# PATTERN-MAKING

## SAMPSON and McCRACKEN

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# PATTERN-MAKING

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# PREFACE

This book has been written to fill the need for a text the use of which will give to students such a knowledge of the principles of pattern-making as to enable them to make a pattern of any usual type.

Every effort has been made to illustrate a definite principle in each pattern. The patterns required are difficult enough to demand an interest and industry on the part of the student but not so difficult as to cause that interest to be sacrificed merely to illustrate a point necessary to acquire.

Chapters are included covering the use of tools, information concerning woods of various kinds and the principles of molding. These should be very carefully studied. They are given because of their value. The student should possess the information as presented if he expects to become a first-class pattern maker.

The course is especially recommended for use in all technical, trade and vocational schools where the desire is to present a practical course in pattern-making.

Criticism that will tend to improve future editions is desired. The wish of the authors is that the course will prove complete and adapted to the purpose for which it has been written.

Many thanks are due those concerns which have kindly furnished cuts, namely: Acme Steel Goods Co., Adjustable Clamp Co., Barnett Foundry and Machine Co., Batavia Clamp Co., Buck Brothers, The Chain Products Co., Champion Foundry and Machine Co., Diamond Clamp and Flask Co., Lufkin Rule Co., Millers Falls Co., Monarch Engineering and Mfg. Co., Oliver Machinery Co., The Osborn Manufacturing Co., Page Belting Co., J. W. Paxton Co., Smith & Caffrey Co., Stanley Rule and Level Co., L. S. Starrett Co., E. T. Woodison Co.

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# PATTERN-MAKING

## GENERAL INFORMATION

THE student of pattern-making should be familiar with the terms allied to the subject. This section is, therefore, devoted to the definitions of such words as the pattern-maker has occasion to use and to various necessary explanations and suggestions. All of the material given here should be carefully read and absorbed.

**A Pattern** is a form or model used in producing a sand mold in which a casting is to be poured. It is usually necessary to make certain joints or sections on a pattern to facilitate its removal from the mold. A pattern may be made of wood, metal or plaster of Paris. Wood is usually the most suitable.

**A Pattern-maker** is more than a woodworker. That is, he must be able to do other things than would be required of one who merely works in wood. He must be able to read mechanical drawings, and determine what views or sections of the scaled drawings require full-sized layouts; he must know how to allow for the shrinkage of metals and where to add finish (extra metal for machining); he must know how the pattern should be constructed so that it can be removed from the mold; he must be familiar with the construction and use of cores (parts of the mold forming the inside of the casting). He must also be a good wood-turner.

## TYPES OF PATTERNS

**Standard Patterns** are those which are built well enough to permit a long period of use. They should be well constructed and so built as to facilitate as much as possible the work in the foundry. When returned from the foundry they should be put into good condition and stored for future use.

**Cheap Patterns** are used when only one or two castings are desired. They are usually made as cheaply as possible and such things as fillets (rounding off corners on internal angles) are cut by the molder.

**Skeleton Patterns** are a cheap type of pattern. The term skeleton means that instead of making a regular built-up pattern with core prints and a core box, the pattern is built up of open rib work, the ribs being the thickness of the metal desired.

This type of pattern does away with the making of a core box because the molder forms the core as well as the mold for the outside of the casting.

Although this is a cheap type of pattern it can be used to greater advantage than the regular form of pattern in many instances. This is especially true on such objects as irregularly shaped pipes and elbows, because the thickness of the metal is apt to be more uniform than if a core box and dry sand core were employed.

This type of pattern is confined to medium and large-size work. There is also another form of skeleton pattern illustrated on Plate 23 (in back of book).

Patterns used in producing a large number of castings and patterns used on molding machines are constructed extra strongly, and all parts exposed to hard usage are surfaced with metal or hardwood. In most cases where the patterns are small they are made entirely of metal, iron, brass or aluminum.

It sometimes happens that when a casting on a machine becomes broken, the broken part can be used as a pattern to produce a new casting.

**Master Patterns** are patterns used to produce a metal pattern. Therefore, allowances have to be made for double shrinkage. To illustrate—Suppose 100 **iron** castings were wanted and a brass pattern were to be used to produce them. There would have to be two shrinkage allowances: $\frac{3}{16}''$ for the brass and $\frac{1}{8}''$ for the iron. That would mean a total of $\frac{5}{16}''$ on the original or master pattern.

## GENERAL METHODS

**Shrinkage.** Most metals used for castings shrink more or less (according to the metal used) in passing from the molten to the solid state. Therefore, to produce a casting whose dimensions will be correct it is necessary to make certain allowances on the pattern. This is usually done by employing a shrinkage rule, i.e., a pattern-maker's one-piece 2-foot rule. (Two feet long plus the shrinkage of metal.) Different rules are used for different metals for the obvious reason that all metals do not shrink the same amount.

The rule is divided into 24 equal parts called inches and each inch into halves, quarters, eighths and sixteenths. The amount of shrinkage allowed for the most common metals is given herewith:

| | |
|---|---|
| Iron | $\frac{1}{10}''$ to $\frac{1}{8}''$ per foot |
| Brass | $\frac{3}{16}''$ per foot |
| Steel | $\frac{3}{16}''$ per foot |
| Aluminum | $\frac{7}{32}''$ per foot |

**Finish** is the allowance made on a pattern to provide for extra metal on the casting which is to be removed later in the machine shop. Some castings do not require finish because they are used just as they come from the foundry. Other castings must be machined all over either because of appearance or because they are to be fitted to other machined surfaces. Most castings are finished only on certain parts and no set rule can be given as to the amount of finish to be allowed on them. This depends entirely upon the size and shape of the casting and the kind of metal used. The following table will give some idea as to the allowances generally made:

| | |
|---|---|
| Cast iron | $\frac{1}{8}''$ to $\frac{1}{4}''$ |
| Brass | $\frac{1}{16}''$ to $\frac{1}{8}''$ |
| Steel | $\frac{1}{4}''$ to $\frac{3}{8}''$ |

On very large castings the above amounts are doubled or made even more. This is especially true of steel castings because of their unusual roughness. In most cases, however, much of the extreme allowance is made necessary because of the distortion of the casting when cooling. The exact allowance to be made depends also on the method of machining or finishing.

**Draft** is the amount of taper given the sides of projections, pockets and the body of the pattern, so that when the pattern is withdrawn after being molded the sand will not be broken away.

Molds broken because of insufficient draft or for various other reasons must be repaired before any casting can be done. This is undesirable because it is apt to produce an irregular surface on the casting.

The amount of draw or draft may vary from $\frac{1}{16}''$ to $\frac{1}{4}''$ per foot—usually $\frac{1}{8}''$. This is usually determined by the pattern-maker himself, although it is sometimes designated.

**Shellacking Patterns.**—As a rule all patterns are given from one to three coats of shellac. This is done to keep the wood from absorbing moisture from the sand and to give the pattern a smoother surface, thus making the removal from the sand easier. The core prints are shellacked a different color from the pattern in order that the molder may know what parts of the casting are cored. The colors are entirely a matter of choice.

**Coring.**—Some castings have hollow chambers within them or holes through them which cannot be produced entirely by means of the sand forming the main part of the mold. These have to be " cored out."

A dry sand core is a baked sand part of the mold, made in a separate device called the core box. It often happens that the core box is more difficult to make than the pattern itself. Sometimes patterns are so constructed that they leave their own core when removed from the mold.

**A Core Print** is a projection on the pattern designed to make an impression in the sand of the mold for the purpose of locating and holding the core in place. There are no fixed rules as to how long prints should be made or how much taper they should have. The theory for horizontal cores is that there should be sufficient bearing surface to support the weight of the core. When large cores are to be supported, instead of using an extremely long bearing, other provisions are made such as imbedding an iron plate in the mold for the core to rest on.

For a vertical core, a print one inch high is generally sufficient. If the core is at all top-heavy a cope* print should be put on the pattern. If round the print should be a frustum of a cone; if square of a pyramid, etc., with the large end next the pattern.

The taper should be about $\frac{1}{4}''$ to $1''$ in height. Having a tapered core and cavity in the cope makes it easier to lower the cope over the core. The cope print should be attached so that it can be removed when ramming up the nowel or lower half of the mold.

If the vertical core is rather long and the horizontal surface insufficient to keep the core erect for the lowering of the cope it is wise to increase the length of the nowel print. If this is done it is advisable to give the nowel print special taper similar to the cope print. This enables the molder to locate the core without crushing the sand, especially when it is difficult for him to see what he is doing.

Fewer castings would be lost if more attention were given to this particular point, because if the sand is crushed when the core is lowered, the core cannot find its proper place. Hence, the casting is spoiled.

Firms making pulleys, sheaves and similar castings, where the dimensions of the holes through the hubs are subject to change, usually adopt a standard pin for all core prints so as to make them interchangeable.

**Heel Prints or Tail Prints.**—To core the holes at *A*, Figs. 1, 2, the print must be carried up to the joint of the mold, while to core the hole at *B*, a straight cylindrical core is used. Study Plate 9 in connection with this. Plain brackets similar to the above may have the holes *A* and *B* cored by means of a plug core print, the use of which is illustrated below.

A **Balance Core Print** is used when a casting will allow a bearing on one end only as shown in Fig. 3. Therefore a sufficient print has to be allowed on the pattern to balance the

* See page 22.

core. Plate 10 offers a good illustration of the application of this particular type of core.

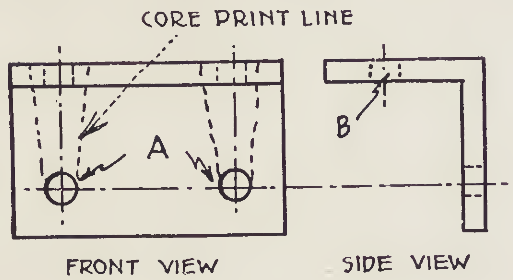



Fig. 1.

**A Plug Core Print.**—A study of Fig. 4 will illustrate the use of the plug core print. Boiler flanges (such as represented here) often have the holes for the rivets cored out. From the sketch it can be seen that the axes of holes *A* and *B* do not run

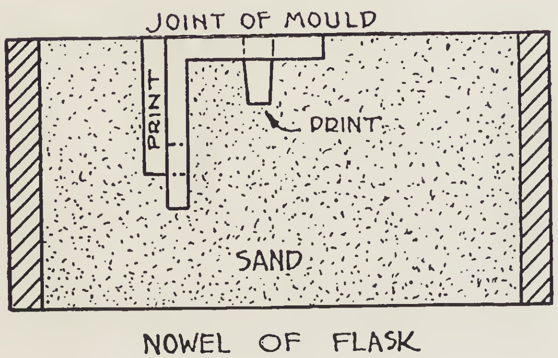



Fig. 2.

parallel to the axis of the flange *CD*. If the core prints were put on they would diverge one from the other and if they were fastened to the pattern it would be impossible to remove the pattern from the mold.

The usual method is to bore holes in the pattern in such a way that their center lines will pass through the same center as

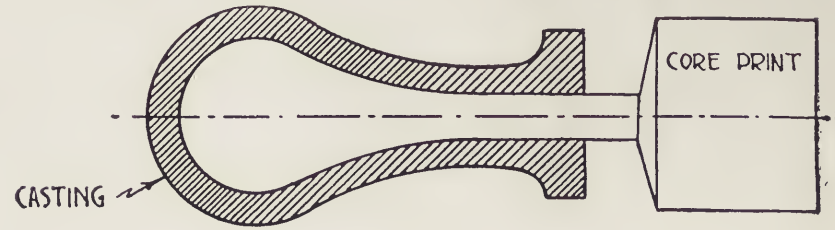



Fig. 3.

the radius used in drawing the arc *GF*. After the cope is removed a plug is inserted in the holes to make an impression in the sand for the purpose of locating the cores. The length of

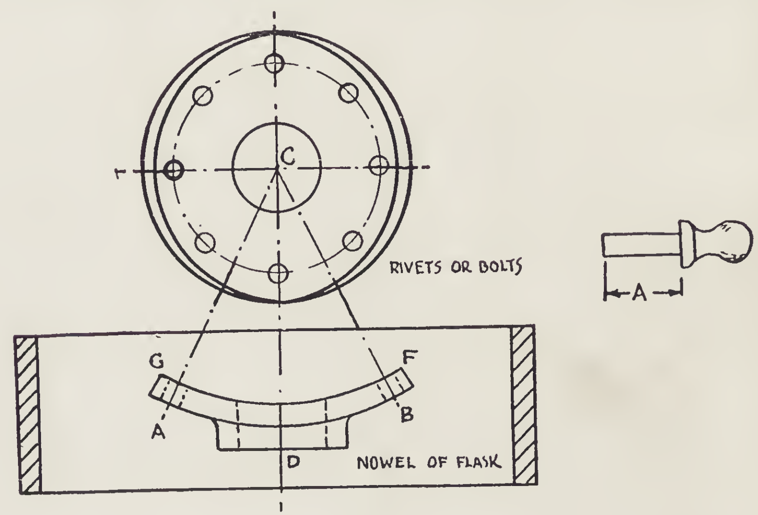



Fig. 4.

*A* on the plug is equal to the thickness of the metal plus the length of print necessary to support the core. Study Plate 12 in connection with this.

**A Cover Core** is simply a flat core used to cover over a cavity in the mold after a certain part of the pattern has been removed from the mold. If the accompanying Fig. 5 is studied it will be seen that unless some provision is made for $A$, the pattern cannot be removed from the mold. To mold this pattern, a joint is made at $B$, the pattern is then "rammed up" to the top of $A$ and then the cover core, which fits over the print $X$, is placed over $A$ and sand rammed around it. It is then lifted off and $A$ removed.

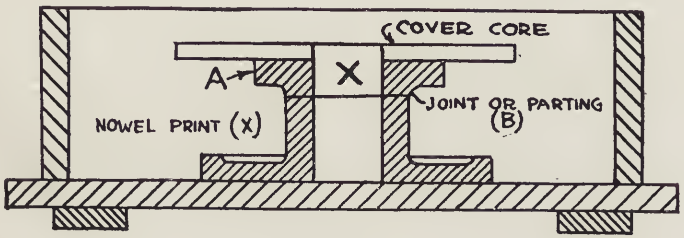



Fig. 5.

The cover core is then replaced, covering over the cavity made by $A$, thus preserving that part of the mold while the remainder of the mold is being completed. Plate 18 shows an application of the principle involved here.

**Loose Pieces.**—A great many patterns have projections on them which cannot be removed from the mold with the main body of the pattern. Such pieces are attached to the main body by means of loose pins from the outside so that the pins may be withdrawn after the parts are supported in place by the sand. After the main body of the pattern is removed from the mold, the loose pieces are drawn into the space left vacant and lifted out of the mold.

The surface covered by the loose pieces on the main pattern is usually painted a distinct color from the pattern and core prints, so that the molder will know that some part belongs there. Study Plate 2 to obtain an application of this principle.

**Parting Lines.**—For convenience in molding, patterns are usually parted along the joint line of the mold and are doweled together so that the parts may be retained in their proper positions during the process of molding.

To illustrate: If a cylinder pattern is made in halves, the molder can take the nowel half of the pattern, place it with the joint resting on the mold board and ram up the nowel. When this is turned over the joint will be formed for the cope half of the mold.

The parting line (the line along which the joint of the mold is made) is on some patterns very irregular. Therefore, if a great many castings are to be made, it is more economical to have a molding board made which will conform to the parting line of the pattern. This is called a *Follow Board*.

**Pattern Lumber.** To construct patterns properly it is necessary to be somewhat familiar with the structure and characteristics of wood. It is not intended in this article to discuss at great length the process of growth, the methods used in cutting logs into boards, seasoning etc. The intention is merely to submit enough facts to enable the student to select and arrange stock properly.

Fig. 6 is an illustration of a log. The concentric rings on the end indicate the years of growth. These rings or layers are formed each year by a ring of cells inside the bark through which the sap is carried to the branches and leaves of the tree. During the year these cells change to sap wood.

Running radially through the log are other cells called medullary rays which convey formative material from one part of the trunk to the other and also serve to bind the annual rings or layers together. It is to these rays that the beautiful effects obtained on quartered oak are due.

All logs may be said to be composed of two parts—sapwood and heartwood. The sapwood (the outer part of the tree) is lighter in color, contains more moisture and is less firm than heartwood. This is because of its more recent growth.

For ordinary purposes logs are sawed into boards by means of the method called slash sawing, i.e., they are sawed into boards without any regard for the grain, each board being cut parallel to the previous one. The boards cut from near the center of the log are called radial or rift boards and are very desirable for certain kinds of patterns. They are less liable to warp because the annual rings cross at nearly right angles to the face of the boards. A study of *A* and *B*, Fig. 6, will serve to illustrate why one tends to warp more than the other. In *A*, some of the annual rings extend across the full width of the board. The rings nearest the bark contain more cells or sapwood because of a greater

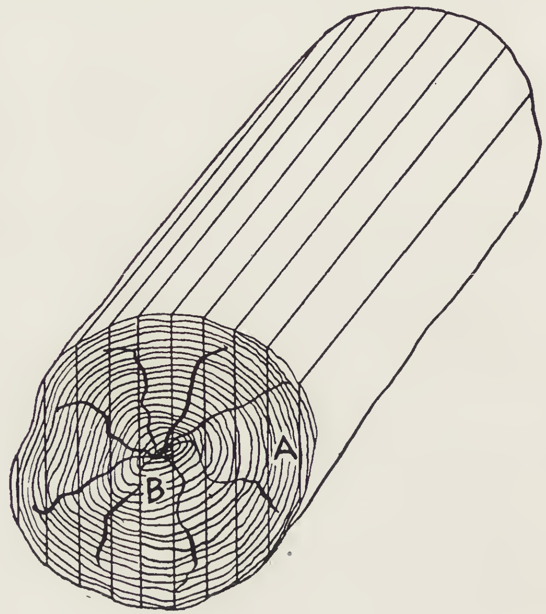



Fig. 6.

diameter. Therefore, the shrinkage will be unequal. It is because of this unequal shrinkage that a slash cut board (Fig. 7), if equally exposed on both sides, becomes concaved on the sap side (nearest the bark) and convex on the heart side.

Boards that are unequally exposed are apt to be concaved on the side exposed to the heat.

In *B*, Fig. 6, the annual rings do not extend across the width of the board as in *A* but at right angles to the width. There is, therefore, as much chance for shrinkage on one side of the board as on the other.

From the above, the conclusion may be drawn that the nearer the heart of a log the board is cut the less the tendency to warp.

Fig. 7.

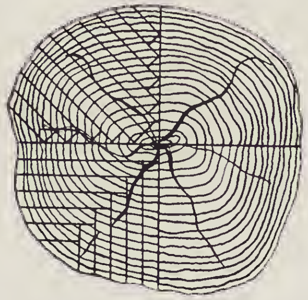


Fig. 8.

Fig 8 illustrates two methods of sawing quartered oak. Oak lumber is quartered chiefly to bring out the effect of the medullary rays.

Fig. 9 shows how stock should be glued together as regards the "sappy" sides.

Fig. 10 indicates the effect produced when stock is glued with the heart sides together. This is almost certain to happen if the stock is at all green (unseasoned).

In Fig. 11, *A* is nailed with the "sappy" side up; *B* with the "sappy" side down. *B* is the better way.

When stock is to be produced for a job, it should be stacked so that the air can circulate around it until it is used. Otherwise it will warp badly.

White pine is the lumber generally used for pattern construction. It does not shrink, warp or twist as much as some other soft woods and is easily worked.

Mahogany is also used on the parts of pine patterns subject to

Fig 9.

Fig. 10.

hard usage. It is harder than pine and will stand the wear better. For this reason a great many small patterns are made entirely of mahogany.

**Solid Patterns.**—Some small patterns may be made out of

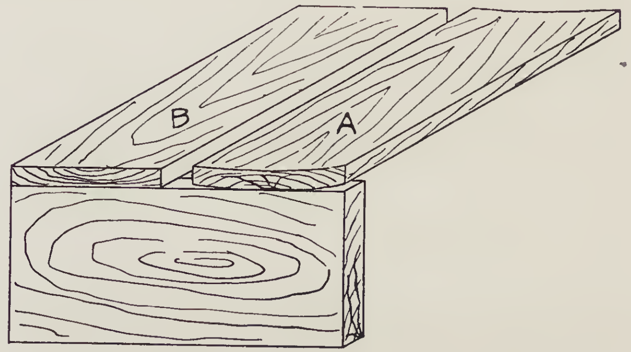



Fig. 11.

one piece of wood while the form of others demands that they be made from stock that is glued up even though it were possible to find a piece of timber large enough.

The objection to using large timber is that it is not as well-seasoned. Therefore in forming a pattern out of it, the tendency would be to warp, shrink and check, thus rendering the pattern worthless. The gluing up of stock overcomes this and by proper arrangement of the various pieces adds to the strength of the pattern.

**Hollow or Built-up Patterns.**—Medium and large-size patterns are as a rule made hollow. The following description of various patterns will serve to make this clear.

A cylinder pattern of dimensions 1′ in diameter and 4′ long (or larger) would be made of several heads lagged over with staves.

A piston pattern 3′ in diameter, 8″ thick and closed on both ends or sides, would be built up of several courses of segments and the ends closed with boards sawed to fit into recesses.

A large rectangular pattern of such dimensions as 3′ long, 18″ wide and 12″ thick would be " boxed up " (several heads boarded over). This form of construction is most practical not only because of the saving in lumber and the ease of handling due to less weight, but because it is not so liable to become distorted because of swelling and shrinking as would be the case in a pattern built in solid form.

Study Plate 24 to obtain the proper idea of a " boxed up " pattern.

There are no fixed rules as to the thickness or width of staves used in " lagging up " a pattern, cylindrical in form. It depends entirely on the pattern. For example, if a cheap pattern were desired (2′ in diameter and 4′ long), the pattern-maker would probably consider that thin narrow staves about $1\frac{1}{4}$″ thick and as wide as he could use them—without hollowing them out to fit the heads—were the proper material to use. The heads would be worked out of a plank and the staves nailed on.

If a first-class pattern were desired, a thicker and wider stave would be used. The heads would be made of segments about 3″ wide of 3 courses each, and the heads flattened off to receive the staves or the staves hollowed out to fit the heads.

Heads for cylindrical patterns sawed out of a plank will not remain a constant diameter because of the shrinkage across the grain of the wood. It is not advisable, therefore, to use solid heads on work over 12″ to 18″ in diameter.

To understand the application of this " lagging up " method, study Plate 22. When such patterns as pulley-rims, flywheel rims, etc., are to be constructed, segments are used. These must be sawed lengthwise of the grain of the wood. *Never* across the grain.

The joints on the different layers or courses of segments should be so arranged that the segments of one course will tie together the segments of the course below it. The use of segments not only permits the production of an exceptionally strong pattern, but also renders the working on the ring easy. The direction of cutting is with the grain and not partly on end grain as would be the case with a solid piece of wood.

The number of segments to a circle or course depends on the diameter of the circle. The main point is to avoid too much cross grain. Therefore, as the diameter increases, the number of segments should increase.

It is not good practice to make a ring of less than three courses. If two courses only are used, one course will warp one way and one the opposite way. The addition of the third course prevents warping.

**Fillets.**—The accompanying sketches, Fig. 12, illustrate the tendency of the crystals in metals to arrange themselves at right angles to the surface of the casting when passing from the molten to the solid state.

If an angle is left sharp it is likely to produce a weak corner or angle. Therefore to avoid this it is desirable to fillet the angle. It also gives a better appearance to castings where such angles are exposed to view. Fillets may be of wood, leather, putty or wax, and in some cases they are worked out of the solid wood of the pattern.

Wooden fillets are nailed and glued in, leather fillets may be put in with glue or shellac. Wax fillets are usually made in round strings of the approximate size and rubbed in with a warm filleting iron of the required size.

**Stop-off Pieces** are used when the pattern, in stock, is longer than the desired casting. For example the pattern in stock for a pipe flanged on both ends, is 4′ long and the casting desired is 3′ long. To use this pattern, 3′ would be measured from one end, a

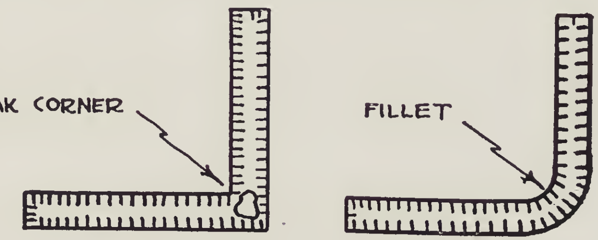


FIG. 12.

flange would be sawed out to fit over the outside of the pipe and it would be screwed to the pattern at the 3′ mark. The part of the pattern projecting beyond the "stop-off flange" is filled up, that is stopped off.

To locate the center core the molder is given a semicircular flange the size of the flange on the stop-off end. This flange has a semicircular cut-out the size of the core. This is placed in the mold and the core lowered into position. The molder then forms a sand bearing for the core similar to that employed when a core print is used.

Stop-off pieces are applied to a great many varieties of patterns.

**Setting Cores.**—In the following sketch, Fig. 13, the bearings *A–B* and *C–D* are the same diameter, but *C–D* is longer than *A–B*. The pattern-maker should, therefore, make some provision to keep the molder from getting the core reversed. There are several ways to prevent such a mistake. One way is to make the tapered part of the nowel half as long as that of the cope, another is to make a larger print on one end than on the other.

Whenever a molder is likely to set a core improperly, the

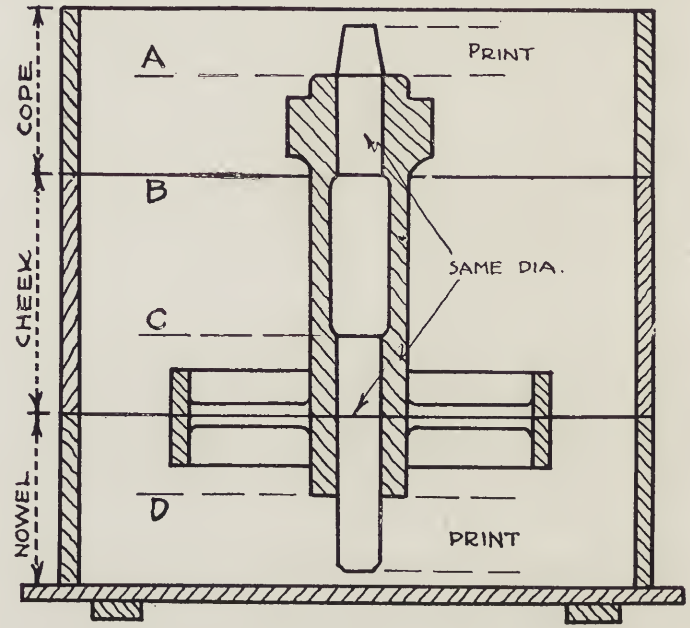


FIG. 13.

pattern-maker should make some provision to prevent such a mistake occurring.

On split, or parted, patterns the core is usually outlined on the nowel half of the pattern. This enables the molder to see just how much metal he should have between the core and the mold.

**Dowel Pins** are made of both brass and hard wood. They are used to locate the various parts of a pattern in their proper relation to each other.

**Draw Plates or Lifting Plates.**—Standard patterns are usually equipped with draw plates which are pieces of iron varying in size according to the size of the pattern.

They are screwed fast to the pattern and contain a threaded hole into which the molder can insert a screw hook for lifting the pattern from the mold. The pattern is preserved because this plate avoids the necessity of driving a lot of holes into the pattern for the purpose of lifting it. These plates are also used as rapping plates, as they afford a good rapping place without injury to the pattern. (The molder always raps a pattern to loosen it before removing it from the sand).

**Center lines are very important** and all measurements should be taken from them. They should not be planed off when finishing up a pattern, but left permanent in case of need for future alterations.

A much neater job is obtained, when marking out a pattern, by marking across the grain with a knife rather than with a scriber.

A **strike** is a flat bar of iron or wood used for striking or sweeping excess sand from the top of a mold or core.

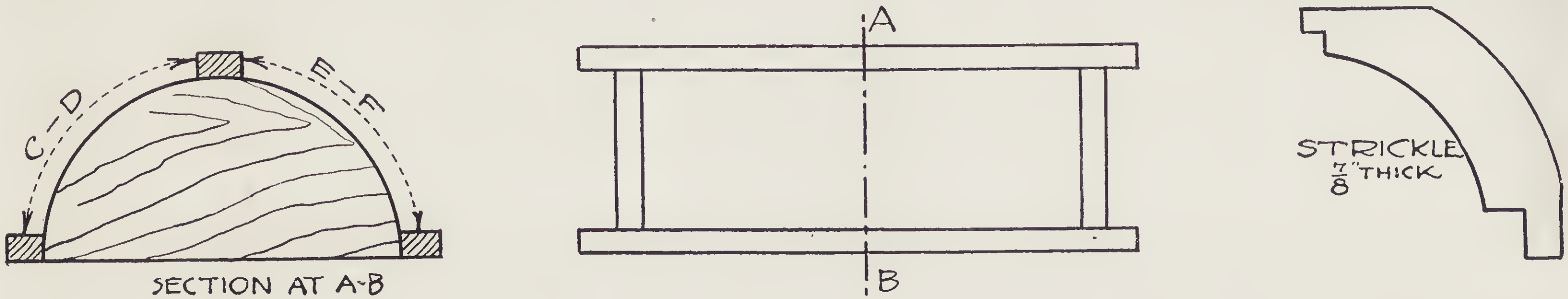



Fig. 14.

A **strickle** is a strike with a form cut in one edge to shape a regular surface on a mold or core. See Plate 23.

Below is a sketch of a skeleton core box, i.e., two semicircular heads fastened together by three staves. The strickle is drawn along the staves to form the shape of the core between *C–D* and *E–F*. In this particular case a straight bar or strickle could be used.

A **sweep** is a piece of wood or iron cut to conform to the radial section of the casting. It is revolved about a center to form the surface of a mold. Much of the expense of pattern work for certain classes of castings of regular form may be overcome by the use of a sweep. Such castings as sheave-wheels, cylinders, tank heads, pulley rims and similarly shaped objects can be easily molded by the use of this method.

Sweep work is confined largely to a class of molding called loam molding; but it is also used to a great extent in green sand molding.

In connection with sweep molding it may be said that there are many castings having projections on them which cannot be produced by the sweep alone. In such cases, parts of the pattern have to be made and located in their proper places in the mold. See Plate 20.

## HAND TOOLS

The hand tools used by the pattern-maker are much the same as those used by the cabinet maker and carpenter except that the chisels and gouges are a lighter grade.

The following illustrations do not represent all the tools in a pattern-maker's kit, but will enable the student to become familiar with those in most general use.

Figs. 15 and 16 show two types of **paring chisels.** The tools illustrated by Figs. 17 and 18 are very handy for paring across long surfaces. Two or three of the bent shank gouges of different sweeps add to the kit. The method of grading gouges is illustrated in Fig. 19. Few pattern-makers possess a full set, but when a set is to be made up it is well to include a few of each of the different sweeps.

**Carving Tools.**—Figs. 20–26 inclusive are quite frequently employed.

The making of many patterns requires a great deal of wood-turning. The **turning tools** illustrated by Figs. 27–30 inclusive are the ones used in all ordinary operations.

Various types of **squares** are used by pattern-makers. The **combination set** (Fig. 31) is practically indispensable. This square can be regulated to obtain different lengths. The center head and protractor are also frequently used.

Fig. 32 shows a **universal bevel.** It is very convenient for use in connection with small work and is especially useful when turning small patterns.

There are several types of **dividers** and **calipers** used on small, accurate work. Figs. 33, 34, 35 and 36 show standard types. Outside calipers (Fig. 34) are used for measuring outside

Fig. 15.

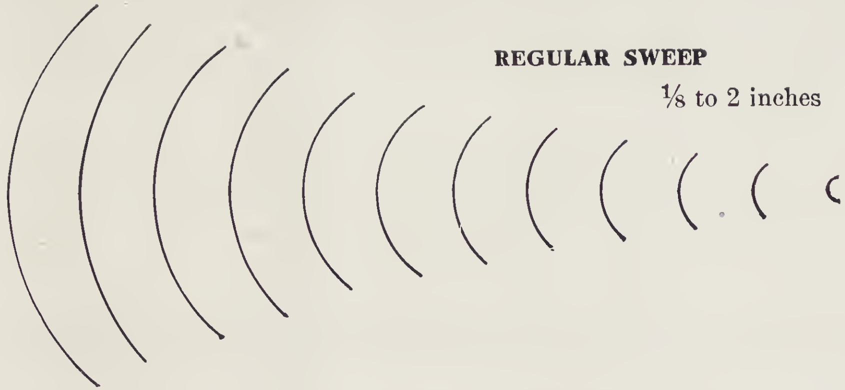
Fig. 17.

Fig. 18.

Fig. 16.

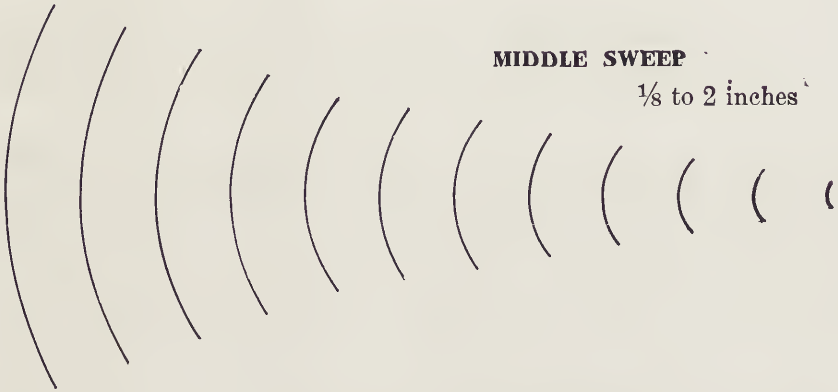
**REGULAR SWEEP**

⅛ to 2 inches



**MIDDLE SWEEP**

⅛ to 2 inches



**FLAT SWEEP**

⅛ to 2 inches

Fig. 19.

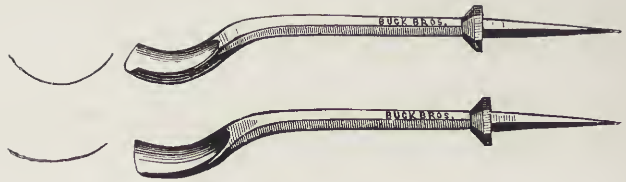



Fig. 20.


Fig. 21.


Fig. 22.

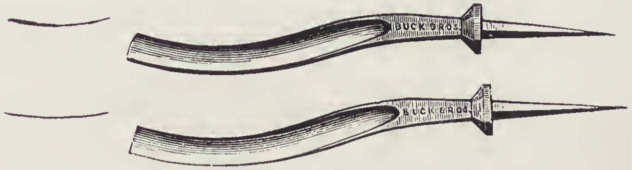



Fig. 23.


Fig. 24.


Fig. 25.

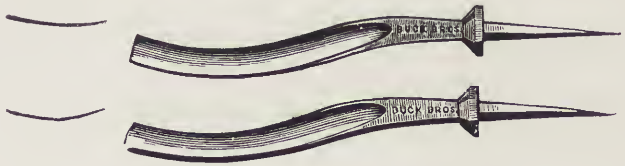



Fig. 26.

Fig. 27.

Fig. 28.

Fig. 29.

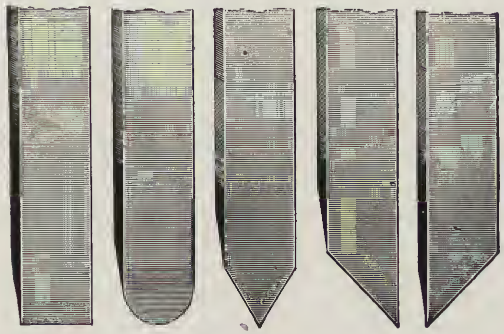


Fig. 30.

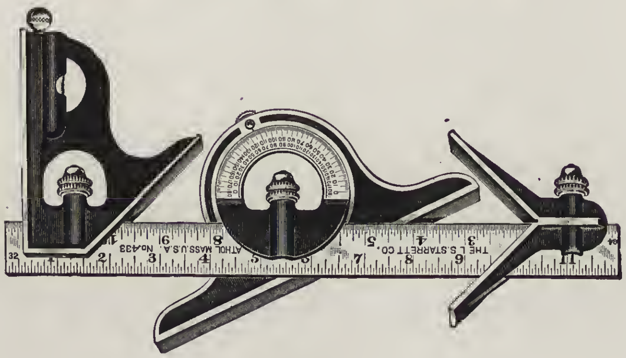



Fig. 31.

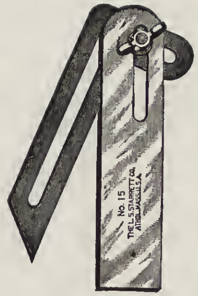



Fig. 32.

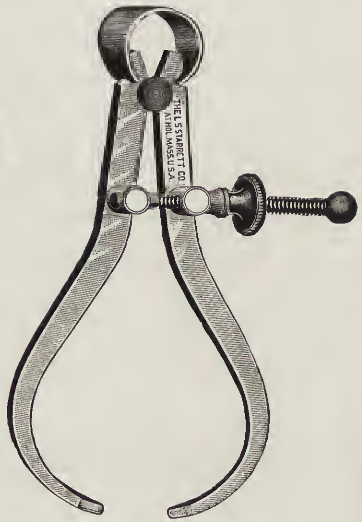



Fig. 34.

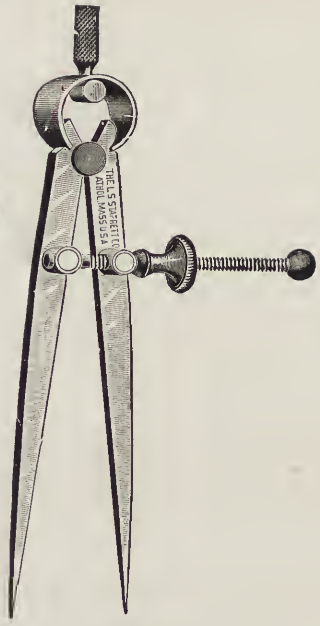



Fig. 33.

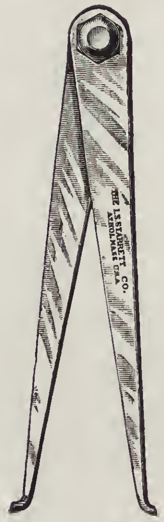



Fig. 35.

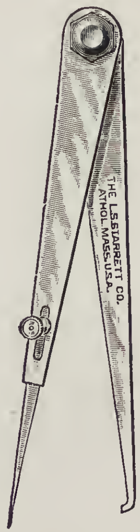



Fig. 36.

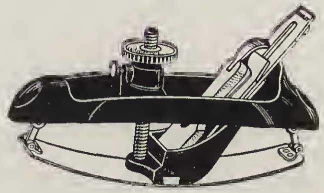


Fig. 37.

diameters. Inside calipers (Fig. 35) are used when turning inside diameters. Hermaphrodite calipers (Fig. 36) are very useful for finding centers, gauging lines around irregular surfaces, etc.

The **circular plane** (Fig. 37) is used for planing either concave or convex surfaces. There are many types of **shrink rules** covering the shrinkages of various metals. The one piece two-foot boxwood rule is most commonly used, but the steel rule (Fig. 38), is more accurate and desirable for fine work.

**Trammel points** (Fig. 39) are used for describing large arcs and circles.

**Pinch dogs** (Fig. 40) are employed for many different purposes. Their function, when driven into two adjoining pieces of wood, is to draw the pieces together to form a good joint. They are used a great deal when gluing because of this.

Fig. 41 shows a good type of **bench knife**. When laying out work, all lines across the grain should be made with a knife. Knives are also used for whittling out patterns.

The **spoke shave** (Fig. 42) is indispensable to the patternmaker. The type here illustrated is made of iron. They are also made of wood.

**Cornering tools** are used for rounding off edges of patterns (Fig. 43), and are made with various radii so that different size corners can be cut.

The **shoot plane** or **jack board** (Fig. 44) may be used for various purposes. It is especially useful for planing the end grain of small blocks, and for fitting the ends of segments.

The **router plane** (Fig. 45) is used principally for working out recesses of various kinds to a uniform depth.

The **core box plane** (Fig. 46) is designed for planing out semicircular boxes. The principle upon which this is constructed is that a right angle can be inscribed in a semicircle. The sides of the plane are at right angles to each other. Consequently

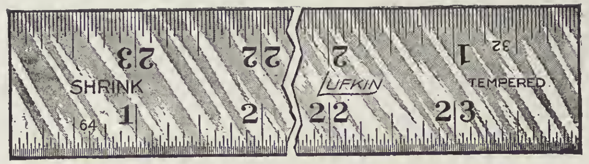


Fig. 38.

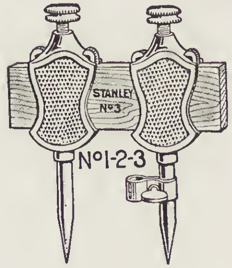


Fig. 39.

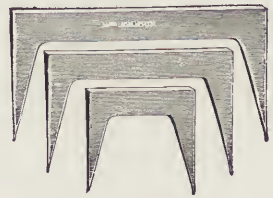


Fig. 40.

Fig. 41.

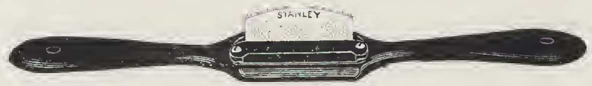


Fig. 42.

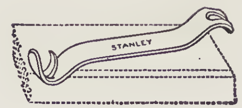


Fig. 43.

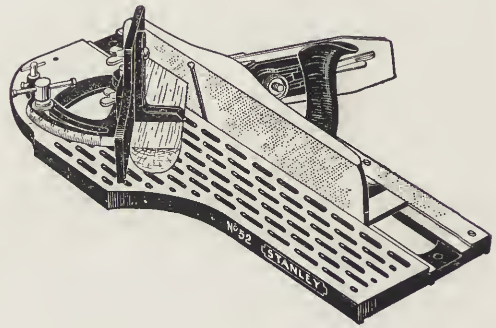


Fig. 44.

the point of the plane will always cut on the circumference of the circle when the sides rest on the edges of the box.

**Cabinet maker's rabbett plane,** Fig. 47.

The cutting-iron of a rabbet plane is made as wide as the body of the plane. This feature makes it possible to plane out rabbets, dados, and other offsets.

**Side rabbet planes** (Fig. 48) are very useful for side rabbeting when trimming dados and grooves of all sorts.

The **hand drill** (Fig. 49) is used for drilling small holes such as screw holes.

Most shops are equipped with a **wood trimmer** as illustrated in Fig. 50. These are very useful for cutting ends of blocks at various angles and especially for trimming the ends of segments.

**Hand screws** (Fig. 51) are made in various sizes and are used principally when gluing stock, but are employed for other purposes.

The **clamps** (Fig. 52) are also used for gluing purposes. These can be adjusted to accommodate various lengths.

The **brad hammer** illustrated by Fig. 53 is useful when working in corners. It may be magnetized to advantage as the brad can then be held erect in all cases.

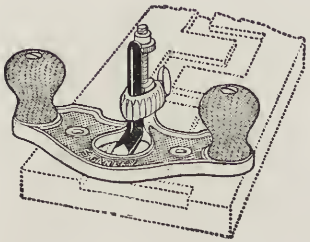


Fig. 45.

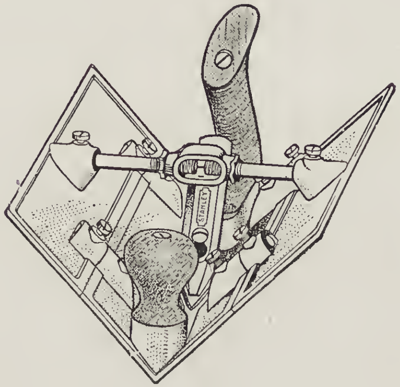


Fig. 46.

Fig. 48.

Fig. 49.

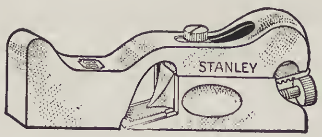



Fig. 47.


Fig. 50.

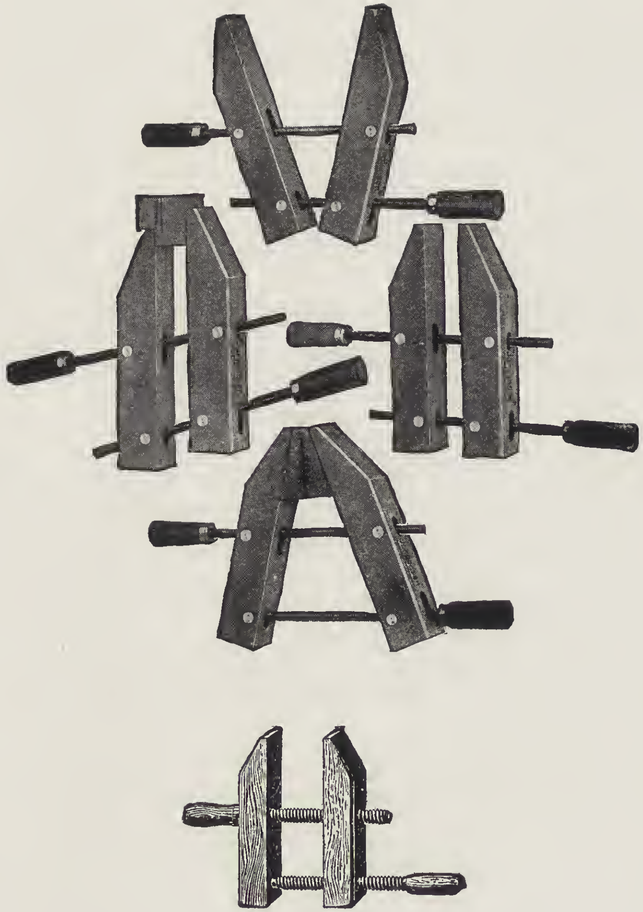


Fig. 51.

