven pulley.

3. *To Find the Number of Revolutions (R.P.M.) of Driven Pulley* multiply the dia. of the driver by its R. P. M. and divide the product by the dia. of the driven.

Example: A driver 18″ in dia. makes 160 R. P. M., and the dia. of the driven pulley is 12″. What is the R. P. M. of the driven?

Answer: 18 × 160 = 2,880 and 2,880 divided by 12 = 240, the R. P. M. of the driven.

4. *To Find the R. P. M. of the Driving Pulley* multiply the R. P. M. of the driven pulley by the dia. of the driven pulley and divide this product by the dia. of the driving pulley.

Example: The R. P. M. of the driven are 500 and its dia. is 6″ while the dia. of the driving pulley is 15″. What is the R. P. M. of the driving pulley?

Answer: 500 × 6 = 3,000, and 3,000 divided by 15 = 200, the R. P. M. of the driving pulley.

Bibliography

1. Kent, *Mechanical Engineer's Pocket Book.*
2. Kimball and Barr, *Machine Design.*
3. Halsey, *Handbook for Machine Designers.*
4. Swingle, *Handbook for Millwrights.*

CHAPTER II

Motors and Currents

18. General Considerations.—In a book of this nature it would not be possible to give complete information for the choice of the type, style or size of electric motors. This is a matter about which teachers should get advice from an engineer or the service department of motor manufacturers. However, a discussion of the problem is of advantage to the teacher if, by such, he sees the many technical points involved in properly choosing a motor, and realizes the advisability of consulting an authority in the solution of the problem as a whole.

The conditions of capacity and efficiency are both of importance in any motor installation. The installation of a motor having too large a capacity should be avoided unless an increase in the load is to be expected in the near future, such as additions of equipment, for the efficiency of a motor is generally at its maximum at its normal rated output. Too small a motor is also undesirable as it is unquestionably liable to be subjected to over-loads, causing the motor to burn out, making temporary use of the machinery impossible.

19. Two Types of Work.—The school shop ordinarily offers two varieties of work for the motor, i. e.,

a) work which requires the motor to operate automatically at a practically constant speed, regardless of load changes or other conditions.

b) work in which the power varies regardless of the speed, or where speed variations with constant torque may be desired.

In (**a**) an example is found in the case of line-shaft equipments with a number of machines operated by the same motor, and where only slight variations are desired. In this case the D. C. shunt of slightly compounded motor or the A. C. induction motor would answer the purpose and the choice would depend upon the type of current available.

Work, of the nature explained in (b) is found in certain types of individual drive machinery, such as machine or wood lathes where the maximum allowable turning speed varies inversely as the diameter of the cut. Such work is best satisfied by the use of D. C. shunt or slightly compounded motors, as their speed is readily controlled.

20. **Advantages of A. C. Motors.**—

1. Motor runs with little change of speed under a heavy load.
2. The usual current in cities is A. C.

21. **Advantages of D. C. Motors.**—

1. Wider air gap, allowing more wear in the bearings before the motor needs repair.
2. The possibility of variations of speeds. This is a decided advantage.

22. **Data Required in Determining the Choice of Motor.**—The following points are essential for the proper choice of type and size of motor:

1. Individual or group drive?
2. If individual drive, the machine and the kind of work to be done on it.
3. If the group drive, and some of the machines operate intermittently, give details of the work of these machines.
4. Statement of insurance rules.
5. Is variation of speed desirable?
6. How is this variation controlled?
7. Speed of machine, size of pulley and belt?
8. Is belt pull at top or bottom?
9. Will there be any combustible material near motor? (shavings, saw-dust, etc.)
10. Where will motor be fastened?
11. Voltage and type of current.

This list does not include all that might be necessary but gives one an idea of the advisability of seeking competent advice when choosing a motor.

23. **Planning for Motor Drive.**—In arranging motor-driven school shop equipment the following points should be observed:

1. To provide ample aisles and operating and stock space between machines.
2. To arrange the machines so that the routing of work, in some order, can be effected.
3. To locate the machines so that good lighting conditions exist.
4. To locate motors where they are accessible.
5. To guard motors, shafting and belts properly and yet make them accessible for cleaning, oiling, repairing and adjusting.

24. **Installation of Electric Motors.**—The foundation for electric motors must be solid, to prevent vibration. Solid masonry or concrete is the best material, but wood or timber framing can be used. All motors should be insulated from contact with metal. Great care should be taken in aligning the motor shaft with the driven shaft if the latter is to be connected directly to the motor.

25. **Care of Motors.**—Only the best quality of oil and grease should be used on the bearings. The best quality of lubricant is more economical than worn bearings. Bearings provided with oiling rings should have a good grade of dynamo oil, and should be filled to the top of the over-flow plugs. The plugs should be kept free, and all dirt, dust and gritty materials must be kept out of the bearings. Excessive belt tension, which heats the bearings, should be avoided. The commutator and brushes should be kept clean. Emery cloth is injurious to the commutator and brushes. A clean cloth or waste should be sufficient to remove the dirt.

Sparking at the commutator of D. C. motors is often caused by:

1. An over-load. Release some of the load.

2. Improper brush adjustment. If a brush fits the commutator properly, the entire face of it will be glazed.
3. Improper brush contact—
   (a) Grease or dirt accumulations.
   (b) Brushes may stick in the holder and need sand-papering to free them.
   (c) Increased brush pressure may be needed—change adjustment on spring.

Bibliography

1. Industrial Application of Motors—*American Handbook for Electrical Engineers.*

2. Installation, Care and Repair of Electrical Motors in Industrial Operations, *Electrical Review,* 1909, Vol. 55, pp. 795, 845, 892, 944.

3. Selection of Direct-Current Motors for Factory Use, *Engineering Magazine,* 1911.

4. Selection of Motors for Different Kinds of Service—F. B. Crocker and M. Arendt, *Electrical World,* Nov. 1907.

5. Choice of Motors for Machine Tools, Kent's *Mechanical Engineer's Pocket Book.*

6. Relative Costs of Group and Individual Drive—G. E. Sanford, *General Electric Review,* Vol. 15, p. 17.

7. Catalogs and literature distributed by motor manufacturers.

CHAPTER III

Installation of Metalworking Equipment

26. General Considerations.—In general, the installation of metalworking equipment requires a knowledge of the floor space necessary for each machine or object of equipment, the space for the operator to work in and the space for the machines to operate in. Also, the placing of the machines, as regards the light for their operation, should be considered. Sufficient aisles should be provided, and the machines located so as to be accessible for adjustment or repair. Safety points on machines, shafting, belts, motors, etc. should receive careful attention. Storage places for tools, raw and finished stock are necessary. The placement of machines, in respect to their convenience to each other, should be considered. Drills, for instance, are used in connection with several machines and operations and should be centrally located in respect to these machines, if possible.

It is possible, sometimes, to economize on space by doubling up on equipment, i. e., a bench, used for chipping and filing, may also be used for sheet-metal work, or in connection with auto repair, depending upon the arrangement of the room and the schedule of classes.

Small machines should be bolted to the floor or foundation. Heavy machines should be grouted or wedged with shingles and bolted. On concrete floors, expansion bolts may be used to advantage.

Speeds and sizes of the pulleys will be determined from the specifications furnished by the manufacturers.

27. Planer.—Daylight should come from the left of the operator as he is at work, if possible. This would mean that the working stroke of the planer would be away from the light. If this arrangement is not convenient, then the planer should be placed so that the working stroke is parallel to the windows and the operator faces the light. Artificial light should be about 2 ft. in front of the tool-post and over the center of the platen.

There should be 4 ft. of space between the end of the table or platen and the wall, or other objects, after the extreme travel of the platen. Otherwise, the table, in running off the gear, as it does sometimes, might pinch a person against the wall and injure him most seriously. There should be at least a 4 ft. space parallel to the side of the planer for the operator.

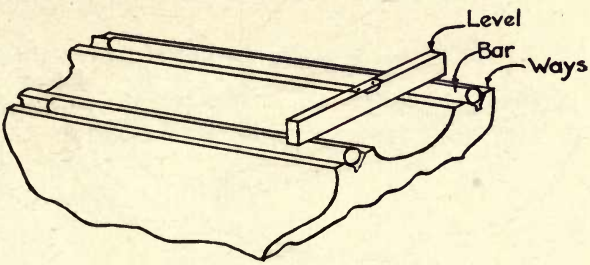


Fig. 3

A consideration, often overlooked, is the necessity of leveling the bed of the planer or the ways in order to obtain the best quality of work from the machine. It should be leveled across the ways and lengthwise of them. To get the two ways level, put two round bars, of the same diameter, in the ways as shown in Fig. 3, and across the bars place a level. Bolster up the planer until it is level at this end and wedge or grout it. Level it thus at each end and intervening points.

To test the ways to see if they are concaved or convexed lengthwise of the planer, place the bars in the ways as before, but in place of the level put a straight edge across the bars. In this case, the bars should be rather short. Similarly, at a distance of 2 to 4 ft. along the bed place two more bars and a straight edge. Across the two straight edges, and connecting them, lay a level, Fig. 4. Repeat this whole procedure by moving these tools along the bed but have each space being leveled overlap the previous space leveled. By this means the ways can be leveled lengthwise and, by wedging, or grouting and fastening to the floor, the planer can be held level.

28. Lathe.—It is preferable that daylight should come from the right as the operator is at work at the lathe, so that he casts no shadow on the work. Artificial light should be directly over the bed of the lathe near its center. Lathes, placed end to end, should have at least 2 ft. of space between them to allow for the opening of cages over the gears and for passageway. Lathes, placed back

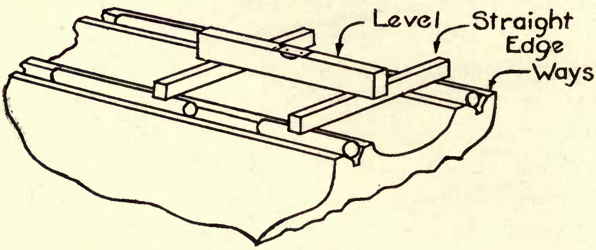


Fig. 4

to back, should have a 1 ft. space between those parts of the lathes nearest meeting. The lathe bed should be leveled as explained for a planer, and the legs properly supported by shingle wedges or grout. The legs should be bolted to the foundation.

29. Drill Press.—Daylight should come from the left or right. Artificial light should be at the height of the head to the left or right of the center. There should be 3 ft. of working space at the front and the two sides. The machine should be set so that the table is level as it is often necessary to set up work by the use of the level.

30. Milling Machine.—There should be space on three sides for the operator. Light should come from the left or right if possible. Artificial light should be in the front of the center of the machine just above the head.

31. Shaper.—Light should come from the left or right as operator works. Three feet of space beyond the extreme travel of the slide is desirable.

32. Forge.—Double forges have an advantage in that the initial cost and that of operation is less, and also because there is an economy of space with this type. Further economy of space is often gained by placing them at an angle of 45 degrees with the imaginary line thru the center of the forges.

Single forges should be placed about 5 ft. 4″ apart on centers as a minimum.

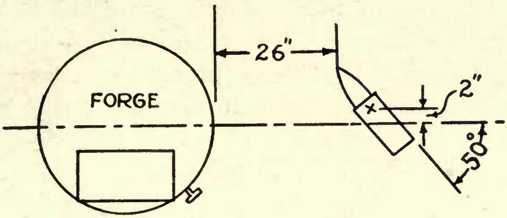


Fig. 5

The hood should be at the left and also the lever that controls the air.

33. Anvil.—There should be from 24″ to 26″ of space between the anvil and the forge. The anvil should be turned at an angle of about 50 degrees and the center of the anvil should be about two inches to the front of the center of the forge, Fig. 5.

There should be sheet-iron around the anvil if it is on a wooden floor. A wood mount for the anvil set 2 ft. in the ground or in concrete is good. Cement mounts or stands crumble. Iron stands are clumsy, in the way of the feet of the worker and have openings around the anvil into which tools are dropped and are bothersome to extract. For a grown person, the top of the anvil should be about 28″ above the floor.

34. Blower.—Individual blowers for each forge are advantageous for it is then not necessary to run a big blower sufficient for all forges when only a few are being used. The cost of installation for underground blast piping is saved, the loss of power due to friction is minimized and the total power required is less, for, with a single large blower, the pressure is kept up to a certain maximum at all times.

In case it seems advisable to install a blower and exhauster, a motor driven fan is preferable. The motor can be placed between the fans of the blower and exhauster, having the shaft extend each way into the fans.

In planning a forge room, it would be advisable to submit, to the engineering department of reputable makers of forge equipment, the dimensions of the forge room, as well as the number of the forges to be installed and the preferred location of same. The engineering department will then prepare a suggestive lay-out showing an economical arrangement of forges, anvils, and underground ducts.

CHAPTER IV

Installation of Woodworking Equipment

35. General Considerations.—No hard and fast rules can be given that will determine for one the exact arrangement of machin-

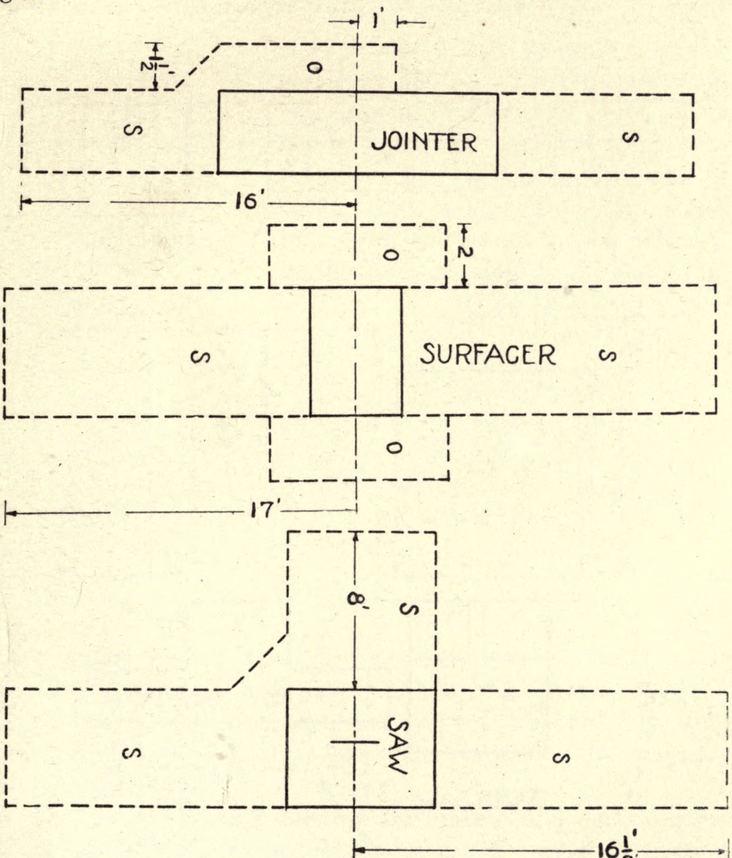


Fig. 6

ery. Existing conditions are varied and only points for consideration can be shown.

