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FOUNDRY WORK

FOUNDRY WORK

A Text on Molding, Dry-sand Core-Making, and the Melting and Mixing of Metals

By

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PREFACE

In preparing this book, it has been the author's aim to provide a suitable text for schools and colleges and for use by apprentices in commercial shops. It is elementary to the extent that the student can grasp the fundamental principles of foundry work, yet deep enough to give a general working knowledge of foundry practice.

The book consists of three parts. The first will enable the student to secure a general knowledge of foundry work, of the sizes and types of blast furnaces, and of the making of pig iron.

The second provides instructions for practice in molding, coremaking and other parts of foundry work.

The third part is devoted to the mixing and melting of metals.

The material contained in this volume was obtained as a direct result of the author's experience in teaching apprentices in commercial shops and engineering students at Purdue University. The information on making coke, mining iron ore, operating blast furnaces, and chemical analysis of iron has been inserted to round out the volume and represents good commercial practice.

For many of the drawings the author is indebted to students taking foundry work under him, and for other illustrations to foundry supply firms.

R. E. Wendt.

W. Lafayette, Ind.
June, 1923.

CONTENTS

PART III

MELTING AND MIXING METALS

PART I

FUNDAMENTAL PRINCIPLES

FOUNDRY WORK

CHAPTER I

FOUNDRY COKES

There are two methods of manufacturing the coke used for melting metals. They are known as the Beehive-oven and By-product, or Retort, methods. The beehive method is the older and until recently the leading method.

In the beehive process the air is admitted to the coking chamber for the purpose of burning all the volatile products of the coal. There is left a hard coke, silvery in appearance, good for melting metals. However, all the other products of the coal are wasted, and for that reason the beehive method is being replaced rapidly by the by-product method.

In the manufacture of by-product coke, almost all of the useful ingredients in the coal are saved, yet the coke is of good quality for melting purposes. The by-product coke is darker than coke made by the beehive process and frequently is not so hard. When the two cokes are used for melting metals there seems to be very little difference between them.

A beehive oven is shown in Fig 1, *A* indicating the furnace, *B* the charging level, *C* the receiving level, *D* the receiving door, *E* the charging hole, and *F* the car tracks. These ovens are built in sizes ranging from 10 to 12 ft. in diameter and from 6 to 8 ft. high. The inside of the oven is made of fire brick and the outside of stone.

Bituminous coal is dumped into the oven from the top to a depth of about 2 ft. for 48-hr. coke or 2½ ft. for 72-hr. coke. From 3 to 7 tons of coke are made every time the oven is fired, the amount depending upon the size of the oven. After the impurities are burned off, the coke is drawn out and cooled with water. From 60 to 70 per cent of the coal charged is obtained as coke. The analysis of a good foundry coke should be as follows: Carbon from 88 to 92 per cent, ash from 6 to 10 per cent, and sulphur not over 1 per cent (as low as possible).

Although beehive-oven and by-product cokes are almost always used for melting metals, both can be used for heating purposes.

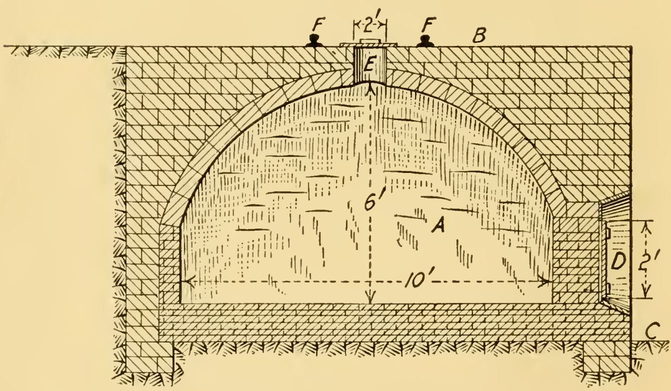

Fig. 1.—Beehive coke oven.

IRON ORES

Iron ore is found in many parts of the United States. The largest iron-ore district is known as the Lake Superior district. The mines are scattered over the northern part of Michigan, Wisconsin, and Minnesota. About four-fifths of the iron mined is obtained in this region, and the ores are known as northern ores. The district next in size is known as the Birmingham district. It is located in the southern part of the country, and its ores are called southern ores.

There are many varieties of iron ore. The ores most frequently used are known as the red and brown hematites.

The red hematite ore is used more than the brown hematite or any other ore. Magnetite and carbonate are used, but very little in comparison with the red hematite. The ores generally used to make pigs for gray-iron castings contain from 50 to 70 per cent of iron. An ore that contains less than 30 per cent is seldom used. The pig iron that the founder uses generally contains from 92 to 96 per cent of metallic iron.

THE BLAST FURNACE

The blast furnace, shown in Fig. 2, is used to extract iron from the ore, and the iron thus produced, called pig iron, is run into forms known commercially as pigs. All the iron that is used commercially is first passed through such a furnace.

The size of the furnace varies in diameter from 20 to 35 ft., and in height from 100 to 125 feet. Fire brick and fire clay are used as linings. The bricks are made of silica, carbon, ganister, coke, magnesia and asbestos. About 450 tons of fire brick and 60 tons of fire clay are required to line a furnace of the size shown in the illustration. Four brick masons and twelve helpers are needed for approximately 30 days to do the work. A space from 4 to 5 in. wide, between the bricks and the shell, is filled with granulated furnace slag mixed with water.

From 1 to 2 weeks' time is required for the lining to dry. It is claimed that the lining will last for about 5 years under continuous operation. After the furnace has run a short time, the lining becomes protected by a carbonaceous concrete from 2 to 12 in. thick.

The furnace is charged from the top. All material is dumped into what is known as the bell, indicated by *C*, Fig. 2. From the bell the charge is dumped into the furnace. The separate charges are made up of about 800 lb. of ore, 450 lb. of coke, and 160 lb. of limestone. About 100 tons of coke, 160 tons of ore, and 35 tons of limestone (530 tons in all) passes through a furnace of the size shown in 24 hours. It is considered that a ton of coke is required to make one ton of pig iron. The metal is drawn out at the

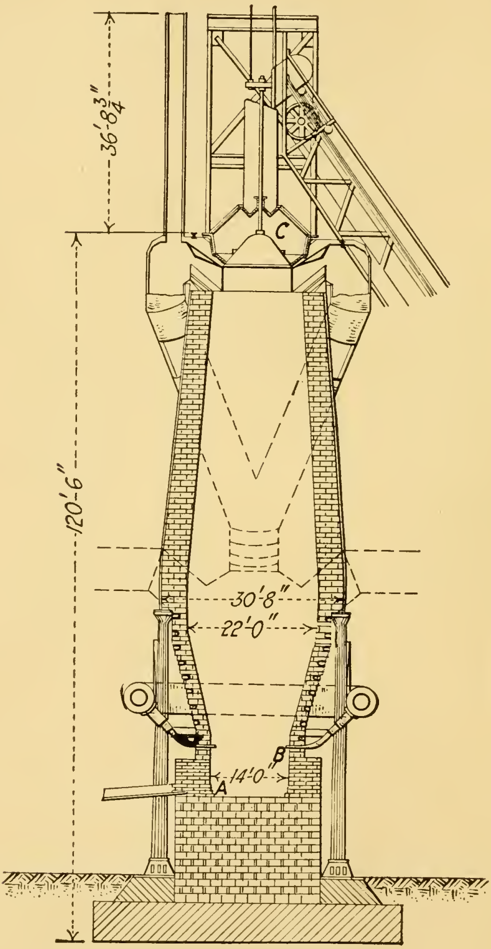

FIG. 2.—Blast furnace.

bottom of the furnace through the tap hole *A*, and the slag is run out through the slag hole *B*. The slag hole is located directly opposite and a little higher than the tap hole.

It is claimed by some blast furnace men that when a furnace is working hot the iron is high in silicon, and that when the furnace is working cold the iron is high in sulphur. When the slag is dark and dense, it is generally considered that the silicon content is low and the sulphur content high. From 600 to 1,000 lb. of slag are produced to every ton of iron.

The air used for draft in the blast furnace is heated to about 1,100 deg. F. and is blown into the furnace under a pressure of from 6 to 24 lb.

There are usually four stoves used to heat the blast. While one is in operation the other three are being heated. The stoves are from 18 to 24 ft. in diameter and from 24 to 40 ft. high. The inside of a stove is made with a checker work of brick. The stoves are heated by the blast furnace gases.

When sand-cast pig iron is made, there are generally two casting floors to a casting house. The sand beds are from 2 to 3 ft. deep. Long channels are made in the beds and the metal is poured into the channels to cool. While a tap is solidifying in one bed, the other bed is run full from the next tap. Furnaces of the size mentioned are tapped about five times in 24 hr., a schedule that allows for removing 40 tons of metal from the casting floor after each tap. After the pig bed is run full and the metal has solidified, sand is thrown over the iron to a depth of about 1 in. Then men having shoes with wooden soles about 1½ in. thick walk over the iron, break it up into pigs, and remove it from the casting floor. It is analyzed and graded according to chemical composition. When used for making gray-iron castings it is known as Nos. 1, 2, 3, 4, and 5 pig iron.

Pig-casting machines have come into use in recent years. They are known as the E. A. Vehling, R. W. Davis, and H. R. Geer machines.

CHAPTER II

COMMERCIAL FOUNDRY LAYOUT

A typical commercial foundry is shown in Fig. 3. The building is 56 x 84 ft. and has the features that are common to all commercial foundries.

Molding Room.—The molding room is 52 x 56 ft. The heap of molding sand with one-half of the space between it and the next heaps is called a floor. From 12 to 24 molders can work in such a room at one time, the number depending upon the class of castings made. In the morning, the molder begins work on one end of the heap, say the end which is furthermost from the outer wall, and by the time the iron is ready to pour in the afternoon, the floor is filled with molds. After the molds have been poured they are shaken out, the castings sent to the cleaning room, and the sand prepared for the next day's work. Castings that are too hot to handle are left in the sand until the next morning, or until they have cooled. The conveying of materials such as molds, castings and melted iron about the room is done by means of trucks, overhead trolleys, or cranes which run on tracks. The trolleys, trucks and cranes are operated by electric motors in some shops, while in others the workmen push or pull them from place to place.

Pattern Storage.—Since processes of molding require patterns, foundries very quickly accumulate great quantities that require storage. The pattern storage room in this shop is shown in the upper right hand corner of the sketch, surrounding the office. One man is in charge. The patterns are stored on shelves, one above the other, from floor to ceiling, and each pattern is numbered and registered on a card index list. Patterns are withdrawn for foundry use and when the work is finished they are cleaned and returned to the pattern storage room.