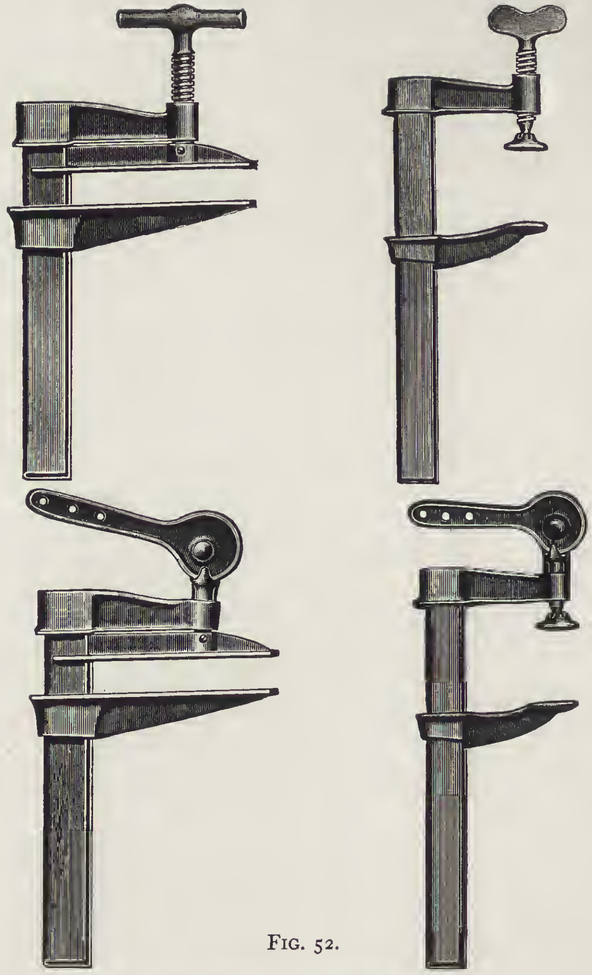


Fig. 52.

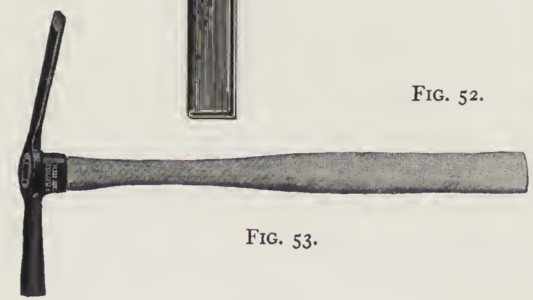
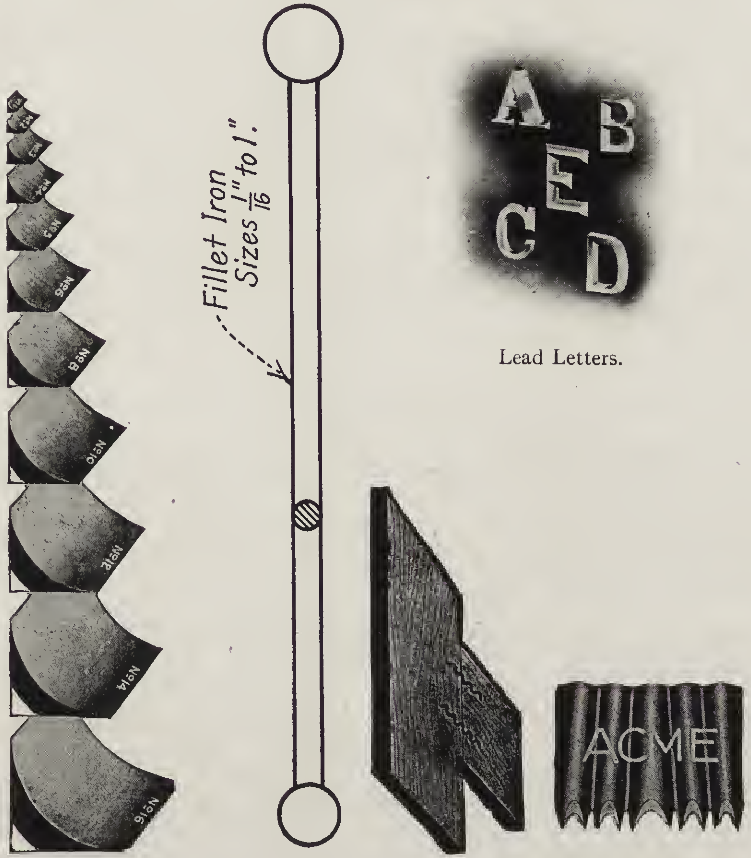


Fig. 53.

The accompanying illustrations (Fig. 54) show a few of the handy pattern accessories.




Leather Fillets.

Lead Letters.

Corrugated Fasteners

Fig. 54.

## MACHINES USED BY THE PATTERN-MAKER

It is not intended that the material presented in this chapter shall give the student complete information regarding the machines and tools used by the pattern-maker. The illustrations have been given merely to acquaint him with the tools generally used in work of this sort.

The instructor is the one to impart the necessary knowledge. He will have the tools before him and is therefore in the best position to give the necessary descriptions and instructions.

The student should understand that the selection given here is that made by the authors and is not necessarily standard. Equipment will vary as the opinions of those who select it. The intention is to present the kinds of tools employed in pattern-making and thus establish familiarity with them.

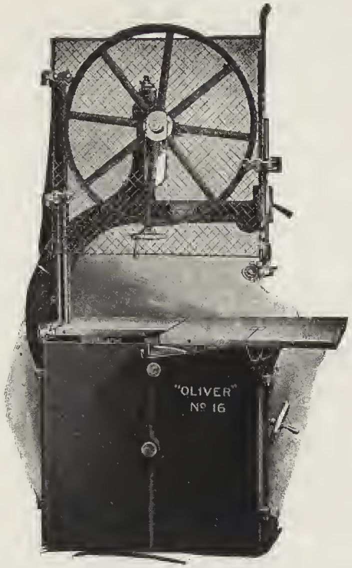



FIG. 55.—Band Saw, 36-inch Wheels.

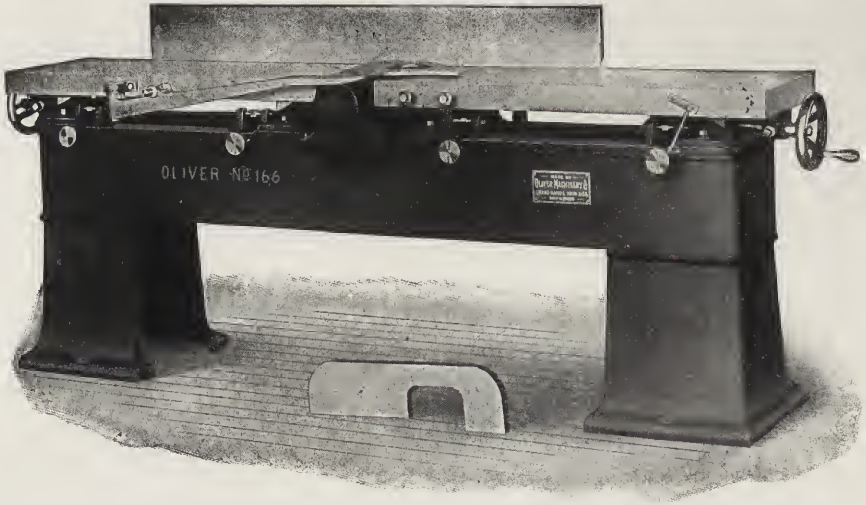



FIG. 56.—Hand Planer or Jointer.

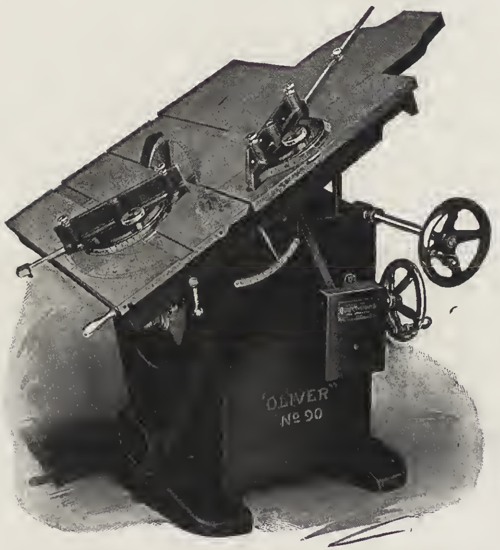



FIG. 57.—Universal Saw Bench Showing Table Tilted to 30 Degrees.

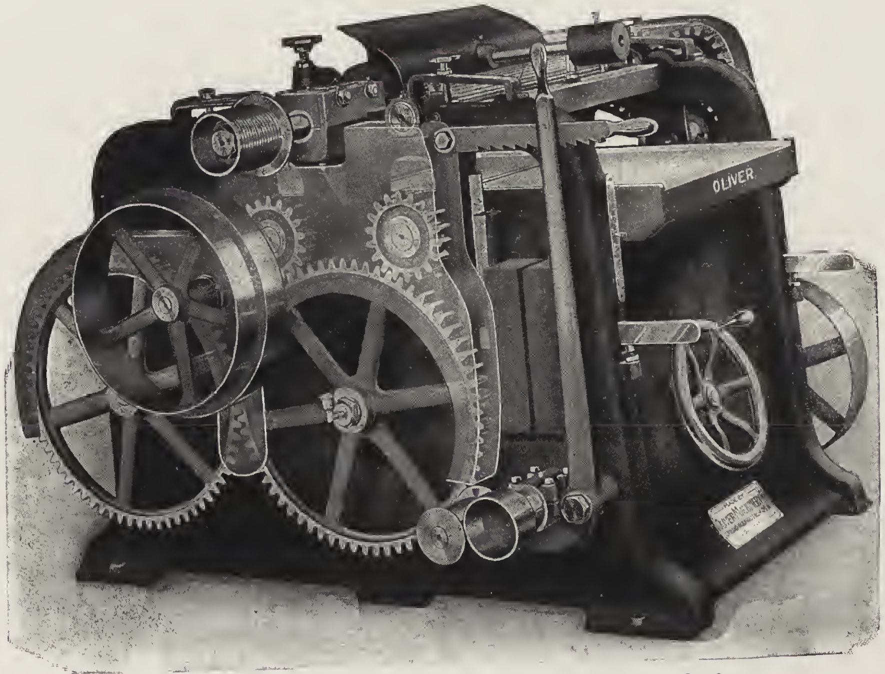



FIG. 58.—Four-roll Single-cylinder Double-belted Cabinet Surfacer.

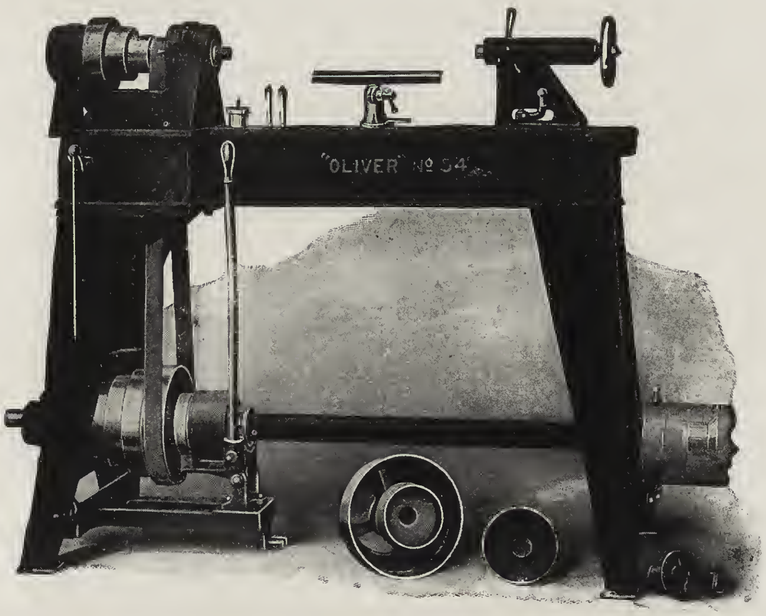



FIG. 59.—Under-belt Drive Speed Lathe.

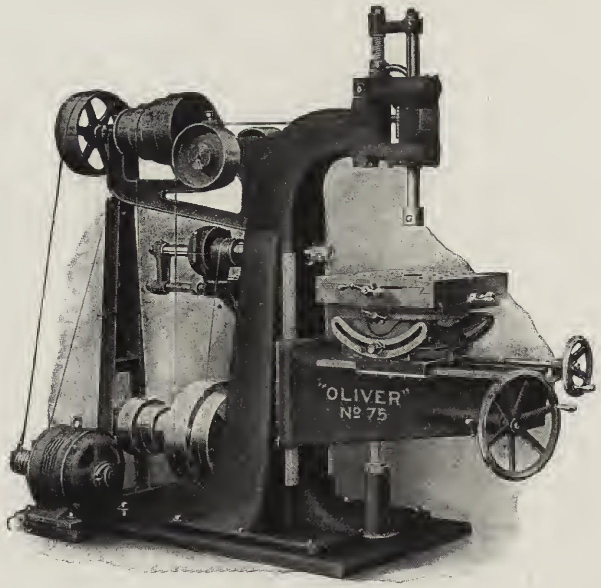



FIG. 61.—Wood-milling Machine.

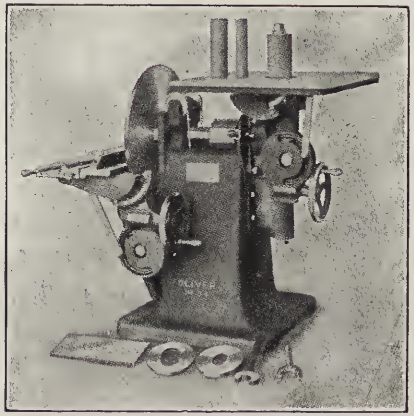


FIG. 60.—Vertical Spindle and Disk Sander.

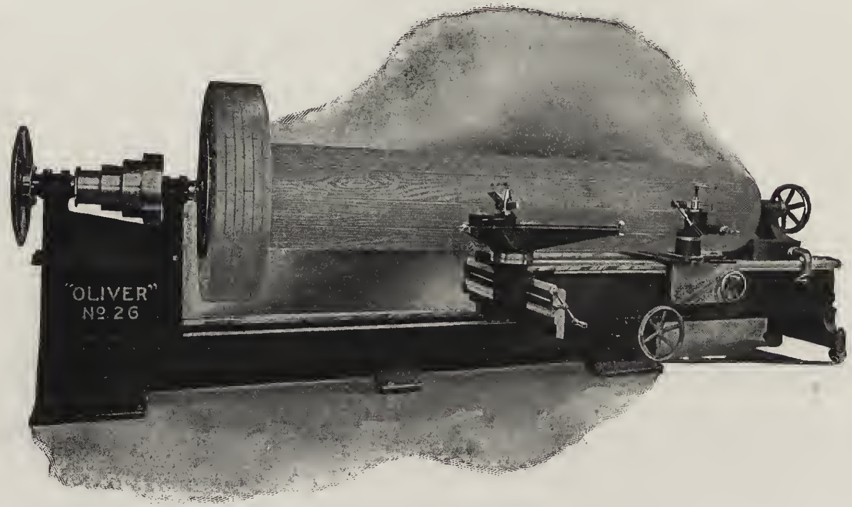



FIG. 62.—Heavy Pattern-maker's Gap Lathe.

The term "molding" as used in connection with the following notes refers to foundry practice.

**Molding.**—In producing a mold of sand in which metal is to be cast, a pattern of the casting is usually employed to form the mold.

**Flask.**—An open frame of two or more parts used to contain the sand in which the pattern is molded. It may be made of iron or wood.

The lower part is called the nowel or drag, the upper part the cope and the intermediate parts cheeks.

The various parts of a pattern are named according to the section of the flask in which they are molded.

**Sprue.**—An opening or hole through the cope for the purpose of pouring the metal into the mold.

**Gate.**—The channel leading from the sprue to the mold.

**Molding Sand.**—A sand composed largely of silica (grains of sand) and a small percentage of alumina (clay). These elements are essential, as the sand must be capable of resisting the heat of the metal and sufficiently porous to afford a free escape of the gas and steam which accompanies the pouring of molten metal.

The clay when moistened serves as a bond, thus enabling the mold to retain its form until the casting is poured.

**Sea Coal.**—This is pulverized bituminous coal. It is mixed with molding sand to prevent the fusion of the sand with the metal. The proportions of the mixture vary, but are about one part of sea coal to six of sand.

**Blacking.**—A coating of plumbago which is composed largely of carbon, applied on the face of a mold to produce a smooth surface on the casting, also to protect the fusible elements in the sand from the intense heat of the molten metal. On green sand molds it may be applied as a powder, but on dry sand molds and cores it is put on in liquid form. The surface of some dry sand molds require a very thick coating.

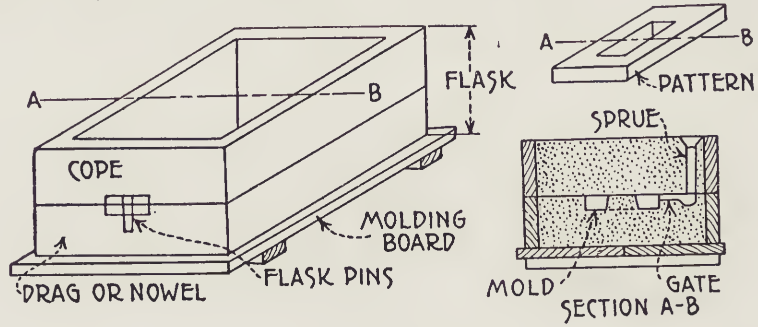



Fig. 63.

**Facing Sand.**—The mixture of sand applied directly against the pattern. This mixture differs according to the class of molding, whether green sand, dry sand or loam.

**Tempering Sand.**—Moistening the sand before using it for molding. It must only be dampened sufficiently to hold together until the metal is poured.

**Venting.**—Providing for the escape of gas and steam from the mold. The molten metal coming in contact with the sand of the mold generates gas and steam which must escape in order to produce a sound casting. The porosity of the sand affords considerable relief, but other provision must also be made. This differs according to the class of molding. For ordinary sand molding (green sand) a vent wire $\frac{1}{16}''$ to $\frac{1}{8}''$ is inserted a number of times from the outer surface of the mold to within about $\frac{1}{2}''$ of the pattern. These openings permit the gas and steam to escape freely.

**Parting Sand.**—This is a dry, sharp sand sprinkled between the joints of the mold to prevent the cope and nowel from uniting. River, beach, burned molding sand and patented compounds are used for this purpose.

**Green Sand Molding.**—Molds made of the regular molding sand are called green sand molds. The sand is usually mixed with sea coal. This protects the fusible elements from the intense heat of the molten metal. (The mixture is about one part of sea coal to 6 parts of sand.)

The majority of ordinary size castings are made in green sand molds. Powdered blacking is applied to the face of the mold for the reasons previously stated.

**Dry Sand Molding.**—A stronger sand or facing is used for dry sand molds than for green sand. There are numerous formulæ for dry sand facings. The following is one commonly used.

2 parts gravel.

1 part Lomborton (regular molding sand).

1 part core compound to 30 of the other two.

These are mixed with water to the consistency of dough. From 1″ to 2″ of facing next on the pattern is sufficient; the remaining part of the flask as a rule being filled with old molding sand called "backing sand." The gravel makes the facing more porous in texture, thus affording a free escape of gas. The core compound acts as a binder.

The pattern is usually molded in a heavy iron flask and when removed the mold is slicked and coated with a thick coat of blacking and dried in an oven or with fire pans. Drying the mold produces a hard, porous surface which can withstand the strain or pressure of the metal that accompanies the pouring of heavy castings.

The heavy coating of blacking gives a very smooth surface to the casting.

Dry sand molding insures a sounder and smoother casting than green sand.

**Loam Molding** may be classed as dry sand molding, as the molds are treated practically the same with regard to the drying and blacking as dry sand molds.

Loam molding is confined chiefly to very large castings, especially to circular castings where the whole or part of the mold is produced with a sweep. The facing or loam, as it is called, is stronger and more porous than dry sand facing, thus affording a very free escape for gas and can withstand a greater strain or pressure when the mold is poured.

A great many of the foundries throughout the East are using "Millville Gravel" mixed with clay water and a little sea coal. Loam mixtures are made to the consistency of mud. The molds are, as a rule, not made in a flask, as in green and dry sand molds, but are built up of brick upon iron plates made especially for each job. The brick work is kept within $\frac{3}{4}''$ to 1″ of the face of the mold to allow for the loam facing.

An occasional course of brick is sometimes spread with straw or a joint filled with gravel to permit the gas to escape.

When the molds are poured they must either be reinforced by lowering them in a pit or placing a curbing around them with sand tamped between the mold and the curb or wall of the pit.

Page 102 illustrates the production of a loam mold.

**Pit Molding.**—Molds formed in the floor of the foundry with a cope to cover over the top of the mold are called *pit molds.*

Foundrymen resort to this practice for several reasons, namely: because some castings are so large that it would require a tremendous sized flask to mold them in. Sometimes the expense of even a medium sized flask may be saved if only one or two castings are wanted, by resorting to pit molding. Again where it is desirable to produce certain circular castings such as large sheaves as cheaply as possible, it is very convenient to mold them in the floor or pit by embedding the base for the spindles in the pit below the face of the mold, using sweeps to form the mold. See Plate 20.

In pouring large castings where the pressure is extremely great it is more economical to resist this pressure in a pit than it would be to make a very strong flask. When castings are made in a pit, provision must be made to carry off the gas from the mold. This is accomplished by digging below the face of the mold about 1′ or 18″ and forming a cinder bed that will be very porous. Iron pipes are connected with this bed and lead up to the top of the floor. As the gas generates in the mold, the pressure behind it will force it down through the cinders and up through the pipes, where it will be burned off.

**Open Sand Molding.**—Rough castings such as parts of flasks molded in the foundry floor without using a cope are termed open sand molds. The mold must be level, otherwise the casting will not be of a uniform thickness.

**Skin Dry Molds.**—These molds are of the same composition as dry sand molds, but instead of being thoroughly dried are only dried about 2″ from the face of the mold. While more economical to use than a thoroughly dry sand mold, certain risks are involved due to the liability of the dampness working out to the face of the mold before the casting is made, thus generating steam which might prove injurious to the casting.

**Chilled Castings.**—Car wheels, rolls used in steel mills, and other castings subject to a great deal of wear, are made in chills. The chill is made of cast iron and forms that part of the mold where the hard surface is desired. The remainder of the mold is made in dry or green sand. The chilling of the casting is effected when the molten metal comes in contact with the iron chill in the mold, which causes the metal to cool quickly holding the carbon in combined form while the remainder of the casting cools more slowly, allowing the carbon to change back to its natural form. Sometimes the chill is heated before placing it in the mold. The chills are coated with shellac or some other preparation to prevent the hot iron from adhering to them. Chills are sometimes used on other castings where a heavy body of metal adjoins a lighter one, the purpose being to cause the heavy body to cool at the same rate as the lighter one.

**Cores.**—Cores are used for forming interior chambers or holes in a casting where the type of pattern is such that it can not form its own cores.

They are usually made of a composition that when baked classes them as dry sand cores. They may also be made of loam or green sand. The composition of cores depends largely upon the class of molding for which they are to be used. The following formulæ are used in a certain foundry to a great extent:

**Light Cores.**—One quart of linseed oil to 45 parts sea sand, mixed with water. The oil acts as a binder.

**Heavy Cores.**—Three parts burned sand, 1 part gravel, 1 part core compound to 35 parts of the other two. The core compound acts as a binder. The face of the core which comes in contact with the iron is coated with blacking to give a smooth face and to prevent fusion with the iron.

**Core Barrel.**—Straight cylindrical cores, often used for pipes, small cylinders, columns, etc., may be made with a core barrel. This is a shell around which the core is formed. The core barrel may be of cast or wrought iron with holes through its surface to allow the gases to escape through the center. To make a core with a core barrel it must be mounted upon a support at each end. The barrel is then wound with straw rope about $\frac{3}{4}''$ in diameter which acts as a lath for the wet loam or core mixture to adhere to. A sweep or strike is placed against it and by means of a crank the core is revolved and swept to the required diameter.

**Chaplets** are used in a mold to support or hold a core in place when it is not possible to support it in an impression made by a core print. Chaplets are made of metal and become a part of the casting when the metal is poured. Therefore precaution must be taken against having rusty chaplets, as they do not fuse properly with the molten metal, hence a weak, spongy spot in the casting.

To avoid this, chaplets are usually tinned. They are made in various forms. The two most commonly used are the "stud and steeple." Fig. 85 in the chapter on foundry equipment illustrates these two types.

**Riser.**—A riser is an opening from the mold leading up through the cope. It permits the metal to rise above the surface of the casting, thus serving to carry off dirt and slag and also allows the gas to escape from the mold.

**Feeder Head.**—A feeder head is an opening through the cope similar to a riser and is used on large castings as a means of "feeding" fresh metal into the mold during the shrinkage of the casting. When "feeding" a casting a rod is moved up and down to keep the feeder head from "freezing." This is known as "churning."

**Sinking Head.**—This is another form of feeder head used to supply the casting with metal during the process of shrinking. Molds for such castings as pump-plungers, hydraulic cylinders and rolls that are cast vertically are generally made several inches longer than the required length of the casting.

The surplus metal acts as a feeder and is cut off when the casting is finished.

**Bars.**—In order to form the cope of a great many molds, it is necessary to make provision for supporting the sand. This is accomplished by means of a framework called bars. The bars not only support the sand during the operation of molding, but also serve to resist the upward pressure of the gases and metal when being poured.

**Soldiers.**—These are strips of wood placed in the mold to support or anchor bodies of sand.

**Gaggers.**—Pieces of L-shaped iron to support the sand in the cope.

**Burning On.**—Flowing molten metal over a broken or defective part of a casting until fusion takes place.

**Cold Shuts.**—Imperfect uniting of the metal in the mold. They may be caused by pouring the metal too slowly or too cold or by gases generated from the use of too great a percentage of sea coal in the facing sand.

**Drawback.**—A part of the mold which may be drawn back by the molder for the purpose of removing a part of the pattern which otherwise would complicate the mold.

**Cupola.**—This is the furnace in which the iron is melted. It is cylindrical in form, is lined with fire brick and is mounted on legs. The bottom is hinged and can be dropped after running off the iron in order that it may be easily cleaned previous to recharging it. The charging floor is situated above the capacity level of the cupola which is usually half way up the stack.

The cupola is charged through a door located about 2′ above the charging floor. Before charging a cupola the interior or brick lining is carefully examined and repaired wherever necessary and a sand bed or hearth formed on the bottom, sloping slightly toward the breast or tap hole where the iron is run off.

The following will give an idea of how a cupola is charged: Sufficient shavings and wood must be placed at the bottom to ignite the fuel. Upon this is placed the coke and coal which form a bed by melting the iron. This is followed by a layer of pig iron, next a layer of scrap iron. The charges may be repeated until sufficient iron has been melted for the day's heat. The iron is melted by means of a forced draft which circulates around the wind belt at the base of the cupola and enters through the tuyeres or holes. As the iron melts it is allowed to rise within a safe distance of the tuyeres and is then run off through the tapping hole or breast. Peep holes are arranged in the casing forming the wind belt opposite each tuyere in order that the attendant may watch the iron as it melts and run it off before reaching the tuyeres.

Each cupola is provided with an alarm tuyere situated at a lower level than the others. Directly below this tuyere a plug having a center of a soft metal is fitted on the bottom of the wind jacket. The molten metal dropping on this causes it to melt, thus giving the alarm and preventing the wind jacket from filling with iron. Fig. 78 shows a modern cupola.

**Malleable Castings** are made of white iron put through a process of annealing that removes most of the carbon, leaving the iron soft, capable of being bent hot or cold and in a condition which permits forging and welding to a certain extent.

First, the castings are made of white iron, then packed in iron boxes with oxide of iron, then placed in a furnace and subjected to a yellow heat and left at this heat until the oxide has absorbed all of the carbon.

It is interesting to know the **melting points** of the common metals in connection with the subject under discussion. They are here given.

| | Centigrade. | Fahrenheit. |
|---|---|---|
| Bronze | 900° | 1652° |
| Brass | 1015° | 1859° |
| Copper | 1100° | 2012° |
| Iron (white cast) | 1100° | 2012° |
| Iron (gray cast) | 1225° | 2237° |
| Steel | 1350° | 2462° |
| Soft iron | 1550° | 2822° |

It is not intended that this chapter will fully describe the various tools and apparatus used in foundry practice. The aim is merely to present a general idea of equipment. A single visit to a modern foundry will give the interested student the information regarding any uses of the equipment with which he is anxious to become familiar.

**Flasks** are made in various sizes and forms depending on the purpose for which they are to be used. Figs. 64 and 65 illustrate two types of snap flasks. There are used for light bench and machine molding where the pressure of iron is not very great. They are hinged at one corner, thus permitting the removal of the flask after the mold has been made. This makes it possible to use the same flask for a great many molds.

As the molds are made they are set in rows on the floor and a binder or band of wood or iron is slipped over the mold to strengthen it. An iron weight is also placed upon it. The binder and weight make it possible for the mold to withstand the pressure when being poured.

Fig. 66 illustrates a tapered flask solid at all corners and fitted with patented withdrawable sand supporting strips. When cope of flask is placed in position in the usual way the sand supporting strips project beyond the inner walls, and when cope is lifted to finish the mold the supporting strips carry the sand and hold it perfectly, preventing dislodging or falling out. After mold has been closed the sand supporting strips are drawn back flush with inside of flask and the cope


Fig. 64.

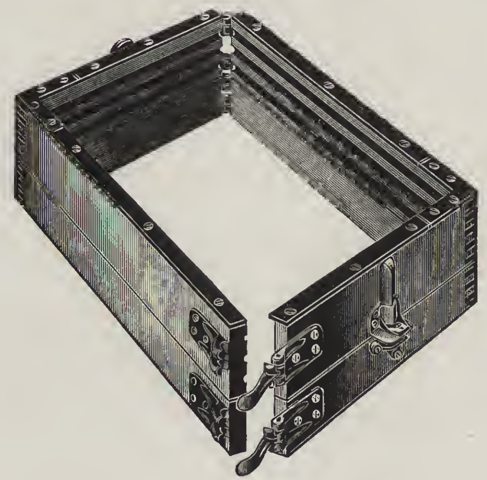


Fig. 65.

and drag—complete flask—lifted from mold without disturbing the sand. This type of flask also permits the making of many molds with the one flask.

Fig. 67 illustrates an automatic adjustable snap mold jacket used in connection with the tapered flask. It adjusts itself automatically to molds of different tapers and conforms to irregularities in shape, either in length or in width or in side or corner angles, giving perfect support to mold.

Figs. 68 and 69 illustrate two types of iron flasks. These are capable of resisting a considerable pressure.

**Core Oven.**—Nearly all foundries are equipped with brick ovens for drying large cores. For drying small cores that illustrated by Fig. 70 is convenient.

Fig. 71 shows a type of **core machine** used for making round stock cores.

**Molding Machines.**—The amount of manual labor in the modern foundry has been greatly reduced because of the introduction of various types of molding and core making machines. Their use is chiefly confined to classes of work where a large number of castings of the same kind have to be made. The patterns have to be fitted for the machines.

Fig. 72 shows a **stripping plate machine.** The flask is placed upon the molding board or stripping plate, which is made to fit around the outline of the pattern. After the flask has been rammed, the pattern is drawn down through the stripping plate by means of a lever, leaving the impression of the pattern in the mold. The plate prevents the sand from breaking away when the pattern is removed, thus eliminating much of the precaution that would have to be taken if the pattern were molded and withdrawn by hand.

These machines are also used as *drop plate machines;* patterns are mounted on plates and are drawn directly from the mold without passing through a stripping plate. The use of

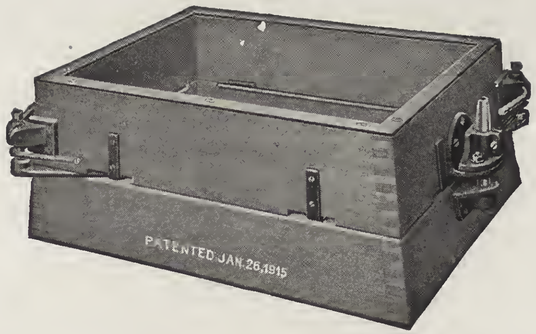



FIG. 66.


FIG. 67.

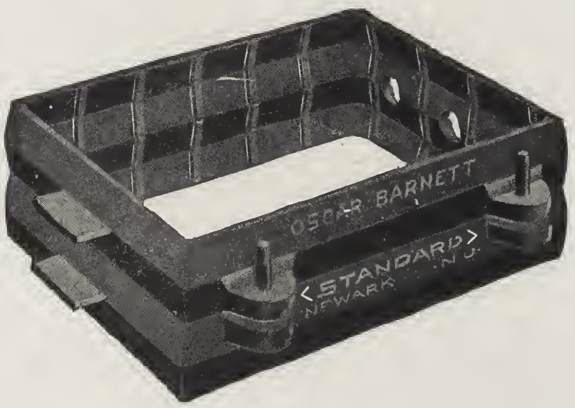



FIG. 68.

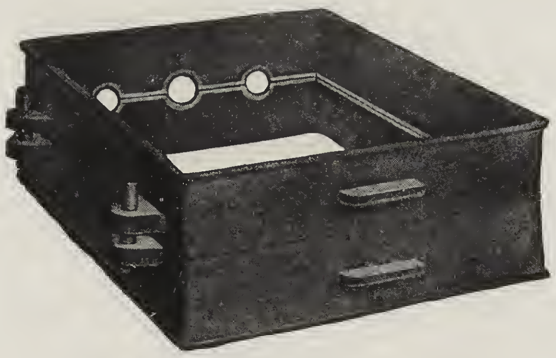


Fig. 69

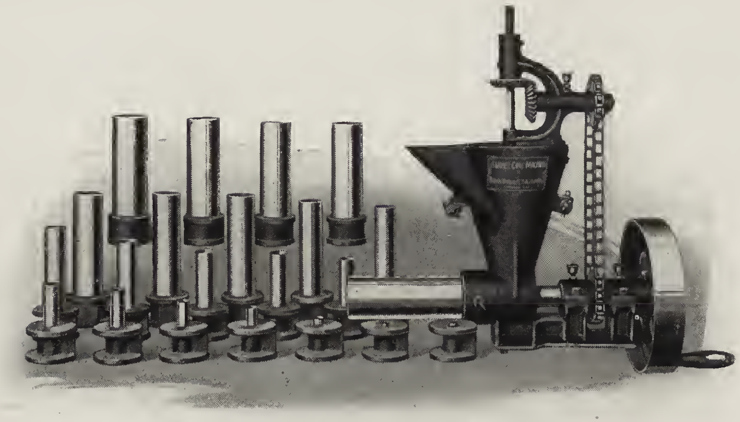


Fig. 71.

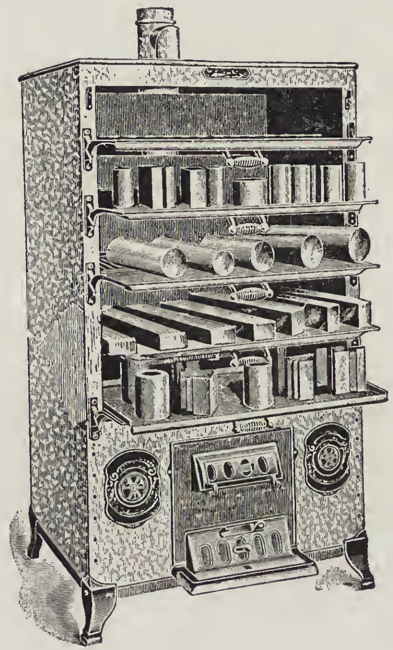


Fig. 70.

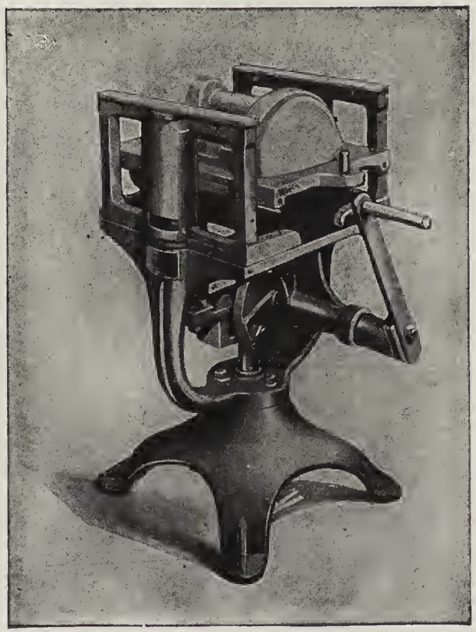


Fig. 72.

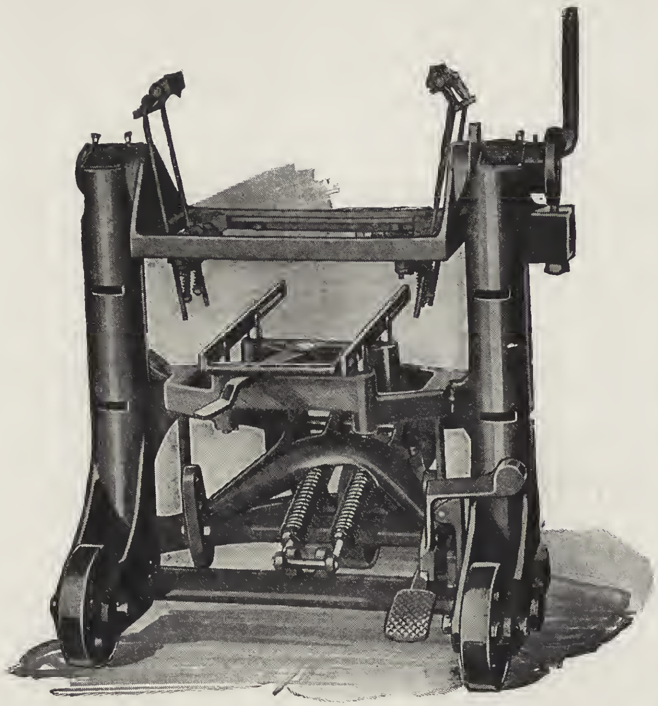


Fig. 73.


Fig. 74.

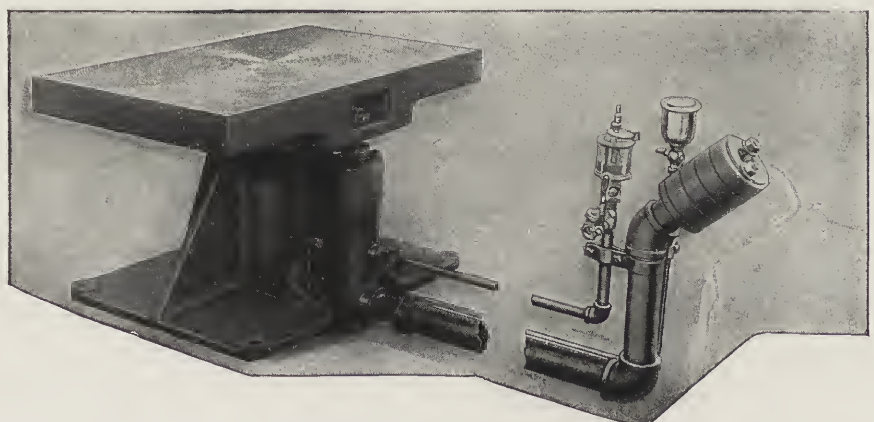


Fig. 75.

Fig. 76.

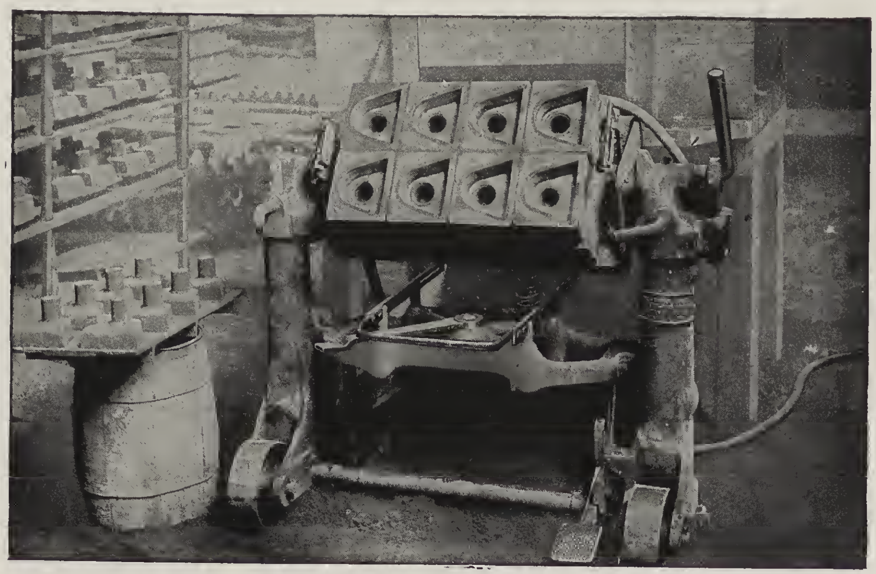


Fig. 77.

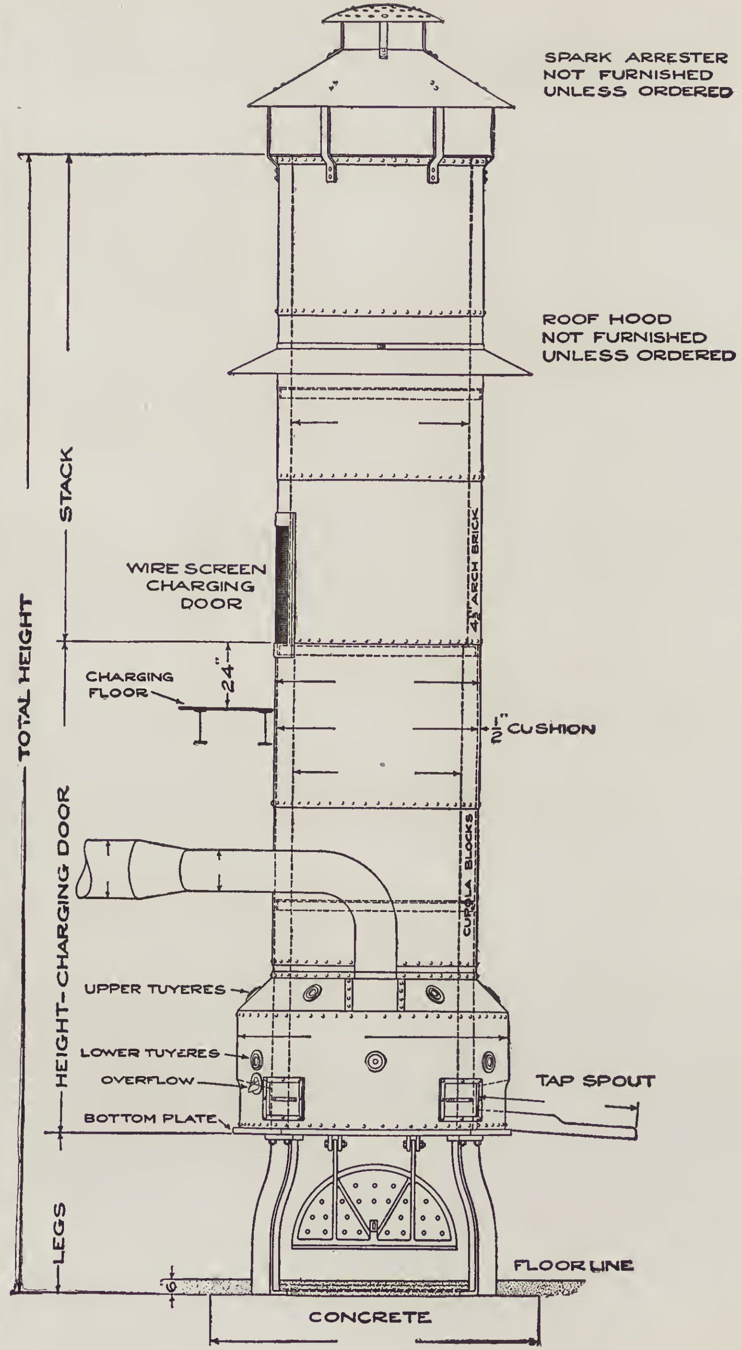




Fig. 78.

FIG. 79.