One should know the approximate floor space necessary for different machines as well as the operating and stock spaces deemed essential. The floor spaces will be given by the manufacturer in the specifications of the machines. The operating and stock spaces for various machines should be approximately as shown in

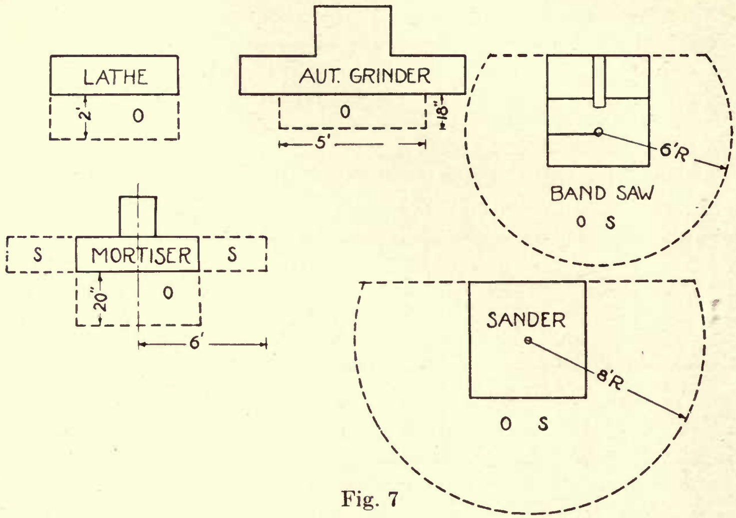


Fig. 7

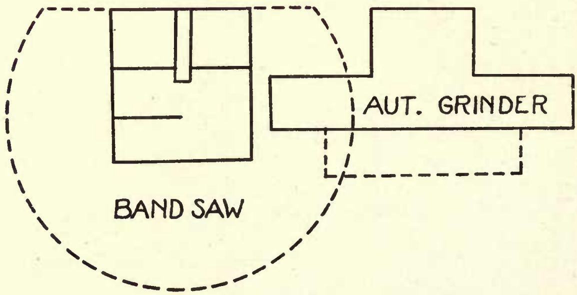


Fig. 8

Figs. 6 and 7. These are respectively designated by *O* and *S*. It might happen that an *S* space, allowed for one machine, might overlap an *S* space for another machine with no inconvenience. For instance, an arrangement like that shown in Fig. 8, where the stock space for the band saw overlaps that for the automatic grinder, would not be a serious inconvenience.

In locating the different machines, it is necessary that the pulleys on the machines line up with the pulleys on the line or counter-shaft over which the belts for the machines under consideration run. If in Fig. 9, a wire or strong cord is stretched tight across the upper and lower rim of pulley *C* on the line-shaft close to the shaft, and

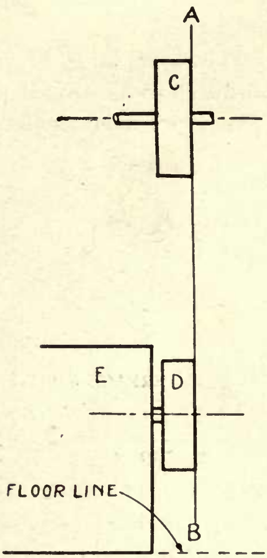


Fig. 9

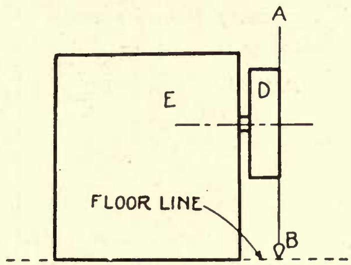


Fig. 10

the machine *E* is so moved as to bring the rim of the pulley *D* just to the line also, and pulleys *C* and *D* are plumbed with a plumb bob, as in Fig. 10, there will be no trouble with the belts running off, provided, of course, that the pulleys are properly hung on their respective shafts.

The speeds at which different machines should run are given in the specifications by the manufacturers. Formulas for figuring sizes and speeds of pulleys, width of belts, etc., are given in the chapters on "Power Transmission" and "Belting."

36. Speeds of Various Machines.— For reference, the speeds of various machines are given below:

1. Grindstone—circumferential speed of from 600 to 800 ft. per minute.
2. Crosscut-saw and rip-saw—rim speed of 10,000 ft. per minute.
3. Jointer—speed of cylinder, 4,000 to 5,000 R. P. M. for large size, and about 5,000 R. P. M. for 6″ knives.
4. Lathe—variations of spindle from 600 to 3,000 R. P. M.
5. Mortiser—bit runs 3,450 R. P. M. with 10 to 35 strokes of the chisel per minute. Driving pulley on countershaft makes 1,100 to 1,200 R. P. M.
6. Surfacer—speed of head 4,000 R. P. M.
7. Band-saw—about 4,500 ft. per minute rim speed.
8. Cut-off saw—10,000 ft. per minute rim speed.

37. Emery Wheel Speeds. —

Diameter of Wheel in Inches	R. P. M. for Surface Speed of 5,000 Feet per Minute
1	19,099
2	9,549
3	6,366
4	4,775
5	3,820
6	3,183
7	2,728
8	2,387
10	1,910
12	1,592
14	1,364
16	1,194
18	1,061
20	955

38. Circular Saw Speeds.—

Size of Saw in Inches	R. P. M.
8	4,500
10	3,600
12	3,000
14	2,585
16	2,222
18	2,000
20	1,800

39. Horse-Power Required for Woodworking Machines.—This can be stated only approximately due to varying conditions of work to which machines are subjected, such as whether wood is soft or hard, 1″ or 3″ thick, whether the machines are kept in good condition or not, etc. The general requirements are as follows:

1. Cut-off saws require 2 to 4 horse-power.
2. Crosscut and rip saws require 3 to 5 H. P.
3. Surfacers, 18″—5 to 7 H. P.; 24″—7 to 10 H. P.
4. Jointers, 6″—1½ H. P.; 8″—2 to 3 H. P.; 16″—3 to 4 H. P. and 20″—4 to 5 H. P.
5. Hollow chisel mortisers, 1½ H. P.
6. Lathe, ½ H. P. each.
7. Automatic Grinder, 2 to 3 H. P.

40. Other Factors to Consider.—Woodworking machines do not require as careful leveling as do most metalworking machines. However, they should be approximately level, and, in the case of the lighter machines, should be bolted to the floor.

The crosscut- and rip-saws should have light from the front, if possible; mortisers from the left or right and lathes from the front or right side as the operator faces the lathe. The light for the surfacer, jointer, sander or band-saw is not so particular a point as for the other machines, provided there is good light in the room as a whole.

Some attention might well be given to the routing of stock when planning for the placement of machines. From the stock room or cut-off saw, the majority of the stock goes to the rip-saw, jointer and surfacer. This would indicate that these machines might well be placed convenient to each other and to the stock room.

PART TWO — MAINTENANCE

CHAPTER V

Fitting Edge Tools

41. **Plane Irons** are not all fitted alike. The usual equipment consists of a jack-plane for making heavy first cuts, a smooth-plane for making finishing cuts and for use on broad surfaces, and a fore-plane or a jointer for making a true, straight edge.

Because of the depth of cut demanded of a jack-plane and because of the fact that a heavy shaving, the full width of the blade or iron, would cause trouble by choking in the throat, the blade is usually ground a trifle rounded, similar to Fig. 11. This

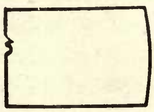


Fig. 11

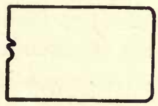


Fig. 12

condition is obtained by bringing slightly more pressure, first on one corner and then the other, than on the center of the iron, when grinding it.

The smooth-plane irons are ground perfectly straight across and then about two strokes are given each corner to produce the effect shown in Fig. 12. If the corners are left square, the different cuts, on a broad surface, would be shown by shoulders or steps. The rounded corners cause the cuts to blend unnoticeably with the rest of the surface.

The jointer iron, because of its duty in forming a true flat plane surface, is ground straight across the edge and the corners are left square.

The angle of the bevel, Fig. 13, should be about 20 degrees, or so that the bevel measures $\frac{3}{16}''$ to $\frac{1}{4}''$ long on each style of plane. Too long a bevel will cause chattering and weaken the edge so that it will more easily chip. Hard wood requires less bevel than soft.

In grinding a plane-iron, the cap-iron, which is the piece that is clamped on the cutting iron or blade, should be loosened and slid back as far as the screw will permit and then fastened again. This will serve as a handle and also make a quicker adjustment than if it were taken off entirely.

Fig. 13

The proper way of applying an iron to an emery wheel or grindstone is shown by Fig. 14. It should be firmly grasped with the right hand and the fingers of the left hand laid across it near the cutting edge. It should be laid on the stone similar to *a*, Fig. 14, and then raised with the right hand until the desired angle of contact is made. This is shown by *b*, Fig. 14. If the bevel already on the tool is correct, this position can be determined easily by watching the cutting edge to see when it first comes in contact with the stone. No tool should be held in one place on the stone, but should be moved slowly back and forth across the stone to keep the wear even on both the stone and tool. The angle of contact with the stone, however, should be kept as constant as is possible. Otherwise, the effect shown in Fig. 15 will result, making a stubby, poor cutting edge. Because of the difficulty in holding the tool at the same angle, a clamp or jig is often used. This has a roller on the end, opposite that on which the iron is clamped, that rests on the stone. This clamp permits of any ordinary angle of bevel and can also be used for chisels. In grinding on an emery wheel, great care should be taken not to burn or draw the temper of the tool. This can be told by a blue color appearing at the cutting edge. A tool that has been burned will not keep an edge as long as it should. Grind

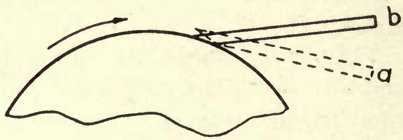


Fig. 14

the irons until a feather edge is turned over on the back of the tool and then stop. Further grinding makes them no sharper and only wears away the tool.

Having ground the irons, the next process is that of whetting. This is done on an oilstone, usually of a size about 6″ x 2″ x 1″. The tool is grasped by the right hand and the fingers of the left are laid across it near the cutting edge. It is applied to the stone like *a*, Fig. 16, and then is tipped up to the position of *b*. It will be noted that this position is not one where the bevel is flat on the stone, but where it is raised from the stone slightly at the heel. Were the bevel laid flat on the stone, the time required to get a fine cutting edge would be much greater than by the former method, and the efficiency of the cutting edge would not be increased. Care should be taken, however, to make this angle only slight and to keep it constant. If a tool is held properly in grinding the form of the bevel will be a concave plane of the same curvature as the wheel upon which it is being ground. When applied to the flat surface of an oilstone, the tool will touch only at the toe and heel, and the time necessary to whet it will be short, even with the bevel flat on the stone. It is hard, however, especially for an unskilled workman, to get a concave bevel on a tool, and for that reason it is advisable to raise the tool as explained above.

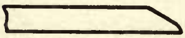


Fig. 15

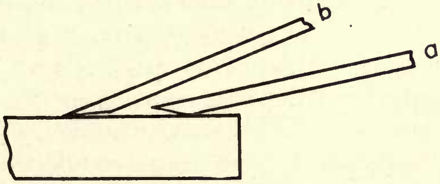


Fig. 16

For the beginner at least, the motion of the iron on the oilstone should be circular as in Fig. 17. This presents the cutting edge more evenly to the stone and keeps the stone in better form. One should keep changing the whetting area on the stone from time to time, also, so that it does not become hollow in any one place. Some of the best mechanics give a longitudinal stroke the full length of the stone in whetting, but it is hard for the beginner to do this and keep the bevel correct. Whetting should continue until a slight feather or wire edge can be felt turned over on the back of the iron, extending clear across the cutting edge. To remove this, lay the tool flat down on the oilstone with the bevel up and give a few light strokes in a circular motion. If the feather edge is not removed entirely by this, hold the tool upright and draw it crosswise of a piece of wood, making a cut like that of a knife. One such cut should remove the ragged edge. In replacing the cap-iron, it should be clamped about 1/32″ from the cutting edge for ordinary work, and closer for cross-grained hard wood.

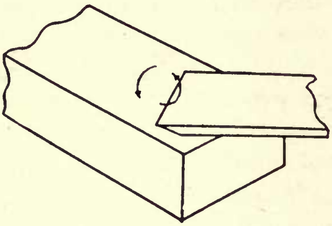


Fig. 17

42. **Chisels** are ground and whetted exactly as are plane irons, with the exception of the angle of the bevel which should be from 20° to 25° for paring chisels and about 30° for mortising or for heavy work on hard wood.

43. **Turning Tools.**—The roughing gouge should be so ground that, on looking down the cutting edge, as it is held on the rest for cylindrical cutting, it will have the appearance of a semi-circle. To obtain this the angle *a*, Fig. 18, should be about 30°. It is held on the grindstone and oilstone as explained for plane-irons, except that it is rolled with the right hand from left to right to give the cylindrical bevel.

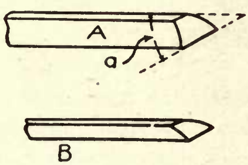


Fig. 18

The small gouge is ground like the roughing gouge, but has the corners of the cutting edge ground farther back as in *B*, Fig. 18, to give a better cutting edge on the side where it is so much used. After a gouge has been ground and whetted on the bevel, it is necessary to remove the wire edge. As this cannot be done by laying it flat on an oilstone, a slip-stone is employed. The curve of the stone nearest matching that of the concave surface of the gouge is placed flat against this surface and moved back and forth over the wire edge. Some prefer to strop the bevel of wood-cutting tools on a strip of leather glued to wood. This is seldom done by the mechanic.

The skew chisels are so ground that the angle of the cutting edge with the length of the tool is between 45° and 60°, varying

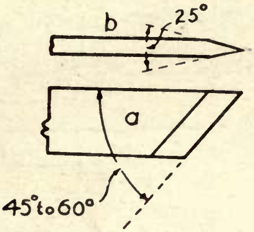


Fig. 19

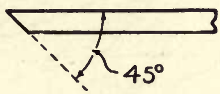


Fig. 20

with the wood and the nature of the work. See *a*, Fig. 19. The angle between the bevels in *b*, Fig. 19, should be about 25°. The skew chisels are ground like other beveled tools, described above, and are whetted on each bevel. It is important to keep each bevel a perfect plane surface and, for that reason, the bevel is laid flat on the oilstone in whetting and is not raised as was the plane-iron in Fig. 16.

Scraping tools are ground so that the bevel makes an angle of approximately 45° with the length of the tool as in Fig. 20.

The parting tool, Fig. 21, has an angle of about 50° between the beveled edges.

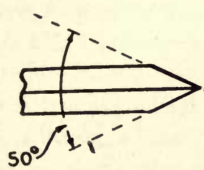


Fig. 21

44. **The Draw-knife** is hard to hold, in grinding, because of the handles, but should be held on the stone as explained for plane-irons and chisels. The whetting can be done very handily by holding the draw-knife, back down, on the bench with the beveled side next to you. It is held there by the left hand while the right grasps the oilstone and applies it to the beveled edge as shown in Fig. 22.

45. **Spokeshave Blades,** being so short, are inconvenient to handle and a holder like that in Fig. 23 is handy. Dotted lines represent the blade in place for sharpening. It is ground and whetted like other beveled tools.