Core Room.—In the lower left hand corner is the core room, containing all the apparatus for the making of cores and the core oven for drying them. Core boxes and other

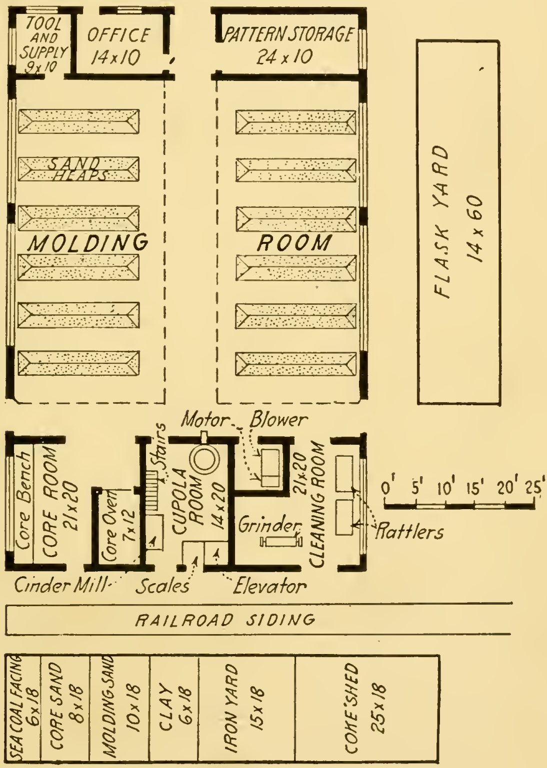

FIG. 3.—Typical layout for small foundry.

materials relating to core making are stored in the pattern storage room.

Cupola Room.—Next to the core room is the cupola room. It is in charge of the cupola tender and has to do with the charging of the cupola, the melting of the iron and the delivering of melted iron to the ladles in the molding room. All iron, coke, coal and other materials used in the cupola are weighed on the ground floor and then taken by elevator to the charging floor, 10 to 18 ft. above the main floor of the cupola room, from which they are charged into the cupola.

Cleaning Room.—When the castings are taken from the sand they are sent to the cleaning room which is shown in the lower right corner of the building. They are dumped into metal barrels, called rattlers, that are revolved until the sand and dirt have been jarred from the castings, from here they are taken to the abrasive wheels and chipping benches, after which they are ready for shipment.

A side track is generally put in for switching purposes, and coke, sand and clay sheds are built within easy reach of the main foundry building. The iron is usually stored in a yard close to the side track and the cupola room.

The wooden flasks generally are stored in a yard out of doors convenient to the molding room. Iron flasks are stored in sheds or rooms to prevent rusting.

THE FOUNDRY PRODUCT AND BRANCHES OF MOLDING

The foundry product is castings. Some foundries make gray-iron castings, some make steel castings, some produce malleable iron castings, while others make brass, bronze and aluminum castings.

Castings are produced by making molds and then filling them with molten metal. After the metal has solidified and the castings are cool enough to handle, the molds are broken up and the castings are taken from the sand. Castings are made that range in weight from a few ounces to many tons. In order to make the different sizes of castings successfully, it has been found necessary to employ various materials in constructing the molds.

Molding operations are classified under five general headings according to the material used and the method of working with it: Green-sand, skin-dried, dry-sand, loam, and iron molds.

Green-sand molding is the cheapest method of making a casting and is the one most commonly used. The name green sand indicates that the metal is poured into the molds while the sand is in a damp state, the same state it was in when the mold was made.

Skin-dried molds are green-sand molds with a facing composed of a mixture of molding sand and wheat flour (or some other mixture) surrounding the pattern to a thickness of 1 in. or more. Before pouring, these molds are dried by a torch flame or some other flame on all parts that will come into contact with the melted metal. This eliminates the steam troubles encountered in green-sand molding.

Dry-sand molds are made of green molding sand mixed with a binder such as wheat flour, resin, core compound, or linseed oil, the entire mold being baked in an oven. The baking process drives off the moisture content of the sand, and the binder holds the mold firmly intact during pouring. Such a mold is usually free from steam troubles.

Loam Molds as a rule are used in the production of large castings only. Forms, built of bricks, are plastered over with loam mortar which is rich in clay. Skeleton patterns and sweeps are used to shape the surface of the mold. When the mold is completed it is thoroughly dried before pouring.

Iron Molds.—Some molds are made of iron, the advantage being that many castings can be made with each of these molds before a replacement of the mold is necessary. Before pouring, the molds are coated with either oil or a graphite paint. Owing to the sizes and shapes of castings the use of iron molds is limited.

A further division of molding is called bench molding. Molds that are too large to be handled on a bench are made on the floor and the process is called floor molding. Molding that requires the use of a crane in handling the molds is called crane molding. Large castings generally are molded in a pit whence the term pit molding.

Molders or foundries usually specialize in one or two branches of molding. One seldom finds a molder who follows all branches of molding, or a foundry that makes all classes of castings.

CHAPTER III

MOLDING SAND

Good molding sand is found along rivers and lakes in many parts of the United States. Albany, N. Y., Sandusky, Ohio, Ottawa, Ill., and other localities are well known to foundrymen as molding sand centers. Sand suitable for green-sand molding must be cohesive when moistened to the proper degree of dampness and rammed to sufficient hardness. It must stick together when the mold is handled and must be tough enough to allow the metal to run over it without washing or cutting into it. The sand must be refractory enough to stand the high temperature of melted cast iron (2,500 deg. F.) without fusing. It should be porous in order to allow the free escape of all steam and gases that are generated when the mold is poured. The sand should be strong so that it will neither wear out quickly nor crumble under heat. A good sand will bake a little when subjected to heat.

COMPOSITION AND SELECTION OF SAND

The composition of molding sand, as given by many chemists, is: 80 to 90 per cent silica, 6 to 10 per cent alumina (clay), and small percentages of other ingredients such as lime, magnesia and metallic oxides.

A good foundryman is very careful when selecting molding sand, for he knows that in order to be successful in making castings he must have sand suitable for the particular class of castings he wants to make. For small castings, requiring a smooth surface, a molding sand of fine grain must be used. When making heavy castings a sand of coarse grain is required to allow the steam and gas to pass out of the molds freely while the metal is solidifying. The sand must be rammed harder for large castings than for small. As the outside surface of a heavy casting need not be as smooth as that of a small one, a coarse and open grained sand is more suitable for it. If a sand suited for light castings is used for heavy castings, there is danger of scabbing, and at times the metal may be blown out of the mold, since the steam and gas cannot escape. Chemical analysis is not frequently used in the selection of molding sand and it is best to leave the selection to some one experienced along that particular line of work. One may write to the foundry supply houses, informing them as to the class of castings to be made, and they will give good advice as to the kind of sand to use.

TEMPERING SAND

The tempering of sand means the mixing of the sand with water to the proper degree of dampness. Water is added to the sand by means of sprinkling can, hose or water bucket. It never should be thrown on to the sand in body or bulk that would produce mud holes, but should be added evenly over the surface. It is best to spread the sand out a little before wetting it.

A shovel is generally used to mix, or "cut," the sand, although some shops use sand mixing machinery. No matter by what method the sand is prepared, all dry and wet parts must be mixed together evenly and all large lumps broken up. If there is more moisture in the mold than can be driven out when the mold is poured, the metal may be blown out by the steam formed. When the sand is too dry it may drop out of the flask when the mold is handled, or the metal is likely to cut into the sand and wash it, causing sand holes in the castings. The production of good or bad castings often depends entirely upon the condition of the molding sand.

When preparing sand the molder examines it by feeling a handful. If it is too dry he adds water sparingly. If too wet he adds dry sand. By repeated test and adjustment the correct consistency will be obtained. In testing by feeling, a handful of sand is squeezed into a long lump that is then held between the first finger and the thumb and shaken with a swift motion. If the lump does not break, the sand is considered to be in good condition for molding. Another test may be applied by breaking the lump apart. If the edges remain sharp and firm after the lump has been broken into small pieces, it is a good indication that the sand is in molding condition.

CARE OF SAND

When the sand is in use every day it is likely to become weak, causing a great deal of trouble, not only in making molds, but because the sand will wash when the metal is poured. After it has been used many times the sharp edges have become rounded, partly from wear and partly from the high temperature of the molten metal, and the clay has burned out. These changes are the main causes for the weakening of sand in use. New sand, that is, sand that has not been used for molding, is stronger than it need be for molding and when added, makes up for the weakening of the old sand. In this manner sand may be used over and over without a complete replacement at any time.

When shaking out molds, some of the sand will adhere to the castings and be lost. If the amount of sand lost be replaced by new sand, the resulting mixture will be suitable for molding and the molder's supply will be kept up to normal.

After sand has been used for a time and is somewhat burned, it will give better results than when new. Generally speaking, castings made in old sand, or sand partly burned, will be smoother than those made in all new sand.

CHAPTER IV

RAMMING THE SAND

The sand must be rammed solidly within the flask and around the pattern. It must be rammed firmly enough to withstand the flow and pressure of the molten metal, and hard enough so that the mold can be handled without having the sand drop out of the flask. With soft ramming the casting is likely to be larger than desired. If the mold is soft in spots only, the casting may have bulges or lumps. Yet sand must not be rammed harder than is necessary, because the denser the sand, the less chance the steam and gas have to pass through it, and because too hard ramming will cause blowholes in and scabs on the castings.

There is no way to learn how hard to ram a mold except by actual practice. At first a great deal of trouble may be experienced, but by keeping at it with a determination to learn, a great deal of skill may be acquired in a very short time.

VENTING THE MOLD

There is considerable air, steam and gas in all molds, and these must be driven out through the sand when the mold is poured else the castings will probably be full of blowholes. Blowholes are usually found in the part of the casting that was uppermost when the mold was poured. Some blowholes may be seen plainly when inspecting the casting, but it is not uncommon for castings to be full of small blowholes that are found only by machining.

Air is found in all molds. Steam is formed when hot metal is poured into damp molds. When fluid metal comes into contact with a mold (the mold may be made of either green or dry sand) the sand next to the metal is heated to a very high temperature and a rapid chemical reaction takes place. This reaction liberates gases from the sand, some of which pass into the open spaces in the mold. If they do not escape quickly they will be caught and enclosed by the metal, or pass to the top of the mold and prevent the metal from filling the mold completely. At times the gases may be confined until their increasing pressure blows the metal from the mold with great force, an occurrence that is dangerous to the workers.

When the ramming is done properly and a porous sand is used, the steam, gas and air will pass out of the mold between the grains of the sand. However, almost all molds must be vented, which means that vent holes must be punched into the sand to afford the steam, air and gas free passage out of the mold. Various methods used in venting molds will be explained when the making of molds is taken up in detail.

FACING FOR MOLDS

Small or thin castings could be made successfully with a fairly smooth surface if the metal were poured into a mold that had no facing. However, if the mold is faced, the castings are smoother than those obtained from an unfaced mold, and usually small castings must have a smooth skin or surface.

The facing materials mostly used for producing small castings are Ceylon lead, East India plumbago, and soapstone or talc. The facing material ordinarily is put into a small bag, and after the patterns are drawn from the sand and the gates cut, a thin layer of the facing material is dusted onto the surface of the mold with the bag. Rubbing the facing onto the surface of the mold with the hand, or brushing it down with a camel's hair brush, will give a smoother surface than that obtained by simply shaking on the facing and leaving it as it falls.

When smooth castings are wanted and the mold has small projecting parts of sand that are likely to be knocked off if the mold is touched with a brush, the pattern may be replaced in the mold after the facing has been dusted on and is tapped down. The facing is pressed into the sand and the pattern is then withdrawn. This process of facing a mold is known as the printing back method. Since the facing becomes damp from the moisture in the sand, if the pattern is left in the sand too long the facing and sand are apt to stick to it causing the mold to be impaired or destroyed when the pattern is drawn.

When heavy castings are to be produced, the part of the mold with which the metal comes into contact should be made from a material that is sufficiently refractory to withstand the high temperature of molten metal without fusing. Molding sands are generally not refractory enough to withstand such high temperatures for any great length of time, and a facing must be used which is put next to the pattern when making the mold. The surface of the mold prepared in this manner must also be treated by about the same method as that explained in describing the facing of small molds.