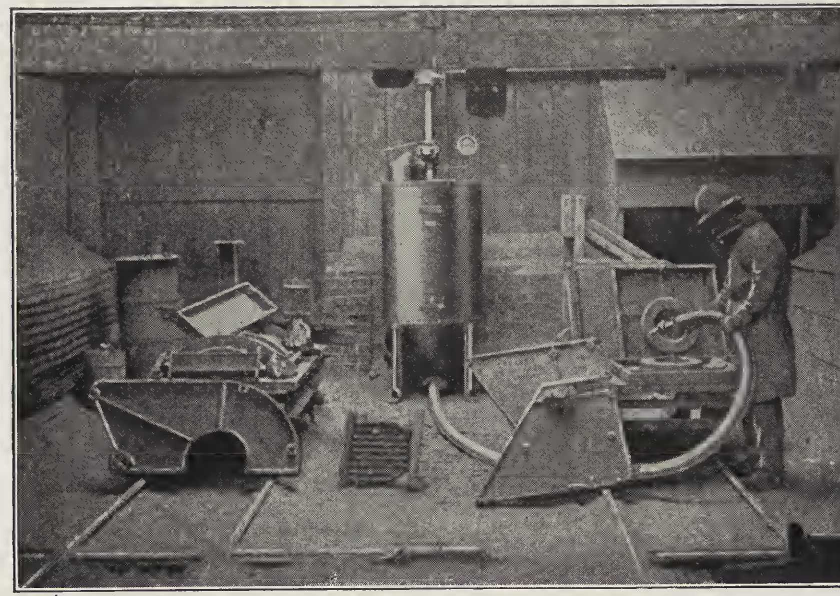


FIG. 81.

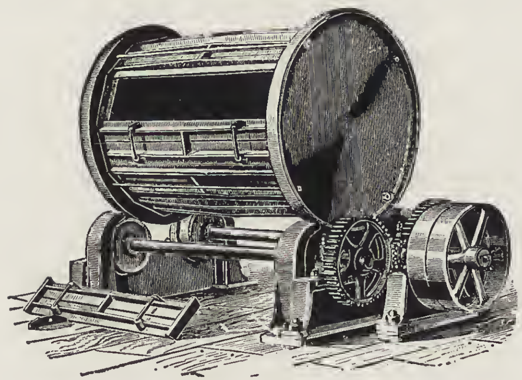


FIG. 80.

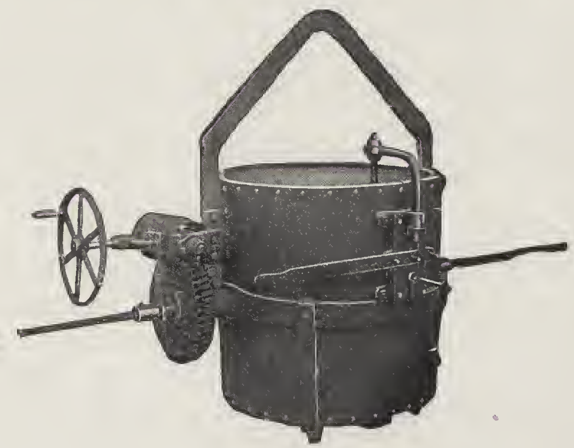


FIG. 82.

FIG. 83.

this machine results in producing a more uniform casting and in great saving of time.

Fig. 73 illustrates the **roll-over machine direct draw.** After the pattern has been "rammed up," the mold is then clamped, rolled over, unclamped, and drawn down clear of the pattern and machine. Rolling over the mold requires little effort on the part of the operator. The table is set to roll on its own center of gravity—the weight of the mold being above the center helps to carry it over. The drawing operation is very accurately controlled by a foot treadle and hand lever working together, which lower the mold receiving table gradually and accurately. Before the mold plate is unclamped it is automatically leveled on sliding arms in the receiving table and the leveling device is locked. The sliding arms are pulled forward to make the removal of the mold from the table convenient.

Fig. 84.

Fig. 74 shows a **roll-over machine** with a pattern ready for molding.

The **air-jarring machine** (Fig. 75) is used for ramming patterns or core boxes. The table or plate is raised by means of compressed air, coming down with a jar. This rams the sand in around the pattern or core box.

**Power Squeezer** (Fig. 76).—The flask rests upon the table of the machine. After filling the flask with sand, a board or plate (which is made to the inside dimensions of the flask) is placed over the sand. Air is then applied and the table raised, bringing it directly in contact with the upper board on the cross beam, thus squeezing the sand around the pattern.

Fig. 77.—A machine used for making cores. It is operated practically the same as that of Fig. 73.

The **cupola** (Fig. 78) is described under the notes on molding.

**The crucible tilting, melting and refining furnace** (Fig. 79) is used for melting brass, bronze, aluminum, ferro alloys, ores, assay, cyanides, etc.

**Friction Tumbler** (Fig. 80).—This machine facilitates the cleaning of small castings after their removal from the mold. A number of them may be placed within the barrel and as it revolves the castings tumble about, thereby loosening the sand adhering to their surfaces. Large castings may be cleaned by hand with a wire brush or by the "Sand Blast Process," as illustrated in Fig. 81.

Fig. 82 shows a common type of **crane ladle**. Fig. 83 shows a **hand ladle.** Both are used for pouring metal.

Fig. 84 illustrates an electric **sand riddle** used for sifting sand.

**Chaplets.**—There are a great many different types of chaplets. Fig. 85 shows three different forms. *A* is single headed and *B* double headed. These are the most common and are made in various lengths. *C* is a special form. See molding notes.

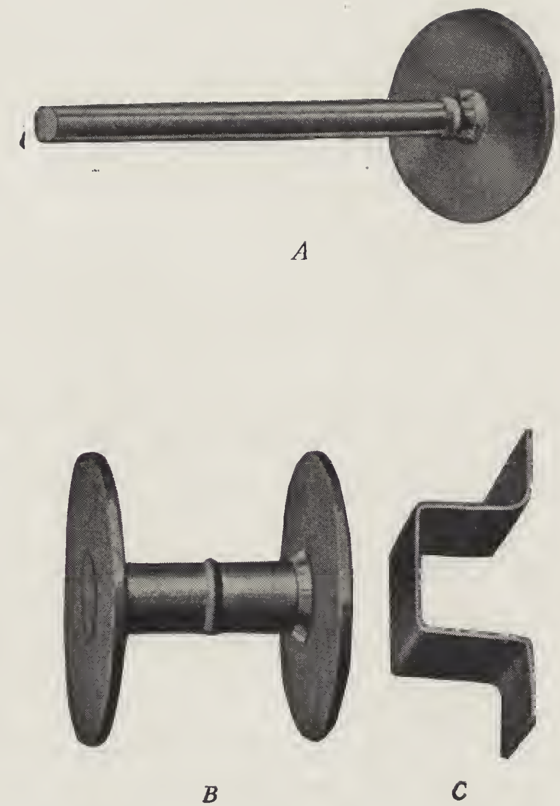



Fig. 85.

# EXERCISES FOR THE STUDENT

# PLATE 1

## JAW FOR STEADY REST

This simple pattern is selected for Plate 1 so that the student may readily grasp the fundamentals of molding and the method to lay out the stock for a pattern. Accuracy in measuring and the ability to do good work should be acquired before proceeding with any of the following problems.

In order to develop skill in the use of the plane and chisel the student should not be allowed to use the jointer or trimmer during the process of making this particular pattern.

Fig. 1 shows a drawing of the finished casting, Fig. 2, a drawing of the pattern and Fig. 3, a cross-section of Fig. 2 through *AB*. "*f*" indicates where the casting is to be machined. Allow $\frac{3}{32}''$ extra metal.

**Instructions.**—1. Get out a piece of 2″ stock in the rough $11'' \times 3\frac{3}{4}''$. Then follow out the steps as given below:

**1.** Plane the working face and edge.

**2.** The width is *E*; the thickness *F* (allowing for finish).

**3.** Gauge center line *X* on faces *C* and *G* (gauge and square all lines from *C* and *D*).

**4.** Mark off length *H* and corners on end *N*.

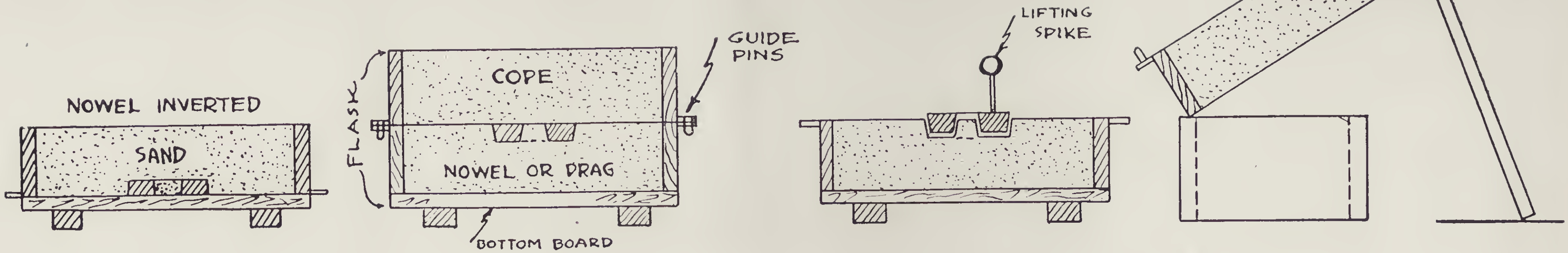
**5.** Lay out oblong hole, keeping hole on the face *C* to exact dimensions and on the side opposite $\frac{1}{16}''$ larger in length and width for draft. (When laying out side lines of the hole set the dividers to half the width and describe small arcs on both sides of the center line. Then set gauge to these arcs and gauge the lines.) To cut out the hole—place the pattern in a vise, gripping the edges *D* and *F*—bore a series of $\frac{7}{8}''$ holes (bore from both sides) or bore a hole at each end and cut out with a compass saw. After cutting out the oblong hole in the rough place on a cutting board (a piece of scrap wood) with the small side of the hole up and pare straight through. Do not try to pare to line on the opposite side. Pare the end of the wood first and then the sides. Turn the pattern over and finish the hole, being careful not to cut beyond the edge of the hole on the opposite side. Keep all chips from under the pattern.

**6.** Cut the ends of the pattern (*M* and *N*) on the band saw. Cut as close to the line as possible. Then place the pattern in the vise and block plane the ends. Keep edges and ends square with the working face *C*. *By all means avoid back draft as shown by dotted lines on section AB.*

**7.** Sandpaper the pattern. Grip the faces *C* and *G* in the vise to sandpaper the sides and the hole. Use No. $\frac{1}{2}$ sandpaper, wrapping it around a block. Avoid rounding the edges because this produces back draft.

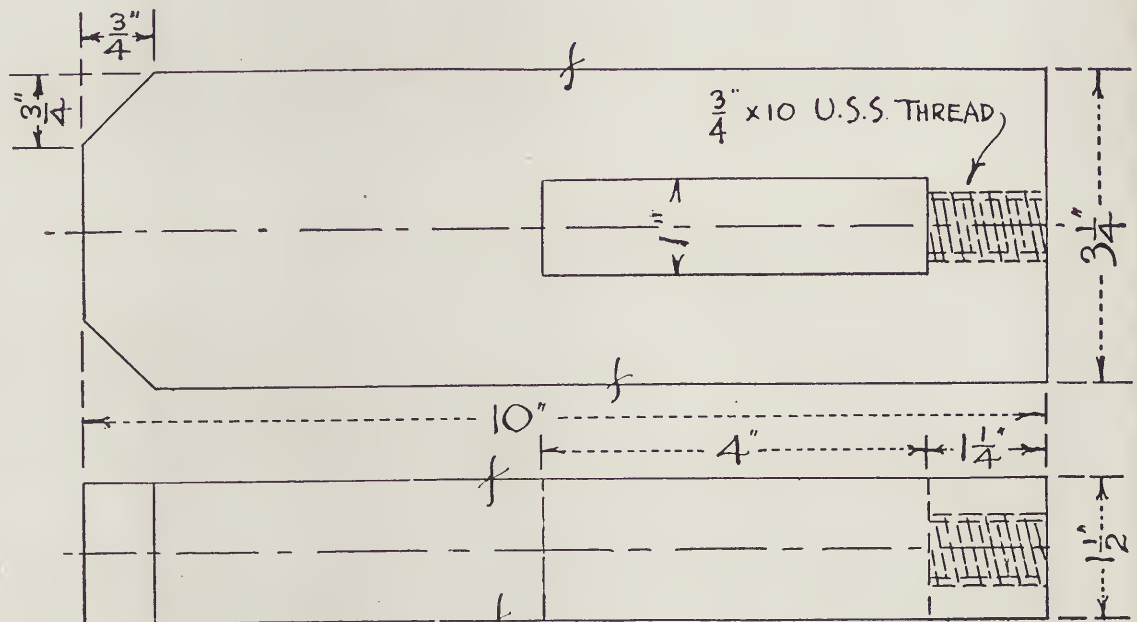
Do not plane off the center lines.

THE SKETCHES BELOW ILLUSTRATE THE OPERATIONS IN MOLDING




NOTE – "ʃ" INDICATES FINISH. ALLOW $\frac{3}{32}''$

DISREGARD $\frac{3}{4}''$ X 10 U.S.S. THREAD. THIS WILL BE TAKEN CARE OF IN THE MACHINE SHOP




CAST IRON FIG. 1

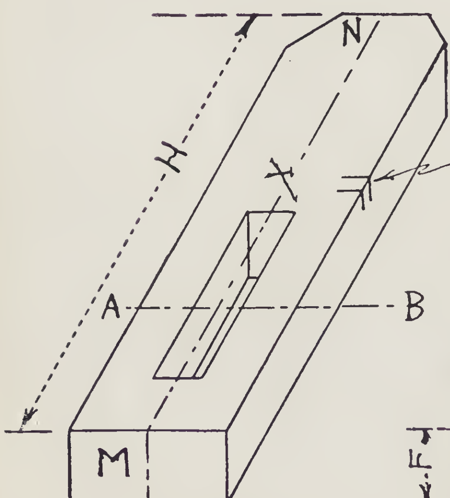



FIG 2

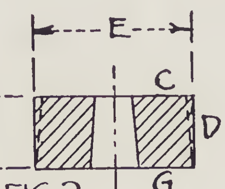



FIG 3

SECTION AB.

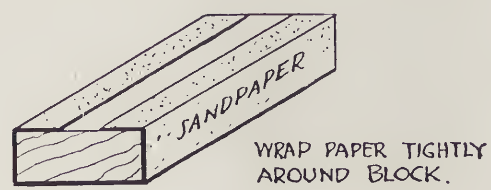



**PLATE 1—JAW FOR STEADY REST**

## PLATE 2

### BEARING CAP

**Instruction.**—Get out a piece of stock in the rough about 5″ or 6″ long, $3\frac{1}{4}$″ wide and $1\frac{3}{4}$″ thick. Plane a working face and edge, gauge and plane to width. (The length and thickness will be taken care of when sawing to outline.) Gauge and square all lines from the working face and edge. Use the knife and gauge for making lines.

**Pattern.**—Fig. 1.

1. Square center line $AB$ on working face and sides.
2. Gauge center line $CD$ on both sides.
3. Strike radius $E$ and $F$ on both sides.
4. Square radius $E$ upon the working face and square lines $GH$, $IJ$, $LM$, and $NO$ across the working face. (Do not forget to allow for finish on $LM$ and $NO$.)
5. Gauge lines $PQ$ and strike radius $R$ tangent with $PQ$ and radius $F$.
6. Mark center lines $S$ and $T$ on both sides so as to locate Babbitt core print.
7. Mark center lines of lugs.
8. Saw on band saw (close to line); place in vise and pare to line.

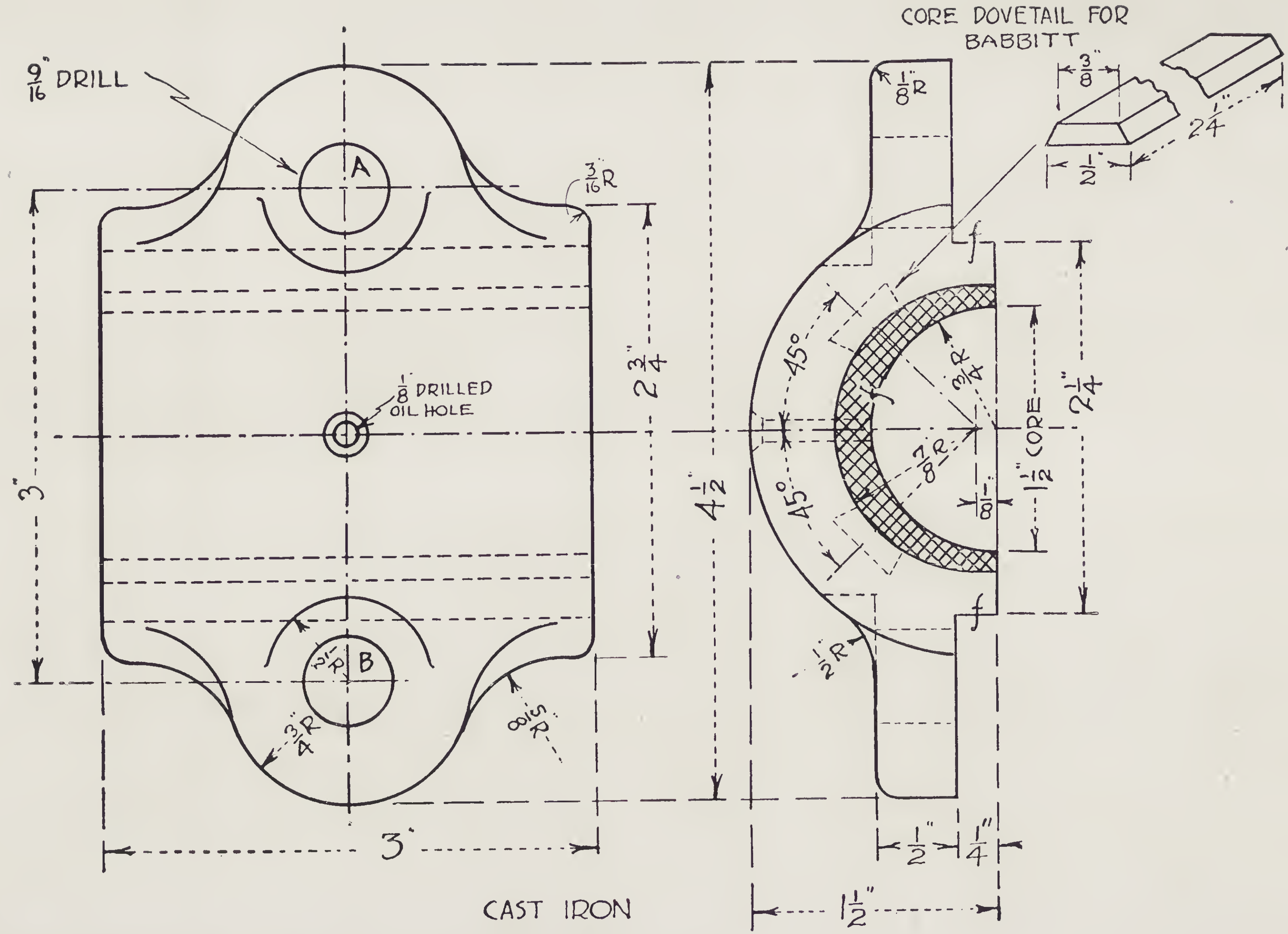
Fig. 2.

1. Transfer center lines of lugs from face side to opposite side and lay out lugs.
2. Saw out on band saw
3. Place on a cutting board (face side down) and pare to line.
4. Strike radius for bolt head clearance and pare out as shown in drawings (avoid back draft).
5. Gauge lines $AB$ around lugs allowing about $\frac{1}{16}$″ draft at $C$ and $D$. (A $\frac{1}{16}$″ draft along this surface will facilitate the lifting of the cope and will not affect the shape of the casting because it is to be machined afterwards.) Saw out and pare to line.
6. Round the edges where shown in the drawing.
7. Place in vise and sandpaper, using cylinder block on semicircle.

**Core Print.**—Fig. 3. Get out stock long enough for two prints. Plane to width and thickness, gauge width of print at top and bevel to line. Next, cut to length and bevel ends same as sides.

**Core Box.**—Fig. 4. The inside dimensions of the core-box are important. The core will not go in place if it is larger than the cavity made by the core print. The outside dimensions are left to the judgment of the pattern-maker.

**Cross-section of Mold.**—Fig. 5. The function of the loose pieces on a pattern is illustrated here. These are held in place by loose pins which are removed after the sand has been tamped around the loose pieces. Note that the distance between $AB$ is greater than $CD$. It is therefore necessary that these prints lift with the cope and be removed afterwards.




NOTE — Allow 1/16" finish where "f" appears. Disregard holes A and B. Machine shop will drill these.

**PLATE 2—BEARING CAP**

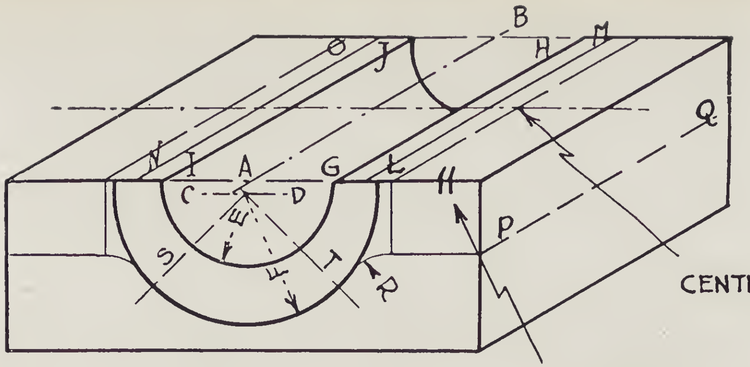



FIG 1

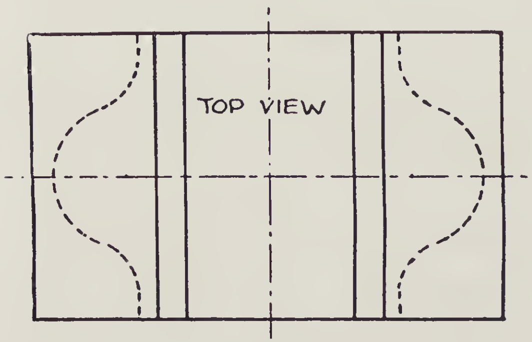
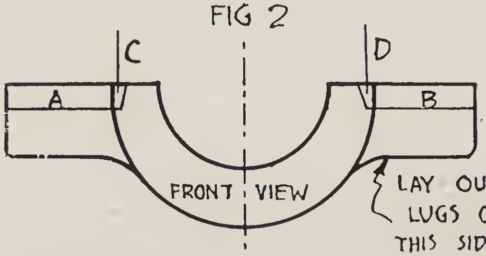



FIG 2



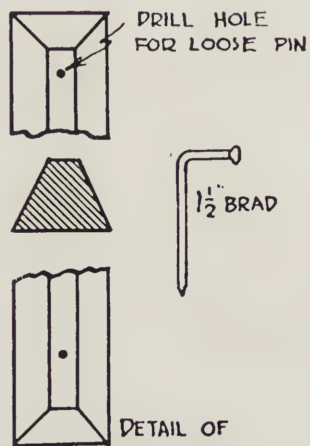




FIG. 3

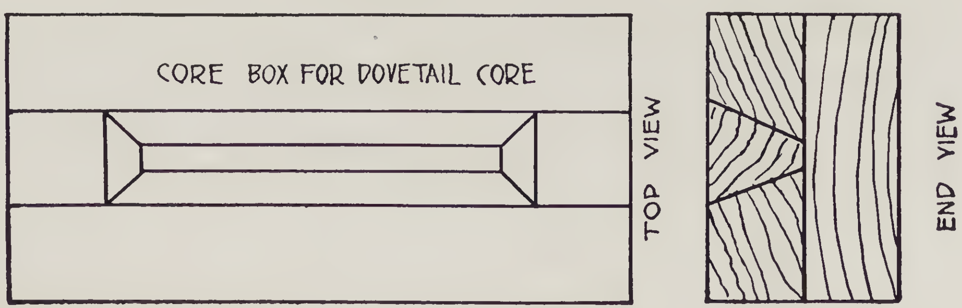



FIG. 4

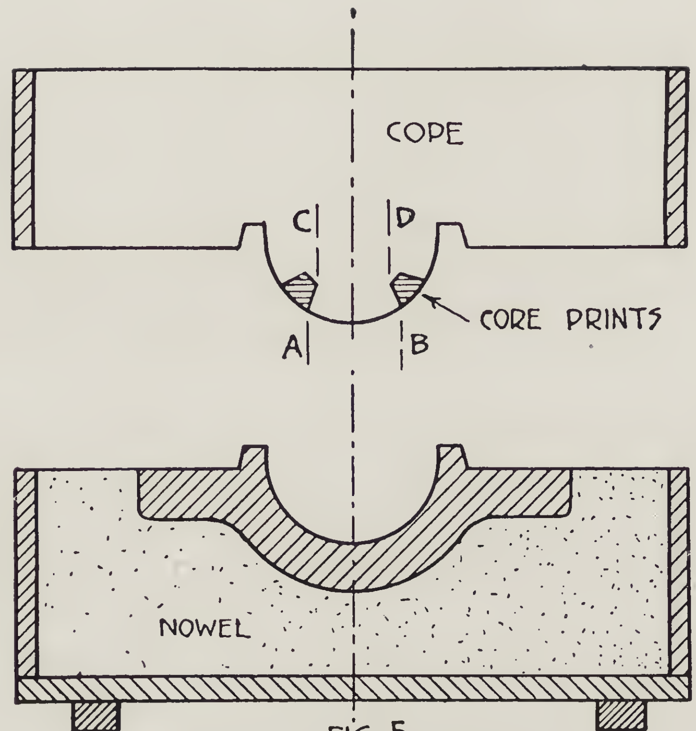



FIG 5

CROSS SECTION OF THE MOLD

# PLATE 3

## SMALL CYLINDER PATTERNS

Figs. 1, 3 and 4 illustrate three different types of patterns that may be used to produce the casting *A*.

Fig. 1 illustrates a split pattern (split through *AB*) molded horizontally. For certain kinds of castings this type of pattern is desirable because it is easily molded and does not require a very deep flask. But for bushings, glands, piston rings and similar castings this type of pattern does not produce the best results.

For example (Fig. 2), when the metal is poured it first settles at *A* and rises as indicated by the arrows. If there is any dirt in the mold it will float on top of the mold and perhaps lodge at *CD*. The dirt may not " clean out " when the casting is finished, thus causing a flaw. The metal also cools a little as it rises and does not unite as well as it would if poured vertically.

Fig. 3 illustrates how a pattern would be constructed if it were to leave its own core. But if the pattern-maker decides that the depth of the core is too great for the diameter or that there is a liability of the core breaking away when the pattern is removed or of being cut when the metal is poured, a dry sand core should be used as shown in Fig. 4.

When pouring (Figs. 3 and 4) the metal forms a complete circle as it rises, thus uniting perfectly. A flaw on the top edge would be less serious than on the sides.

Some foundry men prefer a split pattern, but when the casting is poured the flask is tilted at an angle, thereby obtaining practically the same results as if poured vertically.

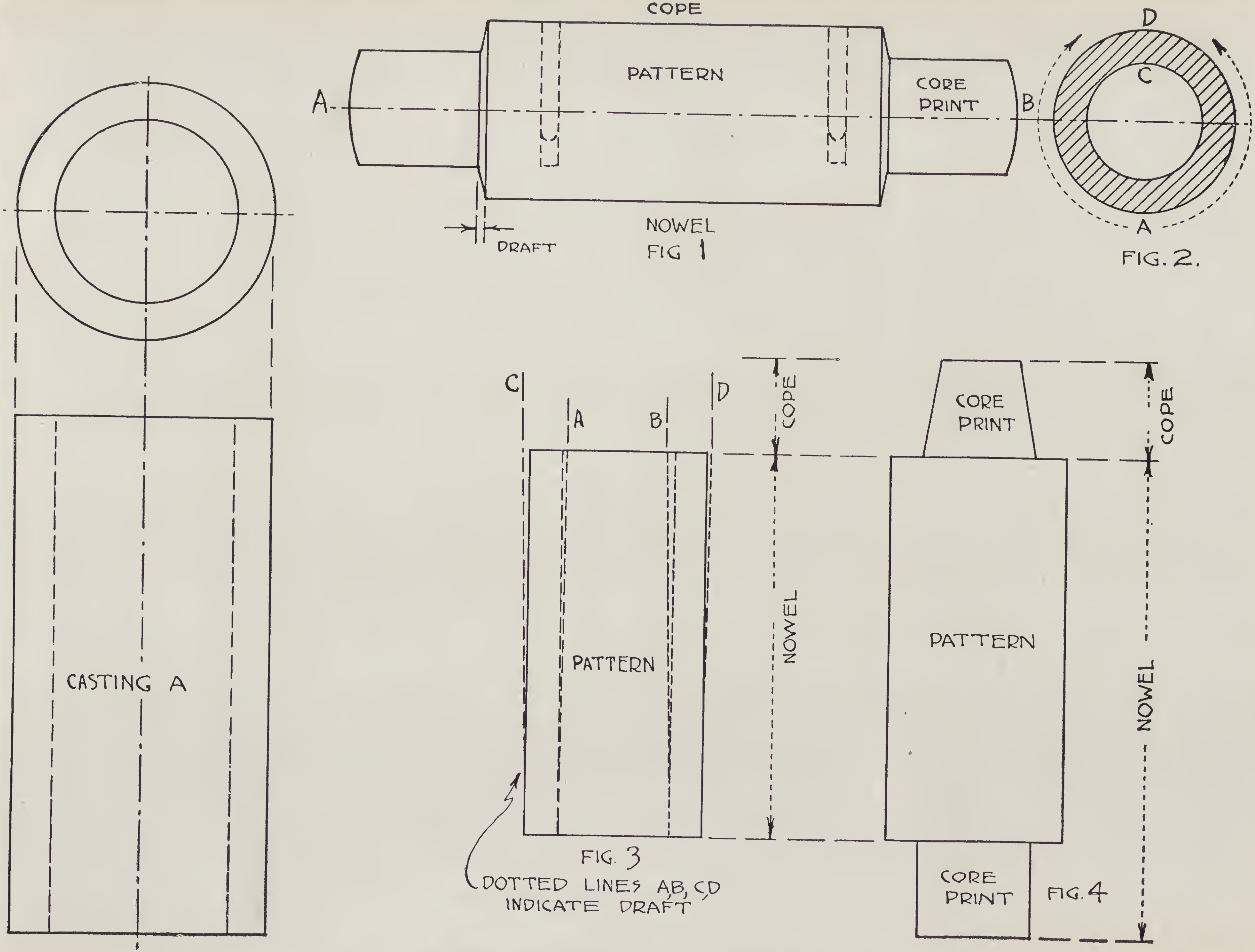



**PLATE 3—SMALL CYLINDER PATTERNS**

# PLATE 4

## SHAFT COUPLING

Fig. 1 shows a drawing of the finished casting. $\frac{1}{8}''$ finish is to be allowed on the bore. This means $\frac{1}{8}''$ on each side of the diameter or $\frac{1}{4}''$ less than the finished size.

This is a simple form of a split pattern parted along the line $AB$ (Fig. 2).

Figs. 9 and 10 are cross-sections of molds. Fig. 9 illustrates the advantage of a split pattern. The nowel half of the pattern is "rammed up" with the joint of the pattern resting on the molding board. This forms the joint of the mold and when turned over the cope half of the pattern is placed upon the nowel half and molded.

Fig. 10 illustrates a solid pattern and shows how the molder is obliged to cut down to the center of the pattern in forming a joint for the cope.

Figs. 3, 4, and 5 show different methods of holding two pieces of wood together while turning. Fig. 3, corrugated fasteners; Fig. 4, screws; Fig. 5, pinch dogs.

Lines $AB$ and $CD$ in Fig. 3 are gauged on both ends from the joint of the pattern. These serve to indicate if the pattern is properly centered.

Some patterns must be split exactly into halves. In such cases, turn the ends first, stopping the lathe after a short time to see if an equal amount of stock is above $AB$ and $CD$. If this condition does not exist an adjustment must be made.

**Instructions.**—Get out two pieces of stock in the rough $11'' \times 3\frac{1}{4}'' \times 1\frac{5}{8}''$.

1. True up the joint of both pieces and fasten together temporarily.
2. Bore for dowel pins as shown in Fig. 2 keeping pin $F$ in further from the end than $E$. This prevents the molder from misplacing the halves when putting them together.
3. Round the ends of the pins and drive them in place.
4. Take the halves apart and see that they separate freely and easily. If this condition does not prevail when the mold is made, the cope half of the pattern may not lift with the cope.
5. Gauge lines $AB$ and $CD$ (Fig. 3). Place together again and fasten.
6. Turn to largest diameter. To do this set the calipers to size and with the parting tool make several cuts along the length about $1\frac{1}{4}''$ apart. Cut out between these grooves using the gouge and finish with flat chisel.
7. Fig. 6. Set dividers to length and mark lines $AB$ and $CD$.
8. Fig. 7. Set calipers to diameter of core print and with parting tool make cuts $AB$, $CD$, $EF$ and $GH$. Keep $CD$ and $EF$ about $\frac{1}{32}''$ away from the line to allow for the draft. Make the print from $1''$ to $1\frac{1}{4}''$ long.

## PLATE 4—Continued

9. Finish turning as shown by Fig. 8.

Sandpaper and shellac.

Use block when sandpapering.

Do not shellac when lathe is running.

The part of the pattern to be orange color should be shellacked first.

When the shellac is dry, sandpaper in the lathe using a very fine grade. Sandpaper orange part first.

Trim ends of prints and shellac outline of core on the *nowel* half of the pattern. This indicates the shape of the cavity in the casting to the molders.

A stock core may be used for a center core.

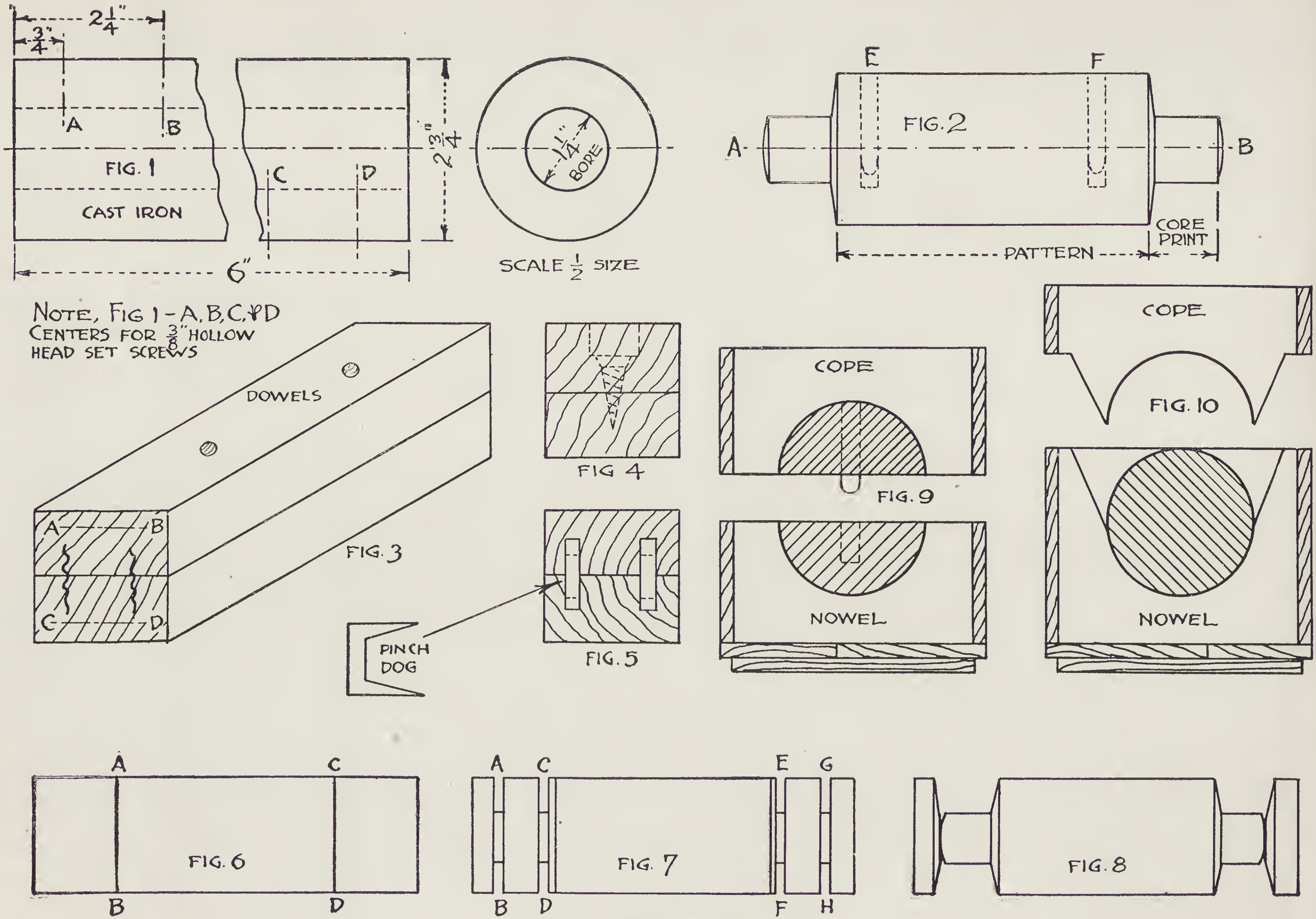



**PLATE 4—SHAFT COUPLING**

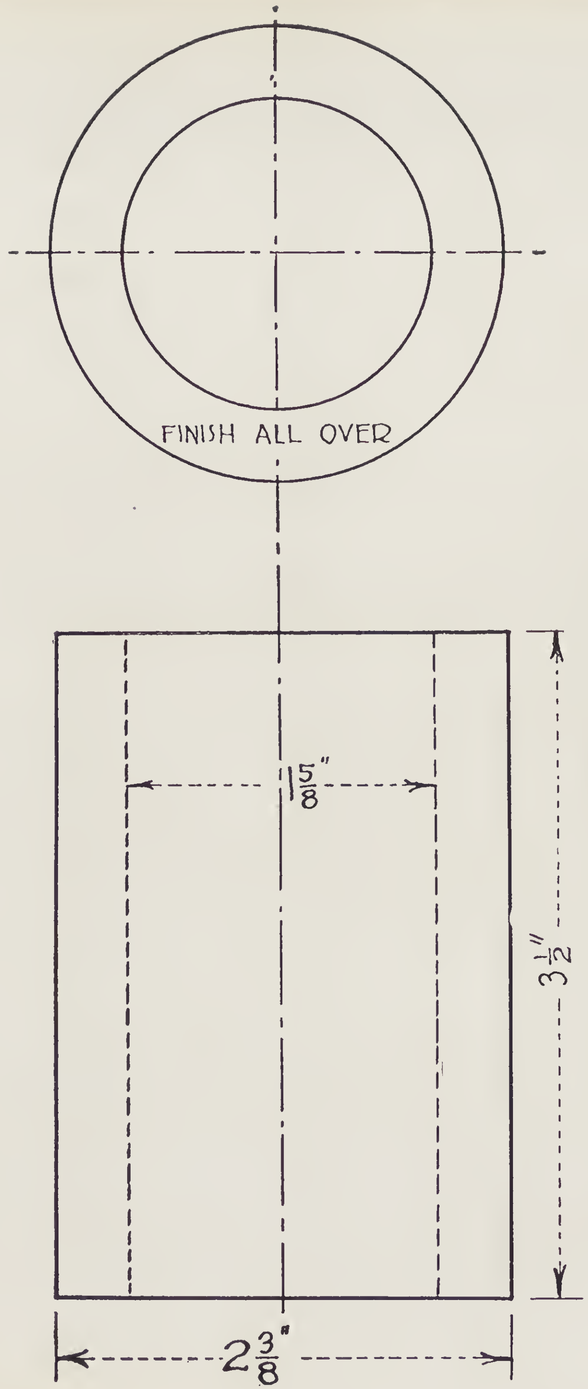
# PLATE 5

## BRONZE BUSHING

It might be decided in actual practice that the pattern for the bushing shown on Plate 5 be required to leave its own core. If such a decision as this should be made it might be rather difficult to turn the center hole straight with the proper amount of taper or draft unless an improved lathe were available. This may be accomplished, however, by the following method:

**Instructions.**—Fig. 1. Get out two half pieces of stock a little larger than the required sizes of the finished pattern. Plane the working face and edge and gauge a center line *AB* on both pieces. On one end draw the semi-circumference *CD*, allowing for finish. On the opposite end draw a smaller semi-circumference *EF*, allowing about $\frac{3}{64}''$ for draft. Draw lines on the working faces connecting these semi-circumferences. Plane out to line, sand paper and glue the halves together.

Fig. 2. When the glue is hard, turn an arbor to fit the hole. Slip the pattern block over the arbor and turn the outside diameter. Note that *AB* is the larger diameter of the hole and *CD* the small outer diameter of the pattern.



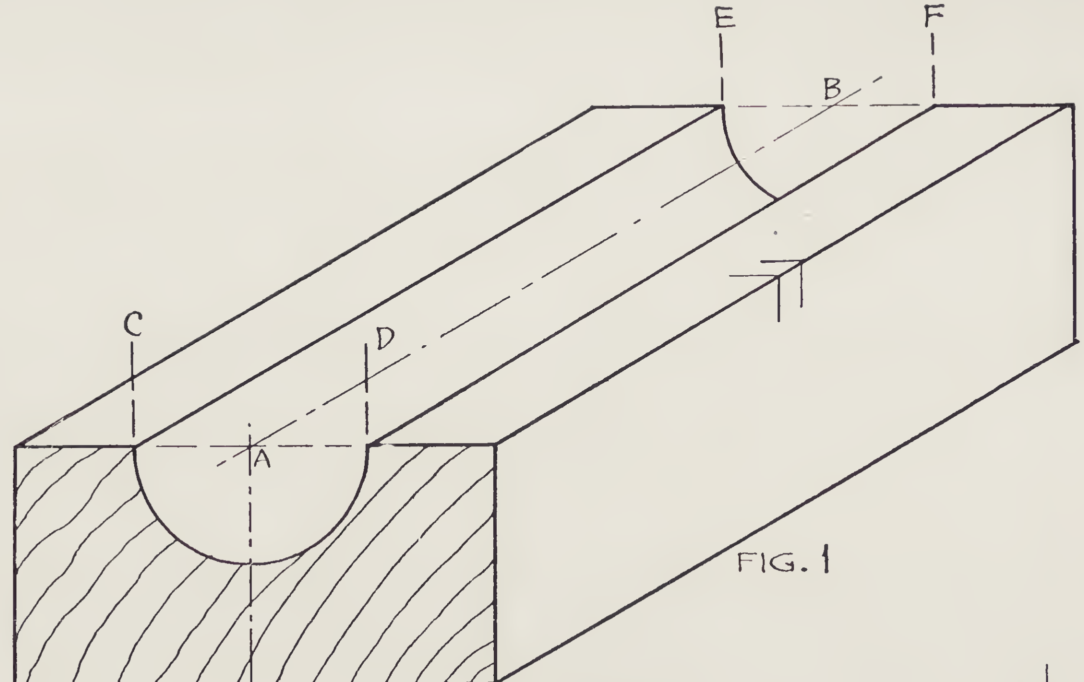




FIG. 1

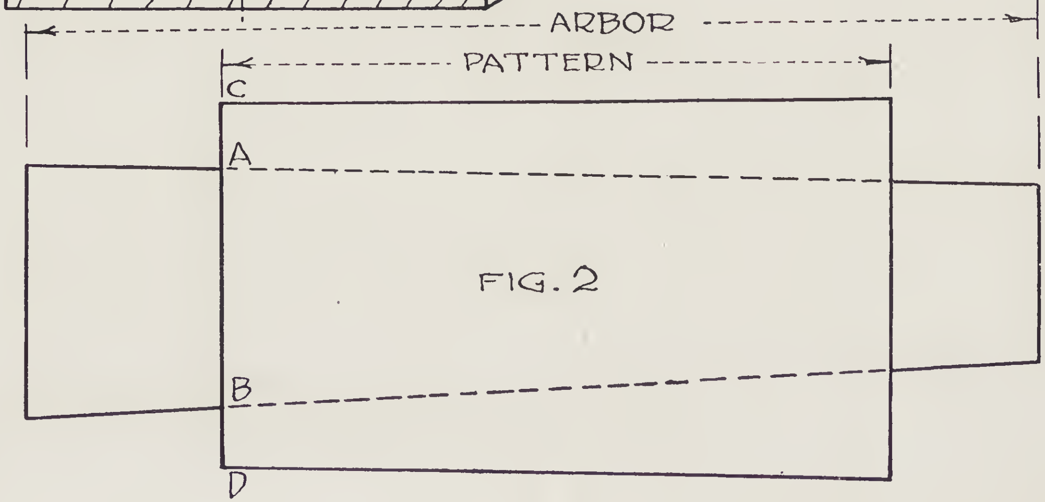



FIG. 2

**PLATE 5—BRONZE BUSHING**

# PLATE 6

## CLUTCH THIMBLE

Fig. 1 shows a pattern-maker's layout. This is introduced here to enable the student to become familiar with the general practice employed so as to be able to apply the principle on more complicated work. There are several reasons why the application is necessary. One would be because the drawing is greatly simplified. The pattern-maker draws only such lines as are necessary for his information. In many cases several different views have to be laid out. Secondly, most patterns and core boxes are made up in sections which, when joined together form the complete whole. Therefore to insure exact dimensions over all, the joints or section lines are drawn on the layout and each piece made up to the proper mark. Thirdly, some castings because of their design require a different shrinkage allowance through one section than another. To avoid any possible chance for error the usual practice is to lay out to the finished sizes first and then add on the finish. All layouts should be made on a board, using the shrinkage rule. All lines should be cut into the board with a knife and gauge, the lines should then be penciled in with a sharp chisel edge pencil.