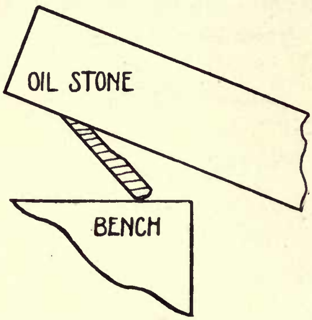


Fig. 22

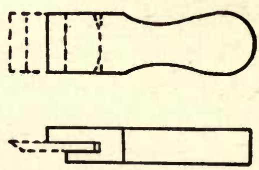


Fig. 23

46. **The Outside Gouge** is given a rotary motion in grinding as is the turning gouge, but unlike the latter it has a square end rather than a semi-circular one, when viewed at right angles to its length. The slip-stone must be used to remove the wire edge in the same manner as for the turning gouge.

47. **The Inside Gouge,** so named because the bevel is on the the inside curve, cannot be ground on an ordinary emery wheel or grindstone. A device that works satisfactorily can be made on a wood lathe and similar in shape to Fig. 24. The small tapered end should fit the tapered opening for the live center. After it is turned smooth from some fine grained wood such as maple, it is coated with a thin coat of glue and dipped in flower-of-emery and allowed to take up all the emery possible. After thoroly drying, it is again dipped. This is repeated until three or four coats of the powdered emery are on it. The cone shape allows for the grinding of different sizes of gouges. Inside gouges are whetted with a slip-stone on the bevel after being ground and a slip-

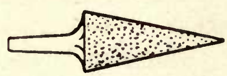


Fig. 24

stone is rubbed flat on the outside of the gouge to remove the wire edge.

48. **Cabinet Scrapers** do their work by means of a turned-over corner or arris. The scraper is fastened in a vise and filed flat, crosswise of the edge, and slightly rounding lengthwise, so that the corners will not dig. It is then draw-filed as in Fig. 25, with one hand grasping the end of the file and the other the handle, causing the file to move in the direction indicated by the arrows. The edge is then whetted keen on an oilstone as shown in Fig. 26,

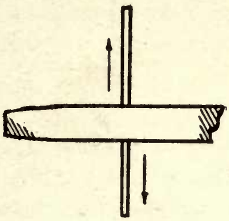


Fig. 25

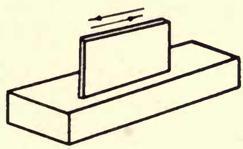


Fig. 26

and the wire edge, from grinding, is removed by whetting slightly the sides close to the filed edge. The scraper should lie flat on its side in this operation. It should now have a square-cornered edge free from roughness. The wire edge desired is obtained by rubbing a burnisher over the corner as shown in Fig. 27. The scraper is held firmly on the bench with the edge being sharpened perpendicular to the bench. The burnisher should be held with the point down, making a right angle with the scraper, like *a*, Fig. 28, at first, an angle like that at *b* next, and finishing with the angle at *c*. This angle should be different from the first by not more than 15°. Turning the edge too far causes it not to "bite" or take hold of the wood as it should. When the edge has been turned too far, it can be raised by running the point of the burnisher along under the turned edge. A burnisher must be hard enough not to be scratched by the scraper. A good one can be made by grinding a round file smooth and sharpening the end. A scraper need not be filed every time it fails to cut well, but should have more of the edge turned.

49. **Planer and Jointer Knives** should be ground on an automatic grinder, where possible, as the cutting edges should be straight and this condition is difficult to obtain by holding them

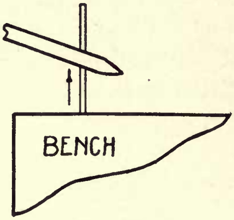


Fig. 27

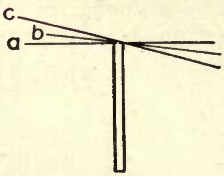


Fig. 28

by hand against an ordinary emery wheel or grindstone. The angle of the bevel with the side of the blade should be about 35°. In using an automatic grinder, care should be taken that the water is turned on to avoid burning the edge. After grinding, the bevel is whetted on an oilstone as explained for the plane-irons and chisels in previous paragraphs. Recently, grinding devices for use on the jointer and surfacer without removing the knives have been perfected. This method allows of such a fine adjustment of the knives as not to be compared to the older methods of sharpening and setting.

CHAPTER VI

Fitting Saws

50. **Hand Rip-saw.**—The purpose of this section is to give the procedure for keeping in order the various saws ordinarily found in the school shop where the number and variety is not such as to require the services of special saw-fitting machinery.

The beginner who is trying to learn to fit saws properly should start with a rather coarse-toothed, hand rip-saw having about four

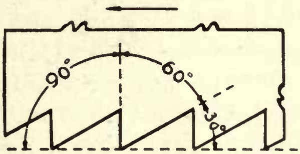
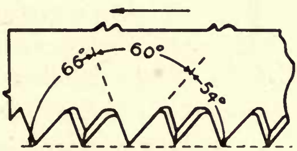


Fig. 29



Fig, 30

or five points to the inch; not an old one with uneven and poorly formed teeth, but one having properly shaped teeth. It is no little trick to fit a saw properly and the learner should have correctly formed teeth to work on first, his aim being to maintain this form as he acquires skill in the handling of his file. Perhaps a still better way is to give the beginner a strip of soft steel about 1/16″ thick, 1″ wide and 6″ long and show him the proper lay-out for a rip-saw tooth of any number of points to the inch, for the form is the same regardless of the number of points to the inch. Have him then lay out on the edge of the strip teeth with points 1/4″ apart, and corresponding in form to the diagram, Fig. 29, the arrow of which indicates the direction of the cutting stroke. Notice that the front of the tooth is at right angles to a line running thru the points of the teeth, and that the angle, between the back and front edges of a tooth, is 60°, and also that the tooth is made by filing square across the blade so that there is no bevel or fleam, as in the crossscut-saw illustrated in Fig. 30. In laying out the teeth, use a bevel, try-square and scribe, and make the marks strong enough to be seen plainly. It should not be necessary to lay them out on both sides of the strip. Place the strips in the vise, as low as possible and still have clearance for the file. If no saw clamp is at hand, a very serviceable one can be made of two strips of 7/8″ hard wood, about 2″ wide, which can be clamped close to the teeth in an ordinary bench or machinist's vise. The outside edges, at the top of the strips, should be beveled to allow clearance for the file.

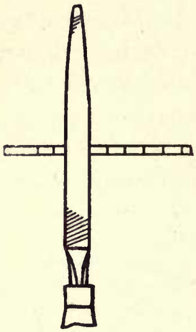


Fig. 31

For filing such large teeth, a slim taper file about 7″ long should be used. It should have a handle on it. With the handle in the right hand and the left holding the tip of the file, assume such a position that the file moves in a direction perpendicular to the side of the strip and at right angles to a line lengthwise of it thru the points of the teeth, Fig. 31. A file is made to cut on the pushing stroke only. It should be slightly freed from contact with the teeth on the return stroke. With a number of firm strokes, file out the metal between the teeth just to the scratch mark.

The first operation, in fitting a saw, is to joint it if necessary. Then it is set and after that filed. Of course the ordinary procedure could not be followed in this exercise. When the learner has carefully filed the teeth the full length of the strip, he has a fair idea of how the teeth should appear and, furthermore, he has acquired some skill in manipulating the file.

The next step for the learner is to try to get this same form in the teeth of an actual saw. First, sight lengthwise of the saw at the teeth to see if they are all in line, and if the line is a slightly crowning one, with the middle portion about 1/8″ higher than at the ends. If the teeth are not even or the line is not crowned properly, the high ones must be filed until all are in line. This process is called *jointing*. For this purpose a 10″ flat file should be used. With the saw fastened in a clamp, the file is laid flat on the points of the teeth and, with the fingers lightly rubbing the sides of the saw to keep the file from rolling sideways, it is pushed forward over the teeth. This is repeated in places where needed until the shortest tooth is just tipped or flattened on the top and the crown is perfect. As it is quite difficult for a beginner to hold the file exactly horizontal at all times, it is desirable to use a jointer. There are several commercial styles on the market, and one can be made like that shown in Fig. 32. Notice the clearance made for the teeth in the block close to the file. Care should be taken that the file is set in the block at right angles to the face of the latter.

The next operation, which is *setting*, means the bending of every alternate tooth slightly to one side and the remaining teeth to the opposite side of the saw, the purpose being to cause the teeth to cut a groove wide enough so that the blade of the saw will pass thru without being pinched by the wood. A common fault is that of putting too much set in the teeth, thus causing them to break. Teeth should always be set to the same side as they were previously. Also, all of the bend or set should be in the upper half of the teeth and not in the base, else they are liable to break. The teeth should be set only enough to allow freedom of the blade in passing thru the groove made by teeth. The least set that is possible, and yet have a free saw, the better. There are a number of ways of setting teeth. One method is to bend them with a tap of a hammer over a stake or small anvil made for the purpose and held in a vise. Another method is that of swage setting where a swage is driven on the points of the teeth causing the points to spread or flare. In this case, all are swaged alike and not bent to the side as in setting.

Fig. 32

The more common method is that of using the spring saw set. It is not feasible to describe the various styles, but most of them have a beveled disc or a sliding bar with a bevel. These pieces are so adjusted that the bend will come in the right place in the tooth according to the size being set. Some sets have numbers on the discs corresponding to the points per inch. There is also an adjusting screw that presses against the side of the saw and allows variation in the amount the tooth is bent to the side. The beveled piece simply determines the distance from the point that the tooth is bent. For ordinary dry woods, 1-100″ bend to each side of the saw should be sufficient. Soft or damp woods require more set. Fig. 33 illustrates the effect of setting the teeth of a saw. In this sketch, the set is exaggerated for sake of illustration. Swage set is shown by *a*; spring set by *b*. Every alternate tooth is set to one side of the saw; the saw is then reversed and the remaining teeth are set to the opposite side.

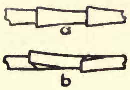


Fig. 33

The saw having been properly set, the next step is to file it. As in setting, every alternate tooth should be worked from one side and the remaining teeth from the opposite side. The bulk of the filing should be done on the front edge of the teeth and on those teeth that point away from the operator, in order to avoid chattering of the saw, with injury resulting to both the saw and file. File each tooth nearly, but not quite, to a point. They will be brought to a point later, when filing the remaining teeth from the opposite side. Some call the fitting completed when the teeth are all filed to a point. Others prefer to *side-dress* the saw. This consists in laying the saw flat on the table or bench and rubbing an oilstone or fine file lightly over the sides of the teeth to remove the burr left by the file. It is certain that a smoother cut is made by a side-dressed saw.

The rip-saw is used lengthwise of a board and the action of its teeth are like a number of tiny chisels, each chipping a portion from the end of the fibre of wood. The crosscut-saw is used to cut across the fibre of the wood and its action is different. Instead of cutting off ends of fibres, it severs them at each side of the saw. One set of teeth cuts them on one side and the opposite set on the other side. For this reason, the teeth are brought to a sharp edge by filing a fleam or bevel on them. This is shown in *a*, Fig. 34. These bevels are filed on the inside edges of each tooth. The bevel of the front edge of the tooth should make an angle of about 45 degrees with the plane of the saw blade. The angle of the bevel in back varies with the nature of the work to be done. Fig. 34, *a*, shows a tooth of a 5½-point hand-saw for cutting soft wood. The bevel on the front is the same as that on the back. In *b* is shown the tooth of a 7-point saw, for medium hard wood, with less fleam on the back, while *c* shows a 10-point tooth for hard wood. There is no bevel on the back. In general, it can be said that the harder the wood the smaller the tooth and the less the bevel on the back of the tooth. *Pitch* is a term used quite ambiguously in connection with saws. In Figs. 35 and 36, this is represented by the difference between angles *a* and *a* respectively. In Fig. 35 the angles *a* and *b* are the same and the tooth is said to have no pitch. In Fig. 36 the point of the tooth has been pitched ahead 6 degrees from its position in Fig. 35 where the front edge makes an angle of 60 degrees with the line thru the teeth. This angle varies according to the work to be done, hard woods requiring less pitch than soft.

51. Hand Crosscut-Saw.—The hand crosscut-saw is jointed and set as was the rip-saw, but it is not filed in the same manner as the rip-saw. It will be remembered that in filing the latter, the file was held horizontally and at right angles to the length of the saw or, in other words, square across the saw. For the crosscut-saw, the file should be so placed that it makes an angle of approximately 45 degrees with a line thru the teeth and at the same time should be parallel to the perpendicular to the side of the saw, or horizontal. In making the above angle of 45 degrees, the handle of the file should swing towards the handle of the saw so that the file is pushed towards the small end of the saw and works on the front edge of those teeth which point away from the operator. As in the case of the

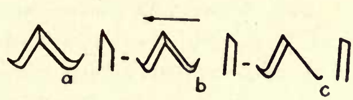


Fig. 34

rip-saw, every alternate tooth is filed from one side; then the saw is reversed in the clamp, and the remaining teeth are filed from the opposite side of the blade. The bulk of the filing should be done on the front edge of the teeth and on those teeth which point away from the operator, in order to avoid chattering. For 8, 7, 6 and 5-point saws use a 6″ slim taper, three-cornered file, and for 9 to 12-point saws use a 5″ slim taper file.

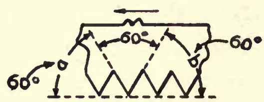


Fig. 35

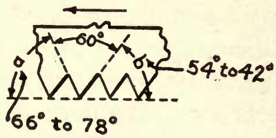


Fig. 36

A circle, turning or web saw is usually filed like a rip-saw.

52. **Key-hole Saw.**—A key-hole saw is filed in a manner which is about half rip and half crosscut. That is, the tooth is pitched more than a crosscut, but not as much as a rip-saw tooth. The front of each tooth should make an angle of about 70 degrees with the line thru the points. The bevel or fleam is not so acute as that of a crosscut-saw, yet the tooth is not square in front like a rip-saw.

53. **Mitre- and Back-Saws.**—These saws have crosscut teeth but, because of the fineness of the teeth, require much care. A cant, safe-back file should be used.

54. **Band-Saws.**—Band-saws have a rip-saw tooth, the proper shape of which is shown in Fig. 37. If fitted by hand, they should receive the same treatment as a hand rip-saw, but it is a long task. There are a number of good band-saw fitting machines on the market that file and set very quickly, filing a saw in from ten to fifteen minutes with little attention after the first adjustment is made and the machine started. They are not difficult to learn to operate. The principle on which they work is the same, tho the construction of the machines varies considerably. The saw runs over pulleys and passes thru a guide on the machine. It is moved thru the guide to receive the stroke of the file by a plunger

finger, usually working on the tooth adjacent to the one being filed. An ordinary slim taper file is hung on two arms operated by an eccentric or cam that gives a motion very similar to that of the human hand. All the teeth are filed from one side of the saw. The plunger and file are adjustable to various sizes of teeth and saws.