The facing material most commonly used for this purpose is known as **sea-coal facing.** Sea-coal facing is made from soft or bituminous coal, ground fine or coarse as desired. The fine facing is used for small castings and the coarse facing for large castings. The sea coal is mixed with molding sand in proportions depending upon the size or weight of the castings and the thickness of the metal. A mixture known as No. 10 is composed of one part of sea coal to ten parts of sand. Usually the sand consists of 75 per cent old molding sand and 25 per cent new molding sand, by volume. The sand is mixed well and the sea coal is then added. This mixture is suitable for castings having a metal thickness of from ½ to 1 in. When the metal thickness is greater than 1 in. a little more sea coal should be used. Too much sea coal will cause the castings to be rough and streaked due to the fact that the metal burns the facing away in places. It is seldom necessary to use sea-coal facing on castings that are less than ½ in. thick, but if desired, the facing should be mixed so that there is a little less than one part of sea coal to ten parts of sand.

A good way to mix sea-coal facing is to estimate the number of shovelfuls that will be needed to cover the pattern to a depth of from ½ to 2 in. Measure the sand and spread it out on the foundry floor, the old sand first, then the new sand spread over the old. The sea coal should then be spread evenly over the sand. To get a well-mixed facing, shovel over the mixture twice and sift it through a No. 2 riddle before tempering it. After the facing has been sifted, sprinkle it with water and temper it in the same manner as molding sand is tempered. The facing will then be ready for use. It has been found that if the facing is tramped down after the water is put on, it will mix better and will be a little tougher than it would be if it were merely mixed with the shovel.

PARTING MATERIALS

For almost all castings it is necessary to make molds in parts, that is to say, one part is made on top of the other. These parts will stick together when an attempt is made to separate them, unless some parting material is put between them. The most common material used for this purpose is called **parting sand,** and the sand best suited for the work is one that has little or no clay in it.

A fine sand which is found along the shores of Lake Michigan makes a good parting material, but some molders prefer to use burned core sand or the burned sand that is cleaned from the castings. Any of these sands is suitable. There are also manufactured parting materials, known as parting compounds, sold to the foundry trade. They are in powder form and are used by being put into bags and dusted onto the mold. Parting compounds give good results but cost more than parting sand and therefore are not used as much commercially. One of the best parting materials known is lycopodium. This material is used when oil has been mixed with the sand, and the only objection to its use is its very high cost. Brick dust and powdered charcoal also are used as parting materials, but they are not recommended.

CHAPTER V

FLASKS

Flasks of some kind are needed for making practically all types of molds. They may be made of wood, iron or steel. Wooden flasks are quickly made and they are the cheapest in first cost. Jobbing foundries use more of them than of the other kinds because they are light in weight, and can be altered without much work. The objections to them are that they soon wear out and burn easily. Metal flasks are the best where they are to be used continuously for producing similar castings, or where altering them would not be too expensive. With ordinary care they will last many years without any expense other than the original cost.

A flask consists of as many parts as are needed to make the casting desired. When a flask has two parts, it is called a **two-part flask**; when it has three parts, it is known as a **three-part flask.** A two-part flask consists of **drag** and **cope.** A three-part flask is composed of a drag, cope and **cheek.** The drag is the lower part, the cope the upper part, and in the three-part flask, the cheek is the part between the cope and the drag. When beginning a mold, whether the cope, drag or cheek is rammed first depends upon the shape of the pattern. The various parts of the flask are held in alignment by **pins** and **sockets.** The molder should always see that the pins fit accurately in the sockets. If they fit loosely there is likely to be a shift in the mold. Loose pins may also cause trouble when making a difficult lift.

Small castings usually are made in **snap flasks,** so called because they have snaps or catches on one corner and hinges on the corner diagonally opposite. They range from

8 to 18 in. square in the form shown in Fig. 4, and from 10 to 20 in. in diameter in the form shown in Fig. 5. The advantage of a snap flask is that any number of molds can be made with one flask without requiring the flask for

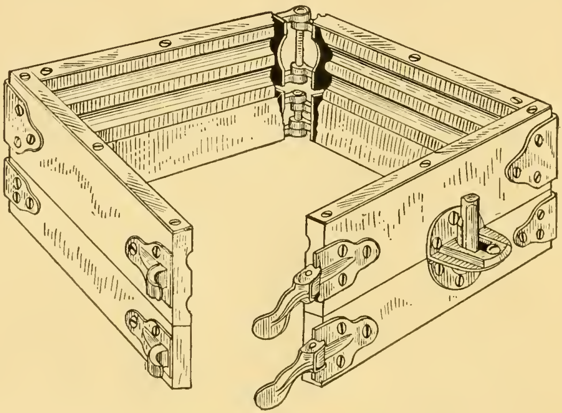

FIG. 4.—Square snap flask.

pouring them. After the mold has been finished, the flask is unsnapped and moved away from the completed mold. Should there be any danger that the sand might burst out due to the pressure of the metal when pouring, the mold is protected with a bottomless box, called a **slip**

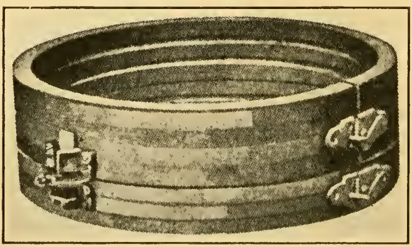

FIG. 5.—Round snap flask.

jacket. The slip jacket is slipped over the mold before pouring.

Slip jackets may be made of either wood or metal.

Figure 6 shows a metal jacket. The number of jackets required for one molder depends on the number of his molds that can be poured with one ladle of metal. Usually a molder needs from three to ten jackets for a day's work.

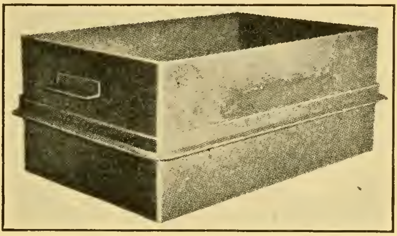

FIG. 6.—Slip jacket.

After the metal has solidified the jackets are taken from the poured molds and slipped over some that have not been poured. This shifting process is continued until the day's output of molds has been poured.

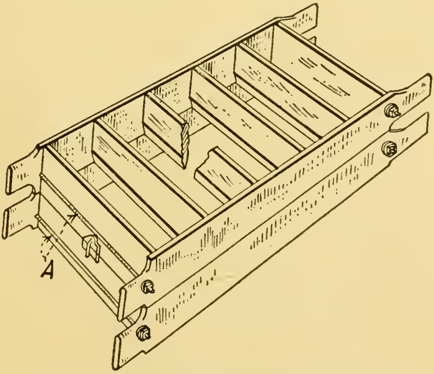

FIG. 7.—Wood flask for floor molding.

The type of wooden flasks used in floor molding is shown in Fig. 7. Flasks larger than 18 in. square should have cross rods varying in size from ¼ to 1 in. in diameter at the end. Such rods are shown at *A*, Fig. 7. For some of the smaller flasks, one rod at each end of the cope and one at each end of the drag are all that are necessary. Larger flasks must have two or more rods at the ends and one or more in the middle, especially when the cope is deep.

Large flasks should be equipped with **trunnions** or **lifting hooks,** which serve as handles when lifting the flasks

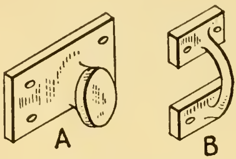

Fig. 8.—Trunnion and lifting hook.

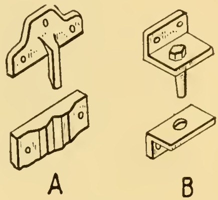

Fig. 9.—Flask pins and sockets.

by means of a crane. Figure 8 shows at *A* a trunnion and at *B* a lifting hook.

In Fig. 9 are shown two styles of flask pins used on wooden flasks. The open slot style *A* is used more than the pin hole style *B*. There are advantages as well as disadvantages to either style.

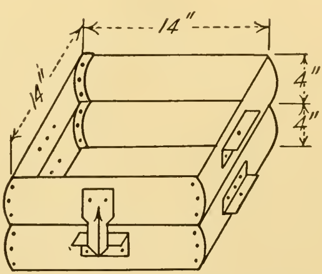

Fig. 10.—Small pressed steel flask.

Small pressed steel flasks, similar to the one shown in Fig. 10, are used instead of snap flasks for bench molding in many technical school foundries. They are very serviceable and have been proved to be quite a success.

Table I gives flask sizes, thickness of lumber required for different sizes, and the number of cross bars necessary in each flask. The number of cross bars required is based on the assumption that it is good practice to allow about 6 in. of sand between bars.

TABLE I.—DIMENSIONS FOR WOODEN FLASKS

Flask sizes in inches	Thickness of sides and ends in inches	Depth of cope and drag in inches	Thickness of cross bars in inches	Number of cross bars required per flask
From 10x10 to 16x16..	1	4 to 6	....	....
From 18x18 to 30x30..	1½	4 to 8	1	2 to 4
From 32x32 to 48x48..	2	5 to 10	1¼	4 to 7
From 50x50 to 60x60..	2½	6 to 18	1½	7 to 9
From 62x62 to 70x70..	2¾	6 to 24	1¾	10 to 12
From 72x72 to 84x84..	3	6 to 30	2	12 to 13

MOLDING AND BOTTOM BOARDS

There should be at least one smooth board for each size of flask. This smooth board is called the **molding board**

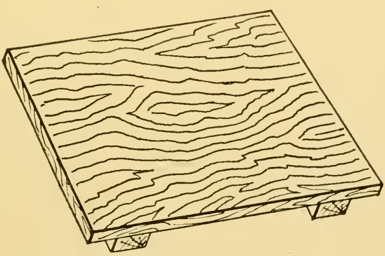

FIG. 11.—Molding Board

and is used to rest the pattern and flask on when starting to make the mold. A molding board should be as large as the outside of the flask and stiff enough to hold up the sand and pattern without springing when the sand is rammed. Cleats of suitable size should be nailed to the under side of the molding board. Their purpose is to stiffen the board and to raise it from the bench or floor (see Fig. 11) to allow the molder to get his hand under it when rolling over the mold. They also provide space for clamps when the mold is clamped for rollover.

One **bottom board** is required for each mold, since the sand must rest on a support until after the mold has been poured. Bottom boards are similar to the molding board shown in Fig. 11, but need not be finished so smoothly. Table II gives the thickness of lumber required to make bottom boards for different sizes of flasks.

Table II.—Lumber Required for Bottom Boards

Board sizes in square inches	Thickness of boards in inches	Thickness of cleats in inches	Number of cleats to board
From 10 to 16............	¾ to 1	1½ x 1½	2
From 18 to 30............	1 to 1¼	2 x 3	2
From 32 to 48............	1¼ to 1½	3 x 3	3
From 50 to 84............	1½ to 2	4 x 5	4 to 5

CLAMPS AND WEIGHTS

Almost all molds except those which have been made in snap flasks must be clamped before they are poured, in order to prevent the different parts of the mold from lifting up and separating, due to the pressure of the metal. Snap-flask molds are held together by weights during pouring. Three types of clamps used commercially are shown in Fig. 12. They are the Thompson clamp, *A;* Chaleau clamp *B;* and an unnamed clamp, *C*, the most widely used. Those shown at *A* and *B* are adjustable and can be made to fit flasks of different sizes. All of the three types can be made of gray cast iron, malleable iron or steel.