The finish is usually designated by filling in the space between the casting line and finish line with some colored crayon. The outline should be shellacked to keep it clean.

Note: When making the layout (Fig. 1) consider diameter of center hole ($1\frac{33}{64}$) as $1\frac{1}{2}''$. When finish is allowed it is not necessary to hold to such fine dimensions.

**Instructions.**—Get out two pieces of stock in the rough $11'' \times 4\frac{1}{4}'' \times 2\frac{1}{8}''$. If thick stock is not available use "glued up" stock. It would be worth the experience to glue up the stock. Proceed as in Plate 4 to get the stock ready for turning.

1. Turn (Fig. 2) to largest diameter (a smooth cut long enough to take in *CD* is all that is required).
2. Set dividers and mark length *AB*.
3. Mark *AC* and *BD*.
4. Mark *AE* and *BF*.
5. Mark *AG* and *BH*.

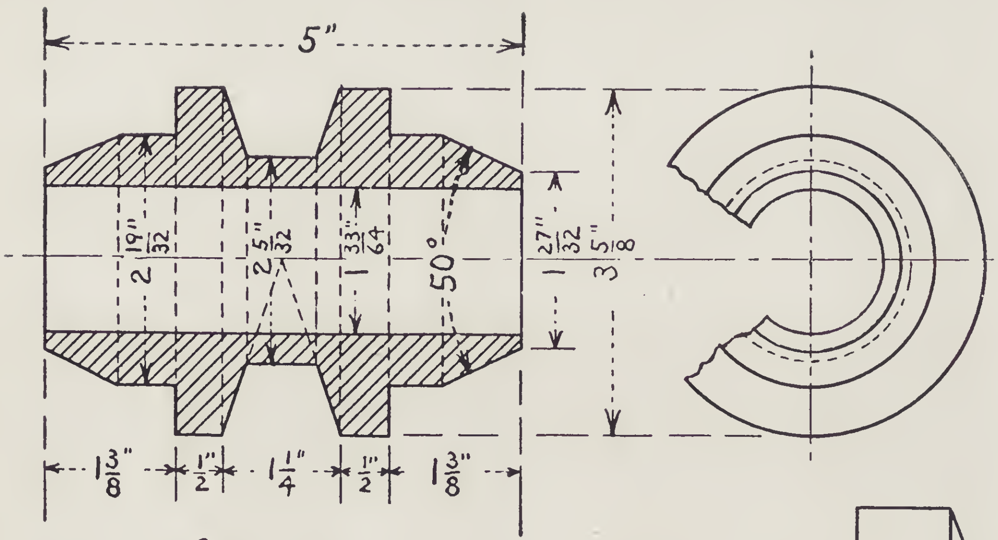
   Greater accuracy is assured if the above lines are all taken from *A* and *B*.
6. With parting tool cut down along lines *A* and *B* keeping about $\frac{1}{32}''$ away from lines to allow for draft. Do not cut to depth of core print until outline of pattern has been turned, but cut deeply enough on *A* and *B* in order not to lose length *AB*.
7. Set calipers to diameter *J* and with parting tool cut along lines *G* and *H*.
8. Set calipers to diameter *I* and cut along *C* and *D* keeping $\frac{1}{32}''$ away from line to allow for draft. Make the second cut with same diameter further out toward tapered end.
9. Turn out between *G* and *H*, *A* and *C*, *B* and *D*.
10. Put on lines *K* and *L* and turn tapered ends.
11. Turn core prints $1\frac{1}{4}''$ diameter and $1\frac{1}{4}''$ long.
12. Turn draft along lines *A* and *B*.

Use block and No. $\frac{1}{2}$ sand paper to finish surfaces. Saw off and trim ends.

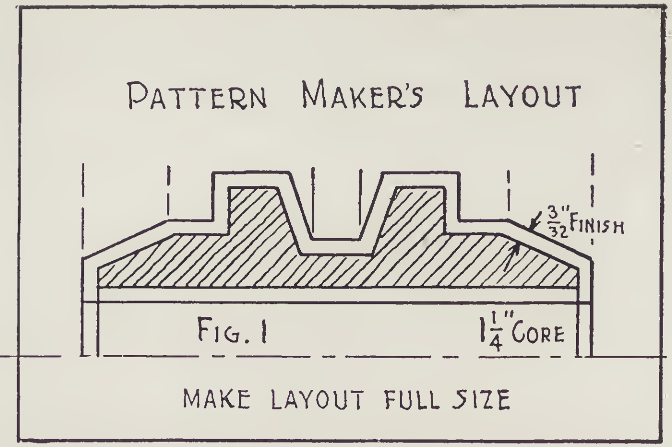
Outline center core on nowel half of pattern.

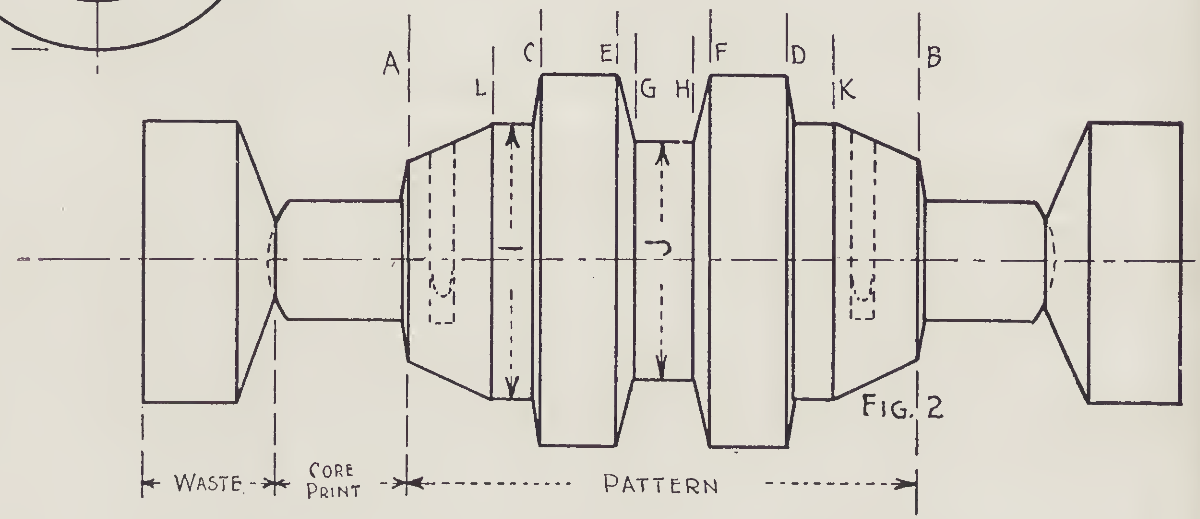
Figs. 3, 4, and 5, show various stages of turning.

Stock core may be used for center core.




CAST IRON
SCALE 1/2 SIZE
FINISH ALL OVER



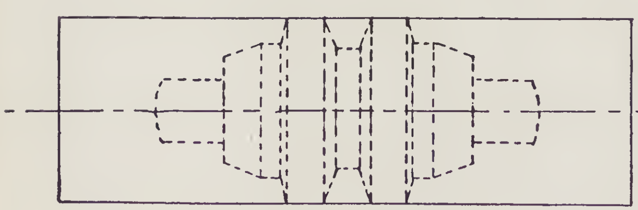



FIG. 3

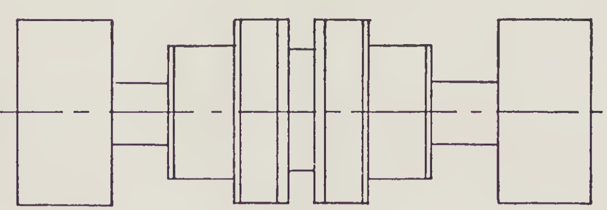


FIG. 4

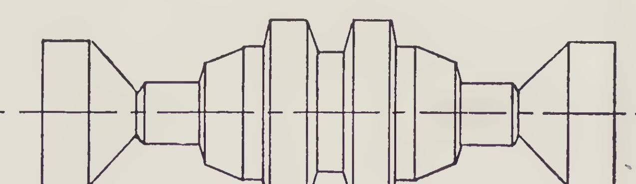


FIG. 5

PLATE 6—CLUTCH THIMBLE

## PLATE 7

### CORE-BOX PLANE

The core-box plane shown on Plate 7 is made by screwing a piece of wood on the side of a $\frac{1}{2}''$ " Rabbet Plane " and at right angles to it, as shown at *A*, Fig. 1 (end view). To make it more rigid glue a three-cornered block as shown at *B* (top view), also a bracket *C* (end view).

Fig. 1 (end view). *A* is made to project about $\frac{1}{32}''$ below the sole of the plane, so that it will come even with the cutting edge of the bit.

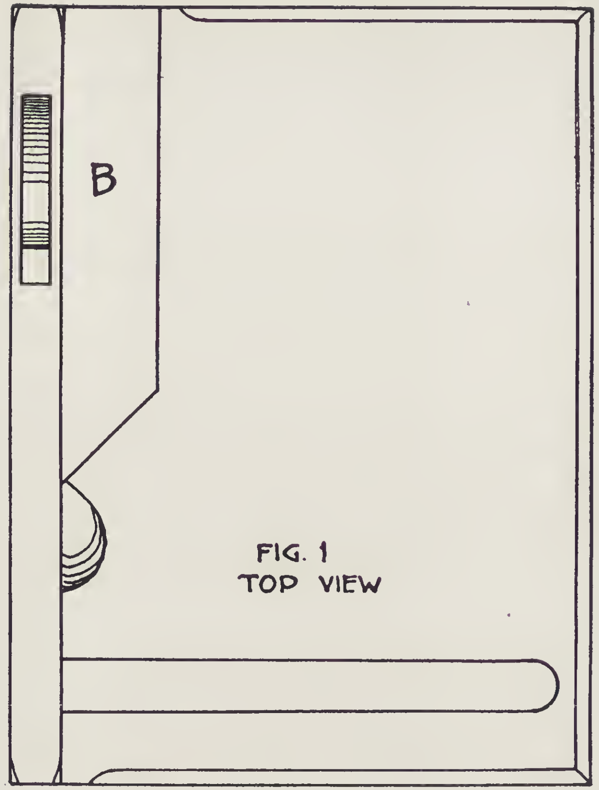
The use of this plane is based on the geometrical theory that the angle inscribed in a semicircle is a right angle.

Fig. 2 shows the end view of a core box. The bulk of the stock can be removed by means of a series of saw cuts followed by the use of a chisel or gouge. Cuts *A* and *B* should not be made over $\frac{1}{32}''$ deep. These serve as a guide when starting to plane out the semicircular surface.

When a saw is not available, the bulk of the stock may be removed with a gouge. In such cases the plane can be started by nailing a thin strip of wood along line *C*, taking one or two cuts, removing it, and then doing the same along line *D*.

Fig. 3. To insure a perfect semicircle, the waste stock must be kept down on both sides so as to allow the sides of the plane to ride on edges *A* and *B*.

A handle is represented in the end view. This is fastened to *B*, Fig. 1. It need not be of any specified shape.



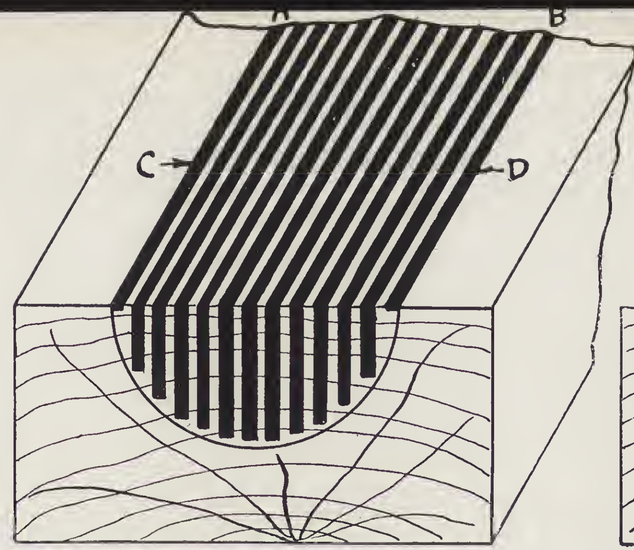




FIG. 2

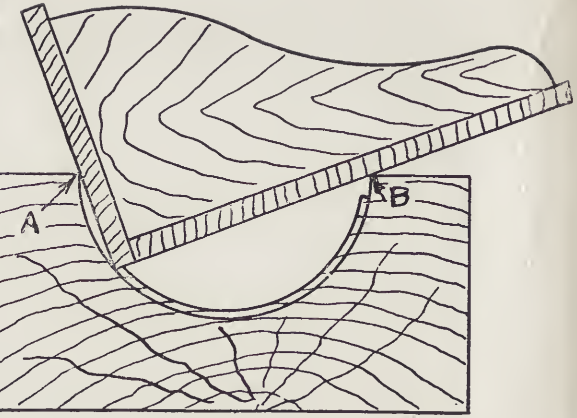
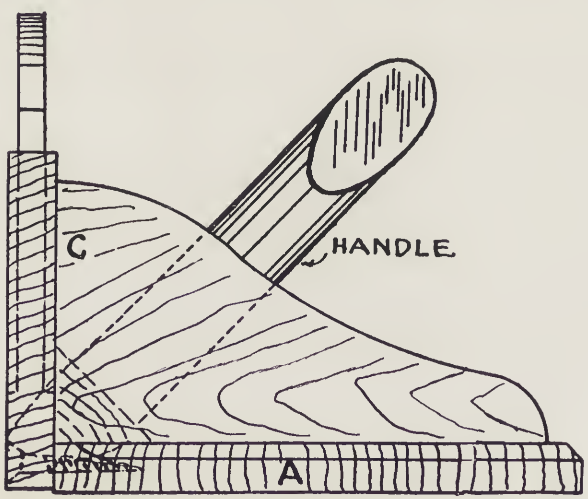



FIG. 3




END VIEW

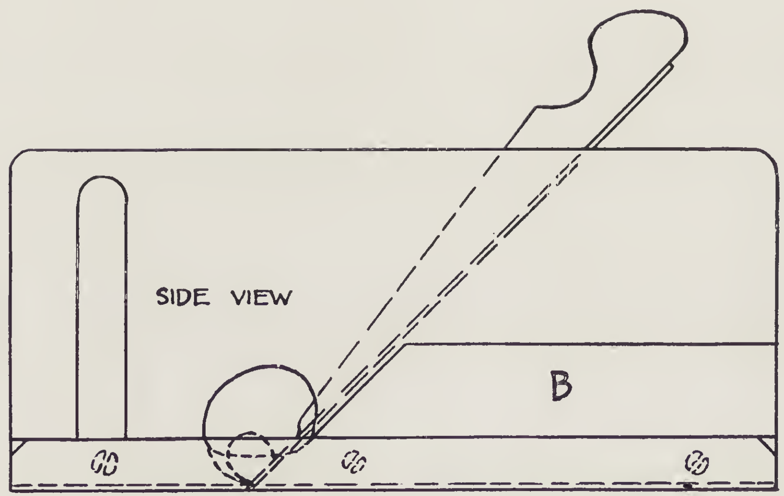



PLATE 7—CORE BOX PLANE

# PLATE 8

## GLAND

The pattern for the gland (Fig. 1) is shown with a cone print on both the cope and nowel sides. A straight print could be used on the nowel side, especially if a stock core is employed. In such cases the molder needs only to file a taper on the cope end of the core. However, it facilitates the setting of the core if it is tapered on the nowel end. The function of a cone print on the cope side is to prevent the sand from crushing when lowering the cope over the core. Fig. 2 shows a cross-section of the mold—drawn to illustrate this point.

A cope print is not necessary when the diameter of the core is sufficient to stand erect and resist the pressure when pouring the metal.

NOTE: Allow $\frac{1}{8}''$ finish all over except around the edge of the oval. $\frac{1}{32}''$ is sufficient here for filing.

### PATTERN

**Instructions.**—Fig. 3. Get out stock thick enough to allow for $\frac{1}{8}''$ finish on both sides.

1. Plane working face and edge.
2. Obtain thickness (the length and width will be taken care of by the outline of the oval).
3. Mark center lines on both sides.
4. Lay out the oval on the face side only.
5. Saw out close to the line, place in the vise and block plane straight parts. Then place on cutting block and pare circular parts. Avoid back draft.

Fig. 4. This is an illustration of the hub or boss. Saw out a piece of stock $3\frac{1}{4}''$ diameter from $2''$ material and have the grain running the same way as in the oval piece. Bore a small hole in the center and fasten it to a screw chuck.

1. Turn to the thickness $A$–$B$.
2. Set dividers to the radius $C$, allowing $\frac{1}{8}''$ for finish. With the lathe running, describe the circle.
3. Swing tool rest around parallel to the axis of the boss and turn the diameter and the fillet. Make the diameter of the boss at $D$ about $\frac{1}{32}''$ larger for draft.

Fig. 5. To turn the prints "get out" a piece of stock about $4''$ or $5''$ long and $1\frac{1}{4}''$ to $1\frac{1}{2}''$ square.

To fasten the boss to the oval part of the pattern describe a circumference on the face side of the oval equal to the diameter $E$ of the boss. Toe nail it in the proper position, then remove it and apply a little glue, replace it using the old nail holes as guides and drive two $2''$ brads from the opposite side as shown in Fig. 3. Next, bore holes for the prints. After shellacking the pattern, the nowel print may be glued in but leave the cope print loose for the convenience of the molder.

### CORE BOX

Fig. 6 shows a half-core box to be used when making the center core. Two half cores are made and stuck together.

This box is made in sections. $C$ is the main part, $D$ and $E$ are for the prints and $F$ and $G$ pieces for closing the ends. The inside dimensions of the core box are the important considerations here. The amount of stock allowed beyond that is merely a matter of good judgment. In this case allow from $\frac{3}{4}''$ to $1''$.

Fig. 7 illustrates a method for inscribing a semi-circumference on the ends of *C*. Hold a small block of wood against the face side of *C* and then place one point of the dividers at the proper place on the joint line and swing the semi-circumference. Then gauge distances *C* and *D* along the face side to the opposite end and describe another semi-circumference here in the same manner as before. Place *C* in the vise and pare to the line. Sandpaper, using a circular block.

The print pieces *D* and *E* are made with the grain running at right angles to *AB* and can be turned in the lathe. " True up " the face plate, locate the center, then nail one piece in line with the center. Next, nail on the other piece and turn out the tapered hole. Use two $1\frac{1}{2}''$ brads in each piece. Some pattern-makers prefer to work *D* and *E* out by hand.

To assemble the pieces nail *D* and *E* to *C* using $2''$ brads on each piece, being careful not to split them. About $\frac{1}{2}''$ is enough for the thickness of *F* and *G*.

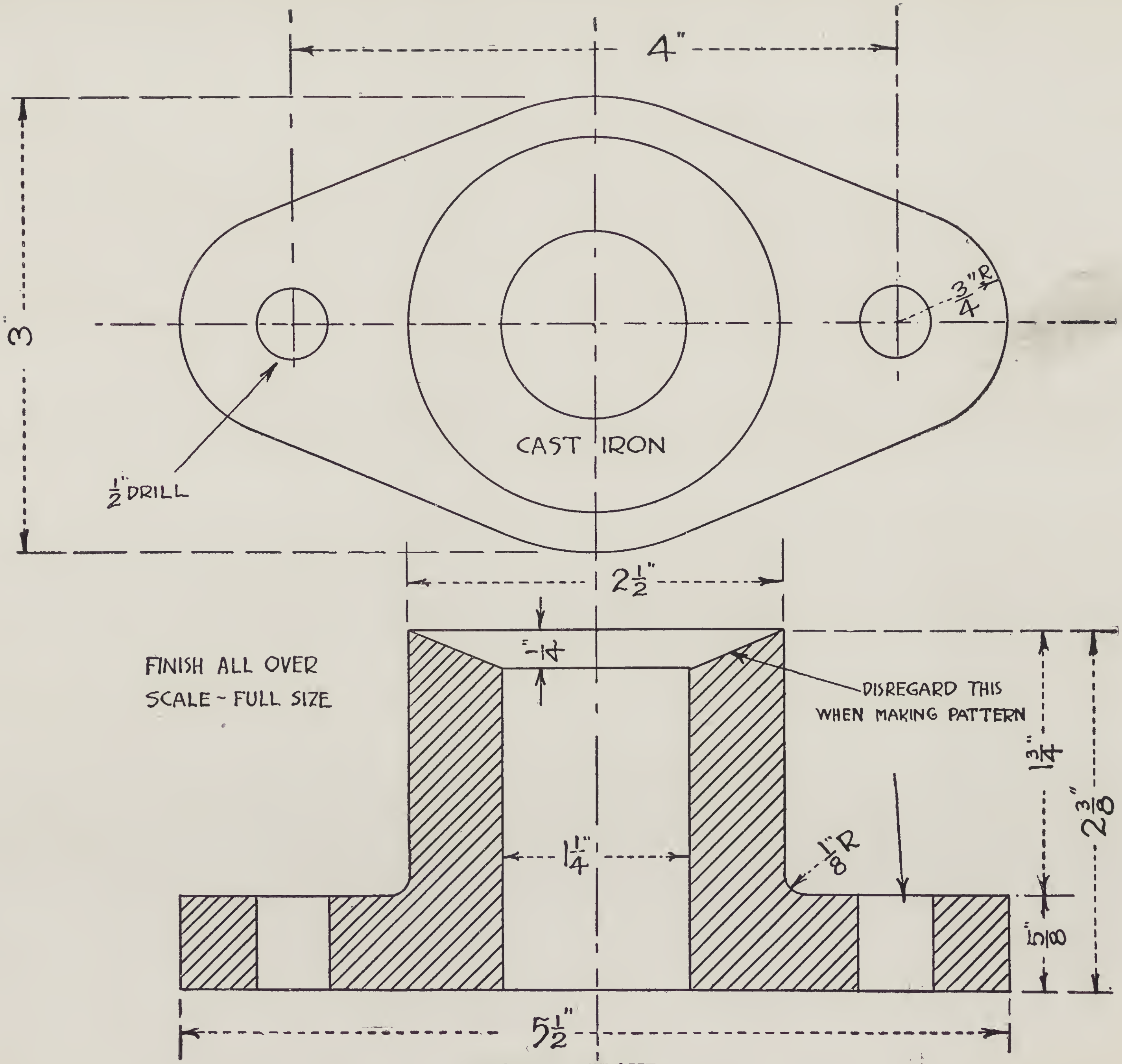



**PLATE 8—GLAND**

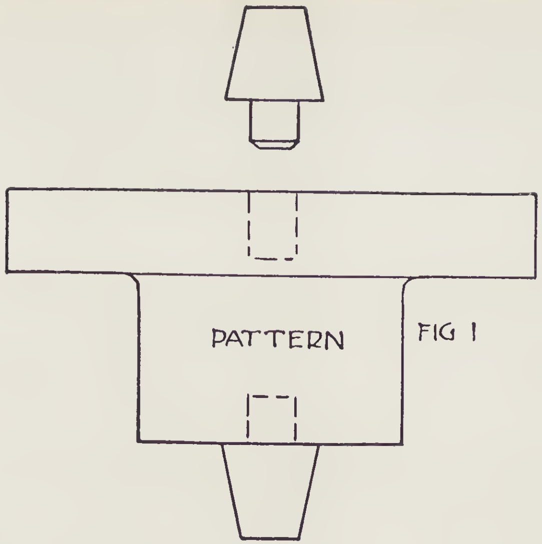



FIG 1

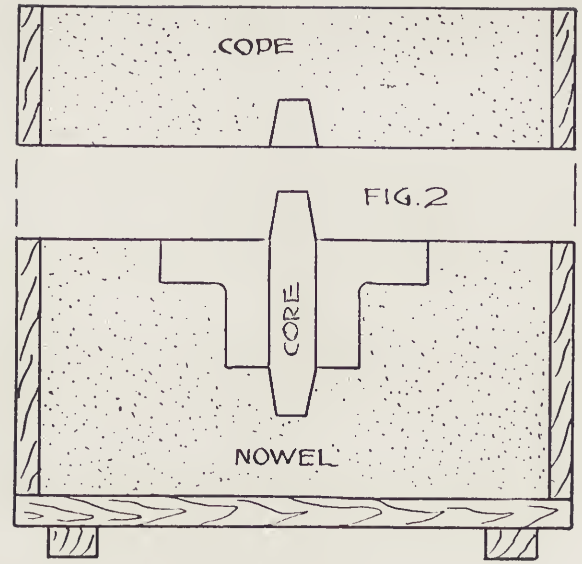



FIG. 2

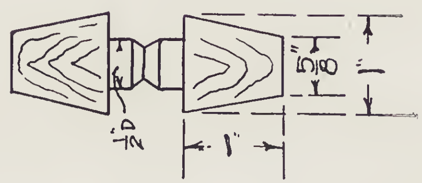



FIG 5

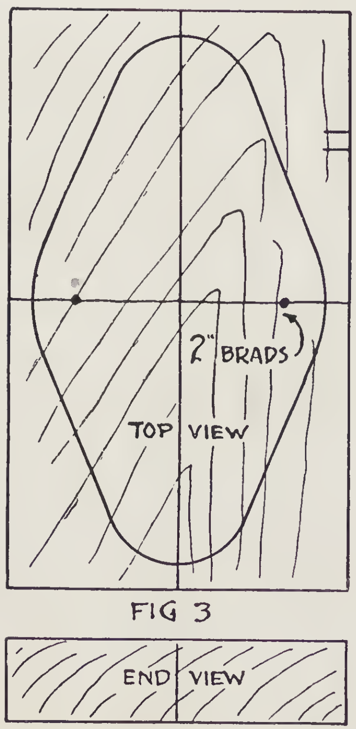



FIG 3

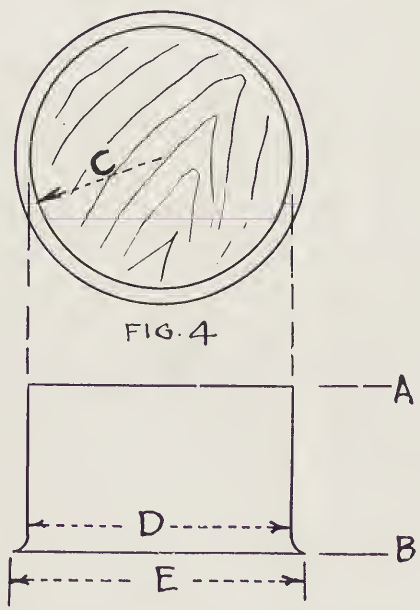



FIG. 4

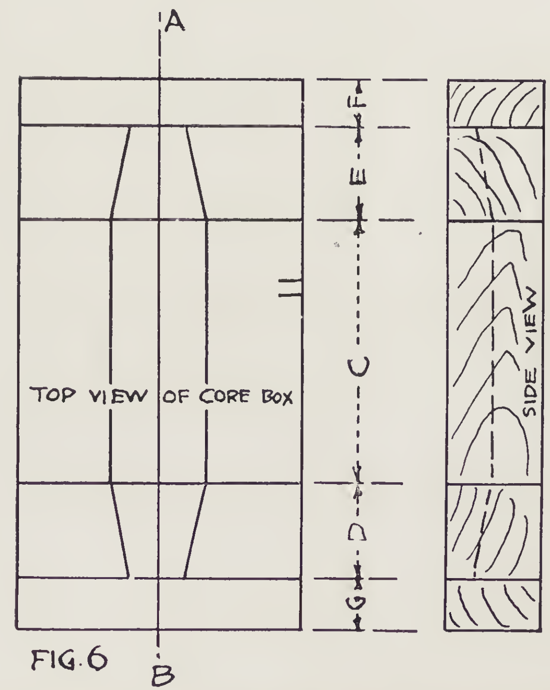



FIG. 6

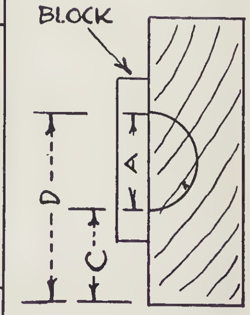



FIG. 7

END VIEW OF C

# PLATE 9

## WALL BRACKET

The pattern of this casting is an illustration of the method used for coring out holes which are located below the parting line of the mold. This type of core print is called a " heel print " or " tail print."

**Instructions.**—Fig. 1 shows the construction of the pattern. About $\frac{1}{32}''$ draft should be allowed on the following parts: the boss should be drawing size at the top and $\frac{1}{16}''$ larger at the bottom, the rib $\frac{5}{32}''$ at the top edge of the flange and $\frac{7}{32}''$ at the bottom or where it meets the web; the flange should be tapered as shown by dotted lines on the end view and on the back side as shown on the side view at *A*.

Fig. 2 shows a detail of the heel print. To make this get out stock long enough for two. Plane to $\frac{13}{16}''$ wide and $\frac{3}{4}''$ thick, gauge center line and mark out the print.

Fig. 3. When a number of such prints are to be made it is more economical to take a piece of stock about 6″ or 8″ wide and then lay out the shape of the prints on both edges and after paring to outline saw up into prints having the desired thickness.

## CORE BOX

Fig. 4 shows the core box parted through *AB*. To make this box proceed as shown in Figs. 5 and 6. Note how the parting is made in Fig. 6. This facilitates the removal of the box from the core. When the box is opened to release the core the distance *AB* serves as draft.

Fig. 7 shows the core in place.

Leather or wax fillets may be used on all internal angles of the pattern. Use a $\frac{1}{4}''$ radius.

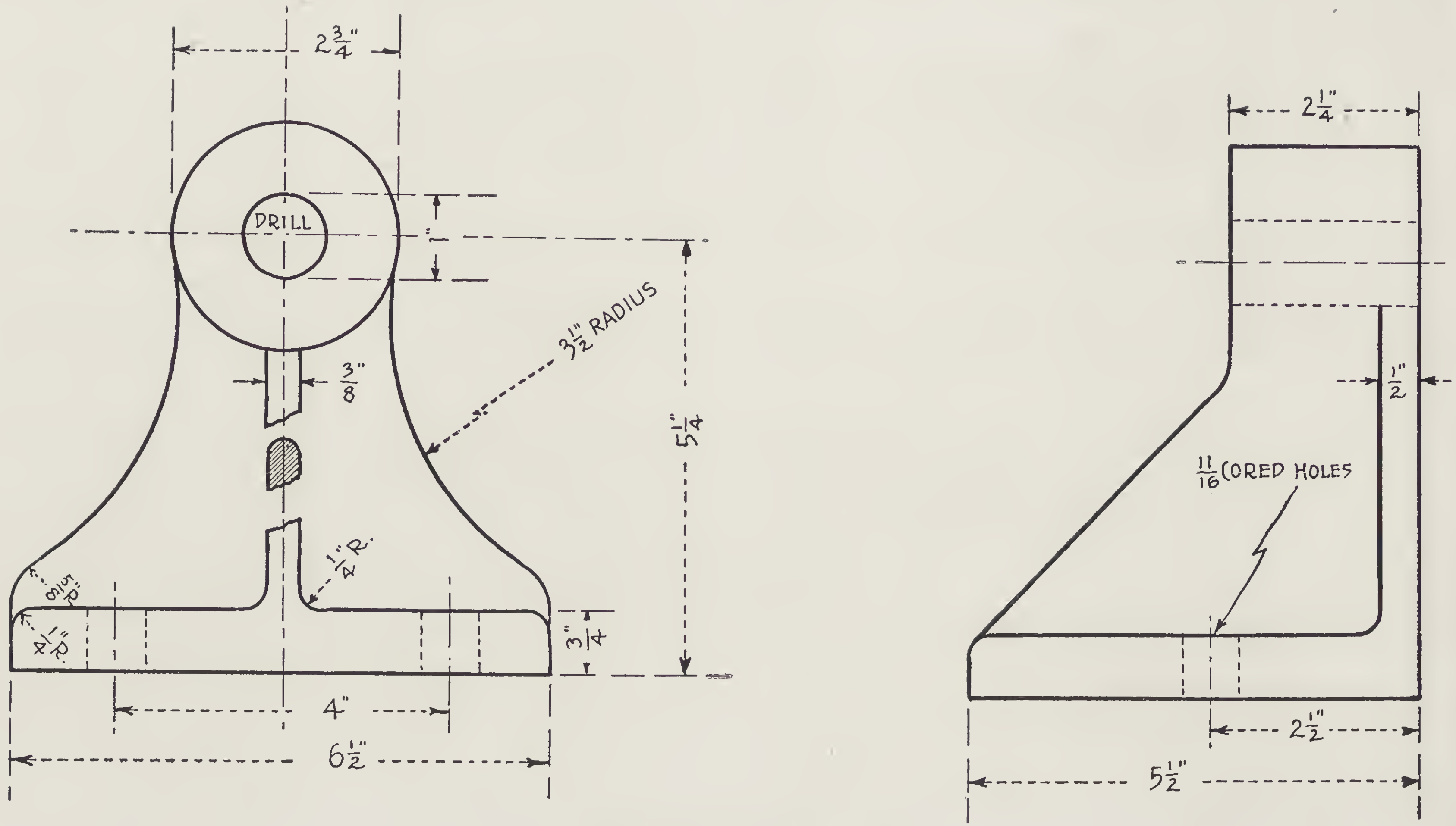



PLATE 9—WALL BRACKET

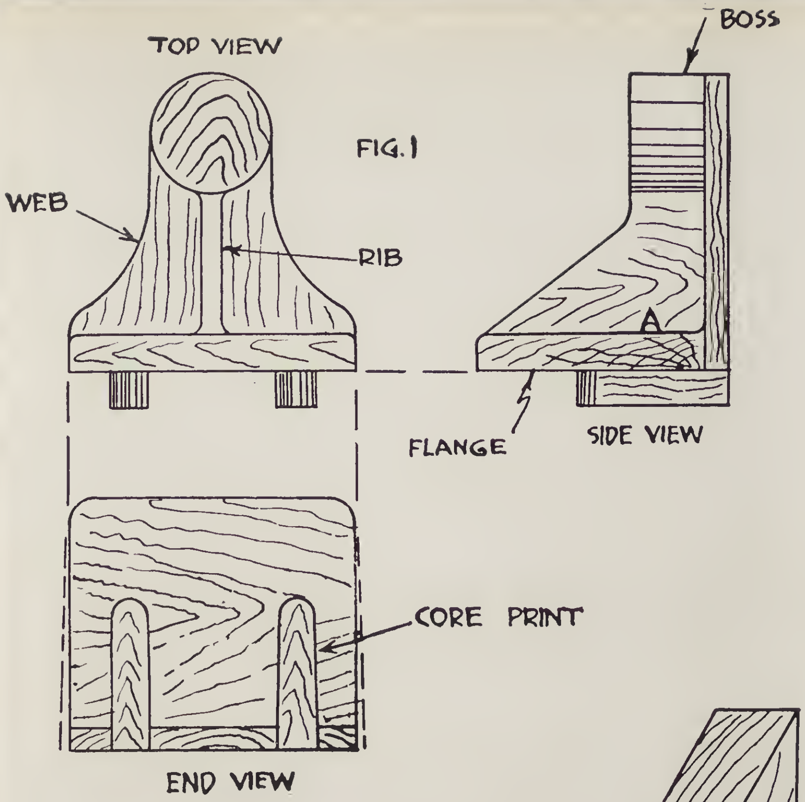


FIG. 1

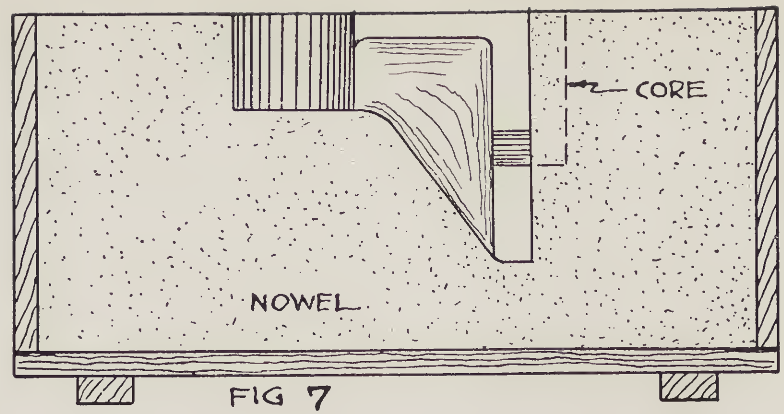


FIG 7

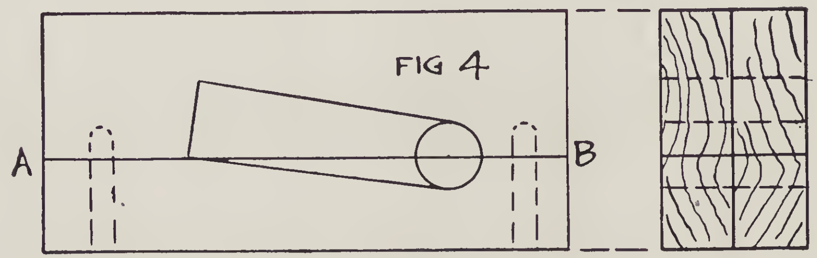
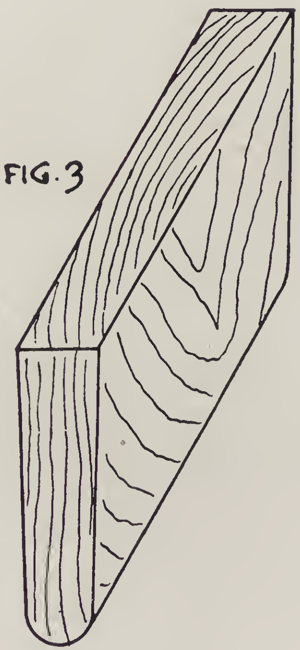


FIG 4

FIG. 3



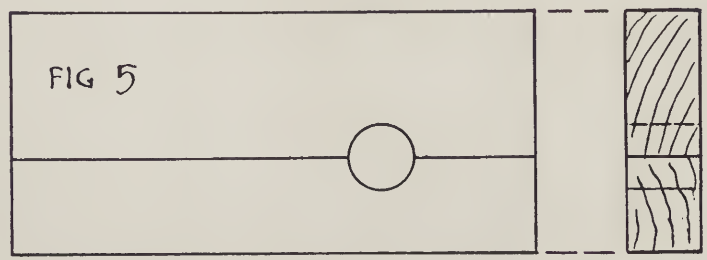
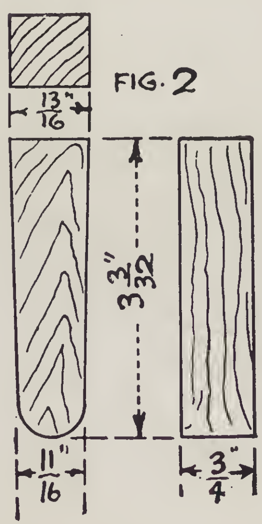


FIG 5

FIG. 2



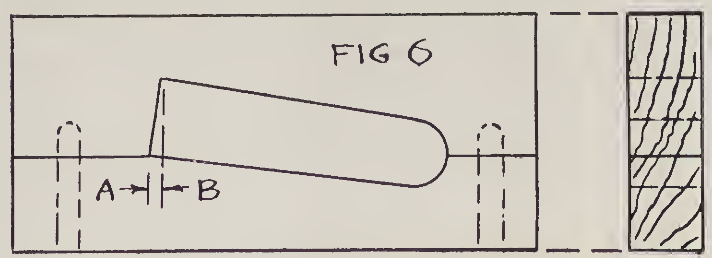



FIG 6

# PLATE 10

## COMPRESSION CHAMBER

Castings similar to the one illustrated on Plate 10 (molded horizontally and allowing a core print at but one end) must have a print of sufficient size to balance or suspend the core in the proper position in the mold. The dimensions of this print must be left to the judgment of the pattern-maker.

Before proceeding with the pattern a layout should be made as shown in Fig. 5. Lines *A*, *B*, *C* and *D* indicate where to make the joints of the core box.

### PATTERN

**Instructions.**—This pattern may be turned by two different methods: Either by means of a templet as shown in Fig. 10; or by observing the following. After the two halves have been doweled and fastened together place them in the lathe (being careful to center accurately) and " true up " both ends to any diameter as shown in Fig. 2 at *A* and *B*. After this has been done separate the halves. Next, determine the true center line on the nowel half and proceed to lay out the pattern as shown in Fig. 3. (Lay out the diameter a little larger ($\frac{1}{32}''$) than required and take all dimensions from the centers *AB* and *CD*, using the knife and dividers for making lines.)

After this has been done, saw to outline, keeping a reasonable amount of stock on the ends to hold the halves together while turning. If in sawing there are places that are not exactly cut to line, pare to the line before placing the nowel part upon the cope, to mark the outline. When sawing out the cope be sure to keep about $\frac{1}{64}''$ away from the line.

Both halves may now be refastened and turned. It is advisable in a case such as this (where the pattern is rather slender, as at *X*, Fig. 1) to put a spot of glue on each half of the pattern with a piece of newspaper in between them. This unites both halves at this point while turning. It can be easily split apart when finished.

Before starting to turn, color along the edge of the nowel half at the joint, using a colored pencil. This will serve to indicate when you have turned to line. Stop the lathe frequently to see where to cut.

### CORE BOX

The core box is made in sections as shown in Fig. 4. The joints are determined on the pattern-maker's layout at *A*, *B*, *C* and *D*, Fig. 5. Each piece should be made exactly to the mark. However, if a slight variation occurs on one piece, offset it by a change on the next.

Note that the grain of the wood on pieces 1, 3 and 5 runs at right angles to the axis *AB* and that on pieces 2 and 4 runs parallel to the axis. There would be too much shrinkage in the wood if the grain in all were in the same direction as 1, 3 and 5.

Figs. 6, 7, 8 and 9 show the details of the core box. To turn 6, 7 and 8 fasten to the face plate at *X*. (9 can be sawed by using the band saw.) Do not have these pieces in halves while turning.

A portion of 6 and half of 7 and 8 will be discarded.

Be sure to plan center lines before cutting.

To assemble 6, 7, 8 and 9 mount them on a piece of board about $\frac{7}{8}''$ thick. Be sure the side of the board upon which they are mounted is perfectly true.

To insure a correct alignment set all pieces to the center line *AB*, Fig. 4. If there should be a slight variation in the width of *DE*, Fig. 4, make the necessary adjustment by planing side *E*.