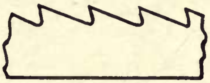


Fig. 37

55. **Circular Rip-Saws.**—In circular rip-saws, the hook or pitch, and the size and shape of the gullet, or bottom of the teeth, are important. An insufficient amount of hook causes the teeth to scrape and tear the wood; the saw requires more power; it cuts slower and gets dull more quickly. Too much hook weakens the teeth and causes them to dodge or break. The shape of the gullet should be round to allow room for the shavings and saw-dust and, at the same time, to strengthen the base of the tooth. A square corner will be liable to cause a crack in the saw at the corner. A well formed tooth is shown in Fig. 38. The distance *a* is broad for strength. The gullet *b* is round and will hold sufficient saw-dust to keep the saw from choking. In Fig. 39, the gullet *b* is too small. The dotted lines show where it should have been filed.

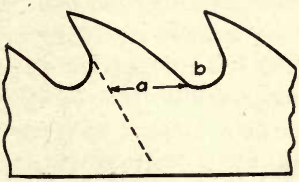


Fig. 38

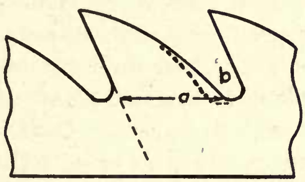


Fig. 39

Fig. 40 shows how they are often filed. A tooth like this could not possibly cut and remove the saw dust properly. It would furthermore be very liable to crack as shown in the illustration.

Fig. 41 shows the lay-out for the teeth. Notice that the front of the tooth, if continued, would make a tangent with circle *A*, the diameter of which is one-half that of the saw. There is a difference of opinion as to whether the back of the tooth should be filed any or not. The argument for not doing so would seem to be the best. If the tooth is filed on the front only, different filings will cause the tooth to appear in the positions shown by dotted lines in Fig. 41, and if the line of the front of the tooth is kept tan-

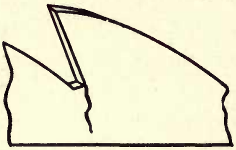


Fig. 40

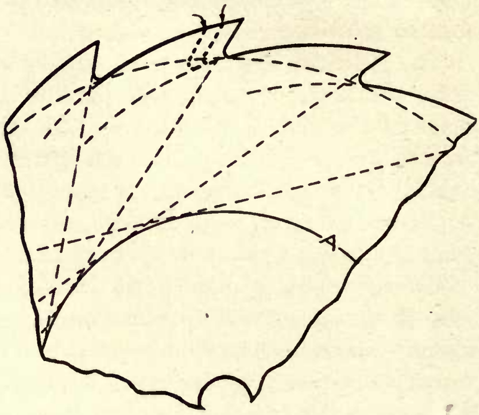


Fig. 41

gent to circle *A* at each filing, the shape will be kept constant. If, however, the back of the tooth is filed near the point, it will be more difficult to keep this same shape.

The first step, in fitting a circular saw, is to see if it is round. It can be made so by lowering the saw or raising the table until the saw rises just above the latter. By holding a piece of an old emery wheel on the table and pushing it gently against the saw while in motion, the points of the high teeth are ground down in line with the others. No more of the points should be ground off than necessary to bring all the teeth in line. Remove the saw from the arbor and fasten it in a saw clamp. Very good clamps can be purchased which tilt at different angles to suit the operator's convenience. A good one can be made of a 1½″ plank of the proper length to reach from the floor to the level at which the filer desires to work. There should be a slot near the top of the plank fitted with a bolt on which the saw should be hung and drawn tightly against the plank by a large washer or another piece of plank. The slot permits of raising and lowering the bolt to accommodate different saws.

In order to keep the teeth uniform, a template can be made from a piece of brass as shown in Fig. 42. A file, with a round edge, should be used for filing, as one with square edges would make corners in the gullets. The teeth should be filed square across the front edge and square across the back except for the upper half near the point which should be slightly beveled, the highest portion being on that side towards which the tooth is bent. Often, the mistake is made of beveling the front as well as the back. This causes vibrations and "runs." If an emery wheel of the proper shape is available, the gullets can be rounded on that. A round file can also be used for this purpose.

Having been filed, the teeth should now be set. In this connection it might be noted that it is perhaps justifiable to insist that teeth be set before being filed, for the process of setting is liable to injure the edge of a keen tooth. Every alternate tooth should be bent to one side and the remaining teeth to the opposite side. This can be done in several ways. A mechanic, if not particular, files a small chamfer on the edge of his saw table, and laying the saw on the table, strikes each tooth a light blow, bending it over the chamfer. This is a make-shift method and does not insure an even setting. If the teeth are not evenly set the cut is not as smooth, and, as some teeth would have to do more than their share of the work, they become dull quicker than if they were assisted by the proper working of the faulty teeth. A setting stake can be purchased which has a beveled disc anvil over which the teeth are bent. The amount of set is adjustable. There are also spring saw-sets, larger than those for hand-saws, but working on the same principle.

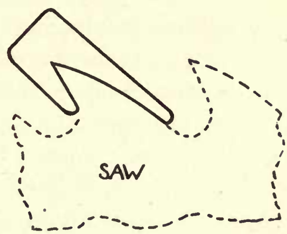


Fig. 42

After setting, the teeth should be side-dressed with a flat file until the amount of set is the same on all teeth. This is determined by some gage. Fig. 43 shows a home made gage that is good.

The screws *a, a, a* project equally thru the wood. Screw *b* is adjusted so as to make *c* the distance from screw *b* to side of saw, equal to the set desired. A circular saw should have set no farther down the teeth than necessary to make it run free and the amount that the teeth bend to each side of the saw should be about $\frac{1}{32}''$.

56. **Circular Crosscut-Saws.**—Circular crosscut-saws are fitted in much the same manner as the rip-saws. The teeth, however,

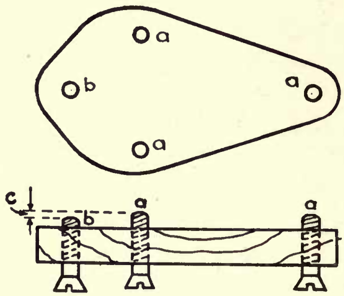


Fig. 43

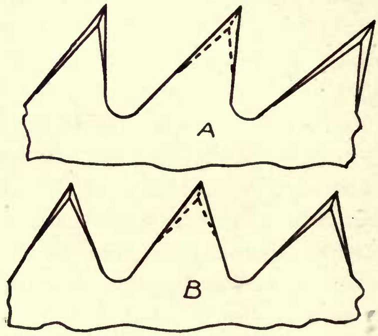


Fig. 44

are different in form and have more bevel or fleam on the back and front. Fig. 44 shows crosscut teeth. The gullet should be round and the bevel should not reach to it, but about half-way down. *A*, Fig. 44 shows a tooth for soft wood and *B* one for hard wood. In using an emery wheel for gumming or rounding the gullets, care should be taken to prevent the saw from being heated to a blue color. It is better, in this process, to work around the saw a number of times, cutting a small amount each time, and thus prevent over-heating the teeth.

If a crack forms near the rim of the saw, it can be kept from growing longer by drilling a small hole at the base of the crack.

Tho it may cause temporary delay, much time is gained in the end by keeping the saws in good condition all the time. Touching up the teeth often is a small job, but to wait until they become very dull makes a laborious job of the fitting.

CHAPTER VII

Brazing Band-Saws

57. **Brazing.**—A good joining of band-saw blades by brazing is a knack not difficult to acquire, and one needs only to work carefully and accurately. Perhaps the best way to learn is to take short, broken pieces of a band-saw blade and practice on these, making a number of joints until always sure of a good braze. The beginner should start on a narrow blade, about 3/8″ or so wide, and gradually try wider ones. As it is probably easier to make a two-tooth lap, i. e., lapping the ends a distance equal in length to two teeth, the novice should attempt this first, but a one-tooth lap is preferable on saws up to 5/8″ or 3/4″ wide, as the strain in passing over the wheels of the saw frame is less liable to part it.

The first operation in brazing is to examine the blade and see how much filing is needed. The lap or scarf will look like Fig. 45 and should be so made that the "set" of the teeth where the ends join will match. If care is not taken in this particular, when the saw is set later on there will be two teeth next to each other which are set to the same side, and unless the operator has kept this in mind and started setting on the lap and finished at the lap, there will be trouble, for he will be setting a number of teeth to the opposite side from which they have been set before and this is liable to break them. A saw should have an even number of teeth in order to have them set alternately to the right and left thruout the length of the saw. After deciding where the joint is to be made,

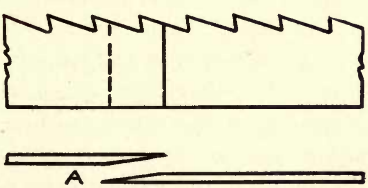


Fig. 45

it is best to first file the ends square with the sides; then each end can be placed on a strip of hard wood, Fig. 46, and held in place by a small clamp. The strip of wood is then fastened tightly in a vise and the end scarfed to appear like *A*, Fig. 45. One scarf will be on one side of the blade and the other on the opposite side. A flat hand or mill file should be used for this purpose. The laps should be perfectly flat surfaces and should fit each other nicely. They should be filed to almost a knife edge at the ends. Some prefer to draw-file the laps as a finishing touch. After being sure that the scarfs bear on each other evenly, carefully clean any grease or dirt from the filed surfaces. This can be done with muriatic acid, slaked lime or a compound made purposely. It is very essential for a good braze to have clean surfaces. Now put the saw in the brazing clamp, Fig. 47, being sure that the edge, opposite the teeth, makes a good contact with the straight edge on the clamp and that the laps and teeth match up. A slight allowance can be made for expansion of the saw upon being heated. When the blade is in proper position with laps over the center of the opening in the clamp, fasten it there with the clamp screws, not too tightly, however, for the saw expands on heating and if not allowed to move under screws a trifle, it is liable to buckle near the joint. It could be straightened, but it is not necessary to have it buckle if the tension on it is proper.

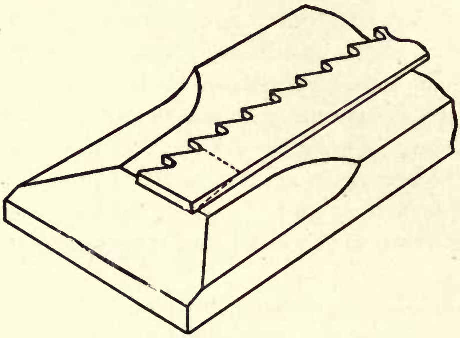


Fig. 46

There are at least three ways in which the blades can be heated and a good braze made for practice. The author has his students use all three methods, as the most desirable appliances are not always at hand. For the narrower saws, tongs will do, but for wider saws a heavier clamp and one including heating irons is necessary. The principle, however, is the same. The treatment for the narrower blades and tongs is as follows: After the saw is in place in the clamp, a flux is applied to the scarfs. Lump borax works very nicely and is prepared by pulverizing, only as needed, and then mixing to a paste with water. Also there are compounds prepared expressly for this purpose. A piece of silver solder, the

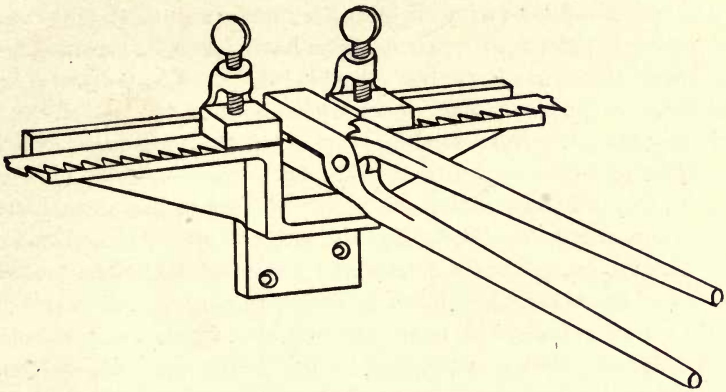


Fig. 47

size of the laps, is cut and cleaned, as was the scarf, and placed between the laps. Two pairs of tongs should be heated, one to a bright red heat—almost a yellow, but not a white heat, and the other to a dull red heat. Take the hottest tongs from the fire and scrape the inside surfaces clean with an old file, edge of a square iron or something similar, and then apply the tongs quickly to the joint, clamping it tight. The tongs should be a bright red color when applied or the solder will not melt and run out properly. When the solder can be seen to melt and run, the tongs should be carefully removed and dull red ones very quickly applied in their place. This change must be made quickly or the joint will open. The second pair of tongs should be left on until they are black. If only one pair of tongs is available, it can be heated to a bright red, and left on the joint until black. Sometimes the handles get pretty hot by that time and the temper of the saw is then liable to be injured, so a second pair is more advisable.

When the saw is cold enough to handle, file the solder out of the joints, clamp the saw on the block of wood used for making scarfs and dress each side of the joint with a file until it is the same thickness as the remainder of saw.

A second method is that of heating the joint with a blow torch to a bright red heat or until the solder melts and runs, and then clamping it tight with a pair of tongs heated to a dull red. This method is often used where no forge is handy. The tongs can be heated a trifle hotter than necessary with the blow torch before heating the joint and when the joint is hot they will have cooled sufficiently to be of the right temperature.

In the third case, a bunsen burner is used to heat the blade. This is, of course, a slower process, but will answer the purpose if other equipment is not available. The tongs should be heated first, as when the blow torch is used. It may be necessary to use two burners in order to get the tongs hot enough. Be sure to allow for the cooling of the tongs while the joint is being heated.

When brazing with the bunsen burner or blow torch, it may be found advantageous to wrap fine wire tightly around the laps after the solder is in place. Twist the ends of the wire at the side where they will not prevent the tongs from pinching the joint tightly.

Where it is necessary to braze saws wider than 1″, it is advisable to use a larger clamp fitted with two irons which can be heated and clamped in position on each side of the joint. These should be left there until cold. It is difficult to get even pressure over such a large joint with tongs.

CHAPTER VIII

Belting

58. Belt Comparisons.—There are three kinds of belts in common use; namely, leather, rubber and canvas or gandy belts. Each has it advantages and disadvantages, and in choosing a belt, one should have in mind where it is to be used and how.

Leather belts are the strongest, wear the longest, stretch the least, can be cut into narrower belts and are not injured by animal oils. However, the first cost is the greatest, and they are injured by water, steam, mineral oils and extreme cold or heat. They are not always uniform in thickness, and for that reason, stress may not be exactly uniform thruout a leather belt.

Rubber belts are uniform in thickness, width and strength and make good pulley contact. Extreme temperatures will not harm them. They are not as expensive as leather, as far as first cost is considered, and are waterproof. But they cannot be cut into smaller belts to advantage, will not wear like leather and stretch easier.

Canvas belts have the lowest first cost, are strong, flexible and make good contact. They are uniform in width and thickness and consequently strength. They are not injured by oils, greases, steam or water and can be run with either side to the pulley. They cannot, however, be cut up into smaller belts, and, if broken or cut, easily fray. They stretch easily and shrink or expand with changes of the weather.

If conditions are right for leather belting, and the belt to be chosen will be subject to hard and continuous wear, the purchase of a good leather belt will undoubtedly pay in the long run.