The number of clamps required on a mold depends upon the pressure of the metal and the size of the mold. Fast pouring gives more lifting pressure than is produced by slow pouring. When a mold is poured with dull or cold metal, there is likely to be more lifting pressure produced than if the mold is poured with hot metal. This is due to the fact that the molder naturally pours the cold metal faster in order to run the casting before the metal solidifies. Molds should always be clamped in such a manner that the metal will not run out at the joints. When there is doubt as to the number of clamps needed, it is a good rule to put on an extra clamp or two rather than not enough.

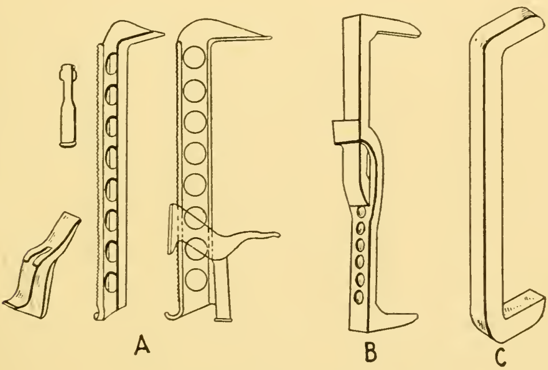

Fig. 12.—Clamps.

Sometimes molds are weighted instead of being clamped. When no other suitable weights are at hand, pig iron or heavy pieces of scrap iron can be used. Almost all foundries, however, make weights to suit their particular kinds of work. Weights are usually made of gray iron, and when they are made for snap flask use, they should be from 1 to 2 in. thick and large enough to cover the entire top surface of the cope. They should have slotted holes in the center to permit the metal to be poured into the mold, and openings at the ends to facilitate handling. A style of weights commonly used for snap-flask molds is illustrated in Fig. 13.

Computation of the weight needed to hold down a cope is not often required. The following rule will be of assistance: Multiply the area of the surface of the metal which presses against the cope by the height from the surface to the top of the sprue, and the product by 0.26. (The factor 0.26 is the weight of one cubic inch of iron.) From the second product subtract the weight of the cope. The result will be the approximate weight that must be placed on top of the mold.

To find the approximate weight of the cope after it has been rammed, multiply the width of the cope in inches, by

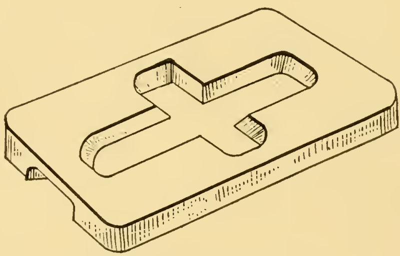

FIG. 13.—Snap flask weight.

the length in inches, the result by the height in inches, and that product by 0.06. (The factor 0.06 is the weight of one cubic inch of rammed sand.)

Example.—Assume that a casting 12 in. wide, 18 in. long and 1 in. thick is to be molded in a wooden flask, 18 × 20 in., with a cope 5 in. deep. How much weight should be put on the mold to hold the cope down?

Solution.—12 × 18 × 5 × 0.26 = 280.8 lb., which is the fluid pressure acting to force up the cope. The weight of the cope is: 18 × 20 × 5 × 0.06 = 108 lb. The fluid pressure is 280.8 lb. and deducting the weight of the cope (108 lb.) leaves 172.8 lb., the weight that must be added.

CHAPTER VI

GATING MOLDS

There is always more or less dirt and scum floating on top of and mixed with molten metal, and many castings have to be scrapped because this dirt finds its way into the molds. Some of the dirt can be skimmed off while the metal is in the ladle. Even though the iron be skimmed, there will be some dirt to deal with and it must be kept out of the mold as much as possible by proper gating and pouring.

The term **gate**, as applied in molding, is any opening in the mold through which metal is poured to run the castings. There are many styles of gates, but they can be classified in two groups, common and special. The gate with funnel-shaped top, the skimming gate, and pouring basins compose the common group, while the horn and whirl gates are called special. The kind of gate to be used depends upon the size and shape of the casting and upon whether or not the casting must be clean. Some castings may be full of dirt holes and still not be disqualified for use, while others have to be scrapped if they have a dirt hole the size of a pin head.

Points to remember when gating a mold are: Cut the gate a little deeper under the sprue than next to the pattern, so that some of the metal will stay in the gate when pouring. This metal acts as a cushion for the following metal to fall on, and prevents cutting of the sand in the gate. Gates should be cut just large enough to allow the metal to run through at a speed that will not fail to run the castings. They should not be so large that when the gate is broken off it will break into the casting proper, nor so large that when the mold is poured the gate cannot be kept full of metal. Dirt is not so apt to run into the castings when the gates are kept filled as it is when they are kept only partially filled. The reason is that the dirt, being lighter than the metal, floats on top, allowing the clean metal to run into the mold. This is one of the reasons why castings gated from the bottom are cleaner than if gated from the top. Thin castings should be gated with a wide and shallow gate, which will allow the metal to run through fast and will leave the gate weak so that it can be broken off without breaking the casting.

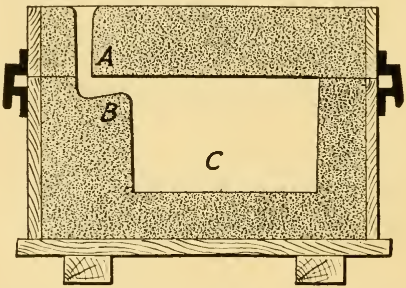

FIG. 14.—Mold gated with common gate

There is always more or less danger that the metal will cut the sand when pouring. It is a danger that can be partially eliminated in three ways: First, by so placing the gates that the metal will flow into the mold without running against obstructions; second, by placing the gates where the metal will not have too much fall when entering the mold; and third, by running the metal into deep places where it will form a puddle for the rest of the metal to run into.

The gate most extensively used for small and thin castings or for castings that need not be very clean, is shown in Fig. 14, in which *A* is the sprue made with a funnel shape at the top, *B* is the gate cut in the drag, and *C* is the casting.

The gate shown in Fig. 15 is known as the skimming gate. It is used chiefly on castings that are to be as nearly as possible free from dirt. The skimming gate is made by setting the sprue, *A*, and the skimmer, *B*, in the cope and connecting them by the channel, *C*, after the cope is lifted off. The channel should be made a little larger than the gate, *D*. The metal must be poured into the sprue fast enough to force it to rise to the top of the skimmer and the sprue and skimmer must be kept full throughout the pouring. If not, the dirt that passes through the sprue will not float to the top of the skimmer but will run into the casting. Skimming gates require more metal than the one

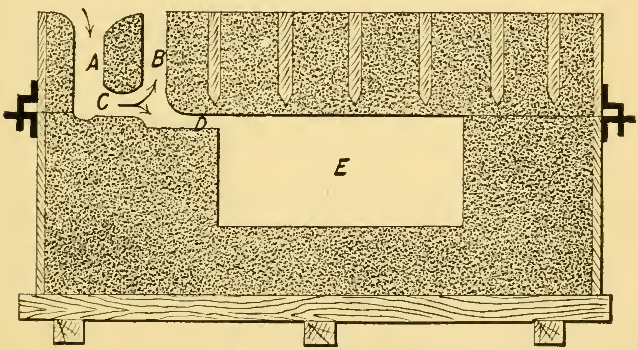

FIG. 15.—Mold gated with skimming gate.

shown in Fig. 14 and therefore should be used only when clean castings are to be made.

Pouring basins are used for running large castings. The sprue may be set on top of the pattern or the castings may be gated on the side. When the basins are made properly they will collect and hold the dirt. Great care, skill and good judgment must be exercised in building proper basins. The size of the basin depends upon the size of the sprue and the amount of metal required to fill the mold. It also depends upon the time in which the mold must be filled. Basins must always be made in such a manner that they can be kept full of metal when pouring, because if they are not kept full the dirt will flow into the casting and the result will be just as bad as though no basin had been used. A mold gated with a pouring basin is illustrated in Fig. 16. The basin is shown at *A*, the sprue at *B*, and the casting at *C*. It will be noted that the basin is lower at *D* than

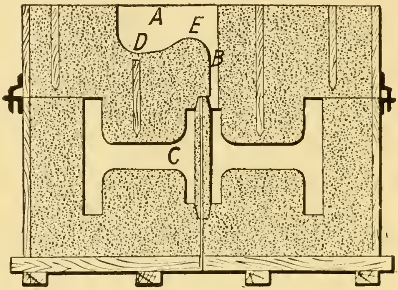

Fig. 16.—Mold gated with pouring basin.

at *E*. The metal should be poured into the basin slowly at *D* until it begins to run over at *E* into the sprue, when the basin should be filled as quickly as possible.

Many large castings must be gated from the bottom because of the long fall the metal has to make to reach

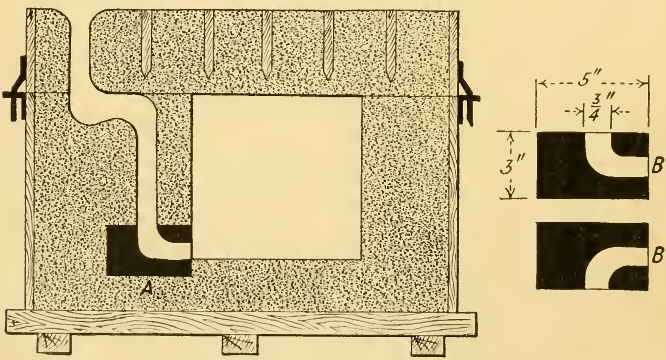

Fig. 17.—Mold gated from the bottom.

the bottom of the mold. It is best to gate very deep molds at the bottom and to run the metal to the bottom of the mold by steps. Figure 17 shows a step gate suitable for large and deep castings, especially if the castings must be made clean. One of the objections to bottom pouring is that extra work is required to make the gates. However, if the metal is run through a bottom gate core, as shown at *A*, Fig. 17, the amount of extra work is very slight. Sometimes it is desirable to fill the mold quickly, in which case more than one gate core may be used. All jobbing shops should carry bottom gate cores in stock. They are easily made in halves, as shown at *BB*, Fig. 17, the halves being pasted together after they are baked. They may be made smaller by rubbing the halves together, or larger by filing the runner, before pasting. A good size of core to carry in stock is one that has a runner about 1 in. dia. The core may be about 5 in. long, 3 in. wide and 3 in. thick. Cores of this size will run any casting similar to a steam engine piston weighing approximately 800 lb.

CHAPTER VII

SHRINKAGE

Iron contracts, or shrinks, as it passes from a liquid form to a solid state. The shrinkage will be more noticeable in large castings than in small ones, although of course the coefficient of expansion (and therefore of contraction) is a constant. More time is required for metal to solidify in large bodies than in small amounts so that in a large casting the mold will have been filled while the metal is still molten. In small castings, the iron shrinks almost as it is poured, providing opportunity at once to make up for a part of the contraction. The metal in large castings will stay in a fluid state for several hours and in such cases much shrinkage trouble may be experienced.

Shrink holes are generally found in that part of a casting where the metal has solidified last. One may look for shrink holes at or near the top of a casting, that is, in the part that was uppermost when the mold was poured.