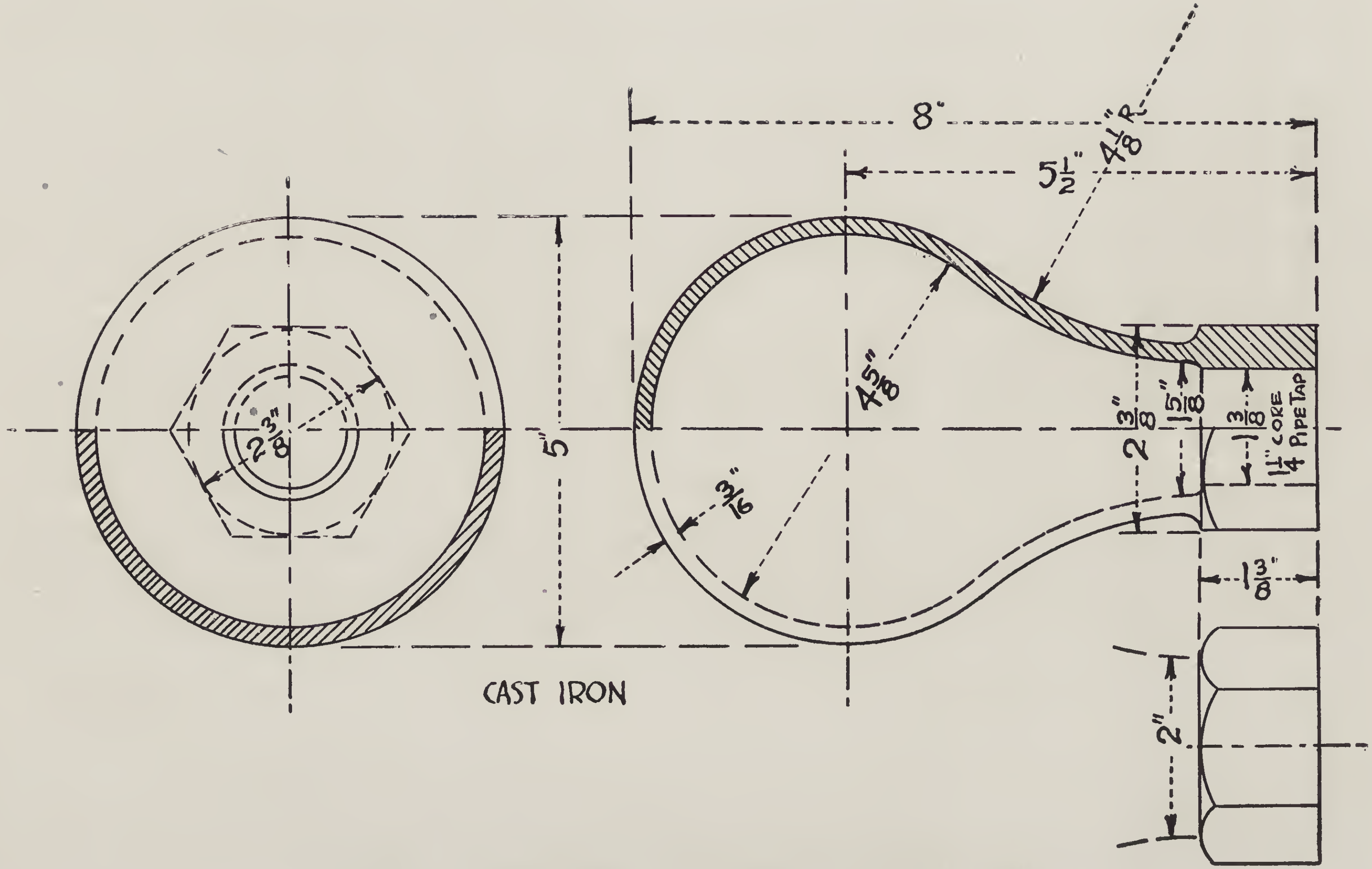



PLATE 10—COMPRESSION CHAMBER FOR STEAM PUMP

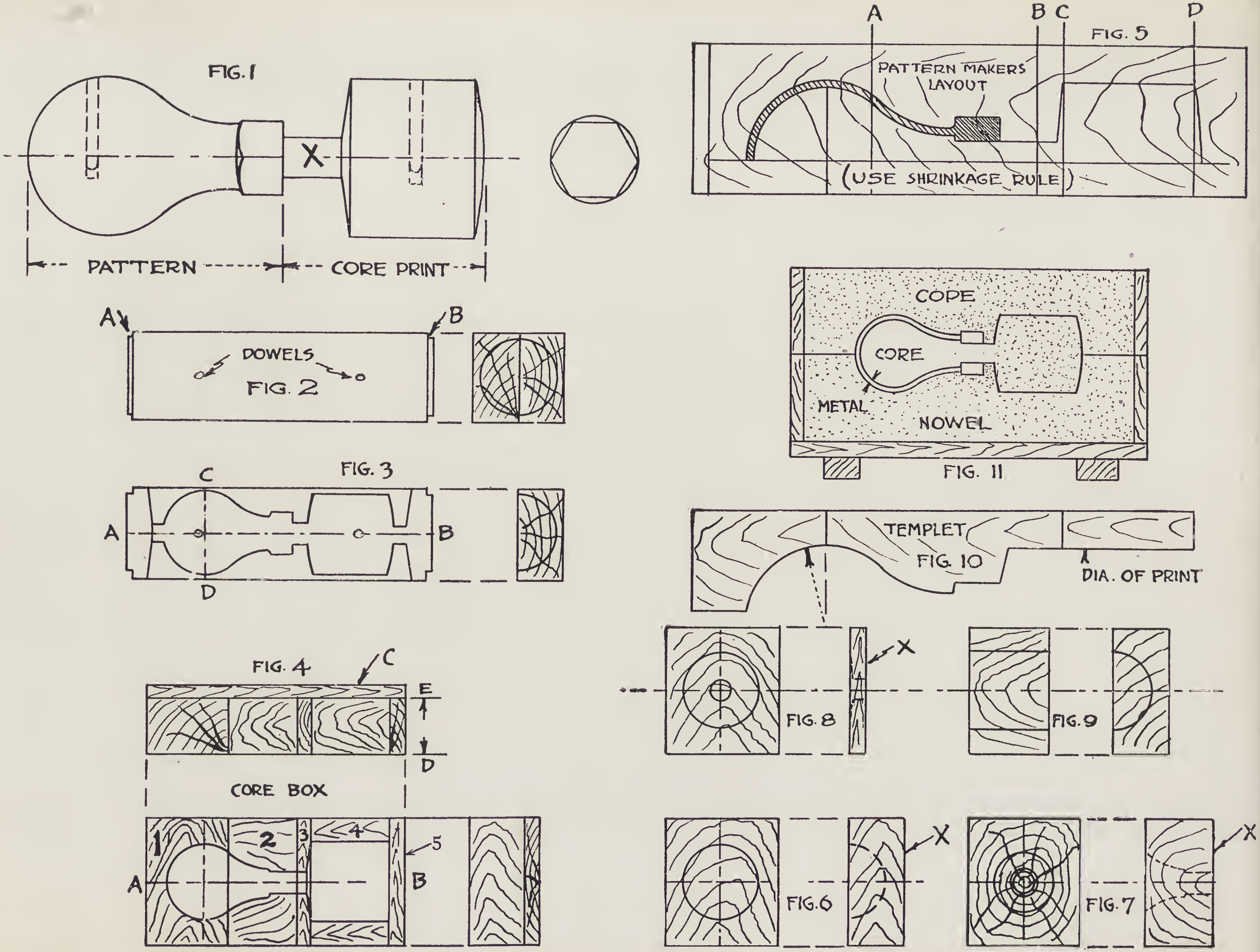


FIG. 1
X
PATTERN
CORE PRINT
FIG. 5
A
B C
D
PATTERN MAKERS
LAYOUT
(USE SHRINKAGE RULE)
A
B
DOWELS
FIG. 2
COPE
CORE
METAL
NOWEL
FIG. 11
FIG. 3
C
A
B
D
TEMPLET
FIG. 10
DIA. OF PRINT
X
FIG. 8
FIG. 9
FIG. 4
C
E
D
CORE BOX
1
2
3
4
5
A
B
FIG. 6
X
FIG. 7
X

# PLATE 11

## ROCKER ARM

The pattern for the rocker arm can be made in several different ways. For the convenience of the molder it would be better to make a split pattern, parted along the line $AB$ (Fig. 1), but this is seldom done unless a large number of castings are to be made. In most shops this would be made a one-piece pattern, causing an irregular parting as shown by line $BC$, Fig. 1.

### PATTERN

**Instructions.**—Fig. 2. Get out a piece of stock $\frac{3}{4}''$ thick and a little longer and wider than required. "True up" a working edge and mark lines $AB$, $CD$ and $EF$ on both sides of the arm. Line $AB$ should be made with the gauge and $CD$ and $EF$ with the square and knife.

After all of the center lines have been drawn lay out the shape of the arm (on one side only) and saw out on the band saw. When sawing, saw to the line but do not pare until the bosses ($D$, $E$, $F$, and $G$, Fig. 1), have been glued on. Figs. 3, 4, and 5, show the details of the bosses. Do not forget to allow $\frac{1}{8}''$ for the finish. The bosses of Figs. 3 and 4 may be sawed out on the band saw and smoothed on the sander or turned out on the lathe. It is hardly worth while to turn the fillets $I$ and $J$ (Fig. 1) because most of it is cut away. A small piece of leather fillet can be glued in where required.

Fig. 5. To obtain the diameters $A$ and $B$ make a layout of that end of the arm as shown in Fig. 6. To turn the bosses get out stock with the grain at right angles to the axis and fasten to a screw chuck.

1. Turn diameter $A$.
2. Measure thickness $C$ and cut in with the parting tool.
3. Describe the circumference having the diameter $B$ and round off the edge of the boss, using the proper radius. Sandpaper and cut off with the parting tool.

Fig. 7 shows a detail of the core print for coring the hole through the large end of the arm. Allow $\frac{1}{8}''$ for finish. This means of course that the diameter of the core print will be $\frac{1}{4}''$ less than the finished hole is to be. The length of this core in proportion to the diameter is hardly great enough to warrant a core print on the cope side. Make the print an inch high and the exact diameter on the small end and $\frac{1}{16}$ larger on the end next to the pattern. Do not fasten the print to the pattern until after it has been shellacked.

**Assembling.**—Now that all of the separate pieces have been made, the next step is to assemble them. Nail and glue the bosses to the main arm. (Nail all pieces with the grain running in the same direction as the main part of the arm.) After this is done the pattern may be "pared up."

Figs. 8 and 9 illustrate a good method for developing oval arms.

1. Lay out a rectangle, to dimensions, at about the center of the arm.
2. Draw an oval.
3. Draw the tangent $AB$ (Fig. 8). This gives distances $A$ and $B$ (Fig. 9). Gauge these lines along the arm and pare to them. This produces an eight-sided figure and gives eight points of the oval as shown in Fig. 9. It is now easy to pare the remaining corners to obtain the oval.

When arms are over a foot in length and taper considerably it is better to make a layout of each end and make a templet for marking the tangent lines along the sides and edges of the arm.

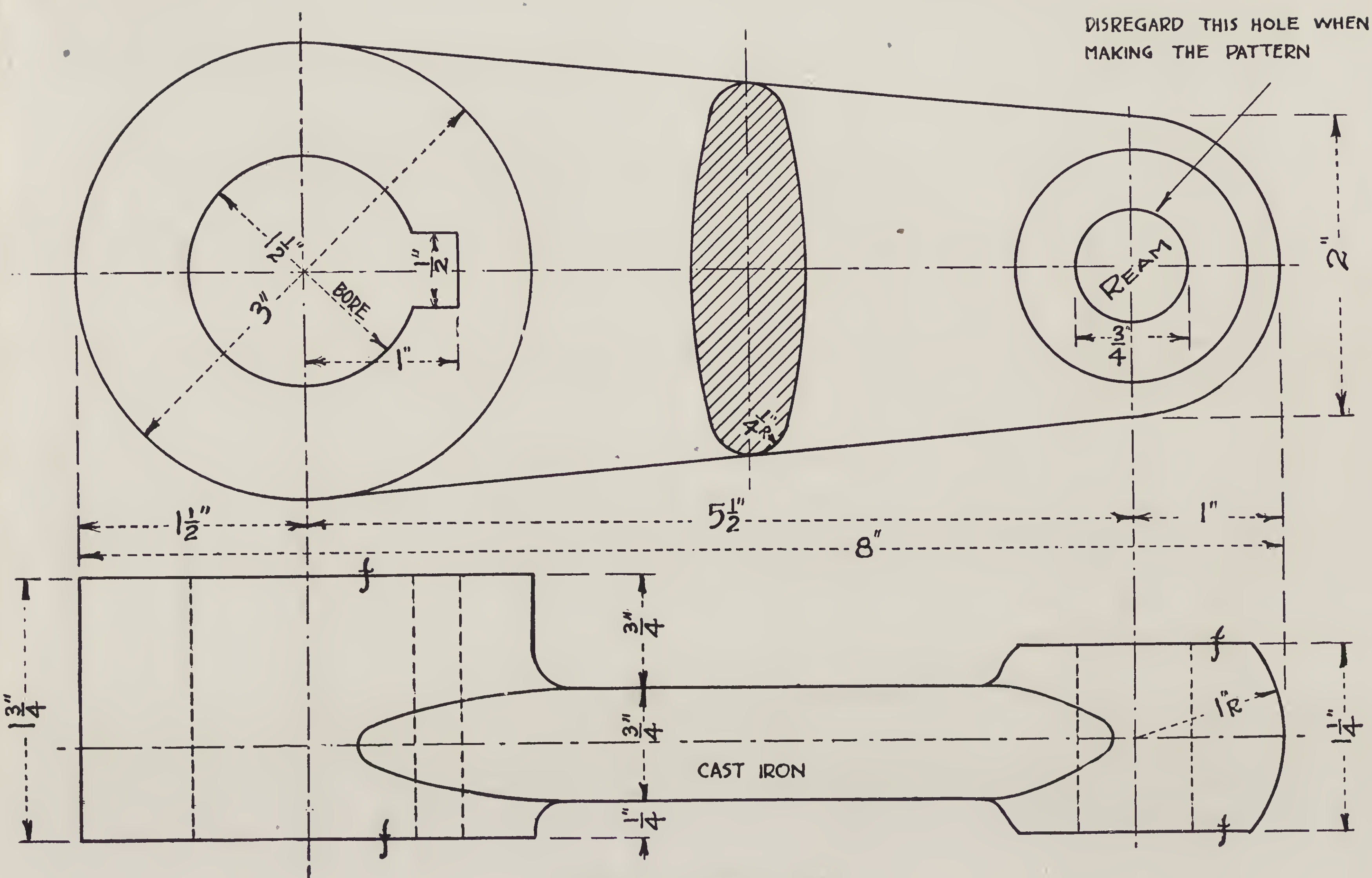



PLATE 11—ROCKER ARM

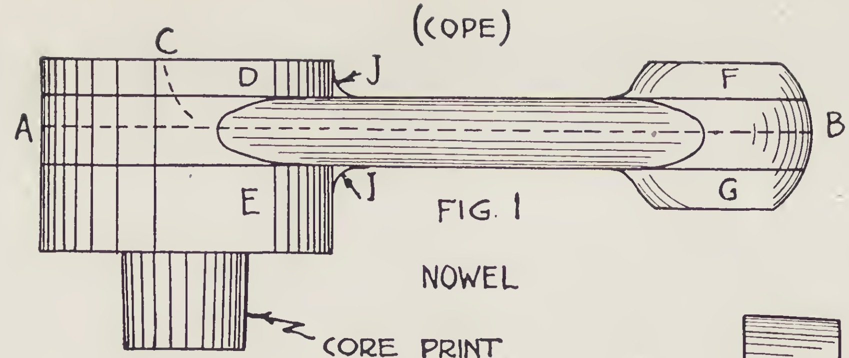


FIG. 1

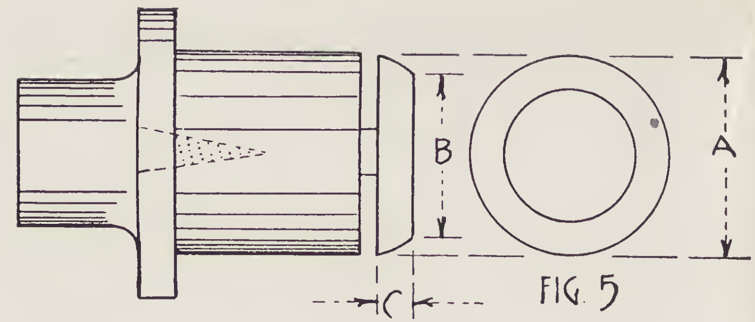


FIG. 5


FIG. 7

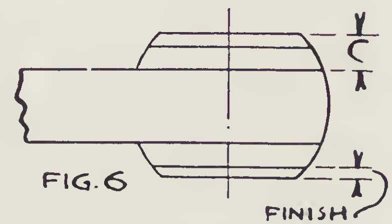


FIG. 6

FIG. 8

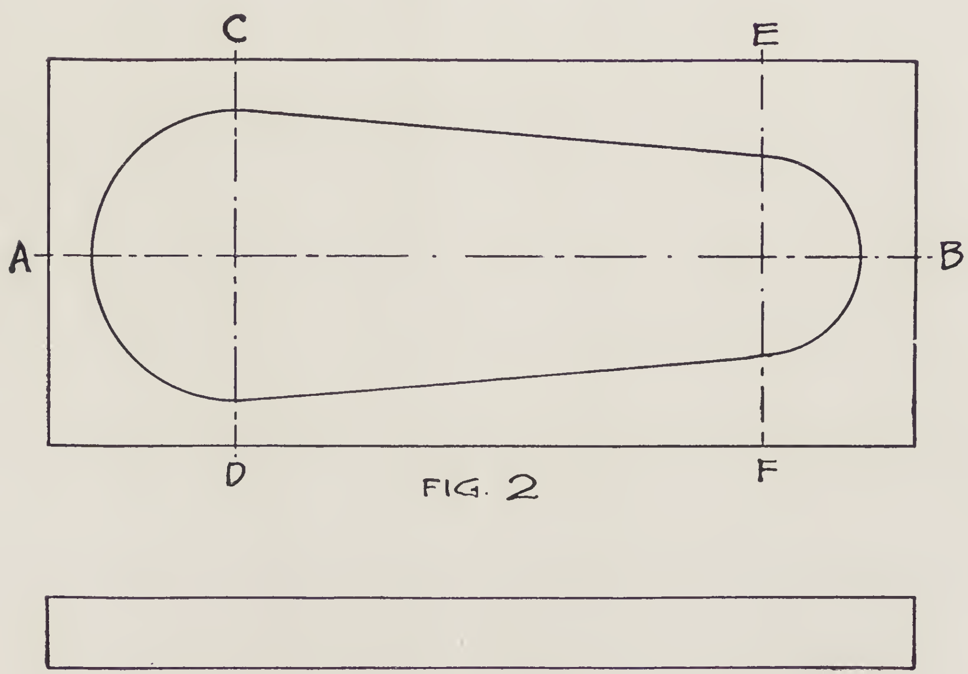


FIG. 2

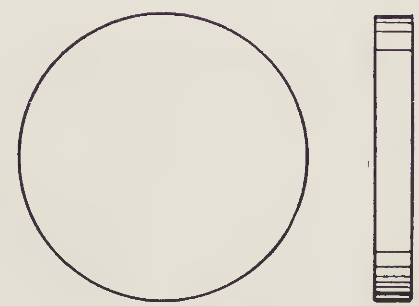


FIG. 3

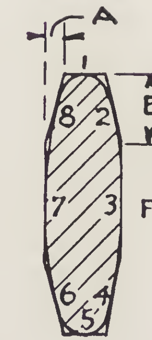


FIG. 9

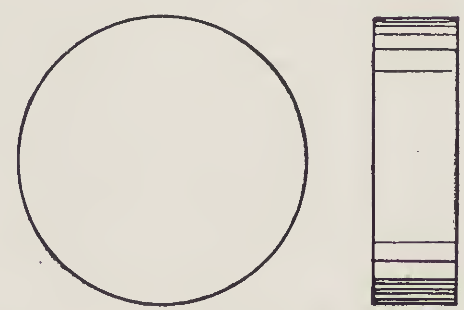


FIG. 4

## PLATE 12

### BOILER FLANGE

Boiler flanges and other castings which are to be fastened to boilers or other cylindrical-shaped tanks offer an opportunity to study an interesting phase of coring.

If core prints were used for coring out the rivet holes some of them would be in a position indicated by the plug (Fig. 9) because the center lines of the holes are radial lines. Therefore, if the prints were fastened permanently to the pattern it is obvious that they would tear the mold when the pattern was withdrawn from it. To fasten them by means of loose pins and remove them after the pattern has been removed would not be practical.

To core these holes the following method should be employed. The location of the holes is determined on the flange of the pattern and holes $\frac{1}{16}''$ larger than the rivets are bored through it. After the pattern is molded and the cope removed (Fig. 9), a plug having the same diameter as the holes in the pattern is inserted in these, protruding through far enough to serve as a core print. This leaves a series of holes in the mold to receive the rivet cores.

### PATTERN

**Instructions.**—The method described for making this pattern is confined to small flanges. In fact, this particular flange could be made differently. The method given here is, however, quite commonly used by pattern-makers.

A pattern-maker's layout of this simple pattern is not necessary, but the experience of making it will help the student to undertake a larger and more complicated one at some future time.

To make the pattern proceed as follows: First, make a layout on a board, Fig. 1. From this layout determine the thickness *A* (Fig. 1) of the block required. Then " glue up " a block out of $2''$ stock about $12'' \times 12''$ and $\frac{1}{4}''$ to $\frac{1}{2}''$ thicker than required. This block is glued in strips to prevent warping.

After the glue is thoroughly dry " true up " a working face and edge. Then fasten the face side to the face plate, getting it about central. With the lathe revolving " face off " the opposite side, keeping the corners of the block turned off as shown at *E* (Fig. 3). Locate the true center and draw lines *A*, *B* and *C*, *D*, Fig. 2. Square these lines across the edges and do not lose them as the remaining operations are carried on.

Fig. 3. With the lathe revolving mark diameters *A* and *B*, then turn out the center hole, making it smaller at *C* for draft. This hole does not have to be turned through the entire thickness of the block, but far enough to cut through after the boiler radius is cut out. Next turn the diameter *A* to the depth of *B*.

Fig. 4. The next operation is to remove the stock to form the arc drawn by using radius *A*. Draw the arc on both ends of the block. The waste stock may be removed by employing

the band saw, provided the saw will "take" a $12'' \times 12''$ block. Or it may be done on a circular saw by making a series of saw kerfs as shown at *B*, cutting as close to the line as possible. The stock between the saw cuts may now be broken out and the arc *A* finished using a round plane (sometimes called a sole or lag plane). After this has been done make several saw cuts on the back of the flange as shown at *C*.

Fig. 5. Take a thin piece of scrap wood and on it draw the center lines *AB* and *CD* and the diameter of the flange. Fasten this temporarily to the pattern in such a way that the center lines on the board and on the pattern will exactly coincide. Then saw out the circle, using the band saw, or, if preferable, saw out to the approximate diameter and turn in the lathe. Be very careful not to lose the center lines.

Fig. 6. Gauge line *A* around for the thickness of the flange. This may be done with a pair of hermaphrodite calipers. Be sure to hold the calipers radially when describing the thickness. The stock at *B* may now be worked off and the flange smoothed to the required form.

The next operation is to locate the centers of the rivet holes. Begin by spacing them off from the center line *AB* (Fig. 2). After the centers are located, bore the holes with an auger bit, boring from both sides so as not to tear the wood.

Figs. 7 and 8 show details of the plug and core box.

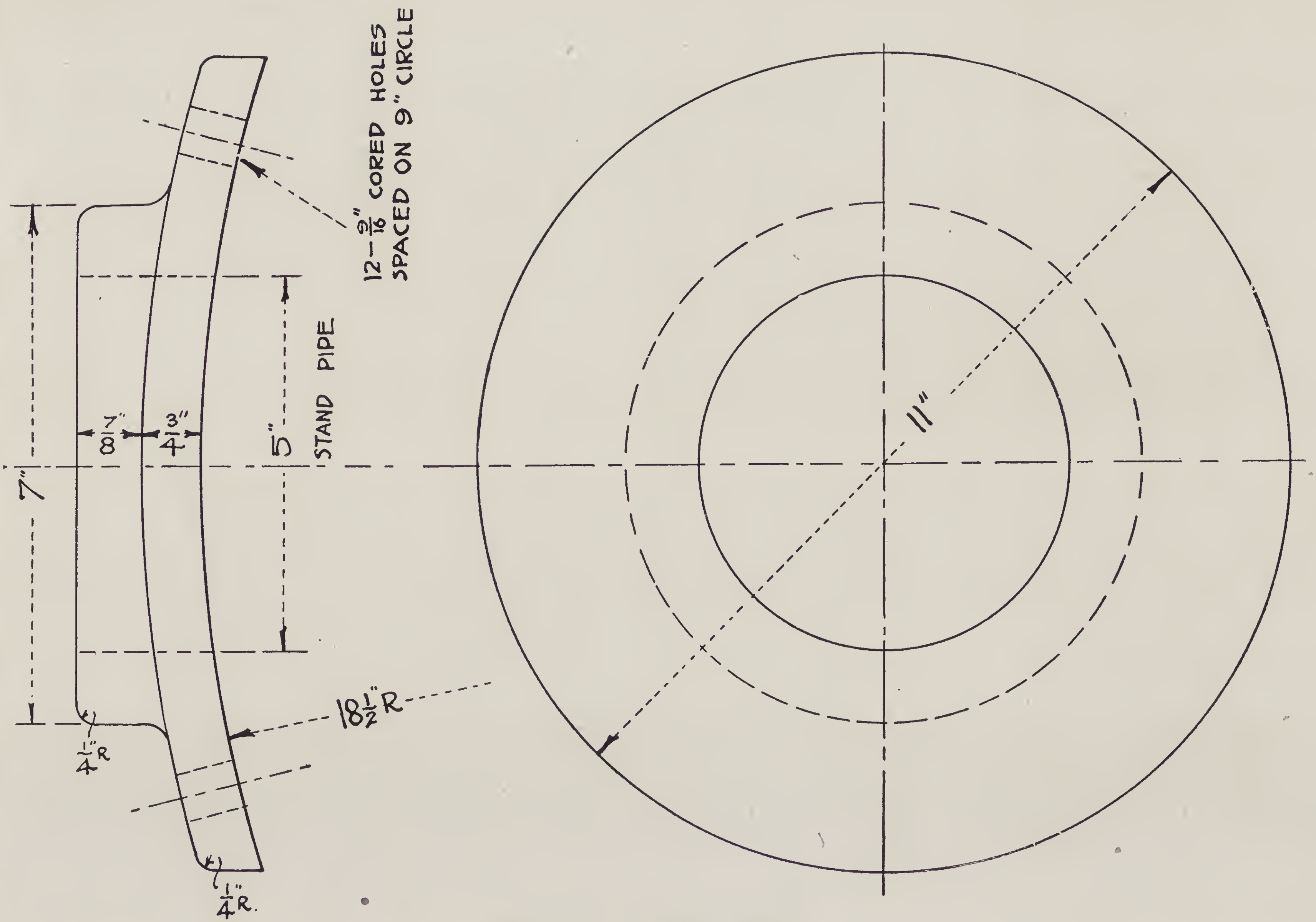
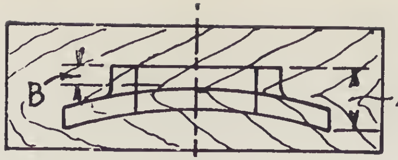



PLATE 12—BOILER FLANGE




PATTERN MAKERS LAYOUT
FIG. 1

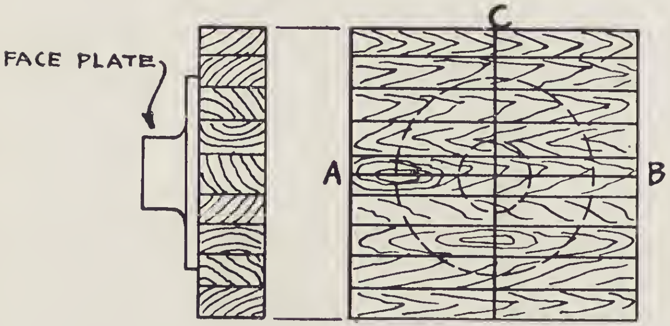



FIG. 2

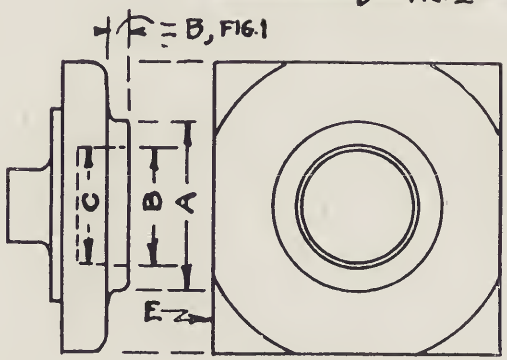



FIG. 3

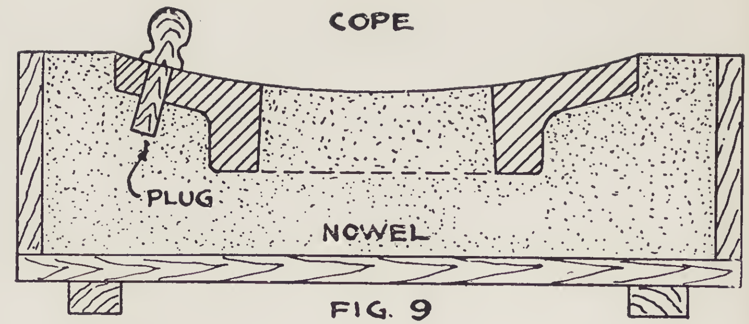



FIG. 9

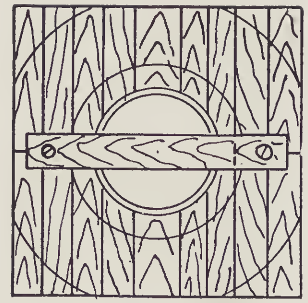
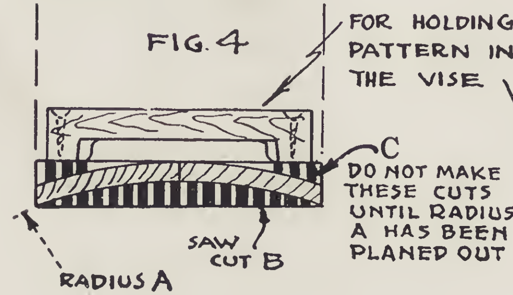


FIG. 4



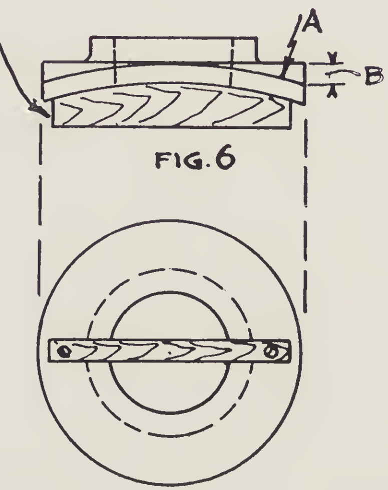




FIG. 6

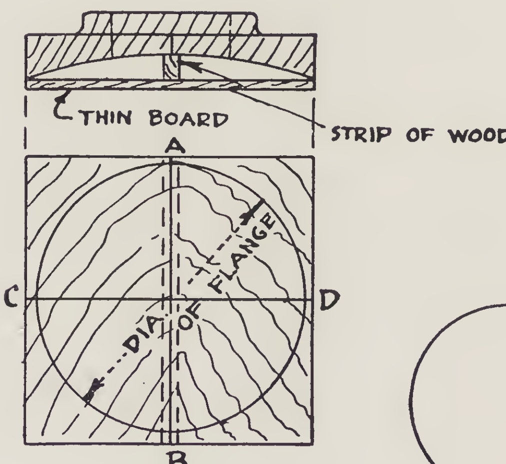



FIG. 5

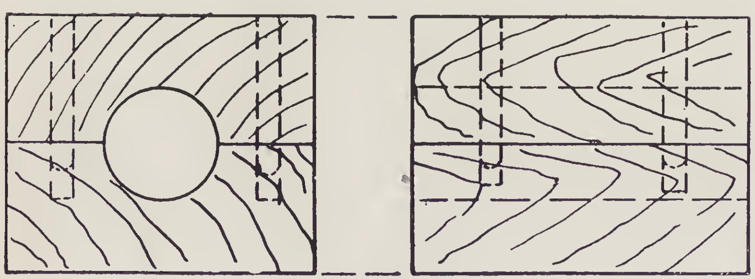


FIG. 8

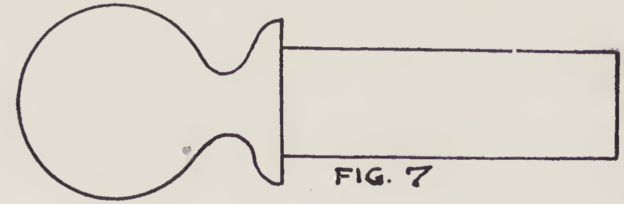


FIG. 7

## PLATE 13

### RETURN BEND

This pattern illustrates another example of the balanced core, the print being made long enough to suspend the core in proper position in the mold.

### PATTERN

**Instructions.**—Fig. 1 shows the complete pattern and core prints.

Fig. 2 shows the core box.

Fig. 3 shows the construction of the pattern. The core print and flange are made of one piece and fastened to the main part of the pattern by means of a rectangular pin. Some pattern-makers prefer a round pin. On a cheap pattern the pins may be dispensed with by simply making a butt joint and using glue and nails.

Fig. 4. Saw out two semicircular pieces, allowing about $\frac{1}{8}''$ for turning on both the inside and outside diameters and about $\frac{1}{16}''$ thicker than required. Have the joint *C* at right angles to the face side.

Fig. 5. With the lathe revolving, " true up " the wooden disk (or as a pattern-maker would say, " true up " the face plate, meaning the wooden disk) and locate the true center. Draw a knife line *CD* through the center at about right angles with the grain.

Next, fasten one of the semicircular pieces *A* or *B*, along the line *CD*. Then fasten the other, making a close joint between them. These pieces may be fastened to the face plate or disk by using two screws in each half, putting the screws in from the back of the wooden disk. If this method is not convenient glue may be used. To do this properly, first glue paper to the disk then glue the pattern to the paper. When through turning pry the pattern off with a chisel.

To turn this part of the pattern proceed as follows: Turn to the thickness *E*. Then to the diameter *F* and next to the diameter *G*. This gives three points of the semicircle. More may be obtained by turning tangents to the semicircle, but three points are sufficient with the aid of a templet as shown in Fig. 9.

First use the quarter round templet and then finish with the full half circle templet.

Fig. 6 shows a detail of the core prints and flanges parted along *AB*. (Put in dowel pins before fastening the two halves together. Also be sure that the prints are centered exactly in halves before turning.)

**Assembling.**—After the core prints and flanges have been fitted to the main part of the pattern care must be exercised in gluing them together. Otherwise the two halves of the pattern will not match nor will the joint be straight.

"True up" a piece of board and lay out lines *AB* and *CD* at right angles to each other as shown in Fig. 1. Assemble the nowel half first without applying any glue, toe nail the main part along the line *CD*, then put the print pieces in place and toe nail them, keeping them exactly parallel with *AB*. The main part may now be lifted, then glue applied and replaced. Allow a sufficient length of time for the glue to harden. Put papers underneath the joint to prevent its adherence to the board. After removal from the board, put a screw in each of the pins.

To assemble the cope half of the pattern substitute the nowel half for the board used when the nowel half was glued. When the glue is hard place a dowel in the main part of the pattern.

## CORE BOX

Fig. 7. To turn this part of the core box use a solid piece of stock; cutting off and discarding one-half of it when through turning. Use the templet shown in Fig. 10. Fig. 8 shows a detail of the print part.

Figs. 7 and 8 may be assembled on a piece of board as shown at *A*, Fig. 2.

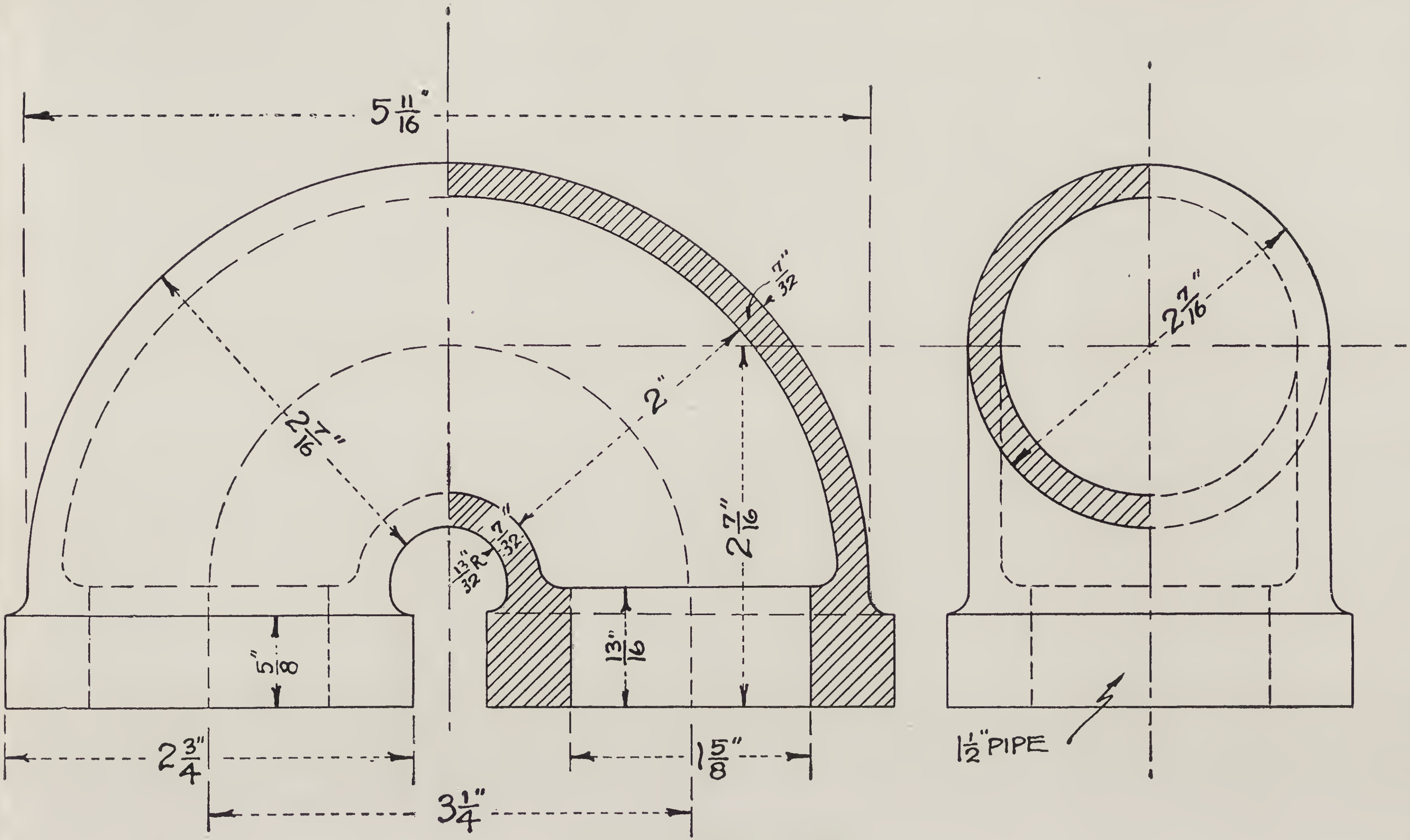



PLATE 13—RETURN BEND

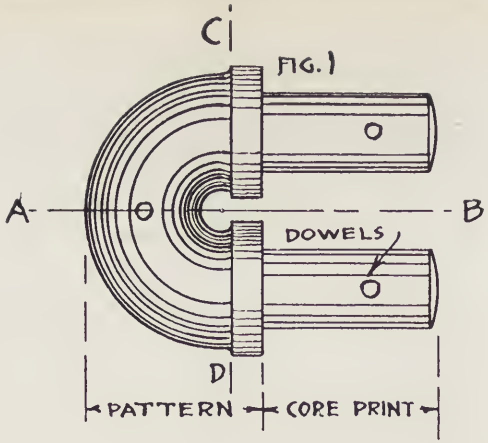
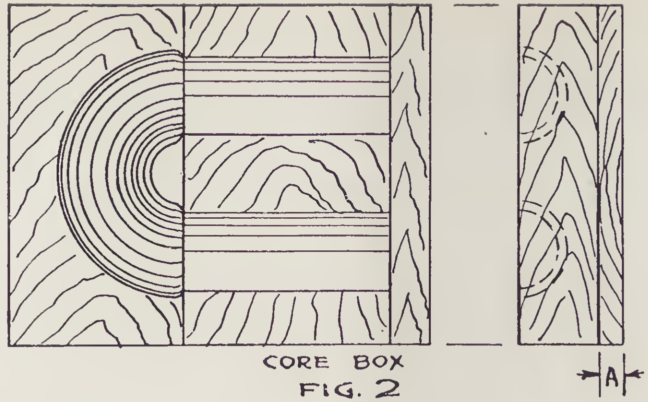



FIG. 1




CORE BOX
FIG. 2

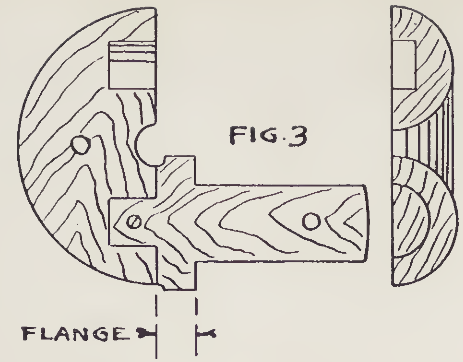



FIG. 3

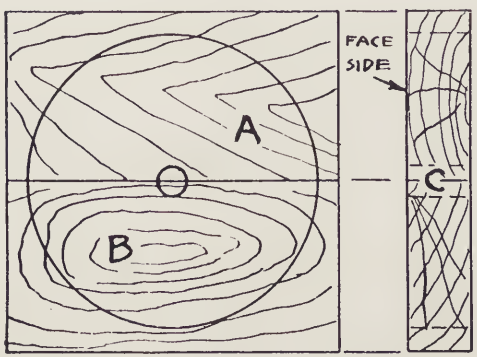



FIG 4

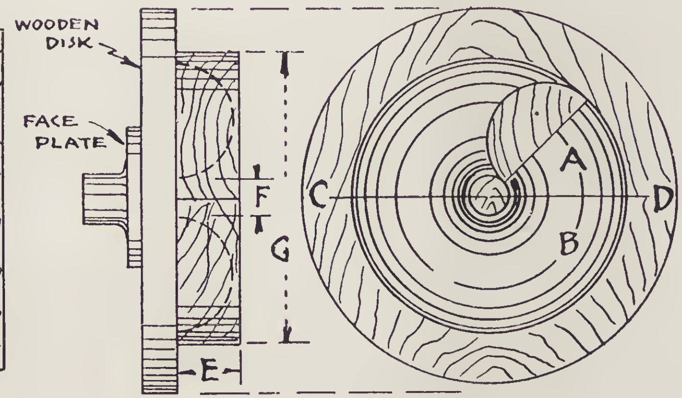



FIG. 5

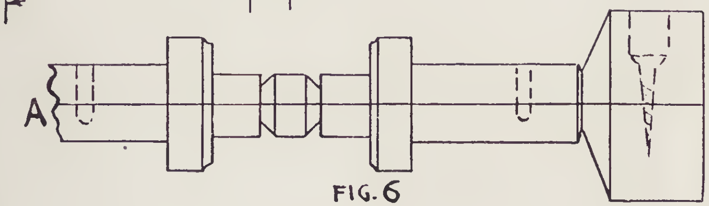



FIG. 6

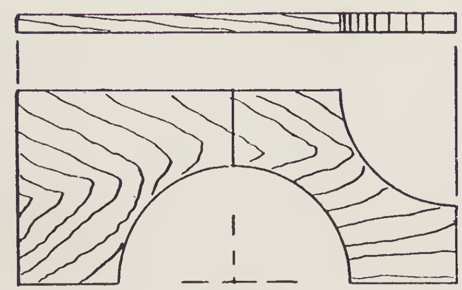


FIG. 9

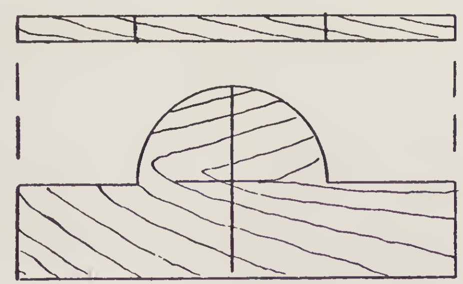


FIG. 10

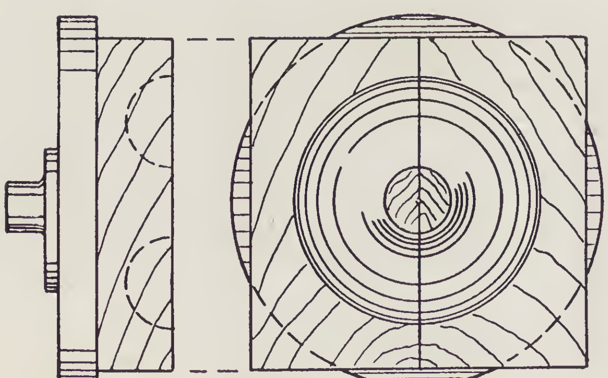


FIG. 7

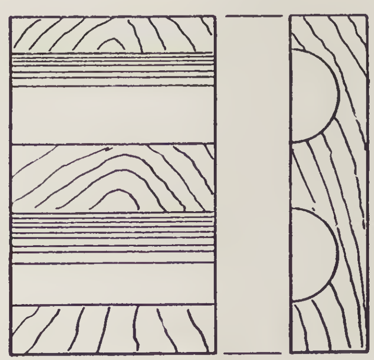


FIG. 8

# PLATE 14

## SHEAVE WHEEL

The methods used for molding sheave wheels depend upon the size and number of grooves.

Figs. 1 and 2 show two different types of patterns used for molding small sheave wheels. Fig. 1 shows the groove turned in the pattern and parted through the center. Fig. 2 is turned with a core print and a core is used to form the groove.

Figs. 3, 4, and 5 illustrate three different methods used for molding sheaves. Fig. 3 shows a three-part flask, the middle part being termed a cheek. Fig. 4 shows another form of cheek, sometimes termed a " false cheek," because the third part of the flask is dispensed with. The cheek in this case is a separate body of sand (as in Fig. 3), supported in the proper position by the cope and the nowel.

The operations of molding illustrated by Fig. 4 are as follows:

The cope half of the pattern is rammed first. The flask is then turned over and a joint formed for the cheek. The other half of the pattern is then placed in position and sand " tucked in " around the groove to form the cheek. A joint is then formed for the nowel.

After the nowel has been rammed it is lifted off and that part of the pattern removed. It is then replaced and the complete flask turned over. The cope is then lifted off and the other half of the pattern removed. During these operations the cheek is supported between the cope and the nowel.

Fig. 5 shows the pattern being molded with a core pint. In this instance a dry sand core is used for forming the groove. This is the method employed for sheaves having two or more grooves.

Fig. 6 shows the core box used for making the dry sand core.

When a pattern for a large sheave is made with a core print instead of making a complete circular core box for the groove a sectional box is used and the required number of cores made to complete the circle.

### PATTERN

**Instructions.**—Fig. 7 shows one-half of the pattern fastened to a wooden disk ready for turning. This can be fastened with two brads. Turn as shown by the dotted line.

Fig. 8 shows the second operation. Turn to the depth *A*, then use the templet (Fig. 10). The fillet on the hub can be turned " by eye."

Fig. 9 shows the pattern rechucked for turning the groove and recess *A*. The recess may be made any suitable size because the other half of the pattern is fitted to it.

Fig. 11 illustrates the templet used for turning the groove.