59. Choosing a Belt.—The best grades of leather belting are taken from that part of the hide which runs parallel to and near the back-bone, and from the tail to a point just back of the shoulders. It is hard to judge a belt by merely looking at it, but in general it is wise to choose the one made of the shortest laps or pieces. If long pieces can be seen in the make-up of the belt, it can be assumed that part of the neck of the hide was used, or else parts farther removed from the back-bone. These parts are easily stretched. Some manufacturers will combine the poorer grades with the best grade, putting the latter on the outside. This makes, perhaps, even a poorer belt than if it were made entirely of the inferior grade of leather, for the parts do not stretch alike, and consequently there is an uneven stress thruout the length of the belt. The leather that is strong, close of texture and less easily stretched is that part close to the spine, and such strips will be not over 4 ft. long. Narrow, thick belts are generally more satisfactory than wide, thin ones, especially at high speeds. The latter, if run fast, run in rolls or waves with considerable flapping on the slack side. This tends to wear the belt rapidly. A light, double belt is considered better than the same thickness in a single belt. It is not good policy to use double belting for twisted belts running fast, nor in places where water or oil come in contact with it. It is advisable to use double belting on pulleys larger than twelve inches in diameter.

60. Care of Belts.—Leather. The life and service of a belt depends upon the care it receives. Rosin is often used to prevent the slipping of belts, but it is injurious to the leather. Neatsfoot oil (if not a substitute for the real thing) is good. Boiled linseed oil gives good clinging qualities. Castor oil does very well. If a belt becomes glazed and dry, rub with a cloth dipped in kerosene and apply a thin coat of the following mixture to the driving side: Two parts beef tallow, one part cod liver oil (by weight). Melt the tallow, and when cool enough to insert the finger, stir into it the cod liver oil. Continue stirring until cold. Do not allow lubricating oils to come in contact with leather belts, if it can be avoided. If belts do become soaked with oil, pack in sawdust, wash in naphtha soap and apply the above dressing.

Rubber. Keep oils and greases off. An occasional application of the following will add to their life: Equal parts of red lead, black lead, French yellow, and litharge, mixed with boiled linseed oil and enough japan drier to make it dry quickly. Paint it on and give it time to dry thoroly.

Stretching. A new belt should be stretched before using. This can be done by fastening the ends to the floor with blocks, and raising the center on blocks and leaving it thus for some time.

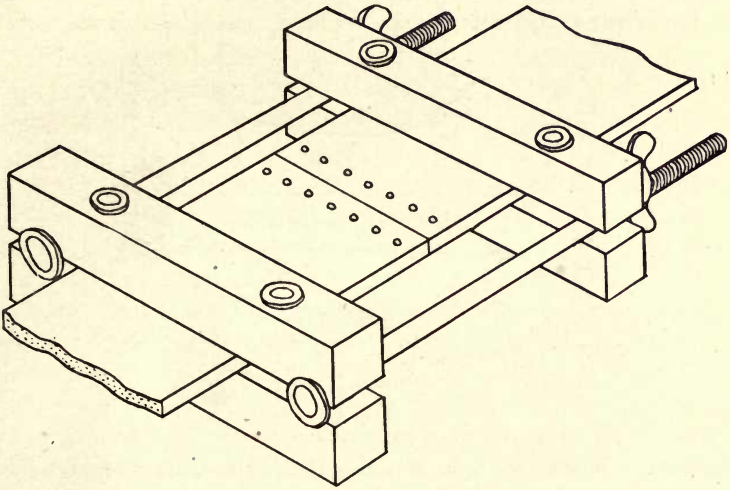


Fig. 48

This should be done before measuring for length or joining ends. If not stretched, then a belt should be from one to two inches shorter than the actual measurements around the pulley, to allow for the stretching which will result when first put to use. Never "run on" a wide belt if it can be avoided. Use a stretcher in joining ends, Fig. 48, and lace or splice them on the pulleys. In the stretcher shown in Fig. 48 two bolts, with nuts or winged nuts, fasten the pieces in each clamp tight against the belt. With a wide belt and a hard pull, it is sometimes necessary to drive two nails thru each clamp and the end of belt to keep it from slipping. This stretcher can be easily made of good hard wood and threaded rods or bolts of the proper size. For belts of medium size use about ½″ bolts and 1½″ maple strips for clamps. Put washers under heads and nuts of all bolts.

61. **Applying Belts to Pulleys.**—There is a difference of opinion as to which side of a leather belt should be next to the pulleys. The totally uniformed person would put the rough or flesh side next to the pulleys, and the hard, smooth or grain side out. It is the more natural way because the hard, smooth side is the better

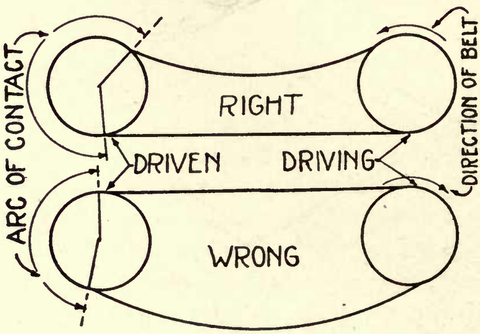


Fig. 49

looking. Whichever side is used, that same side should be in contact with all the pulleys over which the belt runs. If the flesh side is next to the pulleys it should have a coat of currier's dubbing and several coats of boiled linseed oil every year. The grain or hair side should have castor oil or neatsfoot oil from time to time to keep it pliable.

The claim is made that a belt is weakened when the grain side is next to the pulleys because the natural growth of the hide is being worked against. Others argue that the flesh side stretches easier and should be on the outside where the greatest length of belt is. The more common and probably the best practice is the former method, i. e., to have the grain or smooth side against the pulleys. It is certain that there is a better contact between belt and pulleys this way and more horse-power is obtained.

Rubber belting should be applied with the seam side away from the pulley. Where a belt is spliced with glue, there is also a difference of opinion as to application. It is generally assumed, however, that the end of the outside lap should point in the opposite direction from the belt motion, to prevent the air resistance from opening the splices. This rule applies to both leather and rubber belting.

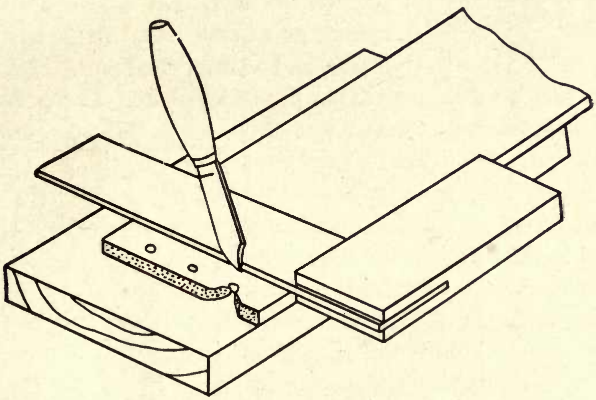


Fig. 50

Where belts run in a position more nearly horizontal than vertical, there is a sag between the pulleys. The sag in the lower half of the belt tends to decrease the amount of belt that actually would touch the pulleys were the belt in a straight line between them. The amount of pulley in contact with the belt is called the *arc of contact.* The sagging at the tops tends to increase the arc of contact and, as the horse-power is increased by adding to the contact distance between pulleys and belt, the direction of the belt should be such that the sagging at the bottom will be decreased or that at the top increased, or both. Thus a rule for this could be stated as follows: The direction of the belt should be from the top of the driving pulley. See Fig. 49 for the right and wrong methods of drive.

62. Joining Belts.—In lacing belts observe the following rules: For belts from 1″ to 3″ wide make holes from ⅜″ to ½″ from sides, and for those from 3″ to 10″ wide make holes from ½″ to ¾″ from sides (not ends). Always have the ends of the belt square with the sides, Fig. 50. Use an oval punch, making the long way of the hole parallel to the long way of the belt. Do not make holes in rubber or canvas belt with a punch but use an awl or sharpened nail. Make holes only as large as necessary to get the lacing thru. The punch cuts the strands of the material but the awl wedges an opening between them. The lacings on the grain or pulley side of the belt should run parallel to the length of the belt. The grain side, the side commonly applied to the pulley, is the smooth, hard looking surface. It is the outside or hair side of the hide. Make crossings of lace come on the outside of the belt. After lacing with rawhide or wire, flatten the lacings with a wooden or rubber faced mallet. Do not pull the lacings tight on one end of the joint until the other end has been brought together with laces. Use pliers in pulling lacing. Fasten the ends of laces by pulling them thru a small hole and cutting a slit on each edge of the lacing close to the belt. See *A*, Fig. 51. These slits or ears will spread out on either side of belt close to the hole and prevent the end of the lacing from coming thru.

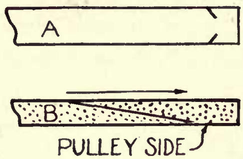


Fig. 51

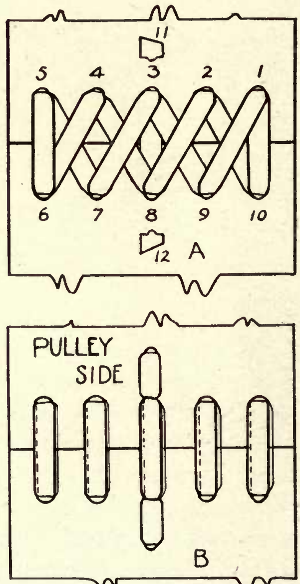


Fig. 52

63. Lacing 2″ to 4″ Belt with Rawhide.—Use method shown in

Figs. 52 or 53. If the method illustrated in Fig. 52 is used and the number of holes in each end is odd, start the lace by putting it up thru 3 and 8 referring to the holes numbered on *A*, Fig. 52, from the grain on the inside of the belt. The end that came thru

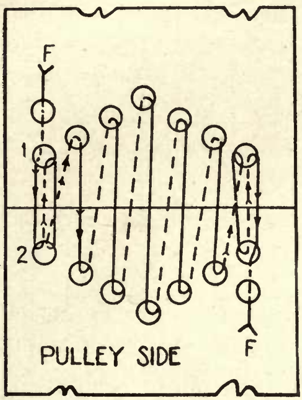


Fig. 53

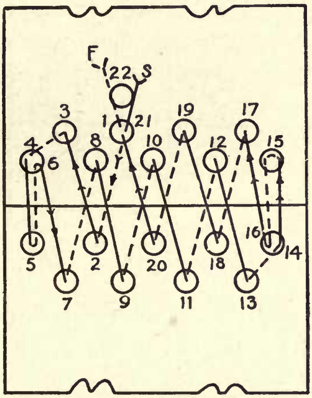


Fig. 54

3 is then crossed over and inserted back thru hole 8 and up thru 3 again, then down thru 9, up thru 2, down 10, up thru 1, down thru 10, up 1, down 9, up 2, and finally down 8. It is then fastened thru hole 12 by slitting. The other end, which came up thru 8, goes down 4, up 7, etc. and finally goes down 3 and is fastened in hole 11 similar to the other end. If method in Fig. 53 is used, start by putting the lace thru hole 1 from the outside and proceed as shown by arrows in the sketch. For simplicity the lace is shown by one line only. Finish by putting the ends thru holes *F* and slitting as shown in *A*. Fig. 51.

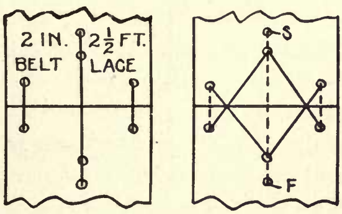


Fig. 55

For light work on large pulleys use single butt lacing method shown in *A* and *B*, Fig. 52.

64. Other Rawhide Laces.—Figs. 56, 57, and 58 show three other common methods of lacing belts with leather. In each illustration *S* indicates the point where the lace is started, and *F* the point where it is fastened. The illustrations suggest the

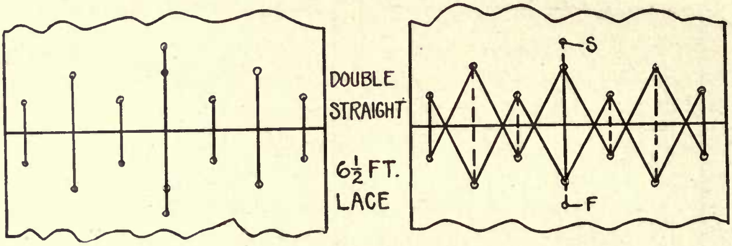


Fig. 56

steps in the process of lacing. One half of the lace is completed first; then the lacing is brought across to the other half and finally back to the center, where it is fastened as suggested in Section 63. Care must be taken to start the work in such a way that the strands fall parallel to the direction of the belt on the pulley side and that all angular strands come on the opposite side.

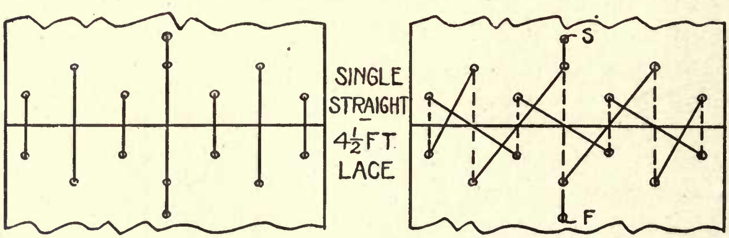


Fig. 57

65. Heavy Work on Large Pulleys.—Use butt lacing methods in Figs. 54 and 58. In Fig. 54 start the lace in hole 1. The arrows and numbers show the steps to take with the lace. Put the ends thru hole 22 and slit. In Fig. 55, start by putting the lace up thru holes 1 and 2 from pulley side. Put the end, that came thru 2, down 3 and across underneath belt and up thru 4. Repeat this operation clear across that half of the belt. Do the same on the opposite half with the other end. When the edge of the belt has been reached, work back the same way but putting the lace also thru holes in rows *A-B* and *C-D* as you do so. This will give a double lacing across ends of belt and a single lacing thru holes in rows *A-B* and *C-D*. Fasten the ends in usual method in *T* and *T*.

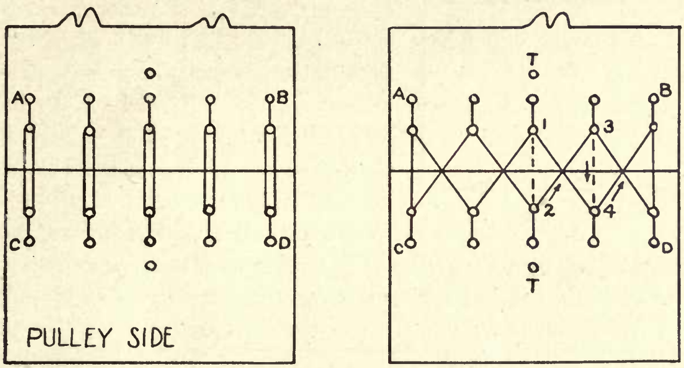


Fig. 58

Rubber and canvas belts, doing heavy duty on large pulleys, should be laced with method shown in Fig. 58. For lacing by this method see previous paragraph. For small pulleys use double hinge method in Fig. 59. In this method, the lace should be started by putting it down thru hole 1 from the top and by bringing it up between the ends of the belt at point *A*. Put it down thru 2, up between ends again and down 3. Now up between ends, down 4, up between ends and down 5. Continue across the belt similarly. Tie one end by putting it down thru hole *B* and up thru 1 and slitting it close to 1. Tie the other end likewise at hole *C*. Dotted lines, in drawing, show lacing on under or pulley side of the belt. Full lines show it on the top.