While nearly all metals shrink when they solidify, there are scarcely two that shrink to the same extent. Aluminum and steel shrink more than brass or gray iron, and not all grades of gray iron have the same shrinkage. That being the case, it is necessary for a molder to study the metals, not forgetting to take into consideration the size of the casting and the length of time that will be required for the metal to solidify. The pouring temperature of the metal, also, is a factor that must be watched, because metal poured when hotter than necessary will cause more shrinkage than it would have caused if poured at the proper temperature.

There are two ways in which shrinkage may be counteracted. One method is to feed metal into the casting while it is solidifying. The other method is to chill the heavy sections of the casting to cause them to solidify as quickly as the lighter sections. If all parts of the casting solidify at about the same time there is not much danger that shrink holes will be produced, but if one part solidifies much before some of the other parts there is great danger that shrink holes will exist in the parts that harden last.

There is shown in Fig. 18 a dumb-bell casting with a shrink hole in each ball. It will be noticed that the shrink hole at B is on the inside of the casting, with a shell of metal around the hole. This kind of shrink hole is common. It exists because the metal becomes hard on the top surface of the casting before it has solidified on the inside. The shrink hole shown at *C* is even more common. The

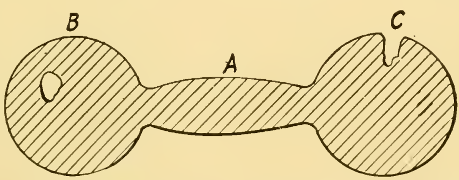

Fig. 18.—Dumb-bell casting with shrink holes in each ball.

metal remained fluid on top until the inside became hard and the metal that was at *C* was drawn into the casting. When a casting of the type shown in Fig. 18 solidifies, the handle *A* and the metal next to the damp sand becomes hard first and while so doing draw metal from those parts of the casting that are still fluid. If the parts drawn upon cannot in turn draw metal from somewhere else, the shrink holes are bound to exist. They can be prevented by feeding metal into the balls as will be shown.

In Fig. 19 the method of **feeding** a dumb-bell casting is shown. It is necessary to feed each ball separately, which is done by placing a feeder on each end as shown at *B* and *C*. If the casting were fed in one ball only, the other might contain a shrink hole, because the handle would probably freeze and not allow the metal to feed through. The connections between feeders and balls, as shown at *DD*, must be large enough that they will not freeze too quickly. Molders who have had very little experience in feeding castings often make the connections between the feeders and casting so small that the metal in the feeders and casting is still fluid after the connections are frozen. When feeders contain shrink holes as shown at *B* and *C*, they have generally done their duty and the castings are almost certain to be free from shrink holes.

Feeders may be placed on top of the casting as shown in Fig. 20. When so placed, the size of the feeder depends upon the length of time necessary for the metal in the cast-

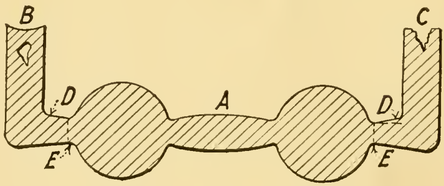

Fig. 19.—Dumb-bell casting with feeder attached.

ing to solidify. Many times feeders that are too small are used and they cause more damage than they do good. When a feeder, placed on top of a casting, solidifies before the casting does, metal will be drawn from the casting by the feeder instead of being fed into the casting from the feeders. On the other hand, if the feeders used on large castings are made large enough for the metal to remain in a fluid state until the casting has solidified, they have to be so large that their removal is very costly.

CHURNING

One of the greatest difficulties found in feeding castings is to keep the metal in the feeder in a fluid state until the castings are solid. This always has been a problem understood by few molders, and those who do understand it are those who have worked a great deal in jobbing shops or where large castings are made. Feeding large castings successfully requires not only good judgment but also a great deal of experience with large work.

The term **churning** as applied to foundry work refers to a method of agitating the iron after a mold has been poured. A wrought iron rod is pushed through the metal in the feeder, down into the casting and is then moved up and down continually being gradually withdrawn as the iron

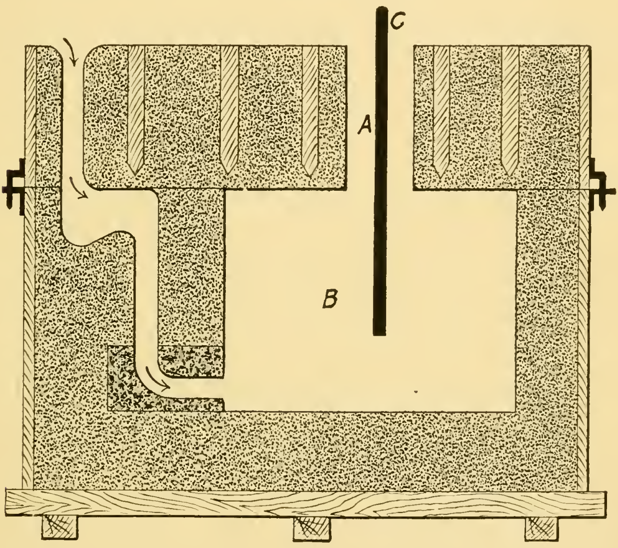

Fig. 20.—Mold gated from the bottom with feeder placed on top.

solidifies. In Fig. 20, *A* represents the feeder, *B* the casting, and *C* the churning rod.

A rod ¼ in. in diameter may be used for a feeder 3 in. in diameter. A ⅜ in. rod would be suitable for a 4 in. feeder. For a feeder 6 in. in diameter a feeding rod about ½ in. in diameter would work well. For feeders larger than 6 in. in diameter still larger churning rods must be used. Rods may be from 18 in. to 4 ft. long. The length of rod to use depends upon the height of the feeder and the depth of the casting to be churned.

A churning rod should be heated before it is inserted into the metal. If it is not heated, the metal surrounding it will chill and stick to it making the operation of churning difficult.

To churn a casting properly, select two rods of the required size. One rod is sufficient for some castings, but it is well to have the second ready if the first becomes unwieldy due to the weight and volume of the metal that will adhere to it. Where there are two feeders on the casting, two rods are necessary of course. Heat the rods before the mold is poured. After it is poured, watch the metal in the feeder. When it begins to show signs of freezing, gently push the hot churning rod through the feeder into the casting and carefully work it up and down. Do not strike the sides of the feeder, push the rod to the bottom of the mold or push it into a core. Continue to pour hot metal into the feeder, whenever the feeder begins to show signs of freezing, until the casting is solid. It is easy to tell by feeling the resistance offered to the motion of the churning rod, when solidification is taking place, and therefore, the time when the rod must be withdrawn. After the rod has been withdrawn, fill the hole in the feeder with hot metal.

BREAKING GATES AND FEEDERS FROM CASTINGS

Gates and feeders are generally broken from gray-iron castings by striking the sprue or feeder a hard blow with a hammer. When gates and feeders are small they break off nearly even with the castings. When large there is danger of breaking into the castings, especially if the feeder connections are as large as shown in Fig. 19. There is also more or less danger of breaking into the casting when the feeder is placed on top as shown in Fig. 20.

When making a feeder connection a fillet should be allowed next to the casting, as shown at *EE* in Fig. 19. The weakest parts of the connections are shown by the dotted lines. The feeders should break on the dotted lines, leaving about ⅛ in. of metal on the casting, which must be romoved by chipping or grinding. This method requires a little extra work, but this is amply repaid by the prevention of scrap.

CHAPTER VIII

GAGGERS

Gaggers are generally used to support hanging bodies of sand when making molds on the floor. They can be made of cast or wrought iron and can be round or square. Figure 21 shows a type of gagger generally used. The toe *A* is from 3 to 5 in. long, and the shank *B* may be made from 4 to 20 in. long, as required. In some shops cast-iron gaggers have the preference, while in others the wrought-iron gaggers are chosen.

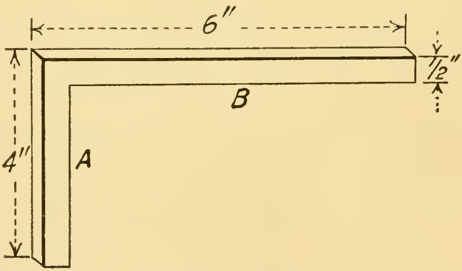

Fig. 21.—A gagger.

Almost all foundries make their own gaggers. They are easily molded when made of cast iron, especially if the patterns are fastened to a plate or board as shown in Fig. 22. It will be noticed that gaggers of various sizes may be made at one time in one mold. When using the gagger board, they can be made either in open sand or in a flask, a matter that each foundry must decide for itself.

A handy gagger mold with two working-sides is shown in Fig. 23. This mold is known as the Falls air-cooled mold. It is made of cast iron and is hung on trunnions on a frame, as shown at *A*. When used it must be set in a level position for pouring. As soon as the metal is solid, the mold is turned over and the gaggers drop out. The second side can then be poured. The advantage of a mold like this is that many gaggers can be made before the mold wears out.

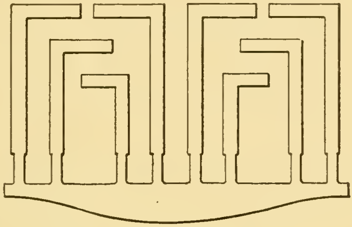

Fig. 22.—A gagger plate.

Some molders prefer to shake a little graphite or black lead on the mold each time that they pour in metal. It is a good plan, because it prevents the metal from sticking. The mold should be free from rust when in use. If rust is present the metal may blow out.

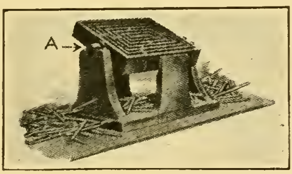

Fig. 23.—Falls air-cooled gagger mold.

SETTING CROSS-BARS AND GAGGERS

The sand on the inside of a pattern must be lifted out of the pattern with the cope and it is supported by cross-bars and gaggers. The bars are nailed to the sides of the cope and should be from 5 to 6 in. apart. They should not be more than ½ to 1 in. from the pattern. Bars 1, 2, 3, 6 and 7, shown in Fig. 24, are placed in the flask properly, but bars 4 and 5 are too far from the pattern. When bars are far from the pattern, there is too much hanging sand under them and it is likely to fall due to its own weight when the cope is lifted.

Good judgment must be used when setting gaggers. The molder should always study the pattern and set the gaggers where the sand is apt to break when the cope is lifted. The sand that is likely to fall when the mold is closed must be supported by gaggers, nails or rods. In other words it must be reinforced. There should not be more than ¼ in. of sand between the gaggers and the pattern. The gaggers should stand straight against the cross-bars, as shown in Fig. 24. Those shown at *B, F, I* and *J* are set properly. Those shown at *C, D* and *H* are not set properly; they would interfere with the ramming of the sand. The gaggers shown at *A, E* and *G* are too far from the pattern; the sand under them would be apt to stay down when the cope is lifted or drop off when the mold is closed.

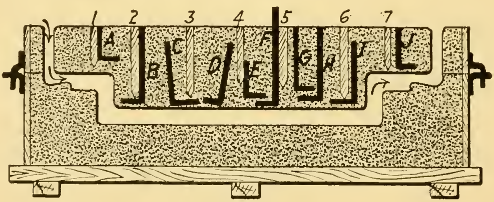

FIG. 24.—Proper and improper methods of setting gaggers.

Gaggers long enough to support the sand must always be selected. They may stick out of the flask as shown at *F*, bar 5, but it is better if they are even with the top of the flask. The gagger shown at *E* would not support the sand, because it is too short. As iron is about four and one-half times as heavy as rammed sand, the gagger referred to would only add extra weight to the sand instead of affording support.