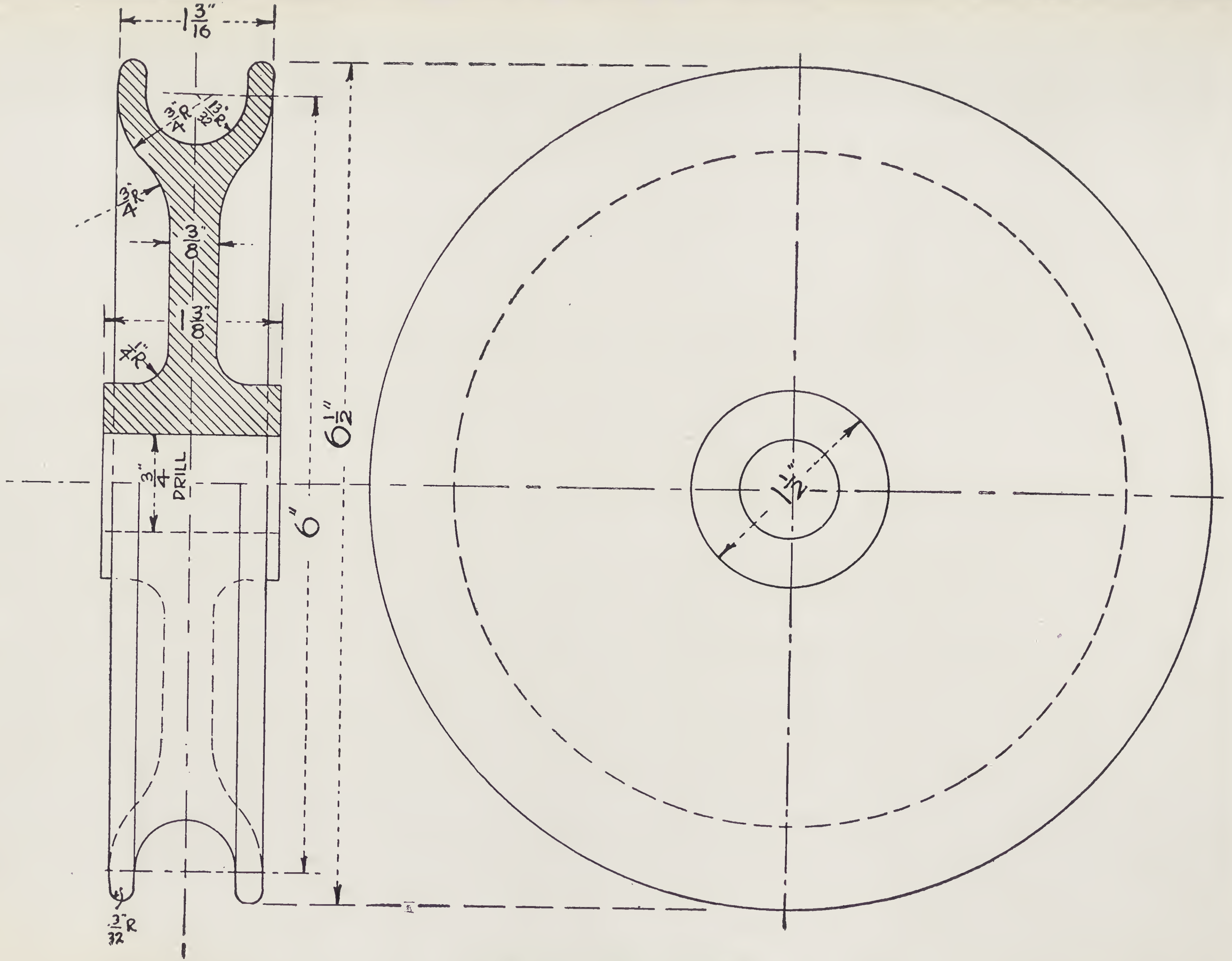



PLATE 14—6" SHEAVE WHEEL

FIG. 1

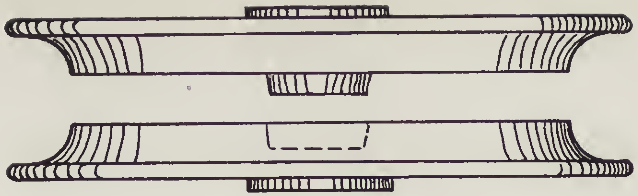


FIG. 2

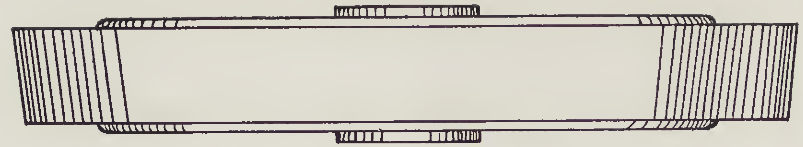
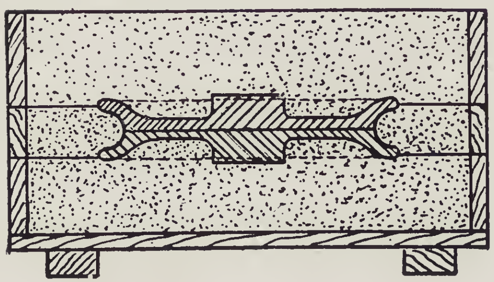


FIG. 3



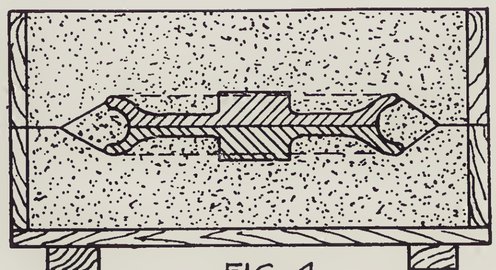


FIG. 4

FIG. 5

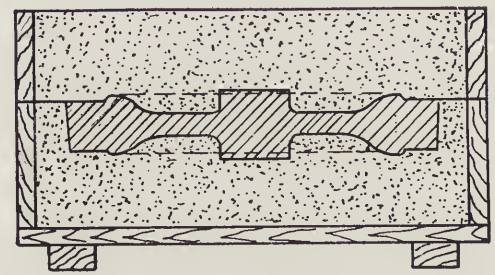
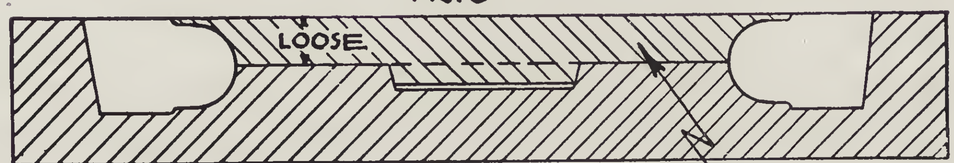


FIG. 6




ON LARGER CORES THIS LOOSE PIECE IS DISPENSED WITH BY USING A SWEEP, PIVOTED ON THE CENTER.

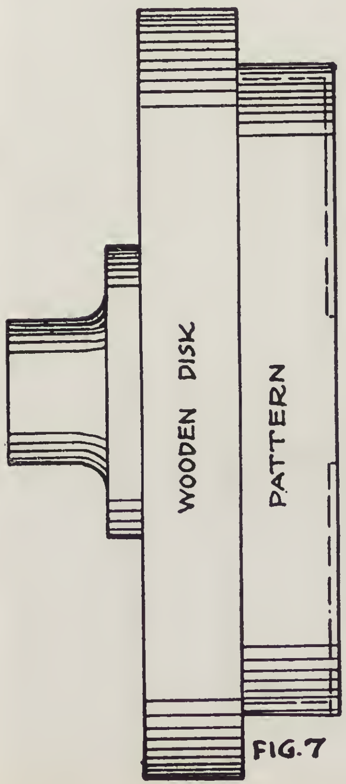



FIG. 7


FIG 8

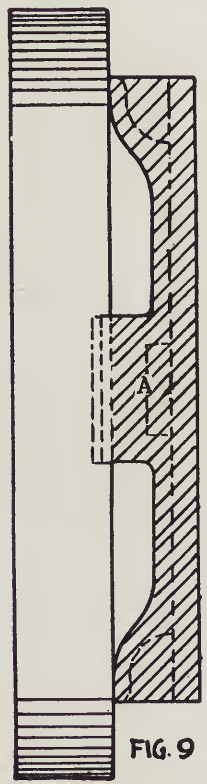



FIG. 9

CENTER OF SHEAVE

FIG. 10

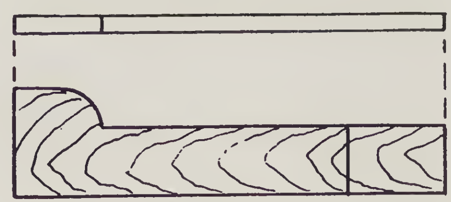


FIG. 11

## PLATE 15

### PISTON

Fig. 3 shows the pattern molded and the mold poured in a vertical position. This position of pouring is desirable for the same reasons as given in Plate 3. The type of core used is called the " overhang " core, or flanged core.

The pattern may be made with a balance core parted along axis $AB$ (Fig. 1) and molded horizontally but gated to be poured vertically. The type of pattern shown in Fig. 1 is preferable in most cases.

### PATTERN

**Instructions.**—Fig. 1 shows the pattern and core print. When making the pattern allow about $\frac{3}{32}''$ finish on end $C$ and $\frac{1}{8}''$ on end $D$. This will give $\frac{1}{32}''$ draft. The grooves for the piston rings are to be disregarded. They will be taken care of in the machine shop. ($\frac{3}{32}''$ finish means $\frac{3}{16}''$ larger in diameter.)

### CORE PRINT

The core print is centered by means of a pin turned on the pattern. Before fastening the print to the pattern, flatten one side of the print as shown at $F$. This is done in order to locate the core in its proper position, which is such that the proper amount of metal shall be back of the recess $E$.

### CORE BOX

Fig. 2 shows the construction of the core box. One-half of the core is made with the pieces $A$ and $B$ and one-half without them.

$B$ provides for metal behind the recess $E$ (Fig. 1). $A$ leaves a flat spot on the core to correspond with the core print.

Allow about $\frac{1}{32}''$ draft on the sides of $C$ and fasten in the box.

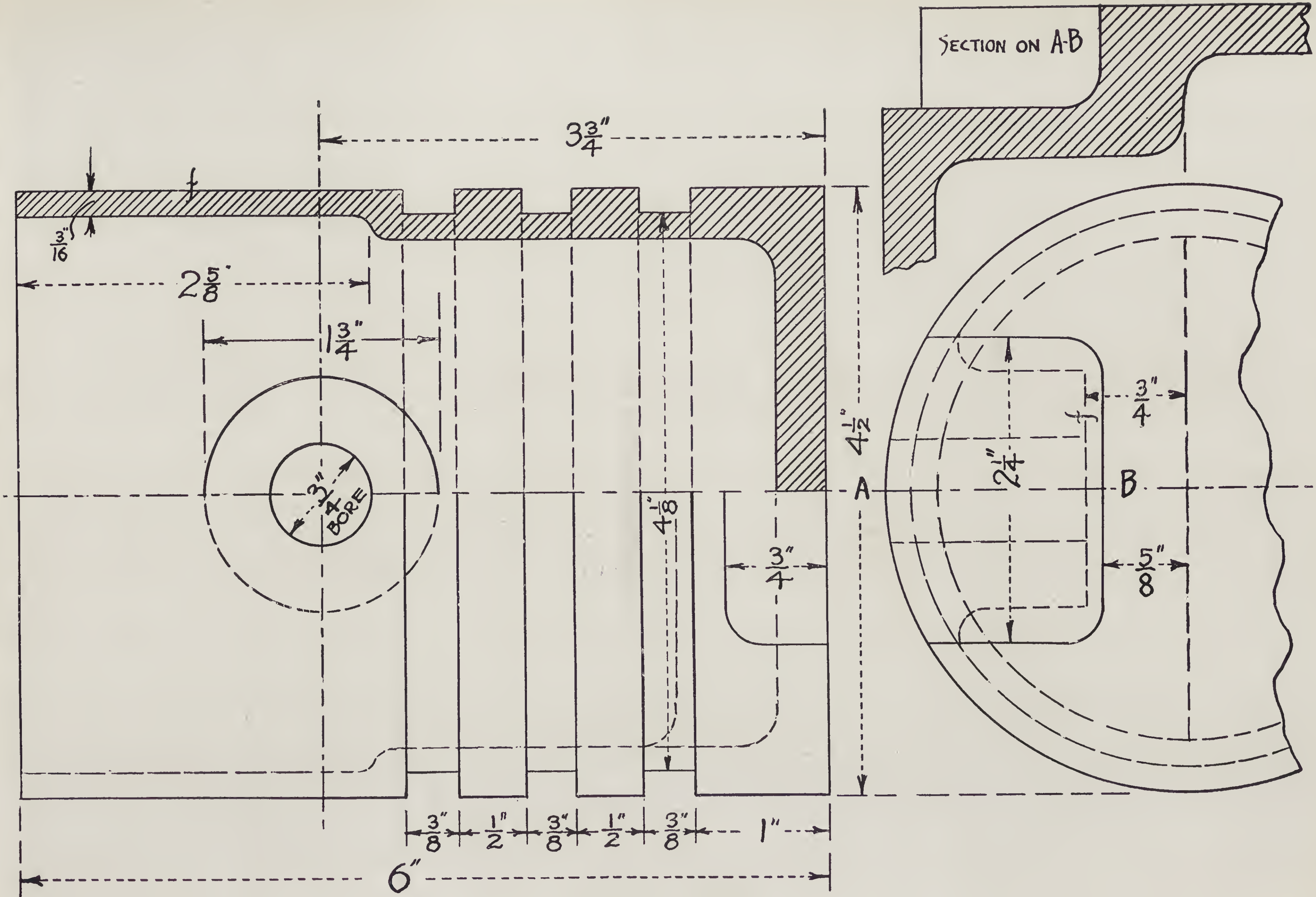



PLATE 15—PISTON

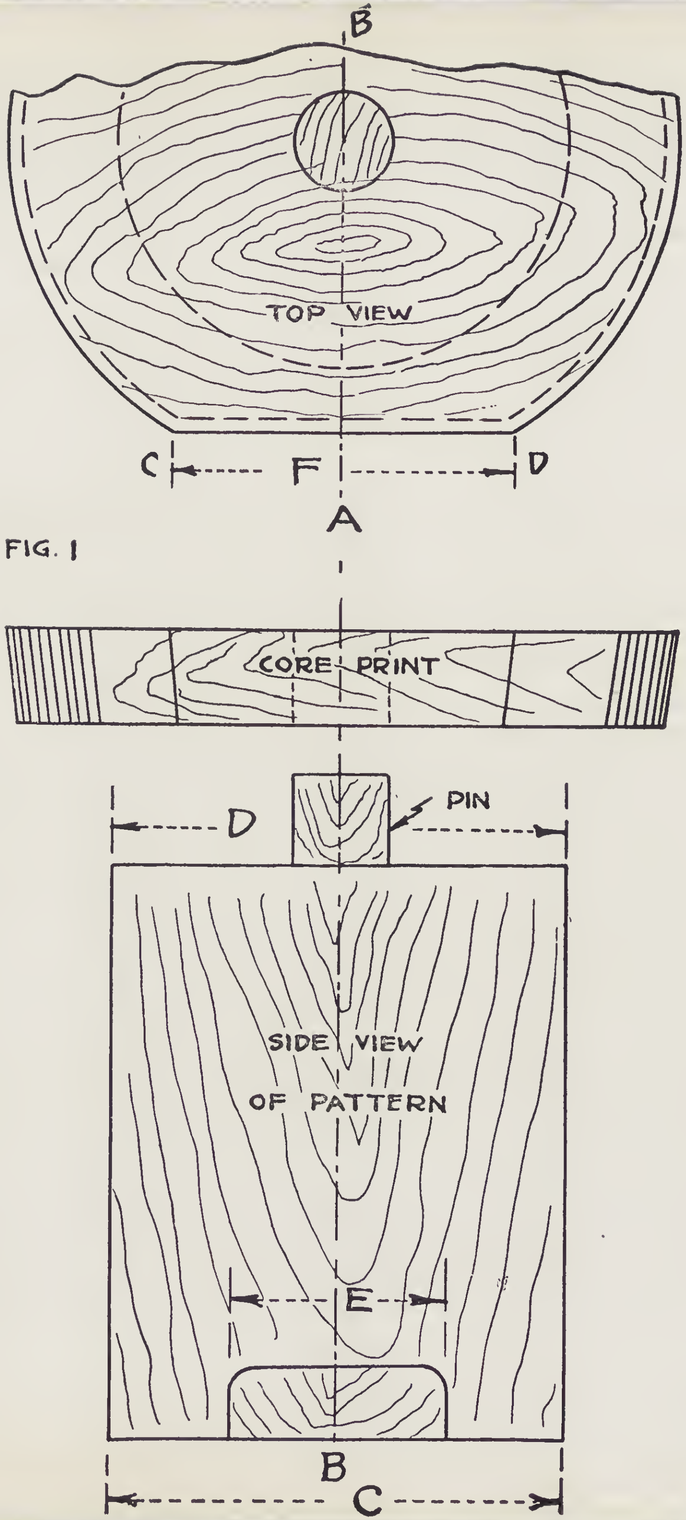



FIG. 1

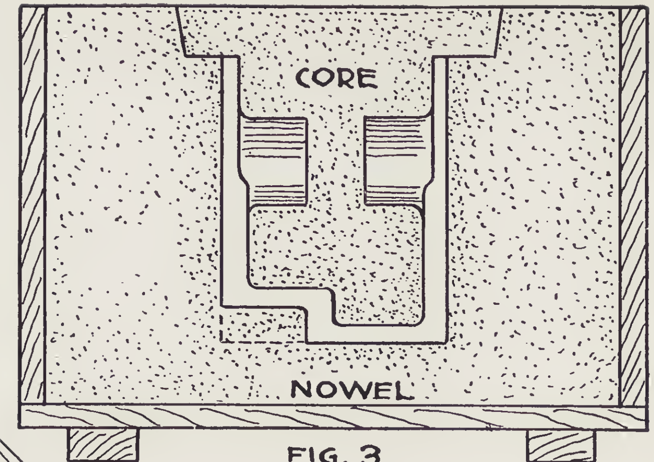



FIG. 3

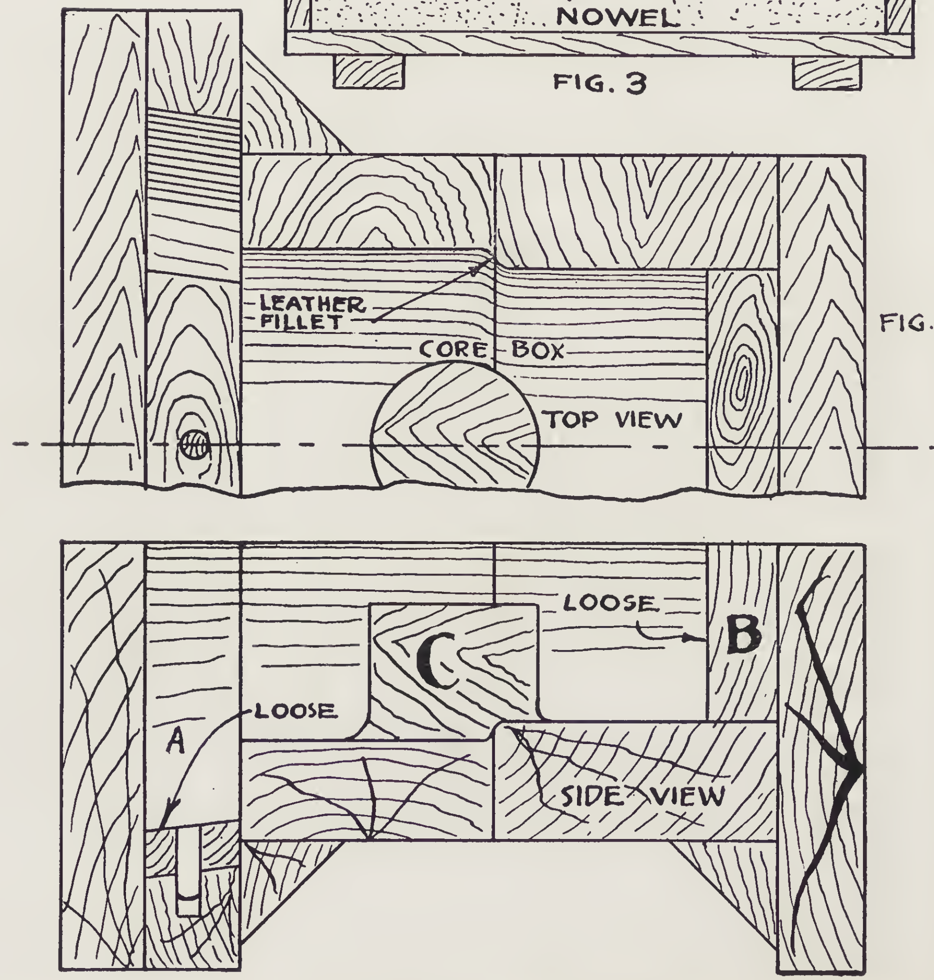



FIG. 2

## PLATE 16

### PISTON RINGS

The pattern for a piston ring is a very simple one, yet it affords an excellent illustration of the purpose of segment construction in the making of patterns for pulleys, pistons, flywheels and other circular patterns.

This form of construction is desirable for the following reasons: It permits an economical use of stock, makes a stronger pattern because one course of segment overlaps the joints of another and because unequal shrinkage is prevented.

Patterns for piston rings are usually constructed by employing two concentric circles to obtain the proper cross-section and by making them long enough to permit the cutting of several rings from the same casting. They are cast with lugs as shown in Fig 2. for the purpose of holding them while they are being machined.

**SEGMENTS.**—The method used for getting out segments and assembling them depends entirely upon the facilities at hand and upon the type of pattern to be constructed. Some patterns can be built up by using nails and glue; others (for various reasons) must be glued up with the aid of hand screws.

In shops properly equipped for work of this sort the segments may be produced to thickness, cut to the exact angle and length and the pattern built with but little hand work being employed. Therefore, it would hardly be practical to give any exact rules for getting out segments. The following points, however, will generally apply to most cases and should therefore be known:

The number of segments to a circle depends upon the diameter. A ring 30″ in diameter would be stronger by using six segments to a circle rather than four, because a fourth of a circle would involve too much cross grain.

The thickness of the segments also depends on the type of pattern. On piston rings and similar patterns where the width is limited, the thickness should not be much greater than the width. On the particular pattern represented here it would not be advisable to have the segments over $\frac{3}{4}$″ thick.

When the stock is scant in thickness it is best to saw the segments out of the rough stock, then surface one side and plane to thickness. If the segments are too short to run through the planer they may be run through the circular saw. If this is properly done it will not be necessary to face off each course. When a number of segments are to be produced they will be less liable to warp if they are stacked in layers, crossing each other.

### PATTERN

**Instructions.**—Fig. 2 shows the pattern sizes. Mark out a templet as shown in Fig. 3, allowing about $\frac{3}{16}$″ to $\frac{1}{4}$″ for turning. If they are to be cut to length and required angle on the circular saw (by means of a gauge or jig) allow $\frac{1}{2}''$ on the length. But if they are to be trimmed and fitted by hand, allow about $\frac{1}{4}''$. When fitted by hand it is not necessary to have each segment the exact length and angle.

Fig. 4 shows a quick method for sawing out a large number of segments. Nail three or four pieces together and make the cuts in the order of *A*, *B*, *C* and *D*.

Fig. 5 shows the face plate upon which the ring is built and turned.

1. True up the wooden disk where the segments are placed.
2. Draw the circle *A* equal to the inside diameter of the templet.
3. If the segments are to be fitted by hand, plane both ends of the first segment and fasten with two $1\frac{1}{2}''$ brads. Then fit and fasten each succeeding segment as it is fitted around in the direction of the arrow, applying glue on the end of each joint. Some pattern-makers fit and fasten all the segments temporarily and then remove them one at a time to glue and fasten them.

Fig. 6. After the first course is completed, turn to the diameter shown, to a depth of about $\frac{1}{8}''$. These sizes allow for draft and serve as gauges when turning the complete pattern. Each succeeding course is placed so that the joints of the previous course come at about the center of the segment above it. Nail and glue each course with three brads in each segment.

When the pattern has been turned it can be pried off and the nails from the first course pulled out. On heavy work, place screws in the pattern from the back of the face plate to hold it while turning. More economical use of stock may be obtained when using wide segments, if marked out as shown in Fig. 7.

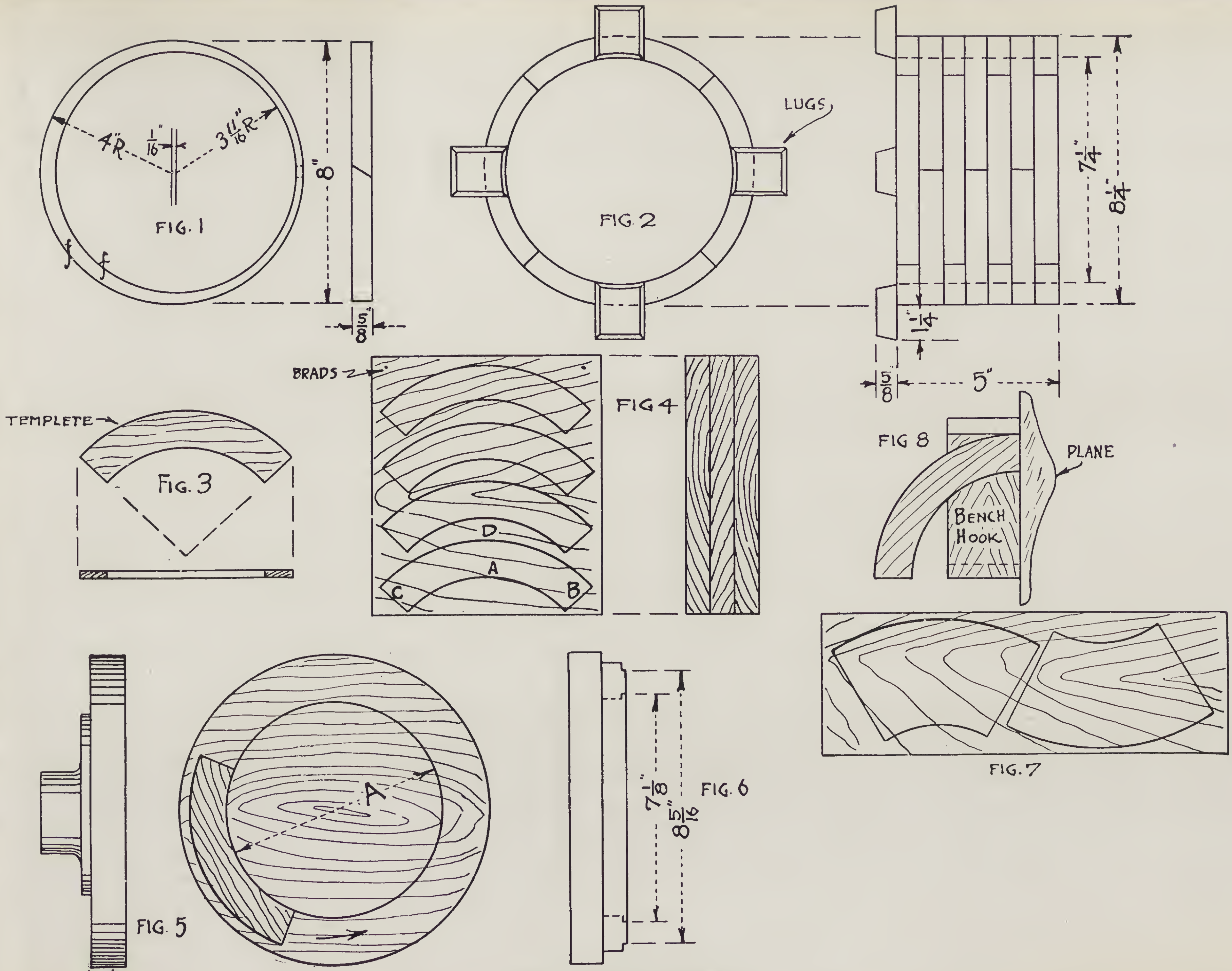



**PLATE 16—PISTON RINGS**

# PLATE 17

## PULLEY AND GEAR ARMS

**Instructions.**—Fig. 1 shows the method of lapping three pieces to form six arms.

Mark a working face and edge on each piece and work from these surfaces when laying them out.

1. Lay out the angles on each piece, using a bevel set at 60° (make the lines with a knife). Where the angle lines cross each other as in arm 1, be sure that point *E* is directly opposite *A* and if the other lines are correct, *H* will come opposite *D*.
2. Set the marking gauge to one-third the thickness and mark line *IJ* on both edges of each piece.
3. Set the gauge to two-thirds the thickness and mark line *ML*.

Do not allow the joints to fit tightly. If they do the arms are liable to become sprung.

To accomplish the gluing, clamp a " true " piece of board on the face side with paper between the board and arms. The board will keep the face side even and prevent the arms from springing.

Fig. 2 represents a half lap joint and Fig. 3 a butt joint.

Arm 1 shows the joints re-enforced by means of a circular disk glued in the center.

Arm 2 shows a spline glued between each of the joints.

To fit the arms together use a face plate or " true " board. Draw the circle *AB* of any convenient diameter and space off five equal parts. Then draw circle *CD* equal to the width of the stock and draw lines as shown by *EF* tangent to *CD*.

Begin fitting the joints by fastening one arm in position by means of two brads, keeping one edge along *EF*. Fasten each succeeding arm as it is fitted. When all the arms have been fitted, number them, then remove them and cut the groove for the disk or spline. When gluing them see that they are set back in the old nail holes. Any number of arms may be joined together in this manner.

Fig. 4 shows the arms of a butt joint re-enforced by gluing and brading the hub to the arms. On a set of large arms it is advisable to lay them out, saw them and shape them before gluing.

FIG. 1

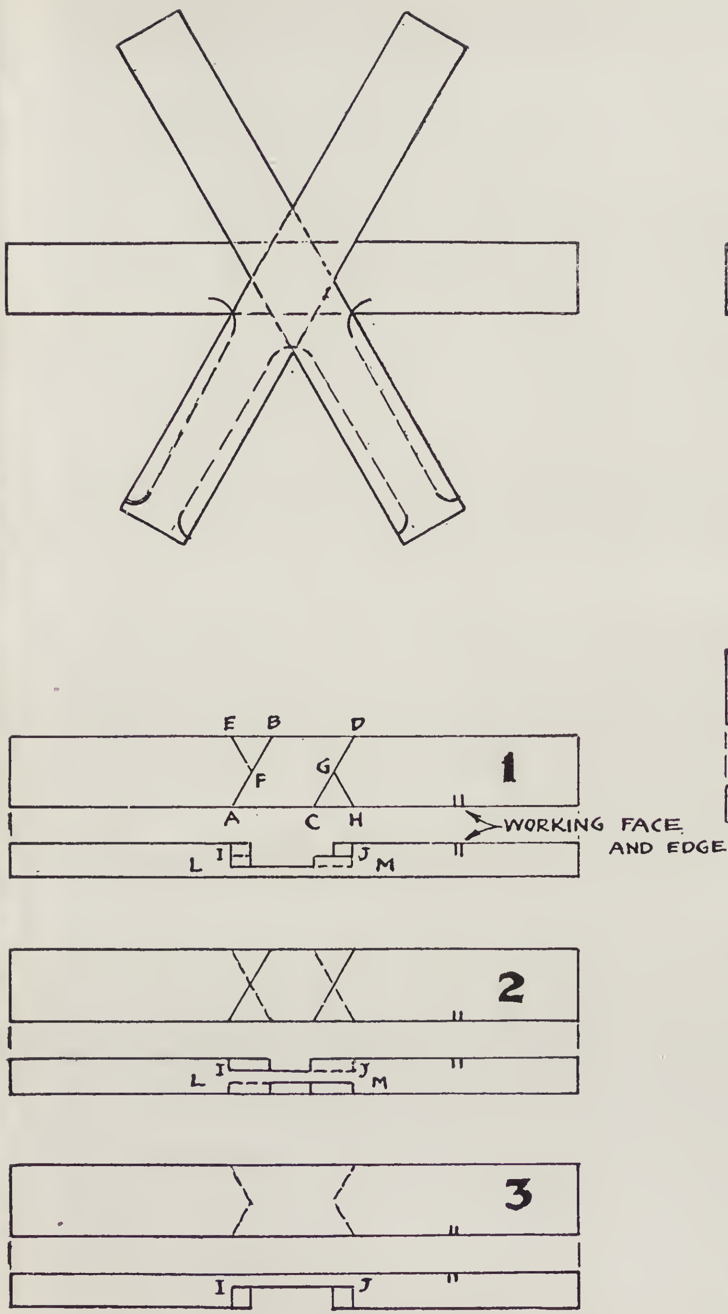



FIG. 2

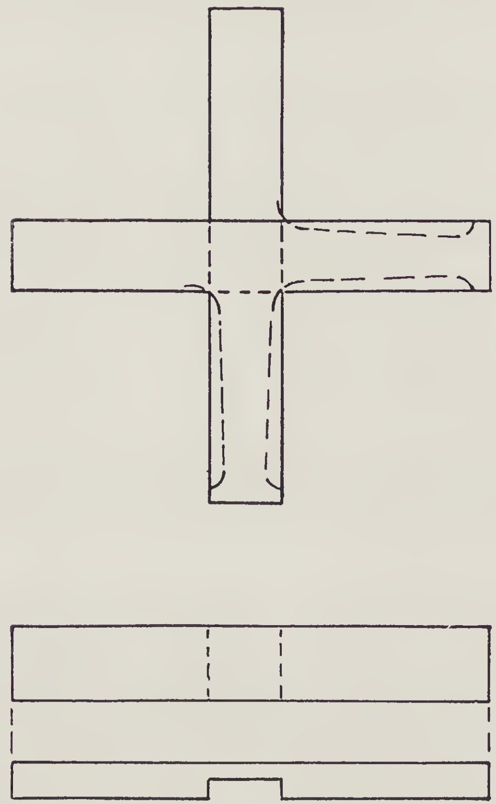
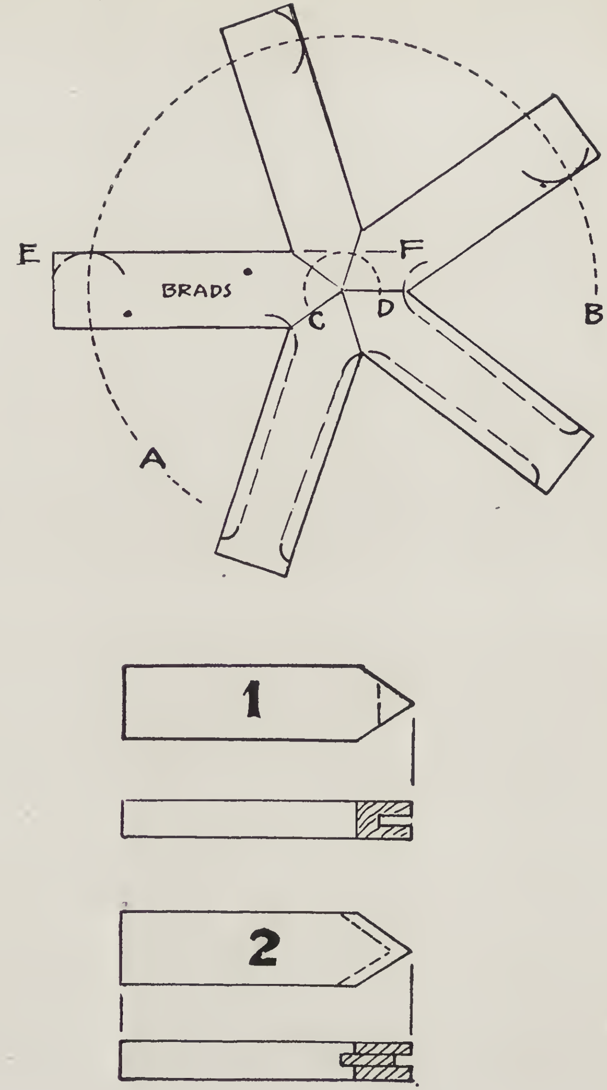


FIG. 3



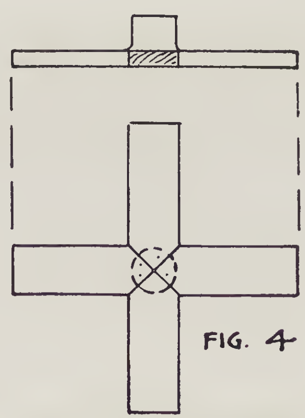



FIG. 4

PLATE 17—PULLEY AND GEAR ARMS

## PLATE 18

### COVERING CORES

A covering core may be used in a number of different ways. The application is illustrated here in the molding of the pattern shown in Fig. 1. Its use in this case dispenses with a three-part flask or cheek.

Fig. 1 shows the construction of the pattern. The gland *A* is a separate piece fitting over the core print *B*. The joint is made along the line *CD*. It is quite apparent that a joint is necessary here if the pattern is to be molded as shown by Figs. 3 and 4, because of the sand between the gland and the flange.

The cover core as shown in Fig. 2 may be made with a core box or left for the molder to make from a piece of slab core, because it is not necessary to have it an exact form.

### MOLDING

The pattern is "rammed up" to line *AB* as shown in Fig. 3. The cover core is then placed in position as shown and sand tamped around it up to the line *CD*. The cover core is then lifted off and the gland *E* removed from the mold.

The cover core is then replaced in order to prevent any sand from going into the cavity formed by the gland *E* when "ramming up" the remainder of the nowel.

Fig. 4 shows the gland *A* removed, making it possible to complete the mold by withdrawing the main body of the pattern.

Another method for molding this pattern would be to attach pieces *E* and *F* (Fig. 1) as *loose pieces*, removing them from the mold after the main body of the pattern has been withdrawn. This is accomplished by drawing them in toward the center and lifting them up through the cavity formed by the body of the pattern.

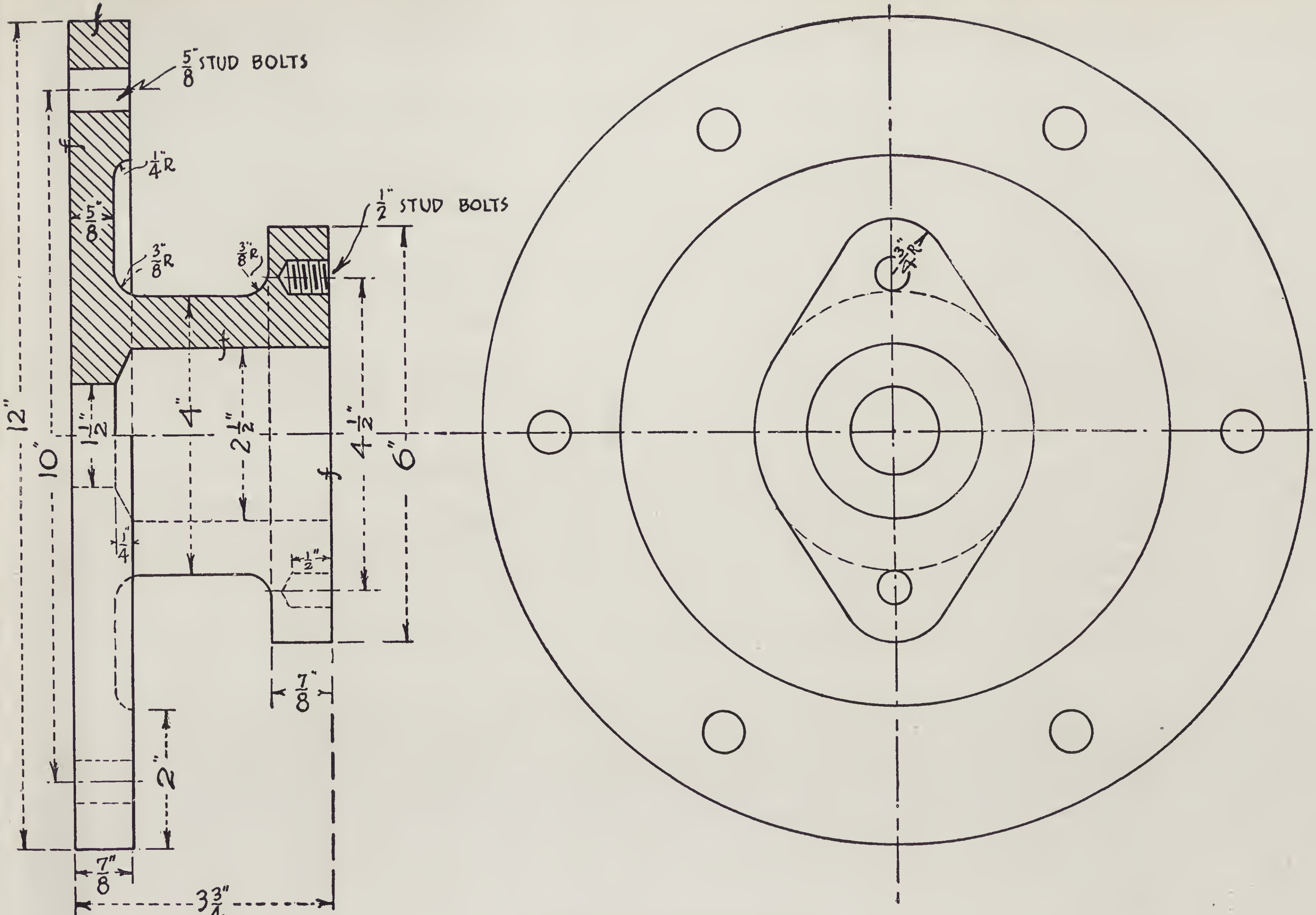



**PLATE 18—CYLINDER HEAD**

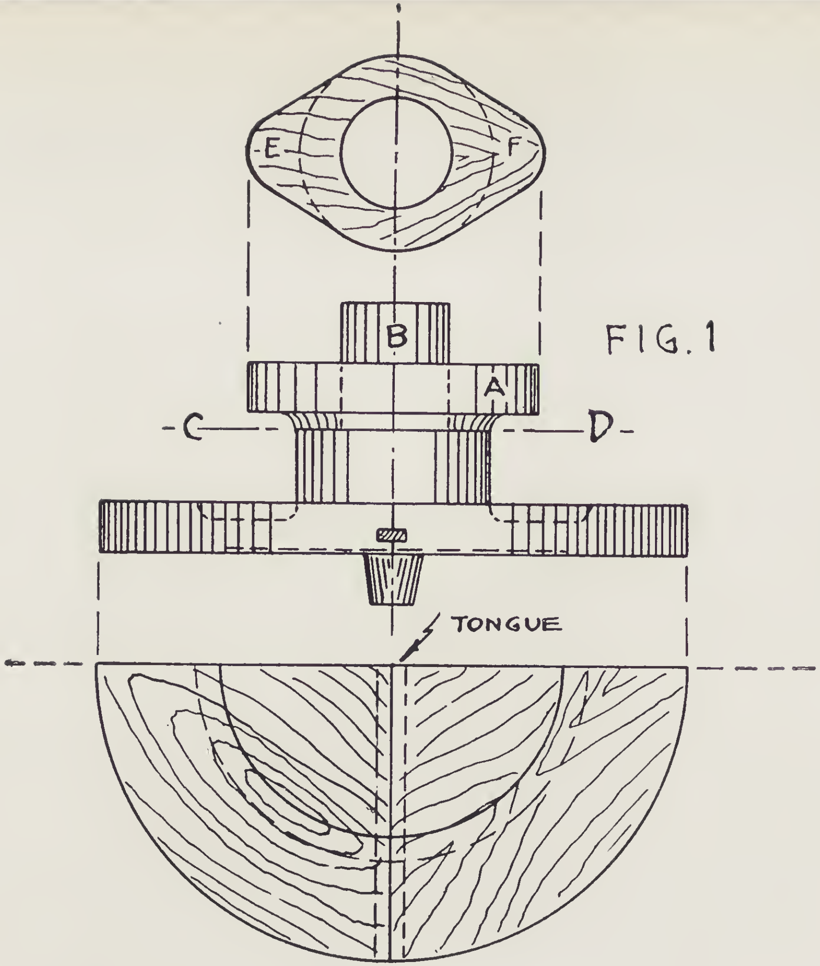



FIG. 1

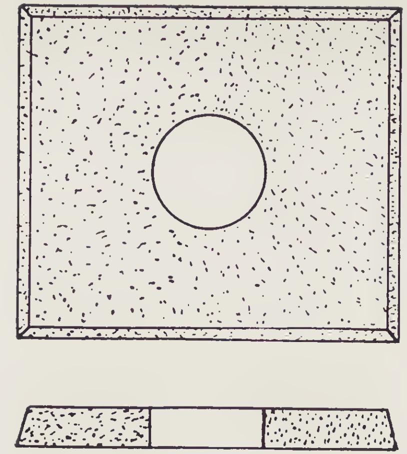


FIG 2

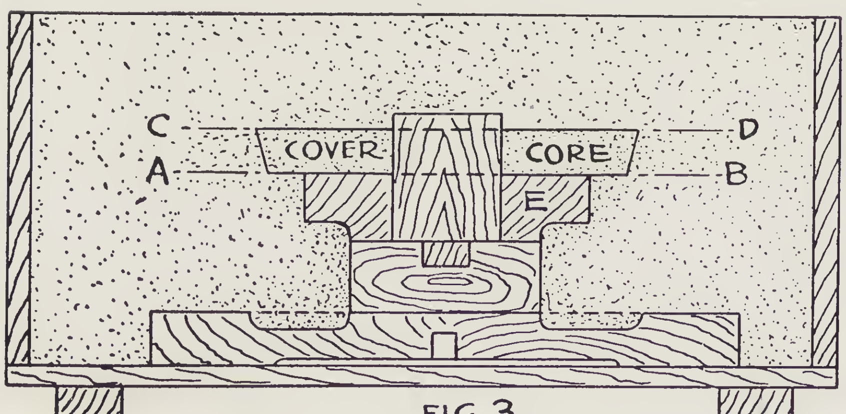



FIG. 3

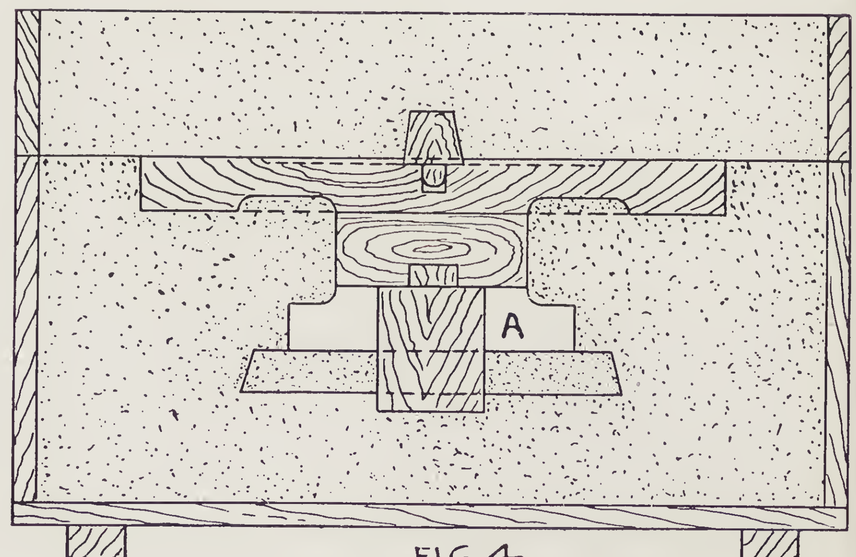



FIG. 4

# PLATE 19

## FLY WHEEL

The method to be used for producing fly wheels and pulleys depends upon the size and the number of castings to be made and the facilities for making them.