66. Lacing with Wire.—In using wire, follow directions on the box it comes in. There are five sizes of wire and the size of wire to use will depend upon the width and thickness of the belt.

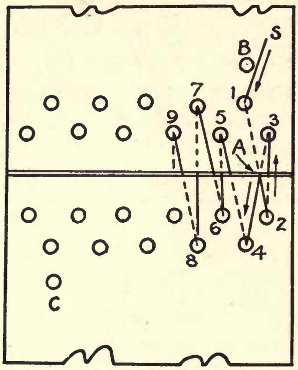


Fig. 59

Belts should not be laced with wire if they are to be shifted by hand as the ends of wire will almost surely tear the flesh of the operator. Where a belt, more than four inches wide, is to be laced with wire, it is a good plan to have the wire in two shorter lengths rather than one long one. The advantage is, that in case the wire breaks in one place, the belt will still be held in place by the good wire and the time required to repair the belt will be less. In leather belts, some prefer to cut a small groove from awl hole to edge of joint on the pulley side for the wire to lie in. This will lessen the wear somewhat. In any case the wire should be pounded

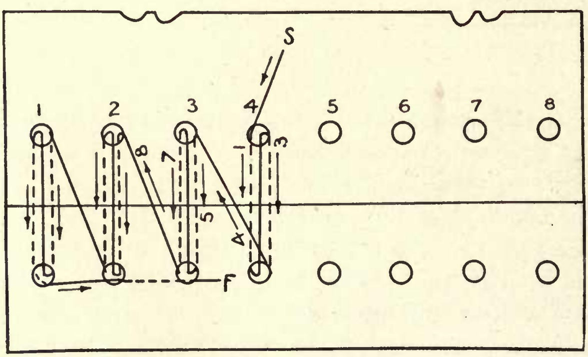


Fig. 60

flat with a mallet. This groove can be made with a knife or a veining tool but should be shallow. The holes for the wire can be made with an awl or finishing nail ground sharp, but should be no larger than absolutely necessary. They should be about 5/8″ from the ends of the belt and 5/8″ apart for a 4″ to 6″ belt. In lay-

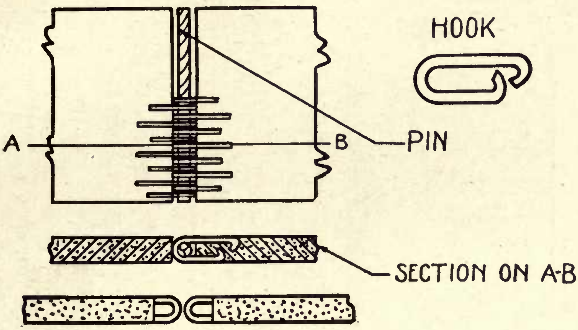


Fig. 61

ing out holes, be careful to get them *exactly opposite each other* on each end of the belt. Always have the ends of the belt square with the sides. Use a square. Do not guess. See Fig. 50. Nothing will get a belt out of shape more quickly than having joined ends out of square.

Use the method shown in Fig. 60. Start in hole 4 and take steps in order of numbers and in direction of arrows.

67. **Patent Fasteners.**—The patent fasteners shown in Fig. 61 are in common use now and are put into a belt with a small machine. One style of machine is called "The Clipper." This is a very good way of fastening a belt for small or large pulleys. It makes a hinge joint and the holes are *not* in line, thereby not causing the belt to break off as quickly as in some styles where the holes are in line. A stiff rawhide pin is inserted thru the loops of wire.

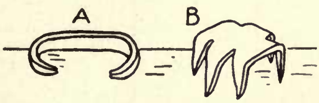


Fig. 62

Another kind of patent fastener is that in which a coil of wire is run thru the ends of the belt with a machine leaving loops thru which a rawhide pin is inserted; this fastener is similar to the style shown in Fig. 61 except that the holes are in line and, because of this, the belt often breaks off in a line thru the holes whereas, if they are zigzagged, this seldom happens.

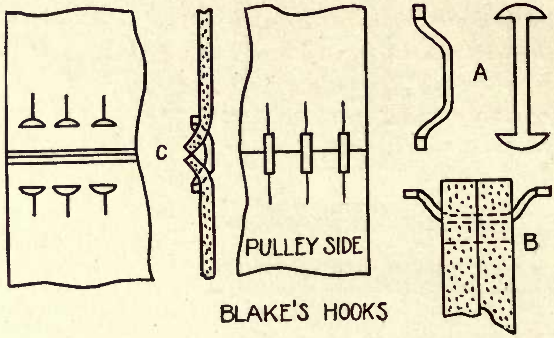


Fig. 63

Belt hooks of the style shown in *A*, Fig. 62 are only good for quick repair jobs. They are put thru punch holes from the outside of the belt so that the points run against the pulley. They are hammered flat with a mallet. They should be no farther apart

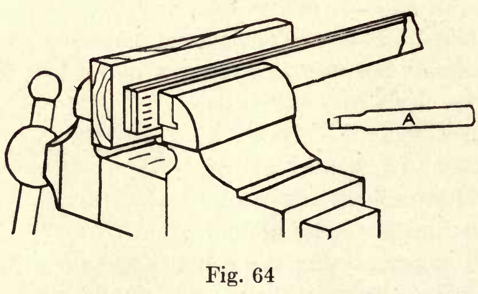


Fig. 64

than an inch. The style of hook, shown in *B*, Fig. 62, is also for hurry up jobs and can not be highly recommended.

The Alligator Steel Lacing, similar in principle to the style in

Fig. 61 is one of the best. In place of wire hooks a perforated steel plate with loops is clinched to the ends of the belt and a rawhide pin is inserted.

Blake's Belt Hooks, *A*, Fig. 63, are becoming quite generally used. The ends of the belt are squared and clamped together against a block of wood in a vise, Fig. 64. A slit is made with a carpenter's chisel of the proper width and ground to a long bevel, or, better yet, with a piece of ½″ or ¾″ band-saw like *A*, Fig. 64. This should be ground sharp and tempered. Both ends of belt

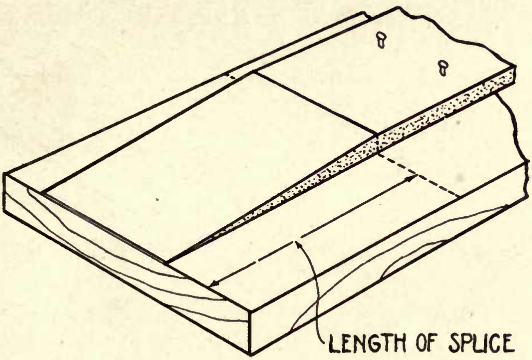


Fig. 65

are cut at once as shown in Fig. 64. The hooks are then inserted as shown in *B*, Fig. 63. The belt, when completed, will look like *C*, Fig. 63.

68. Cemented Splices.—A cemented splice is the most satisfactory way of joining leather belts. The ends should be squared carefully and tacked to a board with two small nails, Fig. 65. On the board, at the proper distance back from the end, place a mark showing where the splice is to end. With a sharp plane, pare each end of belt, being careful to have laps on opposite sides of the belt. On belts from 1″ to 9″ wide laps from 5″ to 10″ long. On wider belts make laps as long as the belt is wide.

After scarfing the ends, place the belt on a straight line drawn lengthwise of a board, as in Fig. 63, or against a thin strip of wood tacked on the board as a straight edge, or have the belt line up with the edge of the board at the edge. Fit laps carefully and apply some good belt cement between the laps. Knead the joint well with a piece of a broom stick used like a rolling pin. Over the joint, lay a piece of board and clamp the two boards together tight. Leave them thus for 24 hours to allow the glue to thoroly set. A good glue can be made by heating a half ounce of white lead with a half pound of good white glue in a double boiler or

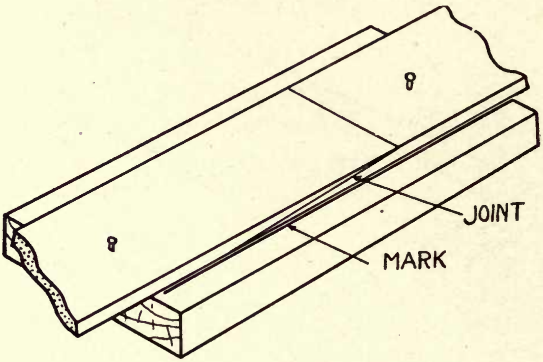


Fig. 66

glue-pot. Stir this mixture constantly until a thick paste is obtained. When it is to be used it should be made into a thin paste with grain alcohol and, if possible, warmed when applied.

Rubber belts are spliced by making laps as in leather belts only that rubber cement is used. Apply several coats, allowing each to dry for several minutes before putting on the next coat. The joints should be clamped tight, and when dry should be further re-inforced by a few copper rivets. The laps should be the same thickness as the rest of the belt whether in leather or rubber belts. Pound and roll the splice to get all air pockets out. Warming the belt and boards will improve conditions, particularly if it is necessary to make the splice in a cold place.

69. Don'ts.—Do not forget to square ends of belt.

Do not punch larger holes or use larger laces than necessary.

Do not use rosin.

Do not become too lazy to gather interest from your investment in a belt by keeping it pliable and free from dirt and mineral oils.

Do not use a style of lacing like that in *A*, Fig. 60 if a binder pulley is to be used. This is a fine way of lacing a belt because none of the belt is cut away by belt holes but the method of joining leaves a ridge on the outside of the belt which does not allow the belt to work well with a binder pulley. In this case, the hinge lace method in Fig. 59 or the Alligator Steel Lacing would be more suitable.

70. To Find the Horse-Power Which a Belt Will Transmit.—*Multiply the width of belt by diameter of driven pulley in inches and multiply this product by R. P. M. of driven pulley. Then divide this final product by constant 2,750, and the quotient will be the horse-power.*

Example: What horse-power will a 12″ belt transmit on a 36″ pulley running 200 R. P. M.?

Answer: 12 x 36 = 432, and 432 x 200 = 86,400, 86,400 divided by 2,750 = 31.4 H. P. transmitted.

71. To Find Width of Belt Required for a Given Horse-Power.—*Multiply the horse-power by the constant 2,750, then multiply the diameter of driven pulley by the number of its revolutions, and divide the first product by the latter, and the quotient will be the width of belt required.*

Example: What width of belt will be necessary to transmit 20 horse-power over a 30″ pulley running 200 R. P. M.?

Answer: 20 x 2,750 = 55,000 and 30 x 200 = 6,000, 55,000 divide by 6,000 = 9⅙″ width of belt required.

72. With Horse-Power and Width of Belt Given, Find the Diameter of Driven Pulley Required.—*Multiply the horse-power by constant 2,750, then multiply revolutions of pulley by width of belt and divide the first product by the latter. The quotient will be the diameter needed.*

Example: What should be the diameter of driven pulley at 200 R. P. M. to transmit 10 horse-power with a 5" belt?

Answer: 10 x 2,750 = 27,500 and 200 x 5 = 1,000. 27,500 divided by 1,000 = 27½" dia. of pulley.

73. To Find the Length of Belt Wanted.—*Add the diameters of both pulleys together, divide by 2 and multiply the quotient by 3.14. Add this product to twice the distance between the centers of shafts in inches and the sum will be the length of belt required.*

Example: The diameter of a large pulley is 36" and the diameter of a small pulley is 14". Their centers are 12 ft. apart. What length of belt is needed?

Answer: 36 plus 14 = 50, 50 divided by 2 = 25, 25 x 3.14 = 78.50, 2 x 12 ft. = 288 inches. 288 inches plus 78.50 inches = 366.5 inches or 30 ft. 6½ inches.

74. To Find the Horse-Power of a Driving Pulley.—*Multiply the circumference of the pulley by revolutions and multiply this product by width of belt. Divide the final product by 600. Circumference = dia. in inches x 3.1416.*

Example: What is the horse-power of an 18" pulley making 160 R. P. M. with a 6" belt.

Answer: Circumference = 18 x 3.1416 = 56.55 and 56.5 × 160 = 9,048, 9,048 x 6 = 54,288 and 54,288 divided by 600 = 9.04, the horse-power wanted.

CHAPTER IX

Babbitting

75. Babbitt Metal.—The term "babbitt" comes from the name of the inventor, Isaac Babbitt, who developed the recessed box with the soft metal lining for machinery bearings. Babbitting means the pouring of babbitt metal into a box, thereby making a bearing for the shaft that runs in the box.

The formula for the original babbitt has been lost, but it probably consisted of 90 parts tin, 3.7 parts copper and 6.3 parts of antimony. The high cost of tin, however, makes it expensive and many alloys of varying compositions have been put on the market as a substitute, and many of them named "babbitt". Other compositions having in them lead or zinc have become common. White metal alloys have several advantages over others. They are easily melted in an iron ladle over bunsen burners or blow torches, or in a forge. Bearings from them may be made with practically no special tools and the time required to run a bearing is not long. They have good anti-frictional qualities and wear well. When badly worn, they are easily chipped out and replaced.

The composition of the metal should depend upon the purpose for which it is to be used. For high pressure bearings at high or fast speed, an alloy called Babbitt Metal Best, and having the composition stated in the paragraph above, is very good. For medium pressure and medium speed, a metal containing 14.38 parts tin, 17.73 parts of antimony and 67.89 parts of lead will be very serviceable and is cheaper than the former. An alloy, having this proportion, is on the market and is called Graphite Bearing Metal. It has no graphite in it, however.

For shaftings, which ordinarily run at comparatively slow speeds, Anti-friction Metal is good and has a composition of 88.32 parts lead and 11.68 parts antimony.

The above proportions are the findings of an analysis of bearing metals (about 50 in number) made by The Pennsylvania Railroad Co. at their laboratory at Altoona, Pa.

76. **Preparing to Pour Babbitt Metal.**—If the job be that of replacing a worn bearing, the first operation, after the shaft is out, is to remove the old babbitt. This can be done with a cold chisel by chipping. It is very important that all water and oil be removed from the recesses. If the water is not removed, it will suddenly turn into steam when the hot metal is poured upon the box, and, increasing in volume over a thousand fold, will "blow" and in all probability cover the operator with molten metal, doing injury to the flesh and eyes. A little oil will not blow but it will blister the surface of the metal and it should, therefore, be removed. Dirt, left in the recess, will also cause trouble for, if loose, it will be floated by the heavy metal and will make a pit in the bearing surface.

Oil and water can be removed with a blow-torch, if one is at hand. Another way to remove it is to pour gasoline into the box and burn it. Care should be taken to keep gasoline away from any flame. Sometimes it may be convenient to put the box in a forge to dry it. In field work, when nothing else is handy, a fire of wood under or on top of the box will dry it out.