CHAPLETS

Chaplets are metal supports that are used to hold dry-sand cores in place when they are set and when the mold is poured. The metal in the casting should burn on to the chaplet and form a union with it. Otherwise the chaplet may be loose and a weak casting result. Or if the metal in the casting and that in the chaplet are not well fused, an air, water or steam test will probably show a leak around the chaplet.

There are shown in Fig. 25 some of the many types of chaplets extensively used. Those lettered *A* and *B* are known as perforated chaplets, a style used for light and thin castings. The cup chaplet, *C*, is used to a great extent

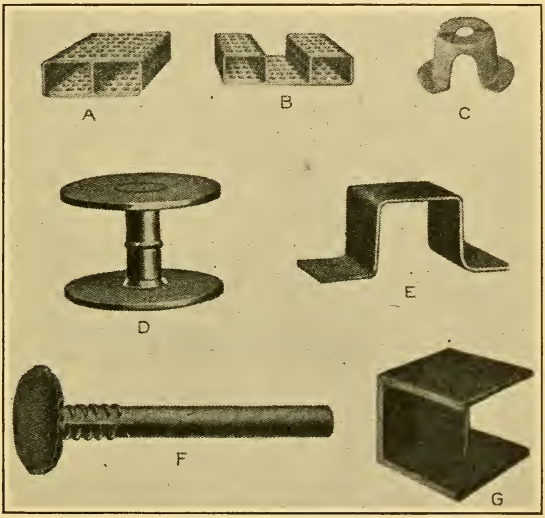

Fig. 25.—Chaplets.

in making small steam engine pistons. The double flanged chaplet, *D*, the bridged chaplet, *E*, and the right angle chaplet, *G*, are used in a great many varieties of castings. The straight stem chaplet, *F*, is used when the pressure of the metal is so great that the other types cannot be used.

Chaplets are generally made from sheet and wrought iron. They are made from thin sheet iron known as tin in sizes up to 2 in. thick. Many foundries make their own chaplets, others buy them from the foundry supply houses. They should be kept in a dry place to prevent rusting.

Coating them with tin, oil, red-lead or chalk will protect them. A rusty or wet chaplet must never be set in a mold as the metal will not lie against rust or dampness.

Care must be used in selecting the proper chaplets for the job. They must be stiff enough to hold the core in place, not only when it is set, but while it is under the pressure of the metal during pouring. If the chaplets bend at any time before the metal has solidified, the core will float, because it is only one-fourth as heavy as cast iron. Chaplets must not be so heavy or thick that the metal around them will chill instead of fusing with them.

SETTING CHAPLETS

The shape of the casting, the shape of the core, the thickness of the metal in the casting, and the pressure to

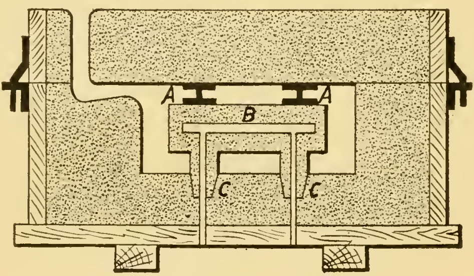

Fig. 26—Core supported with chaplets.

which the core is subjected when pouring are factors that must be considered when selecting and setting chaplets. One of the ways in which a core may be supported in a mold is shown in Fig. 26. The core, *B*, is held in place and located by the two **core prints**, *CC*. The chaplets *AA*, are placed on top of the core. These chaplets should be of the same thickness as the metal on top of the core. When the mold is closed the cope will fit down on the chaplets and the core will be held in place assuming that the chaplets do not melt before the metal has solidified and that the pressure under the core is not so great that it will press the chaplets into the sand of the cope.

In Fig. 27 there is shown a core supported by straight stem chaplets, and a method generally used in securing the chaplets. The chaplet at *F* is driven into the bottom board. which gives it a solid support. The chaplet *G* is driven into a board embedded for that purpose in the sand when the drag was rammed. Either method may be used, but driving the chaplet into the bottom board is the better and should be followed when possible. In either case the chap-

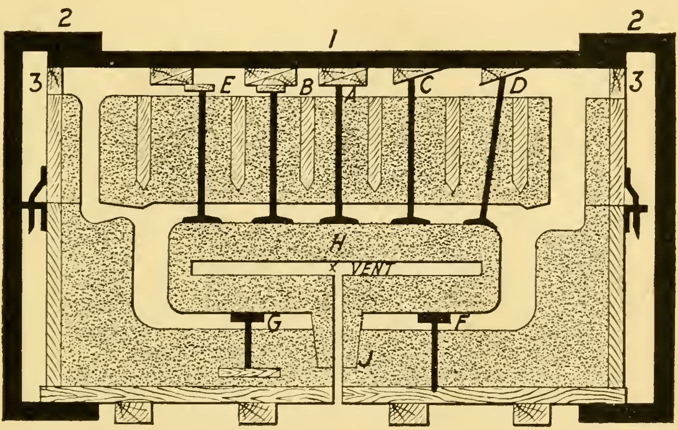

FIG. 27.—Proper and improper methods used in setting chaplets.

let should project out of the sand a distance equal to the thickness of the metal to be in the casting. The core, *H*, is located by the core print, *J*, and is held up by the two chaplets to which reference has been made.

The chaplets *A, B, C, D* and *E,* should project out of the top of the cope about 1/4 in. when they are down on the core, that is, after the mold is closed. They should be in a vertical position and not slanting like the one shown at *D*, which is incorrect because it does not offer as much resistance to the pressure of the iron as do the vertical ones.

The chaplets on top of the core in the cope need blocking and wedging, which can be done in different ways. The method shown in Fig. 27 is safe and is used a great deal for small as well as large cores. The blocks shown at 3 3 are placed on top of the flask after it is closed. They are about 1½ in. thick and as long as necessary to afford a rest for the beam, 1. The beam should be made of either iron or steel. Wood is not desirable because it will burn readily and because it is not strong enough.

The beam should be placed across the mold and chaplets with a space of about 1 in. between chaplets and beam.

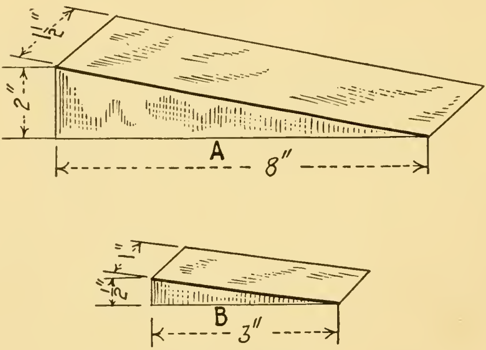

Fig. 28.—Wedges.

That amount of space is needed for blocking and wedging. Before putting in the wedges the mold should be clamped by clamps that reach from the bottom of the mold to the top of the beam as shown at 2. Proper and improper methods of blocking between the chaplets and the beam are shown at *A* and *B*, and *C*, *D*, and *E*, respectively. The methods shown at *C*, *D* and *E*, are likely to give, allowing the core to float.

WEDGES

The **wedges** used for blocking on top of the chaplets should be made of iron. Wooden wedges will burn, especially if a long time is required for the metal to solidify.

Any foundry can make its own wedges or they may be bought from foundry supply houses. They should be made of either hard wood or iron.

The wooden wedge shown at *A*, Fig. 28, is used when clamping molds for rolling over and for pouring. It is of the proper shape, style and size. The iron wedge, *B*, is of the type used for wedging on top of chaplets.

CHAPTER IX

TOOLS

Many types of tools and appliances are used for making molds. The kind of tools to select depends upon the shape and size of the castings to be made. Only such tools as are needed in this course will be taken up.

A line of tools commonly used by all molders is shown in Fig. 29. The **shovel,** shown at *A,* is indispensable. It should always be kept clean, not only to protect it from wear but because a clean shovel can be handled more easily and faster than a dirty one. A rusty shovel or one coated with sand is a very clumsy tool.

There are two types of **rammers.** The one shown at *B* is used for making molds on the floor and is known as the floor rammer. It is usually about 4 ft. long. The rammer shown at *C* is used in making molds on the bench and is known as the bench rammer. It is usually from 16 to 20 in. long. The wedge-shaped end of a rammer is called the **peen** and the other end is called the **butt.** The terms peen and butt are used for both floor and bench rammers.

The **bellows,** *D,* is a standard type, used for both bench and floor molding.

The **riddle,** *E,* is used to sift sand that is put next to the pattern. Riddles are numbered according to the size of the openings between the wires. A No. 2 riddle has two openings to the inch, a No. 10 has ten openings and so on. The No. 4 and No. 6 are used more than the other sizes.

The **brush,** *K,* used by the majority of foundries, is one of the standard types.

The **swab,** *L,* is used to moisten the sand around the patterns before they are drawn. The one shown is made of hemp. Sponges or waste can also be used for swabbing around patterns.

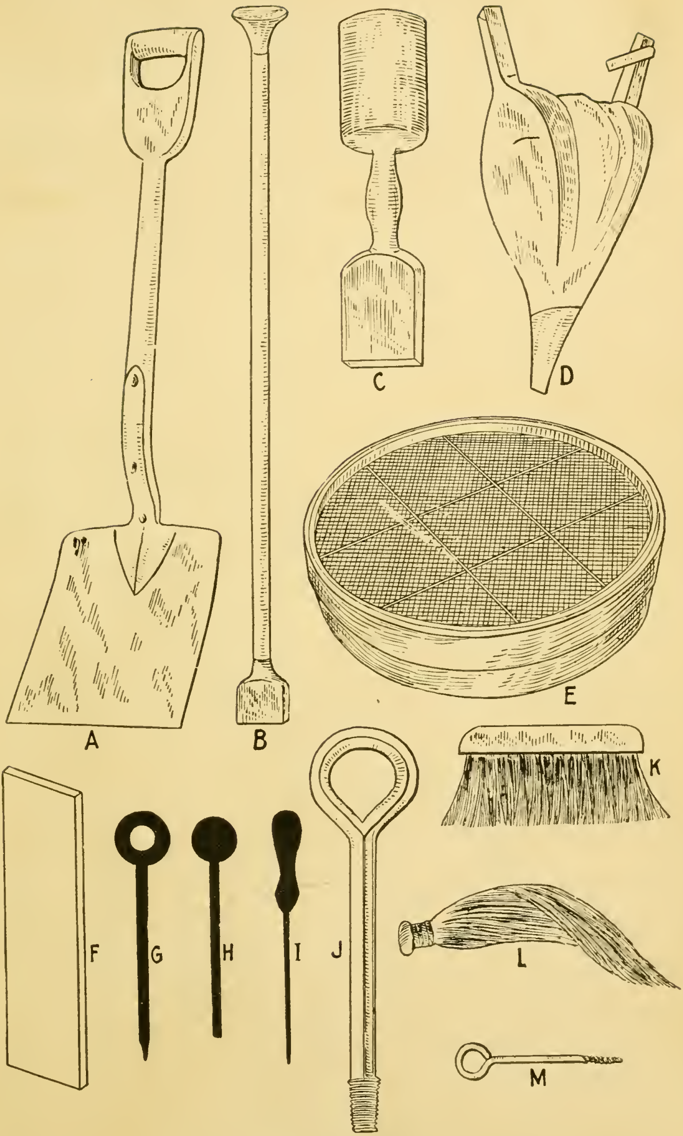

Fig. 29.—Molding tools.