No attempt is made here to explain and illustrate all of the various ways, but the following information will be sufficient to enable the student to handle all ordinary cases. A great many foundries are equipped with standard size " iron " rings, arms and hubs which may be used in producing a great variety of fly wheels and pulleys. The width of the rim or face can be regulated by rising, i.e., drawing the ring or rim up during the operation of molding. Large wheels are often made by substituting the use of cores for the above rigging.

A rectangular core box is made for the arms having one-half arm placed in the bottom of the box with a portion of the hub at one end.

Two half cores are required for each arm. The space between the arm cores may be formed by using dry sand cores or filling between with green sand. The outside diameter may also be formed with dry sand cores or green sand. The mold is formed by striking a level bed and placing the cores in proper position upon it.

Fig. 1 illustrates one method of producing a small fly wheel. The pattern used here is a split pattern parted along lines *A–B*. Fig. 2 shows a pattern where the rim and arms are not split but the cope hub is loose.

Many molders prefer the latter type of pattern for the reason that in either case they are obliged to make provision for supporting the sand in the cope and prefer the whole rim in the nowel.

Fig. 3 illustrates this type of pattern—Arms 1, 2 and 3 show the various ways that they may be set into the rim.

The method of arm 1 is to be used in this particular pattern. Diameter $A$ should be made $\frac{1}{16}''$ larger than $B$ for draft.

Fig. 4 shows a portion of the rim built up ready for turning.

This may be built up in the same manner as described in connection with the making of the piston rings.

After the inside of the rim has been finished turn diameter $A$ equal to diameter $A$ in Fig. 3 to a depth of about $\frac{1}{8}''$. This will serve as a gauge when turning the outside diameter after the rim has been rechucked (turned over) and built up to its full height (Fig. 5).

There is no advantage in turning the outside diameter until the whole rim is built up.

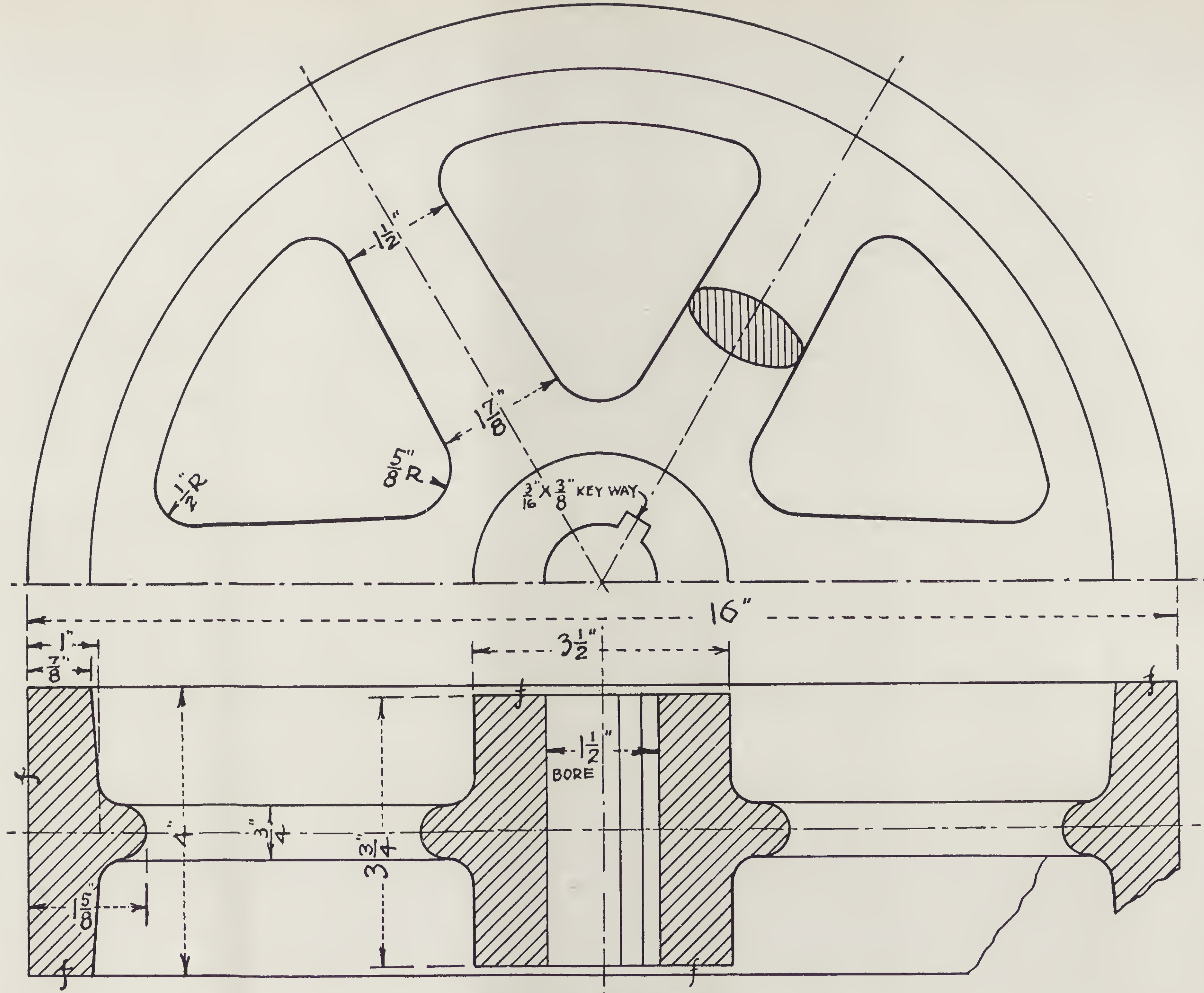



PLATE 19—FLY WHEEL

THE SHADED PARTS IN FIG. 1 AND FIG. 2 REPRESENT THE SAND OF THE COPE

FIG. 3

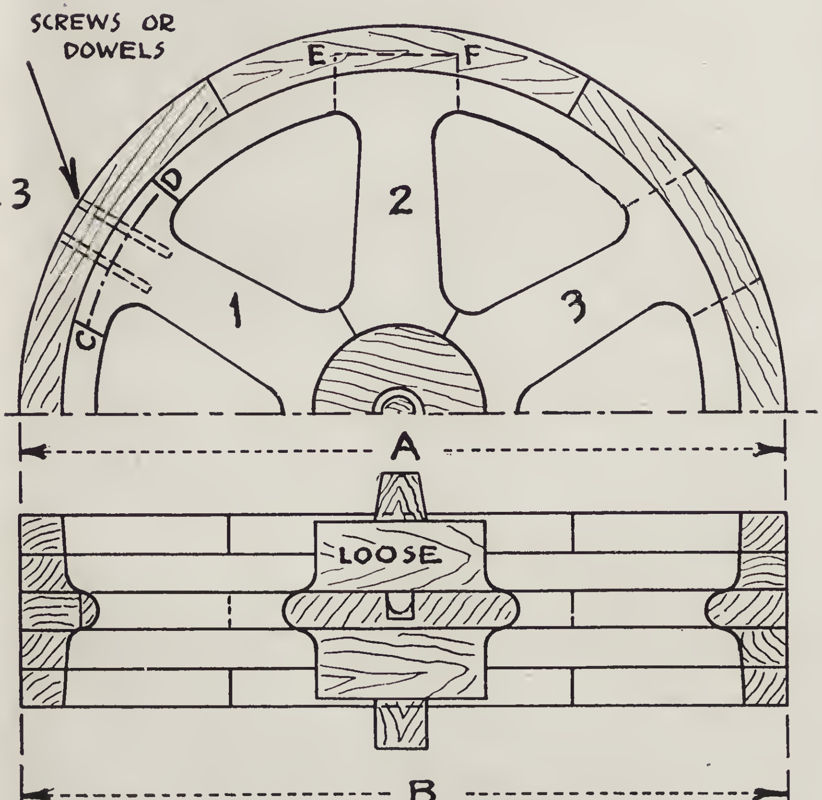



FIG. 4

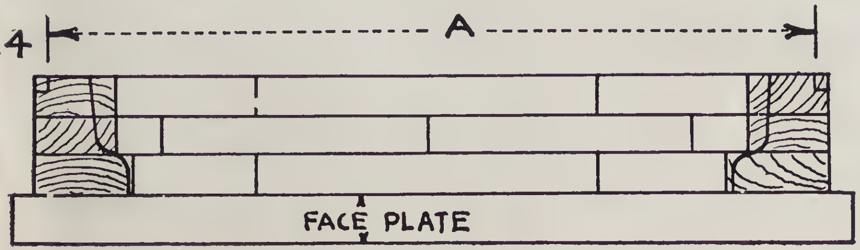



FIG. 1

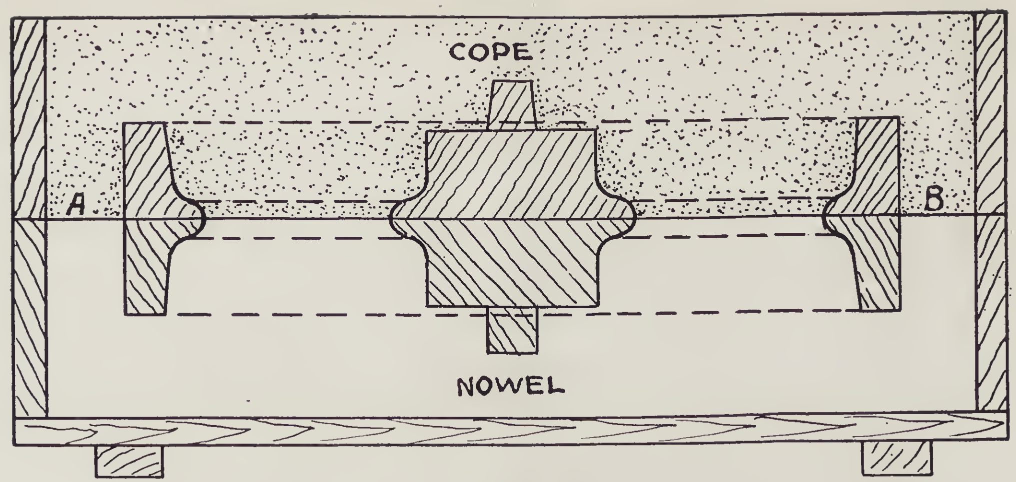



FIG. 2

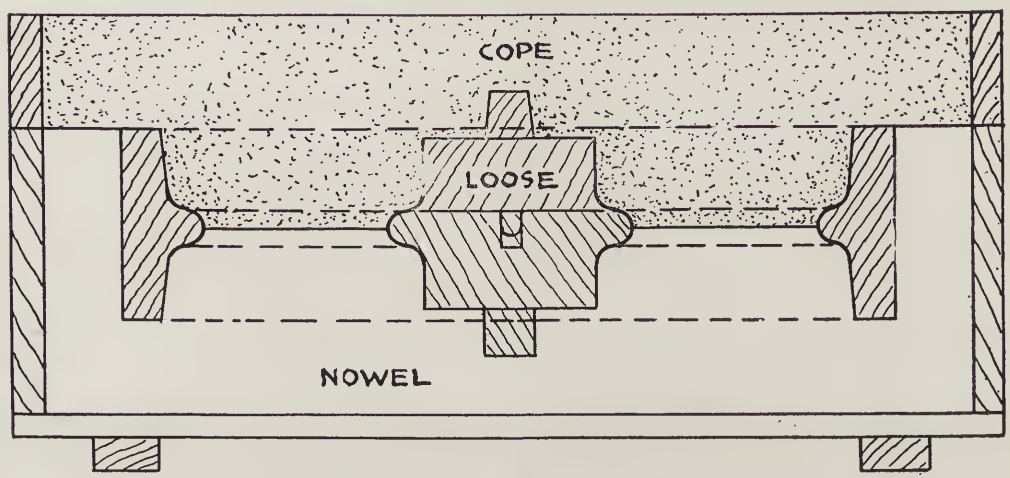
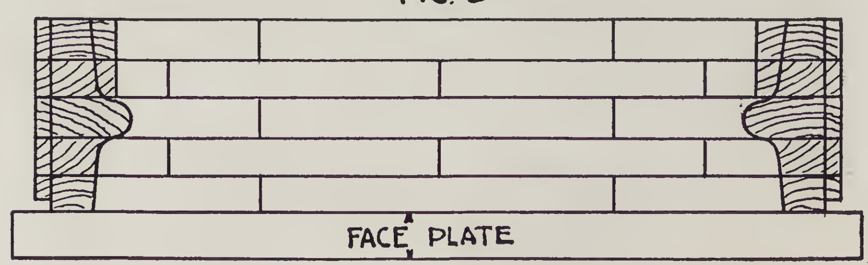



FIG. 5



## PLATE 20

### 54″ SHEAVE—USE OF SWEEPS

Large cylindrical castings such as hoisting drums, sheaves, fly wheels, steam cylinders and tanks of various kinds may be made with the aid of sweeps.

Briefly, a sweep is a board cut to conform to the radial section of the casting. This is fastened to a spindle which revolves in a base or seat. The outline of the casting is produced in the mold by revolving the sweep.

The use of sweeps greatly reduces the cost in producing large castings because of the saving in lumber and the saving of time which would generally be added to the cost of the pattern.

Some have an idea that sweep work is confined entirely to loam molding. But this is not so. Sweeps are frequently used for green sand molds.

The figures on the accompanying plate illustrate the method for producing a large sheave wheel in green sand with the aid of sweeps. If there were a number of castings to be made of this sheave or if it was of such a size as to be frequently in demand, it would be economical to make a pattern as shown in Fig. 1 and a section core box for the grooves as illustrated in Fig. 2. But it is sometimes necessary to produce a casting of this type in as short a time as possible. "Jobbing" foundries are often obliged to make castings of fly wheels, sheaves, etc., as quickly as possible. Such foundries are usually equipped with standard sets of arms, hubs, etc. (Fig. 3) so that work of this sort can be turned out on short notice. In this case, therefore, it is merely a matter of making three sweeps and a sectional core box for the grooves.

### MOLDING

Fig. 5 shows the first operation. A pit is dug in the floor of the foundry and the base and spindle set in place and made plumb. No. 1 sweep is then attached to the spindle by means of an arm (Fig. 4). This sweeps the bed for the arms to rest upon and also the joint line for the cope to rest upon. The joint line is level with the foundry floor.

Note that all of the sweeps extend out along the floor line. This serves as a gauge in setting all of the other sweeps. The arms (Fig. 3) are then placed in position on the bed.

Sweep No. 2 is then attached to the spindle (Fig. 6). This sweeps the impression for the cope. The cope is then "rammed up" and removed as shown in Fig. 7.

Sweep No. 3 is then attached to the spindle for sweeping the nowel. This completes the molding operations with the exception of "slicking up" the mold and setting the cores.

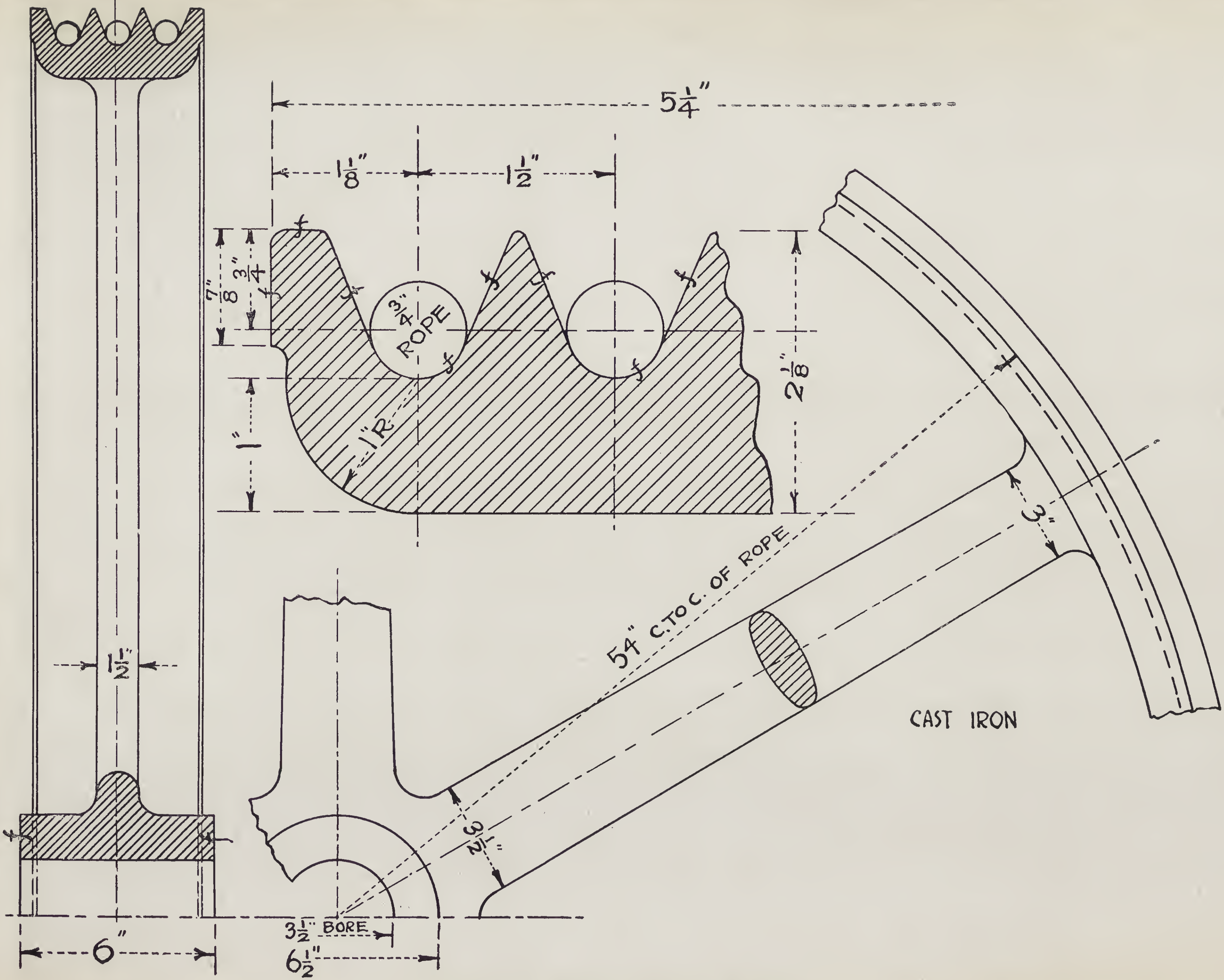



PLATE 20—54″ SHEAVE—USE OF SWEEPS

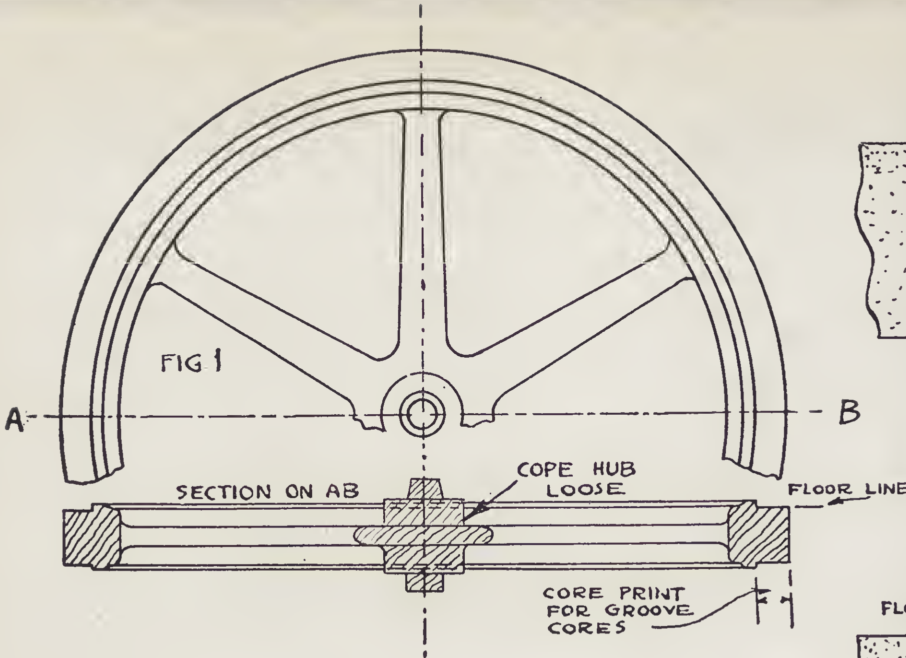



FIG 1

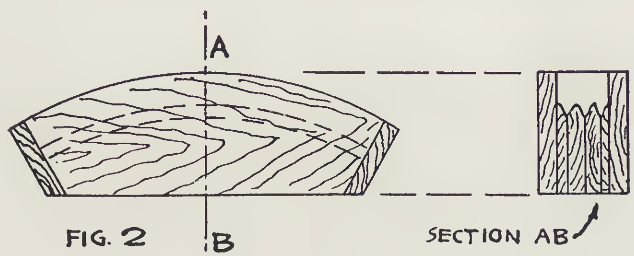



FIG. 2

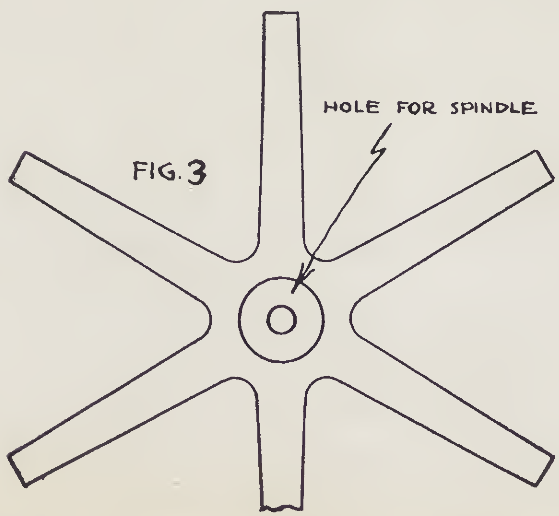



FIG. 3

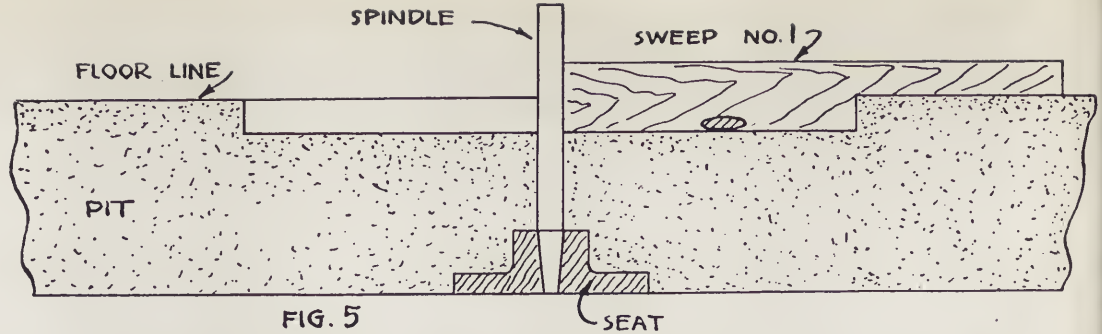



FIG. 5

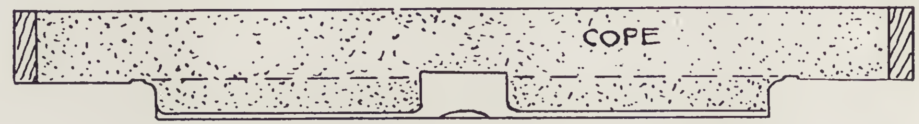



FIG. 7

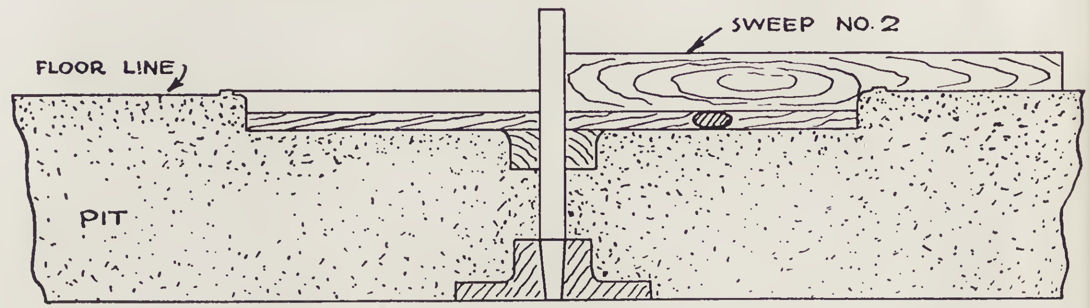



FIG. 6

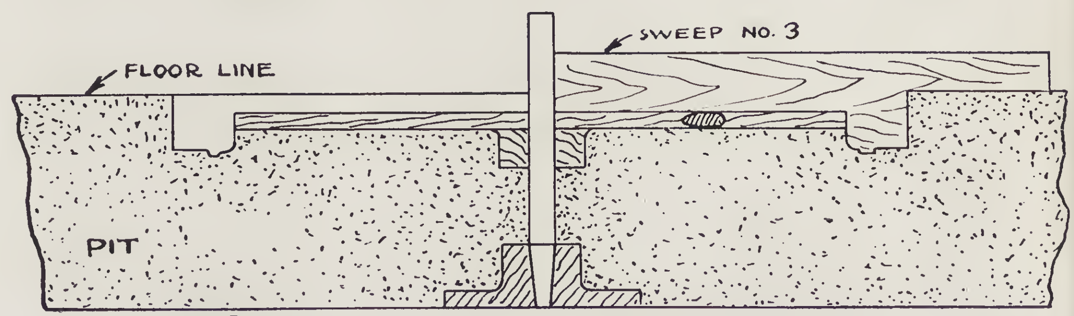
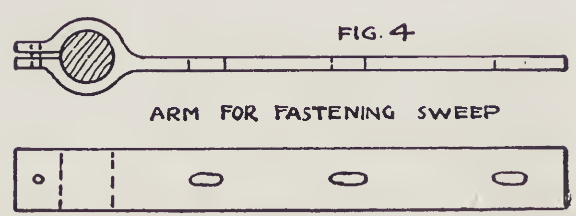



FIG. 8

FIG. 4



ARM FOR FASTENING SWEEP

# PLATE 21

## GEARS

The subject of gear castings is a large one, involving much detail in describing all the various types of patterns and " rigs " used for producing the castings. The following has to do with the ordinary type of spur gear pattern.

The main body of the gear is built up in practically the same manner as described in connection with the fly wheel (Plate 19), except for the draft on the outside of the r m. This draft on a gear should be so small as to be hardly perceptible.

The figures on the accompanying plate illustrate the modern method of finishing spur-gear teeth. The same principles may be applied to various forms of teeth.

The fillet *A*, Fig. 1, is not formed on the stock of the tooth. Leather or wax may be used to form this after all of the teeth have been fastened to the rim.

The stock for the teeth may be in the form of rectangular strips to start with as shown in Fig. 2 with the distance *A* long enough for several teeth. These should be hollowed out as shown at *BC* and then cut into blocks, the exact length of the teeth.

The blocks are then fastened in a jig (Fig. 3) and pared to the approximate form. Before removing them from the jig, star (*) the end of the tooth adjoining the starred end of the jig. This serves to locate the teeth when replacing them for sanding.

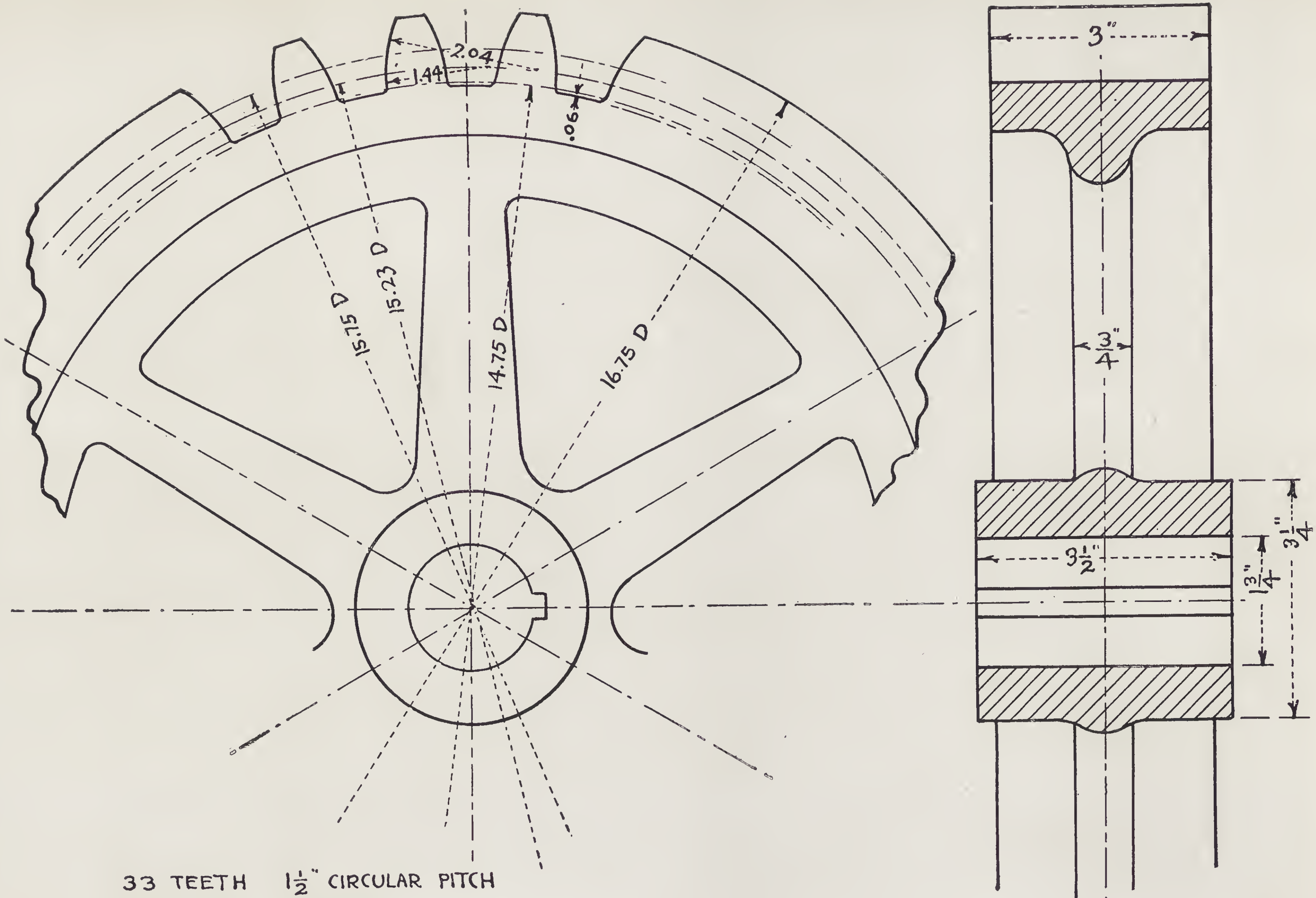
The jig (Fig. 3) is made by fastening two templet pieces *D* at opposite ends of the strip *C* or formed out of one piece.

Some pattern-makers prefer that the line *AB* (Fig. 3) conform to the root diameter of the wheel.

The teeth are sanded to the exact form by replacing them in the jig and rotating them upon a revolving cylinder covered with sandpaper (Fig. 4) until they are the exact form of templet *D* (Fig. 3). The sandpaper may be glued to the cylinder or fastened by a wedge-shaped piece of wood. The latter method is more convenient because of the ease of removing the worn-out sandpaper.

When placing the teeth on the rim of the wheel some pattern-makers prefer to put a center line on each tooth and set the teeth to a corresponding line on the rim. But there is a greater chance for error in setting the teeth in this manner than if the root edges of the teeth were set to the spacing lines.

The student is expected to construct a pattern of the spur gear illustrated on the following plate.




33 TEETH $1\frac{1}{2}$" CIRCULAR PITCH
15.75 PITCH DIAMETER
6 ARMS.

PLATE 21—GEARS

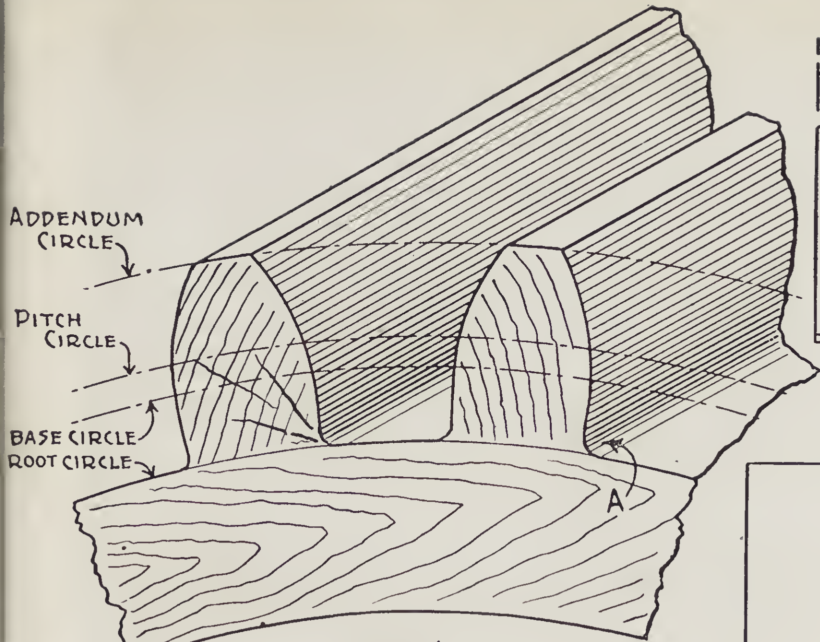
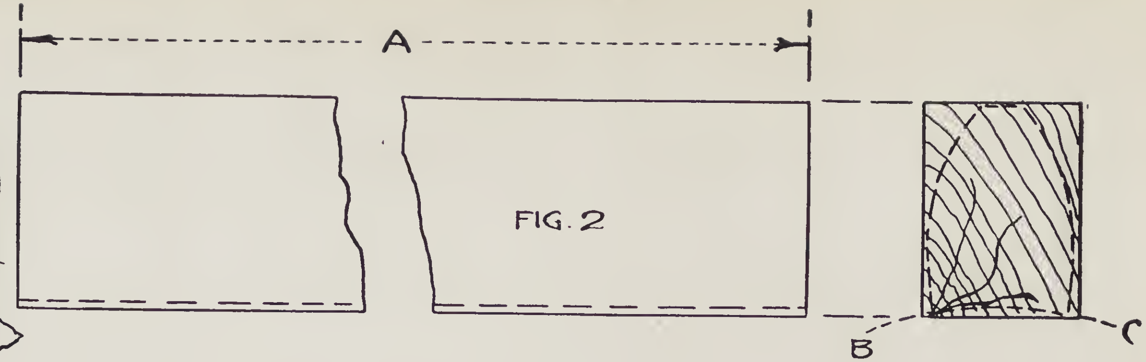
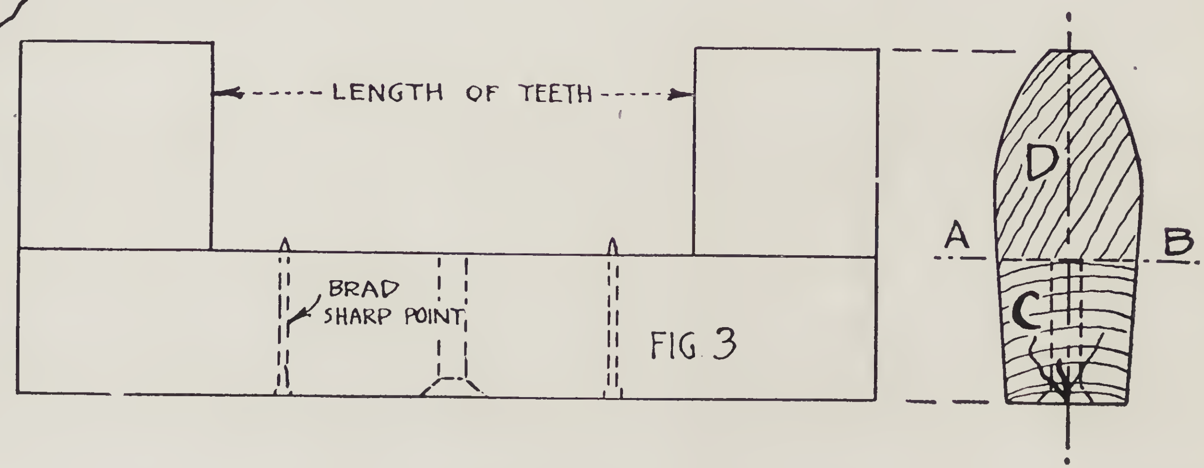



FIG. 1

INVOLUTE TOOTH
CAST GEAR



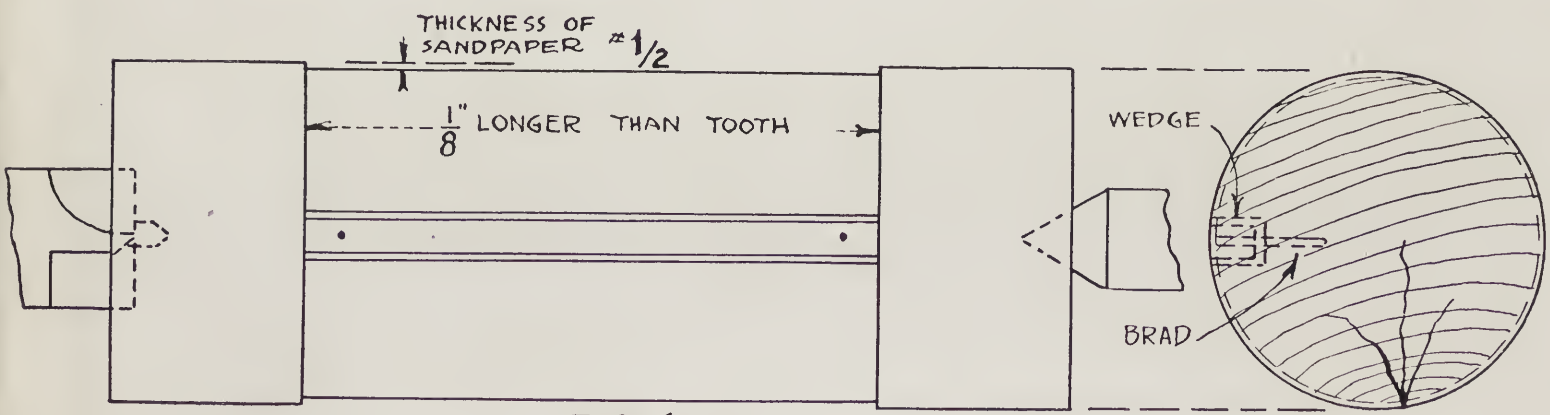




FIG 4

# PLATE 22

## HOLLOW PATTERNS

Patterns for pipes, columns and other similar patterns above 8″ in diameter are made hollow. This is accomplished by nailing staves or lags together, running parallel with the axis of the cylinder, to a series of heads. The number of heads depends upon the length of the cylinder. The heads should not be too great a distance apart, in any case. Glue is applied to the joints of the staves; also where the staves rest upon the heads.

There is a threefold object for constructing patterns in this manner. Economy in the use of lumber is attained, the pattern is much lighter in weight than the pattern as usually constructed and the amount of shrink wood is reduced to a minimum, thus preventing the pattern from being distorted by shrinking and swelling.

**Method of Construction.**—It is not practicable to give any fixed rule applying to the construction of the various forms of cylindrical patterns.

The figures on the accompanying plate illustrate some of the different types.

Fig. 1 shows a barrel for a steam cylinder pattern 24″ in diameter. *A* represents the heads which are built of segments with a tie piece (*X*) across the diameter. It is not wise to make the heads of solid stock for a first-class pattern as it would require that a wide board be used. This would tend to shrink and swell considerably. *B* acts as a head, also as a core print. Some pattern makers prefer to make the core print separate. *C* represents the staves. These are glued along the joints and fastened to the heads with screws. They should be made from 2″ stock and of a dimension about 3″ wide on the outside diameter. The screw holes should be counterbored for the heads of the screws and then plugged. *D* represents the flange. This is made in segmental form. The joints (*E*) are held together by means of a dowel, the dowel hole being bored after the flange is fastened to the barrel. *F* shows a spline or tongue. The key for the tongue may be cut before fitting the segments or the segments may be fitted and fastened temporarily, removed and the kerf then cut. *G* shows the end of the core print closed in with a head. *H* indicates a fillet on the core print. This is desired on horizontal cores of considerable weight because of the tendency to crush the edge of the mold.

Fig. 2 represents a different type of pattern construction which is used for various cylindrical patterns of about 12″ in diameter. *A* represents the head, which is made from solid stock. *B* indicates the staves; *C*, the flange, also solid, and which may be turned with the barrel, or separately. *D* shows the core print. This is built in segmental form and fastened after the barrel is turned.

Fig. 3 shows a different way of constructing the same barrel shown in Fig. 2. In this case the staves are extended to include the core print. This type of construction requires thicker stock for the staves than Fig. 2. The flange is made in the same manner as described under Fig. 1.

Fig. 4 shows a cheap method for constructing a barrel. The heads are made from solid stock and the staves made narrow enough so that it is unnecessary for them to be hollowed out to fit the heads.

Fig. 5 illustrates a method used for patterns 6″ to 8″ in diameter.

## CORE BOXES

Core boxes are not generally required for the cylindrical cores because most foundries are equipped to make cores without the use of a box. Sometimes, however, it is necessary that a box be used and the following paragraph is therefore not out of place.

The same conditions prevail when it is desired to produce heads for core boxes as exist when heads for barrels are to be made. It is not advisable to use solid stock when a diameter of over 12″ exists because of the swelling and shrinking of the wood. Fig. 6 shows one method of constructing a box. This box may be built by sawing circular heads and using narrow staves as in Fig. 4. Fig. 7 shows a method for constructing heads for larger boxes. This method reduces the possibility of wood shrinkage to a minimum. The staves need not be planed to form a perfect circle. By flattening them off as indicated by Fig. 8, sufficient curvature may be obtained. This may be accomplished on the circular saw.

## STAVES

The thickness and width of the staves and the number to a circle is determined entirely by the judgment of the individual pattern-maker and therefore vary. But the following sizes will serve as a basis. In Fig. 1 use 2″ stock; in Fig. 2, $1\frac{1}{2}$″ stock; in Fig. 3, 2″ stock; in Fig. 4, $1\frac{1}{4}$″ stock.

Fig. 9 shows how boards may be cut into staves most economically.

Fig. 10 shows a method for cutting staves to the proper angle by tilting the saw table. If the saw is in good condition the edge will not require " buzzing " (run over the jointer).

Fig. 11 shows a convenient method of removing the excess stock on the staves that are fitted to circular heads. This also applies to core boxes.