77. **Alignment of the Shaft.**—When it is time to align the shaft or locate it properly in the box, it is better to use a mandrel of the same size or a trifle larger, for, whether the shaft or a mandrel is used, conditions are made more ideal by heating the box or the shaft or the mandrel and, if the shaft is heated or hot metal is poured on it, it is liable to be warped, sprung and thrown out of alignment. This will cause the bearing to wear out quickly or burn out. If heated with a blow-torch, heat will not be evenly distributed all around the shaft in all probability, and if the hot metal is poured down thru an oil hole, it will strike in one place on the shaft and cause it to expand there more than elsewhere. The metal, cooling quickly about the shaft and shrinking tight against it, will hold it tightly in this form (expanded on one side) until

cool. Careful testing will show that the shaft is convexed laterally at the point where the molten metal struck it. The amount may be small but the uneveness may be felt if the shaft is turned by hand, and, if turned by power at fast speeds unsatisfactory results will, in most cases, follow. For the above reasons, if several bearings are to be made, it is better to use a mandrel. A mandrel can be easily made on the lathe and kept for this purpose. In an emergency, a piece of pipe of the right size and wrapped with paper may be used.

The matter of aligning cannot be treated of, except in a general way, for seldom are conditions twice alike. However, there are a few considerations which should have careful attention when making a new bearing: For instance, consider a shaft on which a circular saw runs. It is important that the shaft or arbor be parallel to the saw table when the latter is at *O* degrees or in a horizontal position. If the saw table is level then the arbor also should be level, and a spirit level can be used in setting the mandrel in place for babbitting. It is also important that the saw rotate in a plane parallel to the fence or stock guide on top of the table. Again, if the bearing being made is for a grindstone shaft, and the frame of the grindstone is fastened to the floor and cannot be easily moved, it is necessary to have the shaft at right angles to the belt which drives it; otherwise the belt will not stay on the pulley. In this case the easiest way to align the shaft is to make the distance from each end of the shaft to the line shaft the same. If one were pouring the middle bearing of an overhead line shaft having three bearings, he would wish the shaft to be straight; if not supported in the center, the weight of the shaft would cause it to sag there. In this case the best way to align the shaft would be with straight edge and level as explained in the section on shafting (Page 18). The shaft can be kept from sagging in the center by blocking it or tying it up. In a similar way, the horizontal alignment can be made, i. e., by stretching a wire horizontally opposite the center of the shaft at precisely the same distance from the shaft at each end, and tying the centre of the shaft so that it measures the same distance to the wire as do the ends of the shaft.

The matter of aligning, then, is one to be considered differently for nearly every condition under which a bearing is poured and calls for good judgment and mechanical sense. Aligning a shaft for a grindstone is a comparatively simple job but getting a crank shaft for a gas engine aligned properly calls for considerable skill. The matter of holding a shaft or mandrel in its place, after it has been aligned, is a varying problem also, but, in most cases, wood blocking will suffice for this purpose. In any case, shafting should be substantially fixed so that it will not move after much time has been spent in aligning it properly.

78. Preparing the Shaft.—The next step is to prepare the shaft or mandrel so that it will leave a smooth surface on the bearing metal. Some mechanics chalk the mandrel. This will do, provided the mandrel is smooth and the box is of such a type as to allow the mandrel to be heated before the metal is poured. If the metal is poured around the shaft itself and there is objection to heating the shaft, as there well might be, then a piece of good quality writing paper wrapped about the shaft will protect the latter and leave a smooth surface on the bearing metal, and, in case the mandrel could not be heated, this paper acts as an insulator and prevents the metal from cooling too quickly, leaving blisters and folds on the bearing surface. It also prevents the contracting metal from gripping the shaft quite so tightly and makes subsequent removal of shaft and scraping of the bearing less difficult. The paper should be lapped only about $\frac{1}{8}''$ and glued with thin glue or shellac.

After gluing the paper, plans for an oil groove can easily be made by rubbing clay on a small cord or wrapping string and putting the latter around the shaft. One turn around the shaft directly under the oil hole in the box should first be made and a knot tied. Then each end of the string should be wound spirally around the shaft towards an end and in such a direction that the turning of the shaft will cause the oil to work out along the groove that is to be left by the cord. That is, wind each end in the direction the shaft turns, Fig. 67. Make only one to three turns about the shaft with each end and go no nearer the end of the bearing than about ¾″ and fasten the string there by wrapping it square around the shaft once and tying it. This method can perhaps be more easily used on a split box than a solid one but, on the latter, it can be used by gluing the paper around the shaft just at one side of the box, tying the string around it there and finally slipping the

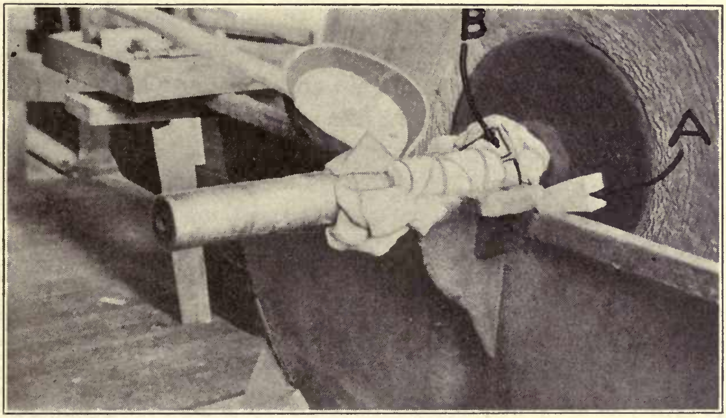


Fig. 67

paper and string gently into place in the box, taking care that the center knot on the string lines up with the oil hole in the box.

79. **Damming up the Box.**—The next step is that of damming up the box so that the hot metal will not run out. A good material for this purpose is clay. It should be no wetter than necessary to mold properly, else steam will be formed and a "blow" result. A "blow" means the scattering of the hot metal by the formation of steam. If a number of bearings are to be poured and the material is to be used for damming again and again, putty mixed with asbestos will not dry out like clay, and requires mixing but once each time bearings are to be poured. Putty, if not mixed with

the asbestos, will get very soft when warmed and will not hold the molten metal in the box.

80. Melting the Metal.—While this process of damming is going on, the babbitt metal can be melting. The melting place should be as close to the pouring place as possible so as to avoid the cooling of the metal between the fire and the box. If it is necessary to carry the metal some distance, it will require heating to a little higher temperature in order to allow for the cooling that will take place when it is carried to the place of pouring. Enough should be melted to allow plenty for filling the box and some for a possible leakage. Much time will be wasted if it becomes necessary to chip the bearing out again and pour over because there was not enough metal to fill the box.

It is a common fault to overheat babbitt. This makes it brittle and may cause a loss of some of the properties thru volatilization. It should not become so hot as to show a reddish purple tinge on top of the molten metal. It should have a yellowish color. A practical test that can be relied upon is that of inserting a piece of white pine into the metal. After immersion for about three seconds, it should be darkly browned, but not charred.

81. Pouring the Metal.—In pouring, it is important that there be plenty of air vents, in order that no air bubbles form, and so as to allow the escape of steam. In case there is only one oil hole, and that one is being used to pour into, air vents can be made in the clay at each end of the box by packing the clay around a match or nail and building it up high so that molten metal will not run away and make it difficult to fill the box. Where possible, pieces of cardboard, carefully fitted around the shaft at the end of the box and held there by the clay, will add to the appearance of the ends of the bearing as well as prevent the clay from drying out so quickly and forming steam.

There are two types of boxes in common use, namely *open* and *closed* boxes. By the former is meant a box in two halves split thru the center lengthwise. The two halves are held together by set-screws or bolts. Between the halves are shims. Shims are thin pieces of brass or other metal, or pieces of oiled paper or cardboard. Their purpose is to make the bearing adjustable for wear. As the bearing becomes worn layers of the shimming material may be taken out, allowing the halves to fit closer together and thereby taking up any play that there may be between the bearing and the shaft.

The closed box is one that is not split and is not adjustable for wear except by a new pouring.

Open boxes can be poured in two ways, namely, pouring each half separately or pouring both at once. Fig. 67 shows the lower half being poured. Notice the blocking which holds the shafting in place. On each end of the box are pieces of cardboard, *B*, cut as shown in Fig. 68. Notice the slit that has been made from the edge of the cardboard to the hole for the shaft. By springing the cardboard, it can be easily forced around the shaft. Against the cardboard is packed clay to keep the metal from running out of the box. Around the shaft is placed a thickness of paper held in place by pasting the edges and assisted by a cord which has been rubbed with clay and is used to form an oil groove. Notice that it is wound spirally and in the direction of the turning of the shaft which in this case is clock-wise. The metal is poured into the lower half until it is full. Heating the box on the outside will assist in making a smooth surface by keeping the metal from cooling too quickly. This can be done with a blow torch. When the metal has set and is cool enough to work, that part of the metal which rises above the top of the box is cut away with a cold chisel. The cutting should be done lengthwise of the shaft and care taken not to cut or score the latter. In fact, if a little ridge of metal is left close to the shaft it will do no harm and can be scraped off later. Shims, of the proper size and shape to fit the flat surfaces of metal on each side of the box, are now cut and put in place and the upper half is fitted over the lower one. These shims should total about 1/8″ in thickness. The upper box is securely fastened and the ends are banked with clay, Fig. 69. One important point to remember

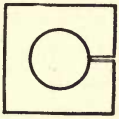


Fig. 68

is that there should be an air vent or two for steam and air. If there are two oil holes in the upper half, one of them can be used for pouring and the other for an air vent. If there is only one hole then a vent should be made in the clay at the end of the box. In Fig. 69, nails can be seen at the end of the box about which clay was packed. When the nails were removed vents were left. In this picture, clay can also be seen built up around the oil hole to facilitate pouring.

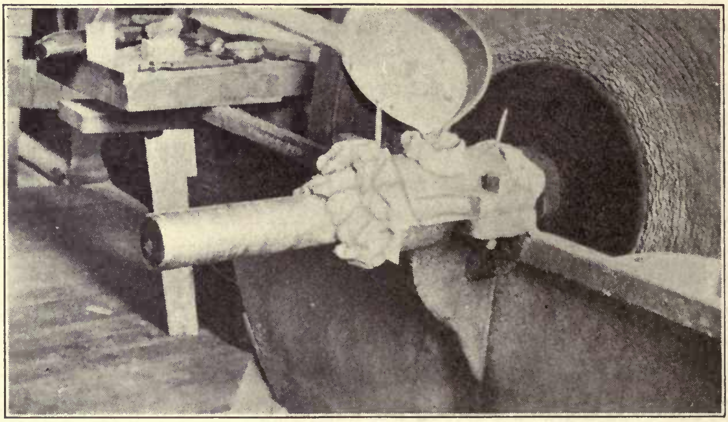


Fig. 69

In case there is no oil hole in the upper half of the box, the metal will have to be poured in the end of the box as shown in Fig. 70. A port is also made here by building up with clay. If the box was vertical rather than horizontal, it would be necessary to pour it at the end; only, in this case, the upper end of the box would not be clayed and would thus serve for both a pouring port and a vent. Any oil holes would be filled with clay.

In pouring both halves at once, shims are placed between the halves, as explained above, together with a piece of cardboard which is notched as shown in *E*, Fig. 71 and should rest against the shaft. The total thickness of the shims and the cardboard should be a trifle more than $\frac{1}{8}''$. The notches should be made twice the size and distance apart shown in the drawing for the metal must run thru them in order to fill the lower box, and if too small the box will not fill easily; whereas, if they are too large, trouble will be encountered in breaking them apart. This cardboard is to make separation of the halves easy. The halves are broken apart by striking several snappy blows with the cold chisel at the parting of the halves after the shims have been removed.

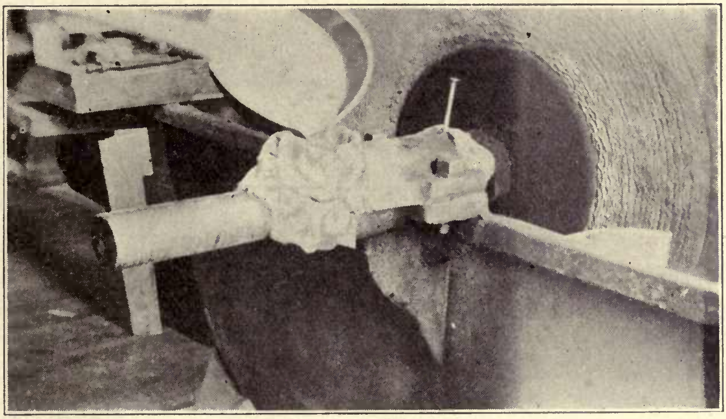


Fig. 70

82. Scraping the Babbitt.—To get a good bearing between the metal and the shaft, the metal must be scraped. There are many good bearing scrapers on the market. A very good one can be made out of a half-round wood file by grinding it smooth and then forming it to the shape shown in, *D*, Fig. 71. The edges should be ground and whetted sharp as shown in the cross section view, *C*, in the same figure.

The first operation, in fitting the bearing to the shaft, is to free the corners so they will appear like spaces, *A*, Fig. 72. This should be done on the lower half and will prevent a possible pinching of the shaft at the corners. The shaft should be free for a distance of $\frac{1}{4}''$ down from the parting on the lower half and an equal distance up on the upper half. After freeing the corners, a little Prussian blue, or lampblack mixed with oil, is rubbed on

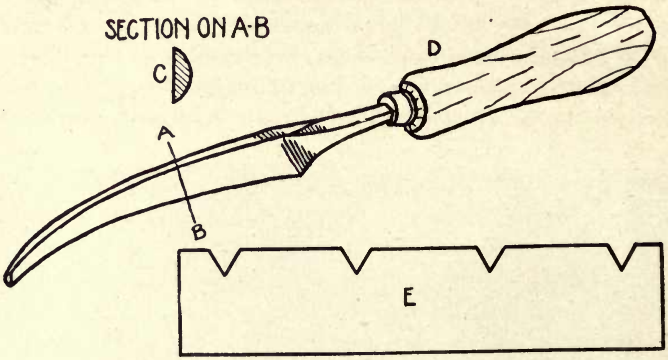


Fig. 71

the shaft and the latter is carefully lifted to its place in the bearing, given several turns and removed. The high places or the points in the bearing that touched the shaft will be colored and the other places will not be. By taking the scraper and removing a slight

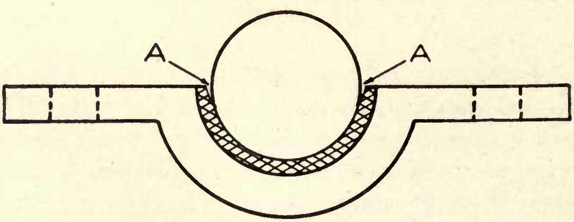


Fig. 72

bit of metal from these high places a more complete touching of the shaft and the bearing will be effected. This process must be repeated a number of times until approximately 75 per cent of the bearing touches the shaft. Care should be taken not to get too much color on the shaft for it will mark the low places as well as the high. Enough color will generally remain, after the first application, to color the shaft two or three times before it is necessary to put more on. When more than one bearing is being fitted for the same shaft, they should be scraped in together, i. e., one bearing should not be completed without fitting the other, for if this is done the scraping of the second bearing will lower the shaft and throw it out of alignment with the first no matter how carefully it may have been fitted.