The **straightedge,** *F,* is used to cut the sand level with the flask, after the mold is rammed.

The **wire,** *I,* is called a vent wire. The object of venting, and the necessity for it, were explained in Chap. IV.

All patterns must be rapped before they are drawn from the sand. The draw-spike, *G,* is driven into the pattern by means of the rapping-bar, *H.* The wood screw, *M,* is also used for drawing patterns. If the patternmaker has put threaded draw holes into the pattern, which is often the case, the draw-screw, *J,* should be used.

A molder should supply himself with a set of small tools. It is common practice to see an apprentice select all kinds

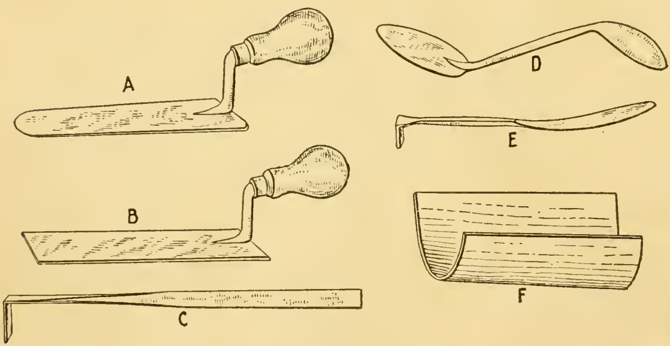

FIG. 30.—Molders tools.

and sizes of tools, only to find later that he has many for which he has no use. That is a mistake. It is better to select a few tools and add to them when necessary. The illustration, Fig. 30, shows a set of tools that will meet nearly all of the requirements for bench or floor molding in commercial foundries as well as in schools. However, for special work, many other tools are needed.

The **trowel,** *A,* is known as the finishing trowel. The one shown at *B,* is called the square trowel. These trowels should be about 1½ in. wide and from 5 to 6 in. long. The **lifter,** *C,* is used chiefly for floor work and usually two lifters only will be necessary. One should be ¼ in. wide and 10 in. long, the other ½ in. wide and from 14 to 18 in. long.

The **slick**, *D*, is known as the double-end slick and spoon. This slick should be about 1 in. wide for ordinary work.

The tool, *E*, called a Yankee lifter is a combination of slick and lifter. It is used in bench molding. A slick about ¼ to ⅜ in. wide is a good size.

The tools just described are used to make parting surfaces, slick down joints, repair any broken parts of the mold and clean loose sand out of the mold.

The **gate-cutter**, *F*, is used to cut gates from the bottom of the sprue hole to the pattern. It can be made from thin sheet iron about 4 in. square, or from thin copper sheeting. When the cutter is made, the iron or copper sheet should be bent as shown in the illustration. Then when cutting gates, it can be bent to suit any requirement.

QUESTIONS

1. Name the essential properties of a good molding sand.
2. How is the sand tempered for making molds?
3. If the sand is used too dry, what effect will it have when making molds?
4. What is the effect on the casting if the sand is too wet?
5. When a mold is rammed too hard what will be the result?
6. What will be the result if the sand is rammed too soft?
7. What is a green-sand mold?
8. What is a skin-dried mold?
9. What is a dry-sand mold?
10. How do the steam and gases escape from the mold?
11. What is a green-sand core?
12. What is the difference between two- and three-part flasks? Name the parts of each.
13. Of what materials are flasks made?
14. What are the advantages of using a snap flask?
15. What are slip jackets and snap-flask weights, and why are they used?
16. Why should not the partings of a mold be slicked down after the cope is lifted from the drag?
17. Name two possible causes of blow holes in a casting.

18. Explain the different methods of facing molds, and name the materials used in each case.

19. Make a sketch of a mold showing it gated with a common skimming gate, and name the parts.

20. Make a sketch of a mold showing it gated with a pouring basin, and name the parts.

21. Explain from a sketch the operation of a skimming gate.

22. Explain from a sketch the operation of a pouring basin.

23. Make a sketch of a mold gated from the bottom and made with a feeder.

24. If the gates are too small what will be the result?

25. What are some of the causes of dirty castings?

26. Why are cross bars used in large flasks?

27. What materials are considered good materials for making partings?

28. Why must heavy sections of castings be fed and how is the feeding done?

29. What is meant by churning a casting?

30. What precautions must be used when removing large feeders from castings?

31. What are gaggers?

32. When must gaggers be used?

33. Name some of the important things to be taken into consideration when setting gaggers.

34. What are chaplets, and why are they used?

35. Name some of the important things to be considered when selecting and setting chaplets.

36. Name at least five tools used in molding.

37. Is the molding sand used for heavy castings the same as that used for light castings? If not, why not? If so, why?

38. Why must flask pins fit?

39. How should gaggers be treated before setting them in a mold?

40. Is the same type of rammer used for floor molding as for bench molding?

PART II

EXERCISES AND PROBLEMS

CHAPTER X

BENCH MOLDING AND MOLDING EXERCISES

Small castings can be made to a better advantage if the molds are made on a bench, that is, if suitable flasks of the proper sizes are used. Flasks 16 in. square, with the depth of the cope and drag 5 in. each, are about as large as one man can handle.

A flask of the proper size for the average college student to handle is 14 in. square with the cope and drag each 5 in. deep. For high school students a flask 12 in. square with 5 in. cope and drag is suitable.

The castings for which the bench molding exercises in this course have been provided can be molded in flasks 14 in. square with 5 in. cope and drag. The snap flask shown in Chap. V, Fig. 4, or the steel flask shown in Chap. V, Fig. 10, can be used.

Either a group of small patterns or one large pattern can be used in the exercises. When a group of patterns is put in a flask there should be 1 in. of sand between the patterns. If the patterns are nearer together than 1 in. there is danger that the sand will be too weak to stand the pressure of the metal allowing the castings to run together. There must be 1 in. of sand between the patterns and the flask to prevent the metal from running out of the mold at the joints. At least 1 in. of sand must separate the patterns and the bottom board or the bottom board may burn when the castings are cooling. The sand in the cope should be at least 3 in. above the top of the pattern.

A wall type molding bench and tool arrangement are shown in Fig. 31. They have been used with success for school foundries. Figure 32 shows a typical portable molding bench that can be used for school as well as for commercial foundries.

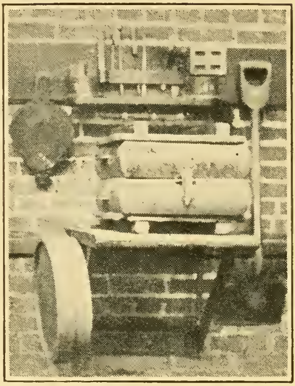

Fig. 31.—Wall type molding bench and tool arrangement.

The exercises in the bench course take up the making of molds in two- and three-part flasks, with and without the use of dry sand cores. The rolling methods of making

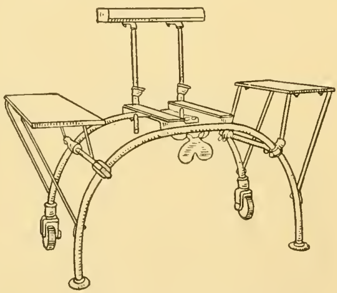

Fig. 32.—Portable molding bench.

molds as well as the method of bedding the patterns in the sand will be studied. Two of the exercises show how castings can be made that will differ from the pattern used.

EXERCISE 1. MOLDING TWO FACE PLATES

When studying the patterns for this exercise it will be seen that the draft runs in one direction, from *A* to *B* and from *C* to *D*, as shown in Fig. 33. The parting line is at *A*.

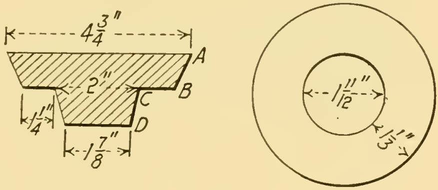

Fig. 33.—Face plate pattern.

Procedure in Molding

Place the patterns and drag on the molding board, with the pins on the drag down as shown in Fig. 34. Riddle molding sand over the patterns to cover them to a depth of about 1 in., using a No. 6 riddle.

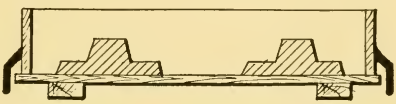

Fig. 34.—Pattern and drag placed on molding board.

Press the sand around the edges of the patterns against the molding board with the fingers. Shovel the drag heaping full of molding sand as shown in Fig. 35. Peen-ram around the sides of the flask first and then in between the patterns.

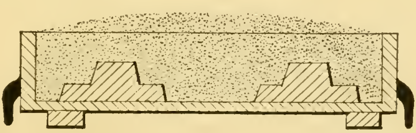

Fig. 35.—Drag filled heaping full of molding sand.

Again fill the drag heaping full and butt-ram it nearly even with the edge of the drag. With the straightedge strike off any sand that may be above the edges of the drag. Punch vent holes with a wire 1/16 in. in diameter, about 1 in. apart and reaching from the bottom of the drag (now uppermost) to within ⅛ in. of the patterns, as shown at

A in Fig. 36. Throw sand, free from lumps, over the drag to a depth of about ¼ in. Rub the bottom board on the sand until it lies on the drag without rocking. Figure 36 shows the drag ready to be rolled over.

Grasp the molding and bottom boards at the ends with both hands holding the drag firmly between the two boards and roll the whole over

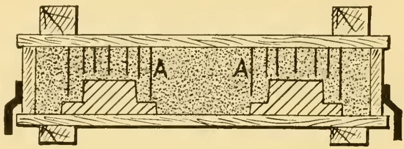

Fig. 36.—Face plate drag rammed.

on the molding bench. Take off the molding board. Slick down the sand with the trowel, to make a solid parting. With the bellows, blow all loose sand from the drag. Sprinkle parting sand on the surface

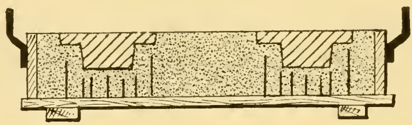

Fig. 37.—Face plate drag ready for the cope.

of the sand in the drag. Blow all parting sand from the patterns. Figure 37 shows the drag ready for the cope.

Place the cope on the drag and see that the pins fit into the sockets. Set the sprue pin half way between the patterns as shown in Fig. 38.

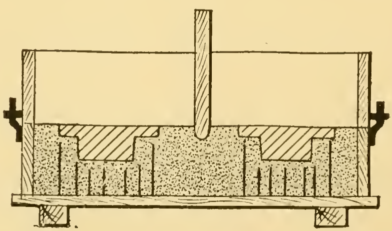

Fig. 38.—Cope and sprue set in making face plate mold.

Sift sand to a depth of 1 in. over the patterns. Fill the cope heaping full of unsifted sand. Ram the cope just as the drag was rammed. Strike off the sand even with the top of the cope. Vent the cope as was done with the drag. Remove the sprue pin and cut the sprue hole to a funnel shape at the top. Pack all loose sand around the sprue hole with the fingers before lifting the cope. Figure 39 shows the mold rammed, ready for the cope to be lifted.