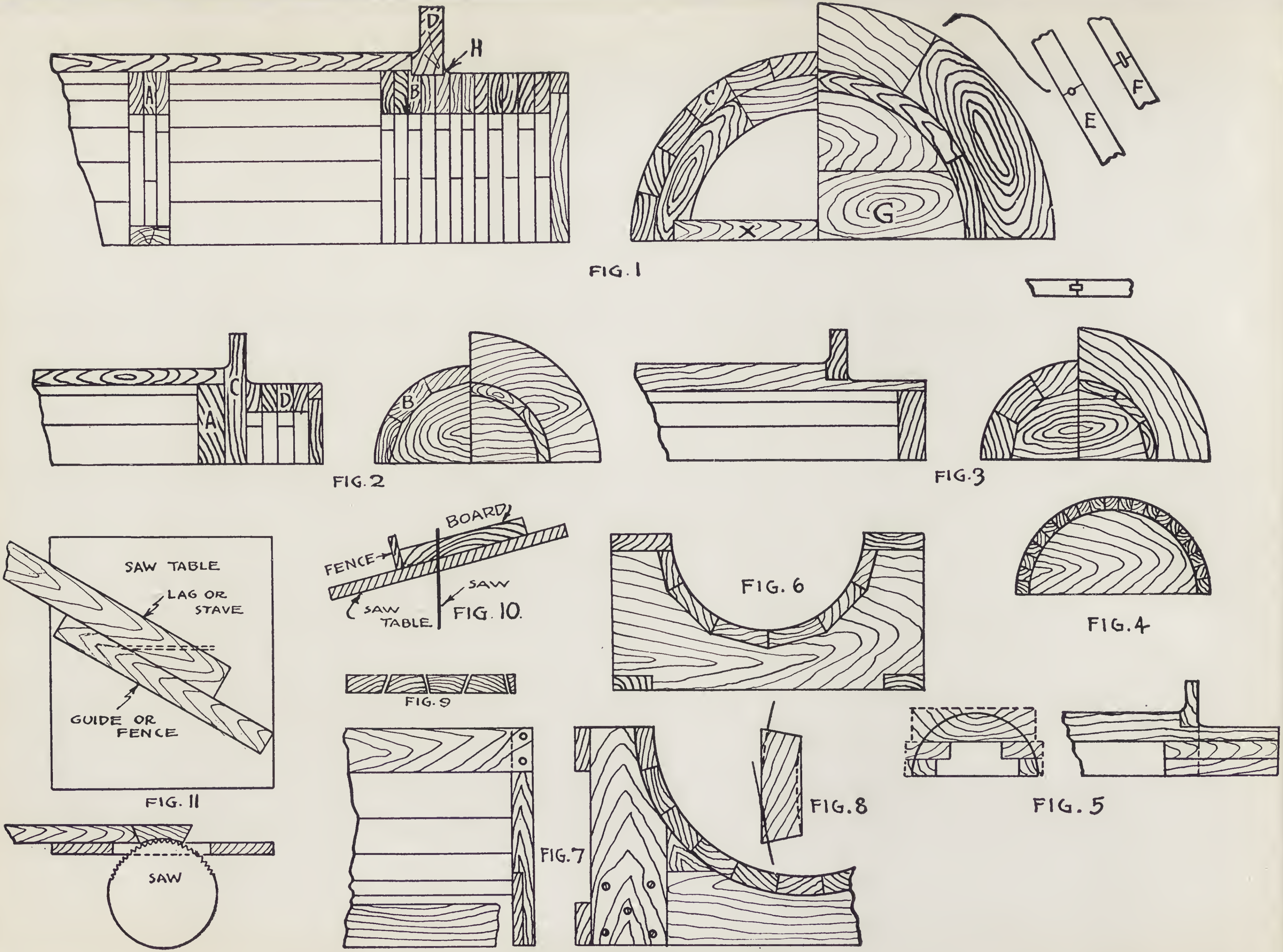



PLATE 22—HOLLOW PATTERNS

# PLATE 23

## SKELETON PATTERNS

The term skeleton pattern usually refers to a type of pattern made in open rib-work form, the ribs being the exact thickness of the metal of the casting. There are, however, other types of skeleton patterns such as shown on the accompanying plate.

Skeleton patterns are confined to medium and large size work and are resorted to chiefly because of the lower cost of making the patterns. This is especially true where but one or two castings are desired.

Certain types of castings may well be made from skeleton patterns. In fact, in many cases this type of pattern is preferable.

### PATTERN

**Pipe Bend.**—Fig. 1 illustrates a type of skeleton pattern that can be used for various forms of pipe work and other similar patterns. The pattern is constructed as follows:

1. Take two boards about $\frac{7}{8}''$ thick and saw them out to the outline of the pattern including the core prints. The boards are to be doweled together in the same manner as for any split pattern.
2. Saw out the flanges *A* to fit over these boards and fasten them in place.
3. Saw out a series of semicircular pieces (*B*) less the thickness of the board to which they are to be fastened and secure these as shown. It is not absolutely necessary to get these exactly the same distance apart.
4. The pieces *C* are made in the same manner as the pieces *B*.

The pattern is now to be completed by the molder. He should proceed as follows: The pattern is placed upon a molding board and sand filled in between the pieces *B* (Fig. 1). With the aid of a strickle *D* (Section *AB*, Fig. 1) the sand between the pieces *B* is " struck off " to conform to the desired shape of the pattern. This sand is separated from the sand of the mold by means of parting sand or newspaper.

The pattern is " rammed up " in the same manner as a regular pattern and any sand from the pattern remaining in the mold after the pattern is withdrawn can easily be removed.

### CORE

Figs. 2 and 3 illustrate two different ways of making the core. There are other methods but the two here mentioned are the ones in most common use.

Fig. 2 illustrates a skeleton box and is made of pieces *A* and *B*. These are held together by the tie pieces *D*. The parts *C* are semicircular in form and serve as the ends of the frame. They are fastened to *D*. This frame is placed upon an iron plate as shown in section *AB*, Fig. 2. Sand is filled in between *A* and *B* and " struck off " to the desired form by means of the strickle *E*.

Fig. 3 illustrates a core board. This is the most economical method for producing this and similar cores but there are cases where the employment of the method described in connection with Fig. 2 is necessary.

To make a core, using the core board, it (the core board) must be clamped to an iron plate.

Sand is then heaped along the outline of the core board and then, using a strickle *C* (Section *AB*, Fig. 3) the core can be "struck off."

## LOAM MOLDING

The accompanying cuts illustrate the various stages of development in producing a casting by means of a skeleton pattern and a loam mold.

Fig. 1 shows the finished casting. In Fig. 2 the skeleton pattern is shown in position for forming the core and mold. It will be observed that the core is partially built up, also that between the spaces of the first two ribs it is filled up with black sand (old molding sand) to conform to the shape of the outer surface of the patterns.

This enables the molder to build up the outer part of the mold as shown in Fig. 3. The outer part of the mold is built up in halves in order that the mold may be taken apart, as in Fig. 4, for the purpose of removing the pattern and slicking up the mold. The two halves of the mold are prevented from adhering to each other by placing newspapers between the joints.

Figs. 5 and 6 show the pattern removed and the mold and core slicked up ready to be assembled for pouring the metal.

Loam molding has been previously described under molding notes as involving molds built up of brick upon iron plates with a special facing (page 21).

The building of the mold upon iron plates permits the mold to be taken apart for finishing and drying. When ready to be poured it is lifted by means of a crane and lowered into a pit where sand is tamped around it thereby strengthening the mold in order that it may resist the pressure of the metal.

Where it is not convenient to lower a mold in a pit, an iron curbing may be set up around the mold and the space between the mold and the curbing filled up with sand.

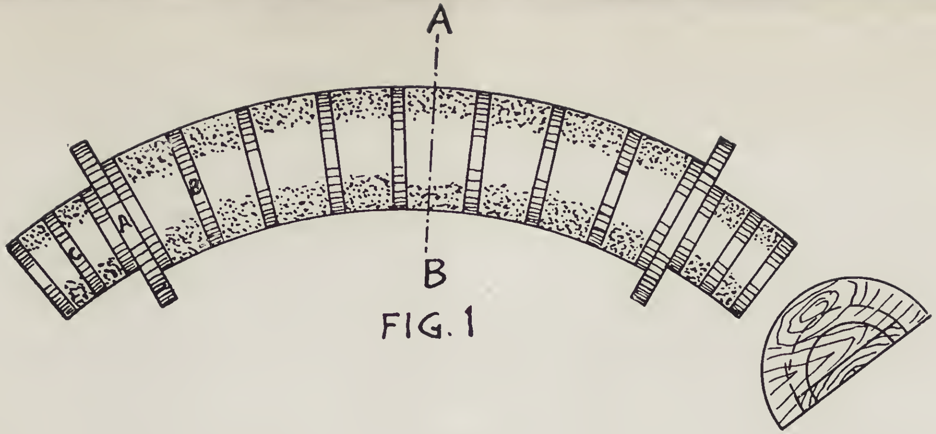
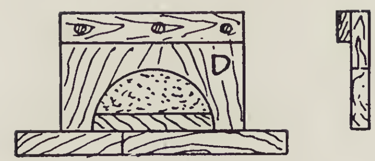


FIG. 1



SECTION A-B, FIG. 1

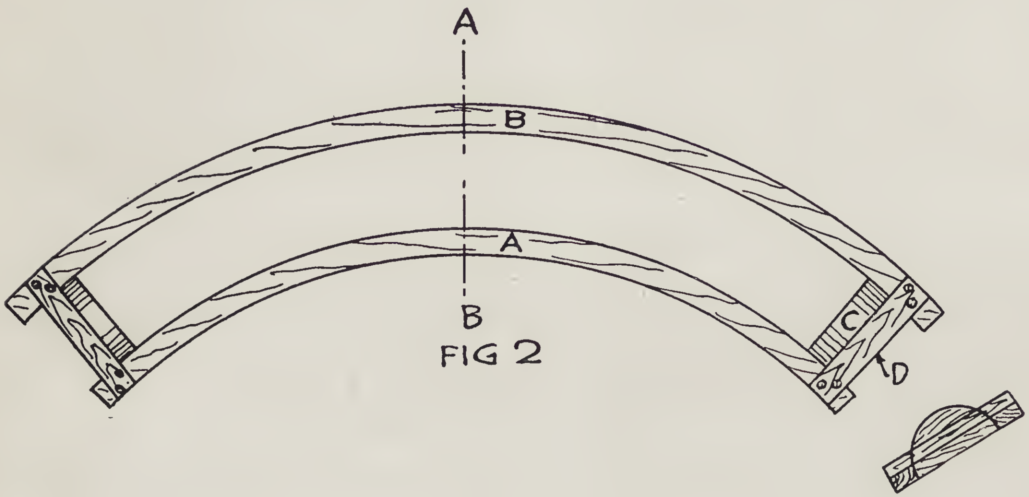
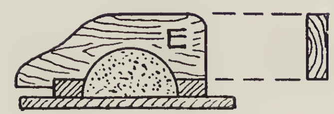


FIG 2



SECTION A-B, FIG. 2

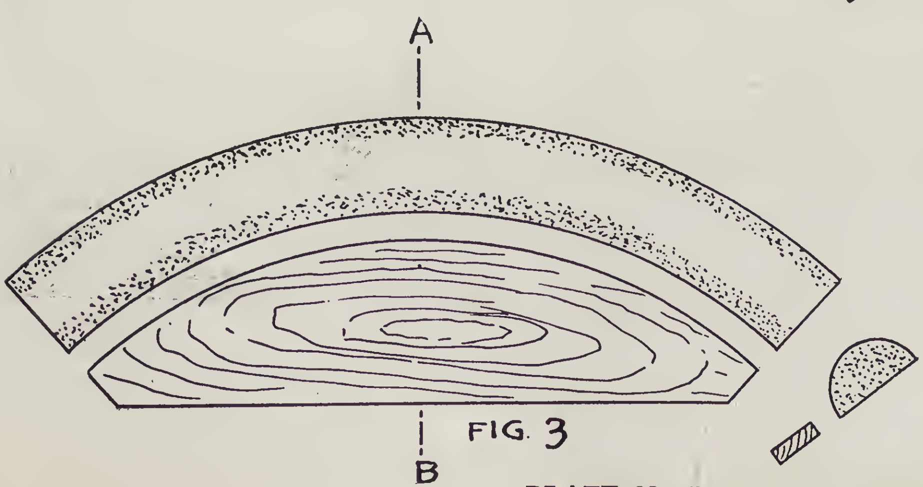
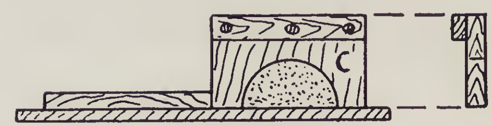


FIG. 3



SECTION A-B, FIG. 3

**PLATE 23—SKELETON PATTERNS**

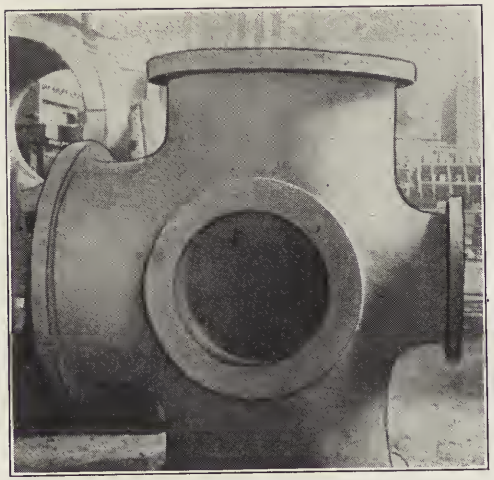


Fig. 1.

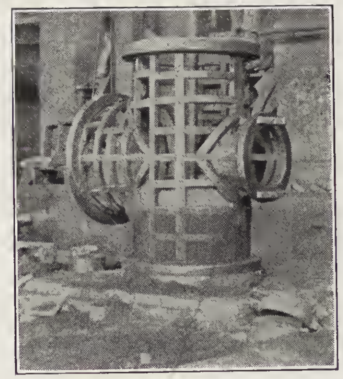


Fig. 2.

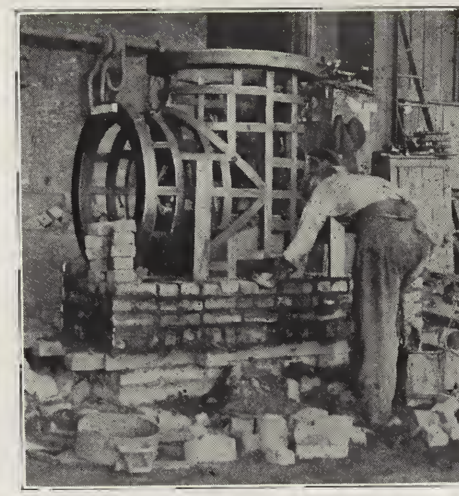


Fig. 3.

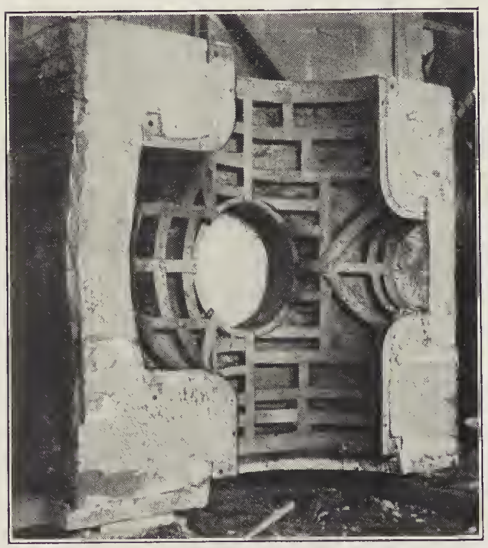


Fig. 4.

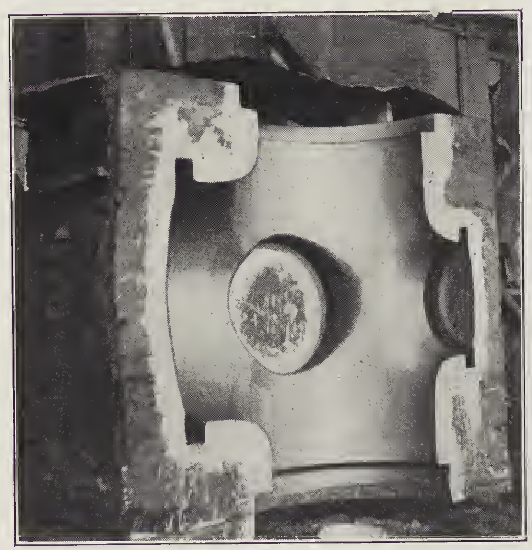


Fig. 5.

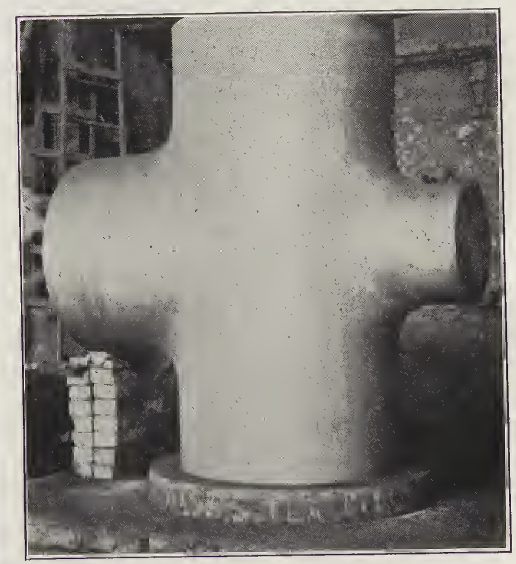


Fig. 6.

## PLATE 24

### TYPES OF PATTERN CONSTRUCTION

Fig. 1 shows a drawing of a machine bed leg. Patterns similar to this are "built up" upon a web as illustrated in Figs. 2 and 3.

Fig. 2 shows the web constructed with half lap joints.

Fig. 3 illustrates the joints notched together with the fillet *A* glued in separately.

The method of Fig. 2 is more substantial, but that illustrated by Fig. 3 is quicker.

Fig. 4 shows how a pattern may be "boxed up," i.e., made hollow. Notice that the sides *A* are the full depth of the pattern.

If the sides were made as shown in Fig. 5, the boards *A* and *B* would be liable to swell when embedded in the damp sand and would project out from the sides. This would result in the "tearing up" of the sides of the mold when the pattern was withdrawn.

When patterns are "boxed up," about $\frac{1}{8}''$ should be left between the boards to allow for swelling. If the heads are more than $1'$ in width they should not be made solid because of the shrinking and swelling, but should be framed together. The intermediate heads are left open in the center, but the end heads should be boarded in.

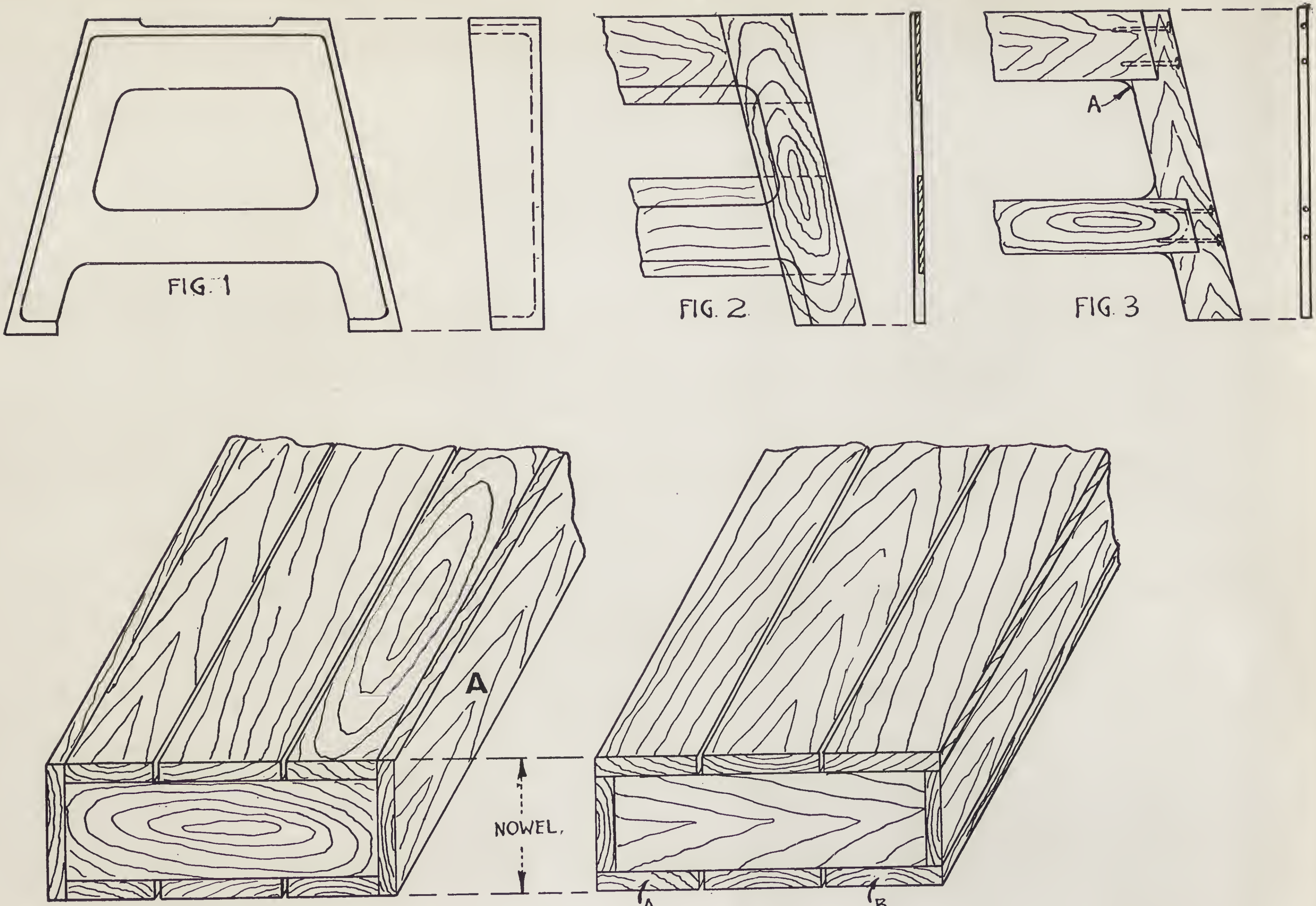



FIG. 4 FIG. 5

**PLATE 24—A TYPE OF PATTERN CONSTRUCTION**

## PLATES 25 TO 30

### ADDITIONAL PATTERNS

A few additional drawings of details are here given. The instructor may desire a pattern of this sort at times. Note that the drawings are dimensioned as finished drawings. This means, of course, that the student will find it necessary to take this fact into consideration and allow for finish.

All students should become familiar with this phase of the work.

The suggestion is made that the instructor allow the advanced students to select one of these objects to work upon without instruction. This will allow the student to depend entirely on his own ability and will enable both the teacher and himself to rate his ability.

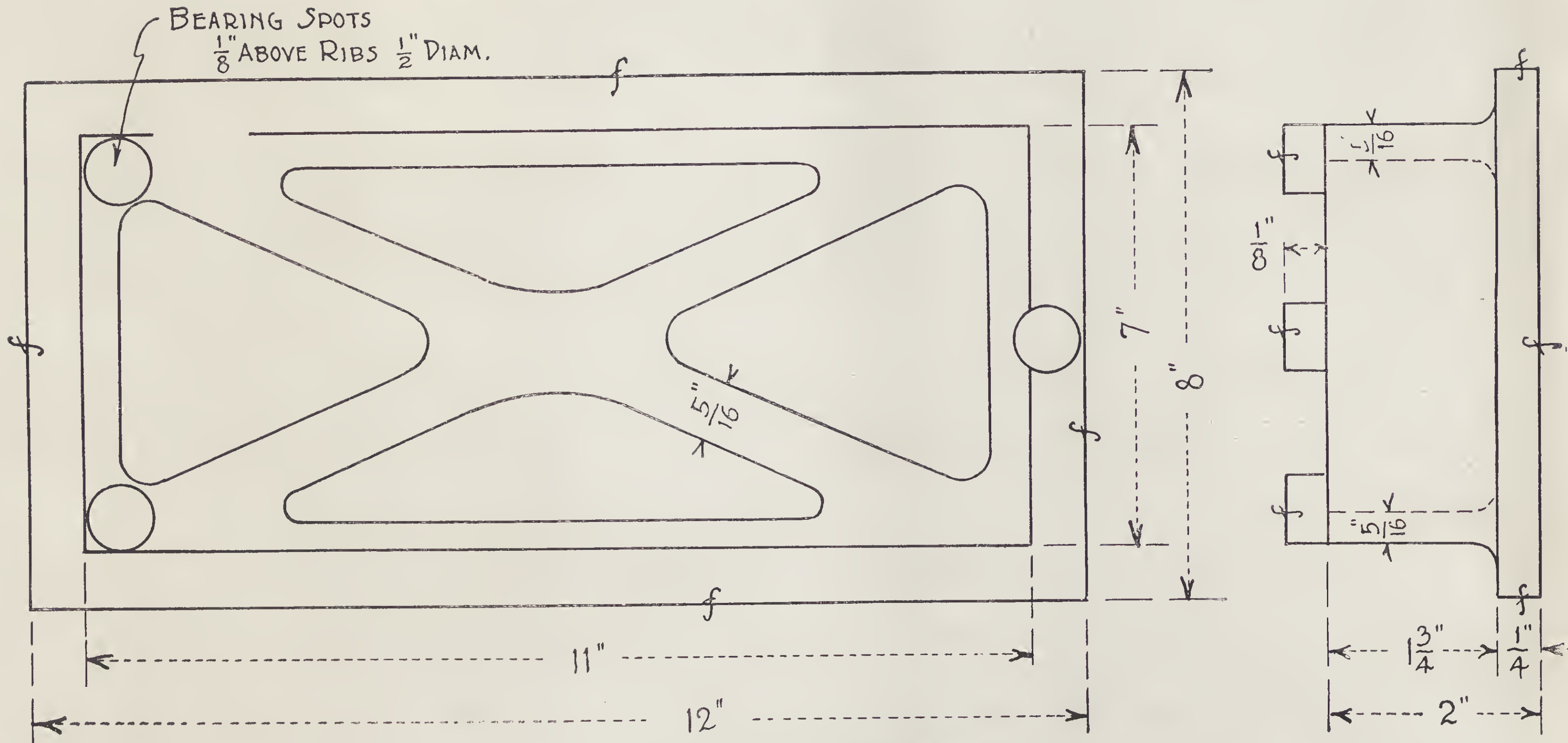



PLATE 25—SURFACE PLATE

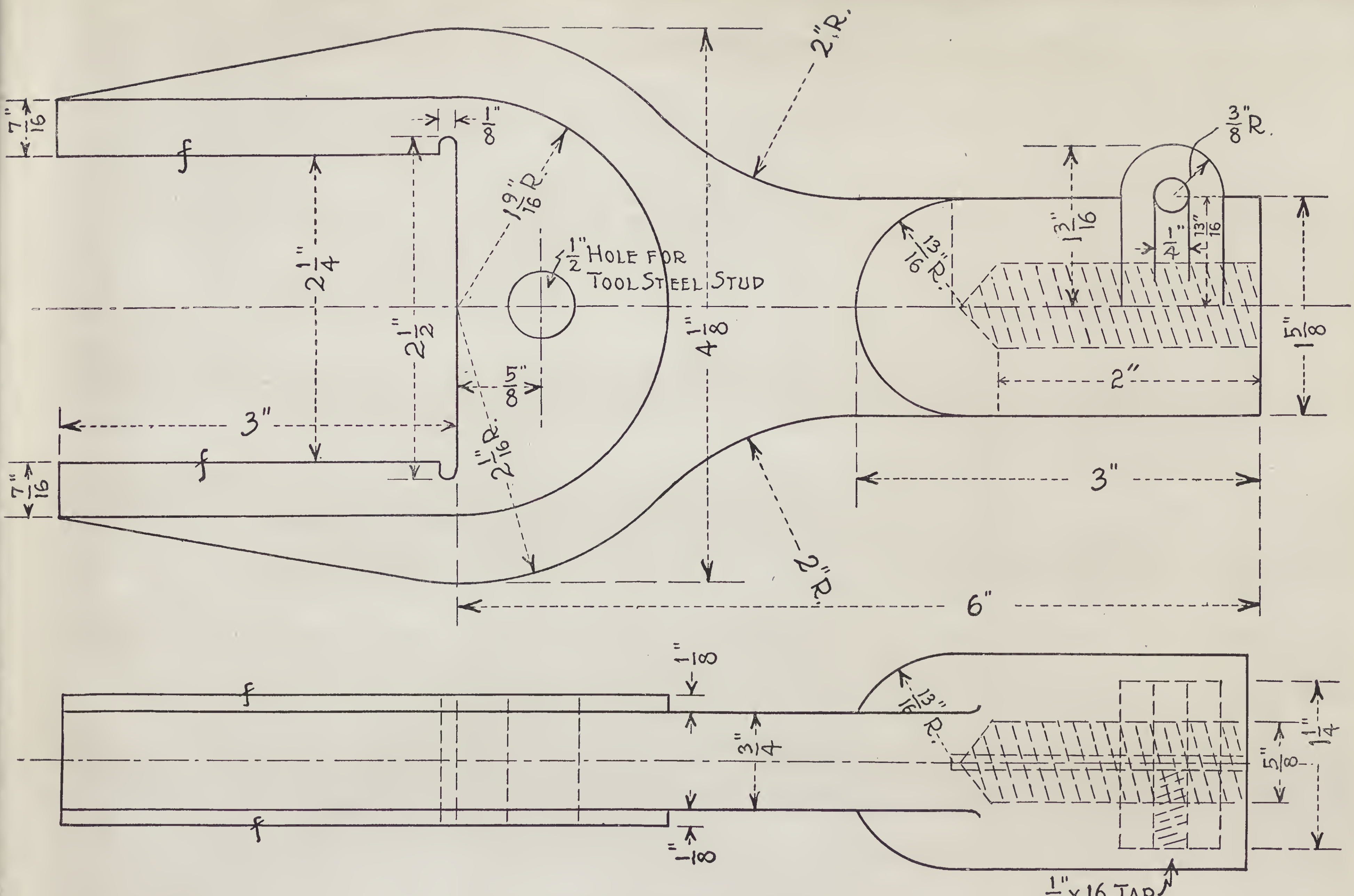



PLATE 26—SHIFTER FORK

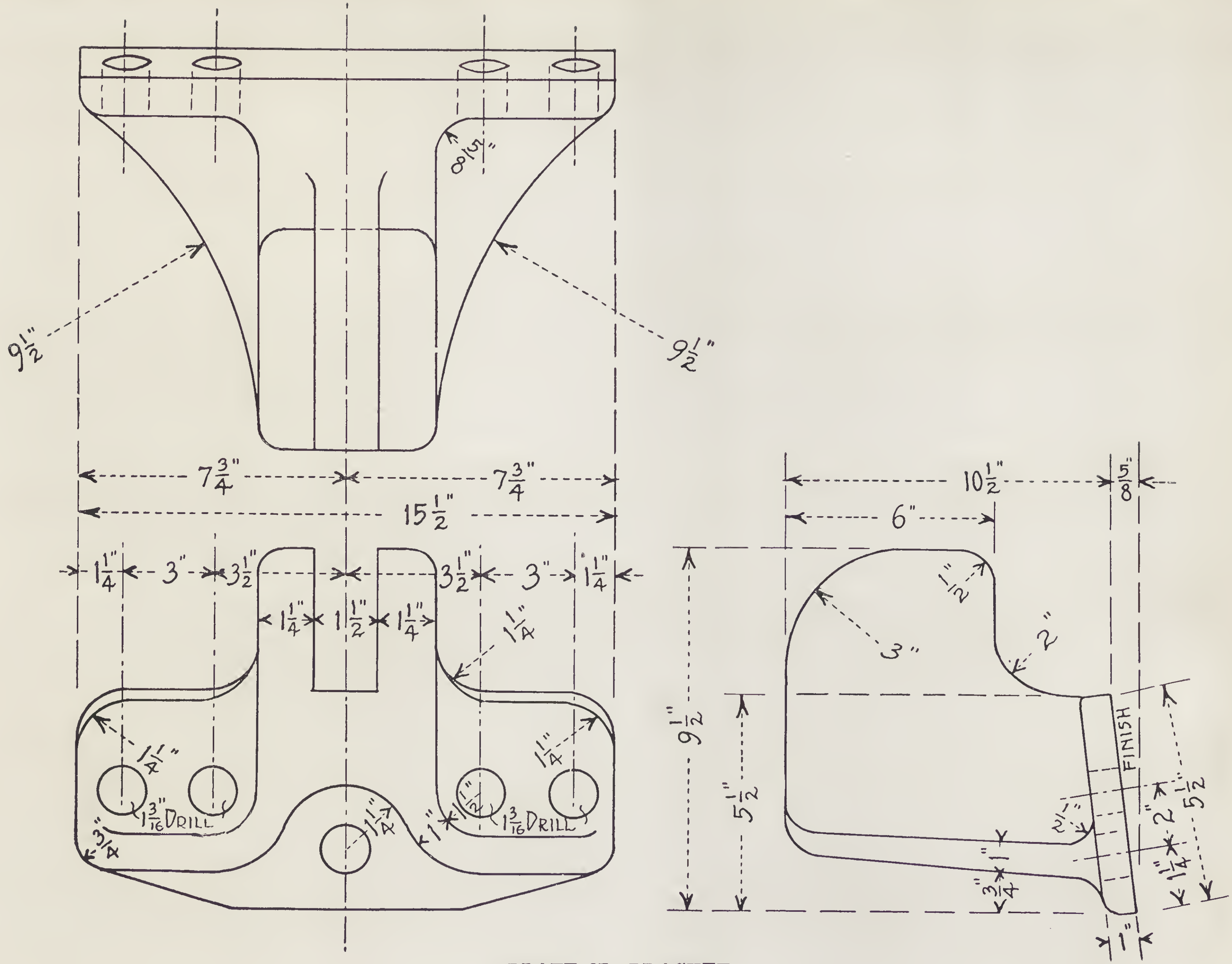



**PLATE 27—BRACKET**

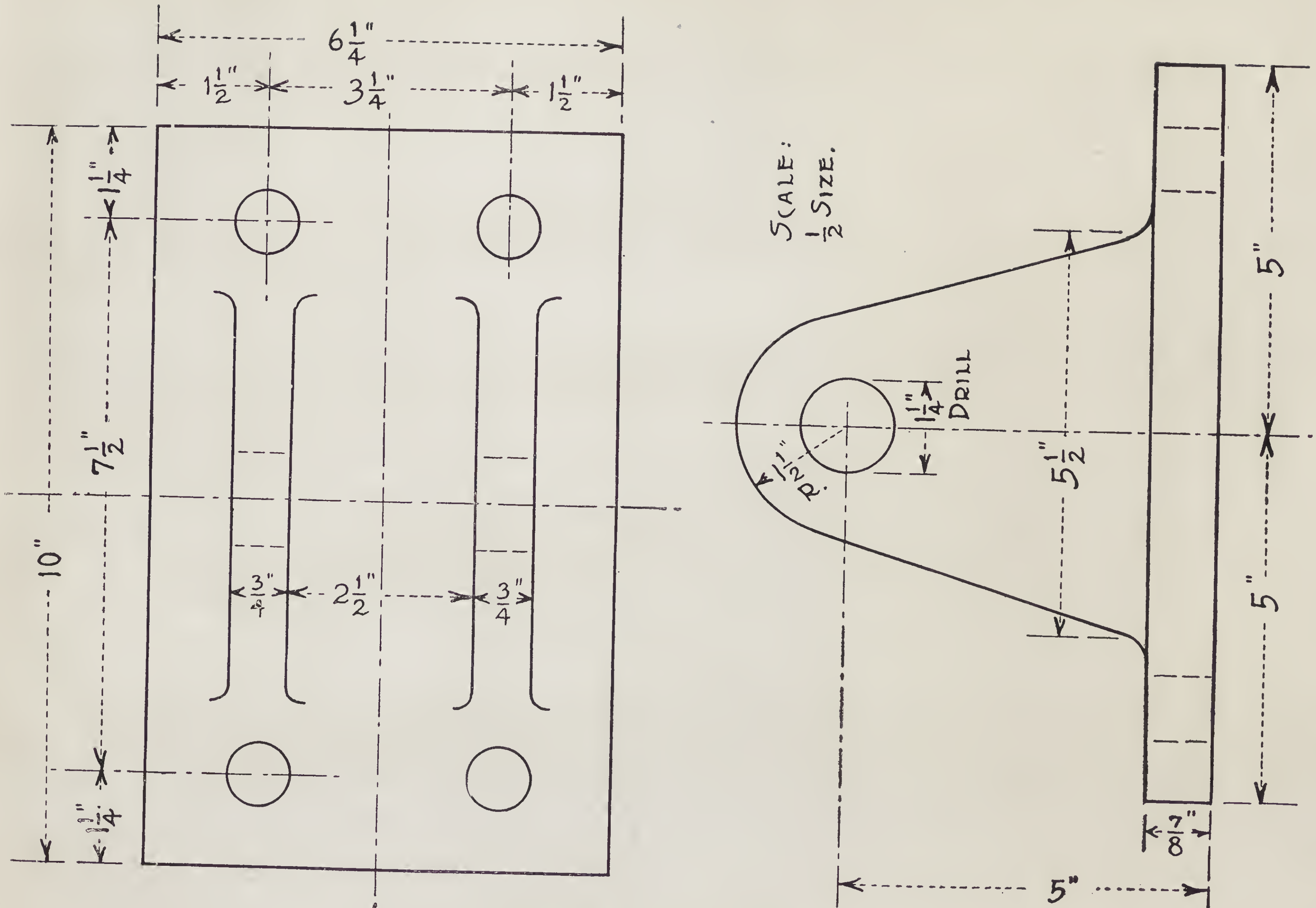



PLATE 28—PULLEY STAND

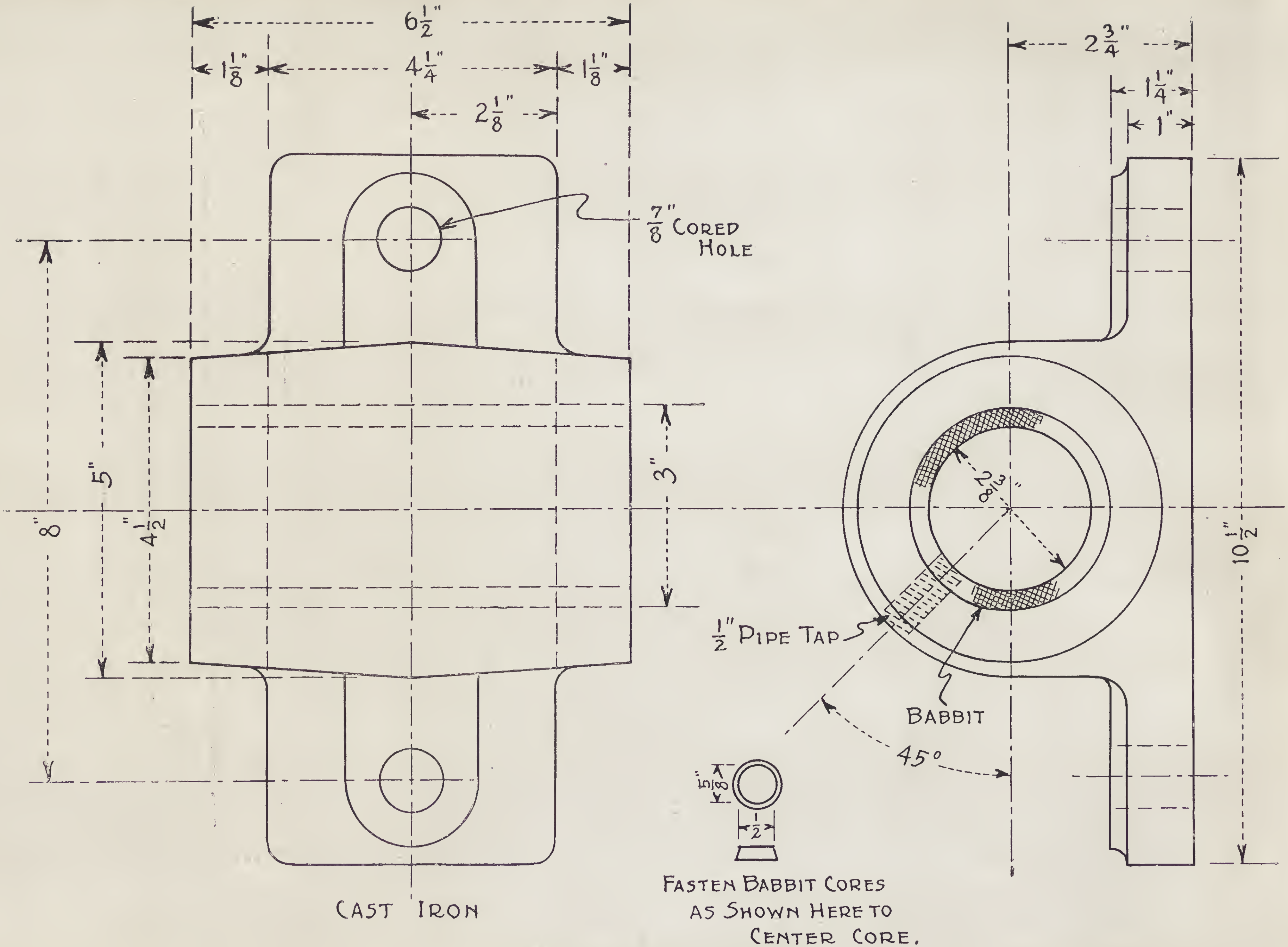



**PLATE 29—JOURNAL BEARING**

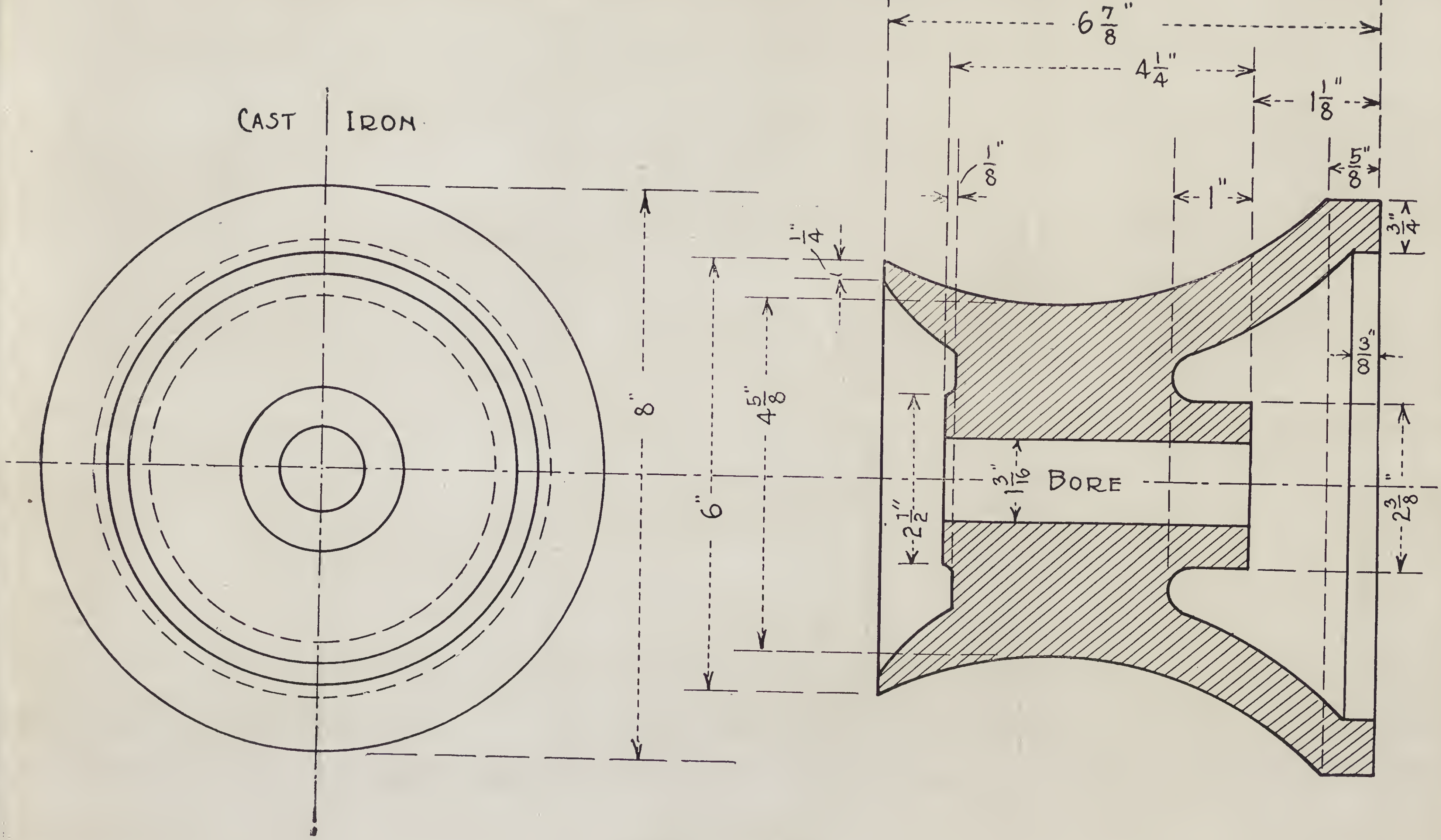



PLATE 30—PULLEY

Date Due

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| 8-5-35 | | | |
| 3-15-41 | | | |