When the lower half of each box has been completed, the upper halves are put in place with no shims and marked by turning the shaft. They are scraped to fit.

The shims should now be inserted between the halves. The thickness of the shims should be the same on each side of the box. A good shim stock can be obtained which is made of very thin sheets of brass lightly soldered together. These thin sheets can be peeled off with a knife making possible a fine adjustment of the bearings. The amount of shims between the boxes should be such that the shaft will be free to rotate when the boxes are fastened tight, yet there should be no noticeable play at right angles to the shaft; or, in other words, up-and-down play. In case of a heavy shaft, this can only be determined by prying the shaft up with a bar or stick. A fitting, that was just right when first fitted, will generally be found to be loose after a little running caused by the "fitting in" of the shaft, and some of the shim stock will have to be removed to do away with this play of the shaft. It is better to remove shims after a little running than to fit the shaft so tight at first that no shims will necessarily need to be removed later on. If the shaft is fitted too tight there is danger of burning out the bearing, due to the extra friction. A new bearing should be kept especially well oiled at first.

CHAPTER X

Adjustments of Woodworking Machines

83. The Circular Saw.—Knowledge of the care that should be given woodworking machinery and the proper adjustments will be gained more from experience than it will from explanations found in texts.

The circular saw should be kept well oiled on the arbor bearings. The sliding table and tracks should be kept free from sawdust and gummed oil. Clean them frequently with kerosene or gasoline, and rub a film of oil on the bearing surfaces with the fingers. There should be but a very slight bit of end play in the arbors. The bearings should be kept as tight as possible without pinching the shaft. The screw that tilts and raises or lowers the table should be well lubricated and kept free from dirt.

84. The Jointer.—Requires a fine adjustment of knives and table in order to do good work. Assuming that the table and knives are entirely out of adjustment, the first step in an attempt to put the jointer in good working order would be to locate one knife in its place in the cutter head. The cutting edge of the knife should project from the head about $1/16''$ to $3/32''$ and this distance should be the same thruout the length of the knife. Tighten the two outside or end nuts as much as possible with the fingers, and then tap the knife gently with a mallet or block of wood until the exact measurement is obtained.

The rear table, the one over which the work slides last, should now be so adjusted that it is exactly in line with the edge of the knife at its highest point of revolution. This is important, for if too high, the stock will hit on the table edge and be stopped, and if too low, it will drop to the rear table at the end of the cut, making an uneven edge. To get the rear table and the top of the knife in line, a try-square or straight piece of smooth, hard wood can be laid on edge on the rear table and allowed to project over the knife. The head can be slowly turned back and forth now, and the rear table raised or lowered until the knife just grazes the straight edge. It may now be found that the knife comes higher above the table at one end than it does at the other. This means that the table is not parallel to the knife. On all later machines, there is an adjustment which allows the level of the table to be changed by raising or lowering one side or the other. This should allow the table to line up with the knife. If the tables are not adjustable in the manner indicated above then the only alternative is that of lining the knife with the table. The author has seen tables that were warped. To ascertain if a table is warped, put a straight edge or winding stick on each end of the table and sight over them. Two framing squares would do very well to sight over. This warping should be taken out by means of the sliding shoe adjustment or similar adjustment under each corner of the table.

The next operation is that of getting the other knife to line up with both the table and the first knife. It is put in place precisely as was the first knife, care being taken to have it graze the straight edge, which is laid across the rear table, with the same friction as did the first knife.

The final adjustment is that of getting the front table, over which the work first slides, in line with the two knives and the rear table. It is adjusted as explained for the rear table. It can be raised to the same height as the rear table and, by sighting or by stretching a line, one can determine whether they are lined up lengthwise or not, and by means of framing squares or straight edges, one on each table, the side alignment of the two tables with one another can be determined. While lining the tables with one another, the cutter head should be so turned that neither knife is at the top of the revolution and in the way of sighting. Of course when work is to be done on the jointer, the front table is lowered an amount equal to the thickness of cut that is to be taken from the stock. This adjustment is made with a wheel at the end of the table or on the side, and does not alter the condition that should exist between the two tables, namely that they should be true planes parallel to each other. These table adjustments must be so perfect that when stock passes over the knives it should be neither raised nor lowered even a trifle as it passes on to the rear table. Wherever possible, a belt from a jointer should pull down on the cutter head pulley so that there will be the least up-and-down motion to the knives, often caused by loose bearings or belt slap.

85. The Surfacer.—The attachment for grinding surfacer or planer knives can not be adequately described here. Reference is made to one that fastens on the planer and grinds them without removing the knives from the machine. A finer and better adjustment can be obtained this way than by the old method of removing the knives for grinding, and necessitating skill and much pains in getting the knives properly in place again.

The old way, spoken of above, is one that must frequently be used, due to the fact that all equipments do not include the grinding attachments. For adjusting the knives after they have been ground and jointed, the following plan is followed: Two strips of accurately planed hard wood are placed between the bed, or table, and the rollers. These strips must be of exactly the same thickness and the thickness must be known by the operator. The table is then raised to such a position that, when the knives project from the cutter head about $\frac{1}{16}''$ or $\frac{3}{32}''$ they will just graze the strips of wood. At the same time the pointer, which indicates the thickness of stock being planed, should be adjusted so that it registers the thickness that the strips of wood measure. The nut at each end of the knives should then be turned tight enough to keep the blade from falling out, and the other nuts left rather loose. The blades should be left out of the cutter head a slight bit more than the $\frac{1}{16}''$ and gently tapped in with a mallet until they just graze the strips of wood evenly at each end. If the other nuts are tightened at first, too hard taps are required to make the knives move in the head, and when they do move they will, in all probability move so much as to throw the knives farther out of adjustment.

Great care should be taken, however, that all nuts and bolts are left tight before the machine is ever started, or serious injuries or damage may be caused. A thoro inspection should be made after it is thought that everything is in perfect shape.

The rollers on the planer or surfacer should be so set that they will keep the stock moving steadily thru the machine, yet they should be no tighter than necessary to get this result. They are adjusted by tension springs which may be located by observation. Methods of tension vary on different makes of machines. All bearings should be well oiled at all times.

86. The Mortiser.—The mortiser needs more care than adjustment. All moving parts should be kept clean and well oiled. One mistake, often made, is that of having the bits, in a hollow chisel mortiser, drawn up into the chisel so far that when the bit is revolved, unnecessary friction is caused between the bit and the very bottom of the chisel, and the latter is bulged at the bottom and the temper drawn. This is not necessary; it only requires a little care to keep the bit just free from the chisel when they are tightened in place. It must be remembered that the bit travels fast and that a little friction between the chisel and the bit will soon heat the chisel.

87. The Band-Saw.—A band-saw is a simple machine to keep in shape, yet one that is often neglected. On all machines there is an adjustment that permits of lining the wheels with one another. This will, in most cases, be found on the upper wheel. Observation of how the saw travels on the wheels when it is running free of the guides, will tell whether the wheels are properly aligned. The saw should center both wheels when unhindered in its revolution. The saw guide wheel should be so adjusted that it does not revolve when the saw is running idle and no work is being done by it. However, the guide wheel should be as close to the saw as is possible without being revolved by the latter. Under such conditions, one is assured that the saw is taking its own course over the wheels and will run true. Of course, when wood is pushed against the saw to be cut, the wheel should run. The jaws of the guide should be close together to prevent the saw from twisting too much, yet they should not pinch the saw. They should reach as far to the front of the saw as possible without interfering with the set of the teeth. That distance will be almost, but not quite, to the center of the teeth from the back edge of the saw.

The chief causes of broken band-saws are poor tension on the saws, dull saws which will not do their duty, and poorly brazed joints. The tension should be such that the saw is taut and free from vibration, and yet is not subjected to undue strain. Dull saws mean that the work has to be forced against them so hard in order to be cut that the saw is under a strain which will generally cause trouble. Thick laps or brazes will cause friction between the saw guides and between the saw and the kerf in the wood, and will often cause the blade to snap. The laps should be filed until they are of the same thickness as the rest of the saw. The saw should also be straight where it is brazed. There should be enough set in the saw to allow it to follow a curve.

88. The Lathe.—The lathe should be kept well oiled at all times. The live center should be sharp, so that heavy blows are not required to sink it into wood the proper distance for revolving the latter. Drill the wood for the center and make saw cuts thru the drill hole so as not to require so much hammering in order to sink the center into the wood, and thus save the bearing from abuse. The bearings should be kept tight at all times to insure a minimum of vibration both endwise and up and down.

As a suggestion worthy of trial a sketch is shown in Fig. 73 of a handy grinder that can be made in the school shop. It is intended for use on the lathe for grinding edge tools. It consists of a maple arbor on which is mounted an emery wheel of the size desired. The wheel should have at least a 1″ face for edged tools. A keyway is made in the lead lining to the arbor hole in the wheel and also in the arbor and a wooden key is driven in. A collar can also be made of wood and slipped on to the arbor, tight to the wheel, and be held in place by the key. One end of the arbor can be tapered to fit the opening for the live center in the head-stock, and the other end made to fit the dead center. The tool rest can be used as a guide on which to steady the tools. A good saw gummer can be made by mounting similarly on a longer arbor an emery wheel that has the proper shaped rim for gumming. Care must be taken in holding the saw to keep it from binding and breaking the emery wheel, possibly to the discomfiture of the operator.

89. Play in Bearings.—Bearings on the saw, jointer, surfacer, lathes, etc. should be free from much play or looseness. There

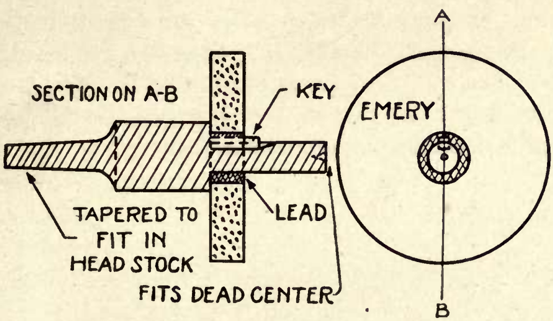


Fig. 73

should be end play for the jointer and surfacer heads so that they can work back and forth as they revolve and a little play is not objectionable in the spindle of the lathe, as friction is thereby reduced, but the saw should have the least end play possible, to avoid over-heating the bearings. The looseness in machines like the lathe, saw, and small machines can be determined by testing with the hands, but on larger machines like the 12″ jointer or the surfacer, it will probably be necessary to use a stick of wood as a lever because of the weight to be lifted. Otherwise, one might be misled into thinking the bearings were tight when the real difficulty was that the weight made it impossible to detect the looseness without a lever.

Between the halves of the bearing should be found shims of thin material. When it is decided that a bearing is loose, these thin pieces of shimming stock can be removed until the play is reduced. The amount taken from each side of the bearing should be equal. The bearing bolts should then be snugly tightened. If after this, it is found that the bearings are too tight, some of the shimming material should be replaced, for it is not a good plan to make the bearings free on the shaft by loosening the bearing bolts. They should be tight at all times and the amount of shimming material between the bearings should decide the play of the shaft.

Bearings on some makes of lathes are adjusted with special devices. Instructions for adjusting these are furnished with the machines. The end play in saws is adjusted in different ways, the common method being that of turning a collar on the shaft. This collar can be locked when properly adjusted.

APPENDIX

Organization of the Preceding Material for Teaching Purposes

The subject-matter presented in the preceding pages can be used as a basis for training vocational and manual arts teachers who may be responsible for the planning and installing of their school equipment and who surely are expected to keep it in good running order. Much of this material can also be used by teachers in instructing students in vocational classes about such work as saw fitting, machine adjustments, repair of belts, etc.

The most effective use of this subject-matter would be that of the laboratory-class method where much supplementary material, other than the text, might be used, combined with reading assignments and class discussion.

The plan of organization to be suggested in the remaining few pages is ample for a full 40 weeks' course of six to nine hours of work each week, and even then, some of the work covered would need to be dealt with rather superficially. In this last statement, reference is made to the use of the material for teacher-training purposes.

The order of topics, as given in the preceding pages, is not necessarily the best order in which to present the matter for instruction purposes. In fact, it is doubtful if the student should study installation and shop planning problems until he has become familiar with the machines and equipment thru maintenance work on them.

The following plan of organization is for teacher-training purposes and is suggestive only:—

1. *Fitting Edge Tools*—Application on the regular edge tools of the shop.
2. *Fitting Saws*—The first work may well be done upon strips of soft steel as indicated in the text so that students get actual lay-outs

of teeth by use of the bevel, protractor and scribe. Saws, badly out of form, are the most difficult to work upon, and should be given to the students last.

3. *Belting*—Short pieces of belting of the several kinds and widths should be provided so that the various methods of lacing can be practiced. These pieces may be used repeatedly, and when the holes become badly worn, the ends of the pieces may be cut and new holes punched. In case it is inconvenient to provide pieces of belting or in case it is wished to supplement them, methods of lacing may be practiced by means of the Standard Belt Lacing Card. Holes may be punched in the proper places in the cards and shoe strings or cord used for lacings. Samples of various patent lacings may be procured from manufacturers.
4. *Brazing Band-Saws*—Odd pieces of broken saws may be used until students become sufficiently proficient to make brazes on the regular shop saws.
5. *Adjustments*—To be performed on the regular shop equipment if needed. If not needed, the methods for making the adjustments should at least be demonstrated.
6. *Babbitting Bearings*—Old boxes and arbors or pieces of shafting, or in an emergency, pieces of pipe filed smooth, may be used. For the first lessons, these pieces may be supported by wooden V blocks on the benches or table. Later, bearings in actual use should be poured and fitted.
7. *Power Transmission in a School Shop*—The material in this chapter can be assigned for study and class discussion. For more detailed study and reports, the references given in the bibliography may be assigned. Examples or illustrations of various hangers, pulleys, etc. may be provided and actual problems in installation may well be undertaken.
8. *Motors and Currents*—For study and class discussion mainly. More detailed technical information may be obtained by use of the references given.
9. *Installation of Metalworking Machines*—For study and class discussion. Actual work in installation should be given students if possible.
10. *Installation of Woodworking Equipment*—For study, class discussion and practice; if possible, by actual installation of equipment.
11. *Shop Planning*—Altho no space is given to treatment of this subject as a separate unit in the preceding pages, yet all discussions on installation bear directly on planning the shop. An actual problem of shop planning may be assumed and the details worked

out and applied in the form of drawings on large sheets of cross-section or drawing paper. These drawings should be made to scale, ¼″ to the foot being a good scale for this purpose. Later, details of shafting, pulley and belt plans may be drawn, and, if time permits, lists of equipment giving numbers, sizes, types, costs, makes, etc. may be compiled. In attempting the shop-planning problem, as indicated here, much time will be necessary, and it should not be attempted until the student has familiarized himself with the material on installation and maintenance. If actual planning problems for solving can be obtained, and the installation of some of the equipment can follow the planning, then the very good contact between theory and practice should result in a group of individuals thoroly prepared to solve almost any school shop installation and planning problem.

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