Lift the cope and place it on the molding board, with the impression taken from the drag, uppermost. The drag, after the cope has been

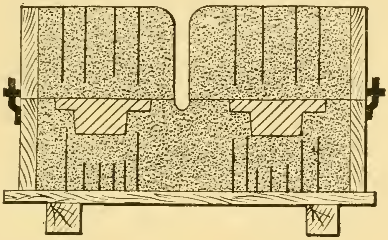

FIG. 39.—Face plate mold rammed ready to lift the cope.

lifted, is shown by Fig. 40. The cope, properly placed, is shown in Fig. 41. Blow off any loose sand that may be on the mold. Swab the sand next to the patterns with water, being careful not to get it too wet. (Blow holes in the castings may result from wet sand.)

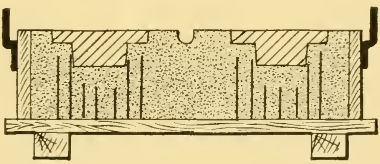

FIG. 40.—Shows drag of face plate mold after cope has been lifted off.

Drive the draw spike into each pattern in turn rapping on all sides of the spike to loosen the patterns. Draw the patterns from the sand carefully so as not to break the sand. If the sand does break the broken places must be repaired and all loose sand in the mold must

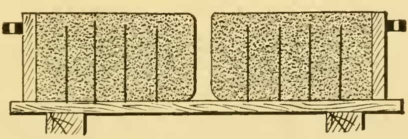

FIG. 41.—Shows cope of the face plate mold lifted from the drag.

be cleaned out, using either the lifter or the slick. If the tools are dipped in water the sand will stick to them better than if they are used dry. With the gate cutter, cut the gates in the drag, deepening slightly that part into which the metal will enter from the sprue. The gates should be about ¼ in. deep and ½ in. wide.

After the mold is patched and all the loose sand has been cleaned out, close the mold by placing the cope on the drag with the pins in the

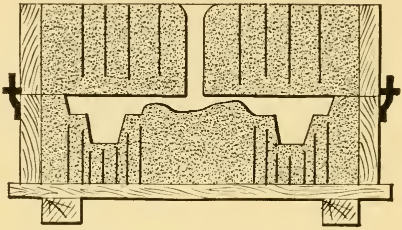

Fig. 42.—Face plate mold closed.

sockets as shown in Fig. 42. The mold must then be clamped together as shown in Fig. 43, or a suitable weight must be placed on it. (See

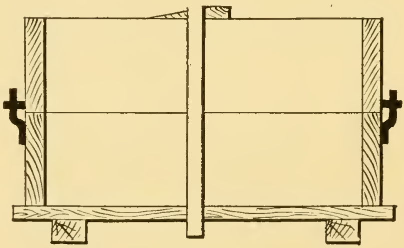

Fig. 43.—Face plate mold clamped.

Chap. V.) The castings as taken from the mold, with the gates and sprue attached, are shown in Fig. 44. A casting of the size made in

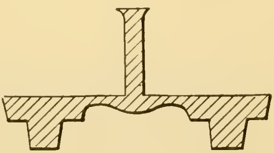

Fig. 44.—Casting with sprue attached.

this exercise should remain in the mold about 20 min. before the mold is broken up.

EXERCISE 2. MOLDING TWO HEXAGONAL NUTS

The pattern of a hexagonal nut is shown in Fig. 45. It is made in such a manner that it forms its own core which remains in the drag when the pattern is drawn. The draft is in one direction, from *A* to *B*. The procedure in molding is similar to that used in the first exercise, but there are some differences.

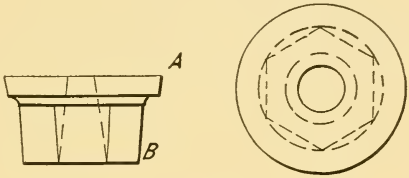

Fig. 45.—Hexagonal nut pattern.

Procedure in Molding

Place the drag and patterns on the molding board with the pins down as shown in Fig. 46. Riddle molding sand over the pattern.

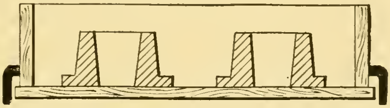

Fig. 46.—Pattern and drag placed on molding board.

Press the sand into the inside of the pattern with the fingers to insure a core that will not be too soft. Fill the drag heaping full of molding

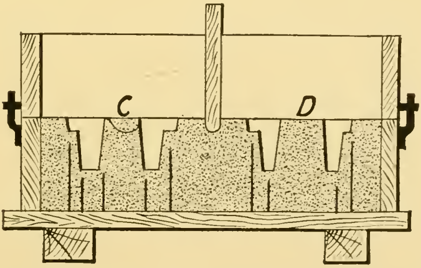

Fig. 47.—Cope and sprue set when making hexagonal nut mold.

sand and ram as in Exercise 2. Strike off the excess sand, vent, place the bottom board and roll the drag over. Take off the molding board.

Before making the parting, press the sand that is to form the core and if it sinks down as shown at *C*, in Fig. 47, fill the depression with molding sand, even with the top of the pattern as shown at *D*. Make the parting and sprinkle parting sand on the drag.

Set the sprue pin between the patterns and ram the cope. Level the sand even with the top of the flask, vent, remove the sprue pin,

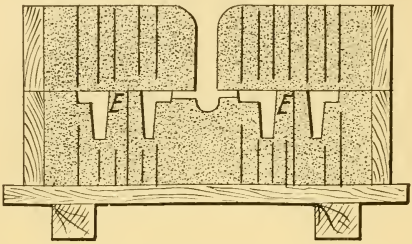

Fig. 48.—Hexagonal nut mold closed.

and cut the sprue hole to a funnel shape. Lift the cope and place it on the molding board with the face up. Blow all loose sand from the drag and swab around the pattern being particularly careful not to dampen the green sand core too much. With the vent wire, punch a hole through the core as shown at *E* in Fig. 48, from the top down to the bottom board. Rap and draw the patterns. Cut the gates, as in the first exercise. Close the mold and clamp. It is now ready for pouring.

EXERCISE 3. MOLDING A BALL HANDLE

The pattern used in this exercise is shown in Fig. 49. The parting line is at *A*, the draft running in opposite directions. When the draft runs in opposite directions it is good practice to have the parting line even with the joint of the flask. This may be done by placing two strips of wood half the thickness of the pattern, between the drag and the molding board.

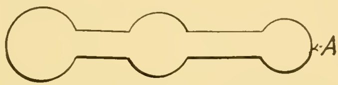

Fig. 49.—Ball-handle pattern.

Procedure in Molding

This exercise should be begun by placing the pattern and drag on the molding board with the two strips of wood under the drag as shown

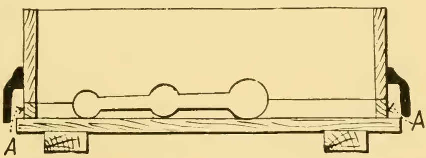

Fig. 50.—Pattern and drag placed on molding board.

at *AA*, Fig. 50. The drag is then rammed as in the preceding exercises. After the drag is rolled over, remove the strips and molding board from

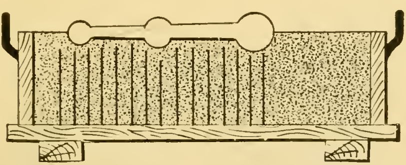

Fig. 51.—Drag rolled over and parting made.

the drag. Make the parting by cutting away the sand from the edges of the flask to the parting line of the pattern. One-half of the pattern will then be above the drag as shown in Fig. 51. Set the sprue and cope as shown in Fig. 52. Ram and vent the cope. Lift the cope and place it on the molding board. Blow all loose sand from the drag. Swab, rap and draw the pattern. Cut the gate as shown in Fig. 53.

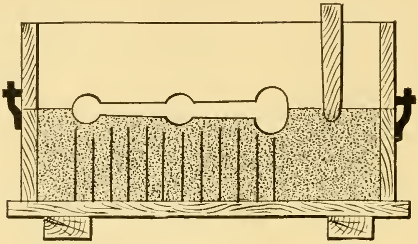

Fig. 52.—Cope and sprue set to make ball handle mold.

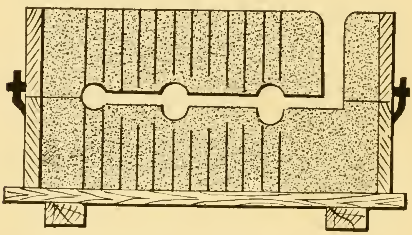

Fig. 53.—Mold closed.

If the mold in the cope is broken, repair it by replacing the pattern in its impression and patching around it. Close and clamp the mold.

EXERCISE 4. MOLDING AN OIL DRIP CUP

The pattern of the drip cup, shown in Fig. 54, has its parting line at *A*. The mold can be made with the pattern in either the cope or drag. When made with the pattern in the drag, the sand on the inside of the pattern has to be lifted with the cope, an operation that is troublesome on account of the tendency of the sand to stick in the pattern. A

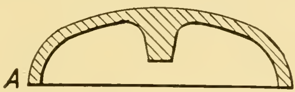

Fig. 54.—Drip cup pattern.

better method is to place the pattern on the molding board and ram the cope first. Then the sand on the inside of the pattern will be in the drag and will not have to be lifted out. This method is followed here.

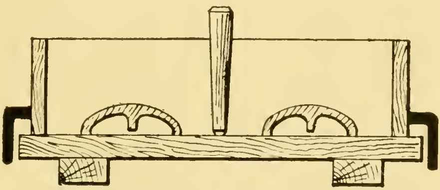

Fig. 55.—Pattern, sprue and cope placed on molding board.

Procedure in Molding

Place the pattern, cope and sprue on the molding board as shown in Fig. 55. Sift sand over the pattern. Fill the cope with sand and

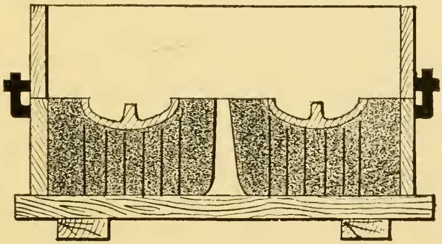

Fig. 56.—Drag placed on top of cope.

ram as in the preceding exercises. Vent, draw the sprue pin, and roll the cope over. Make the parting and sprinkle parting sand over the cope. The parting sand that falls into the pattern must be blown out.

Place the drag on the cope as shown in Fig. 56. The sand must be kept out of the sprue hole when ramming the drag. To do so, press a handful of molding sand into a ball about 3 in. in diameter, break

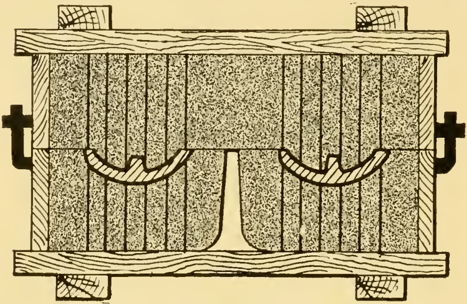

Fig. 57.—Mold.ready to roll over.

the ball into halves, and place one-half over the sprue hole. Sift sand over the pattern and ram the drag as in the preceding exercises. Vent the drag and roll the mold over. Figure 57 shows the mold ready to be rolled over.

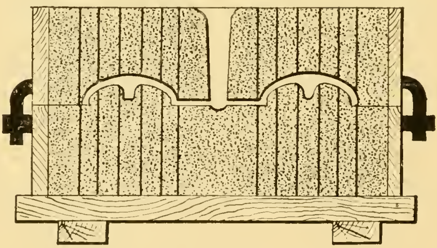

Fig. 58.—Mold ready to pour.

Lift the cope and place it on the molding board. Blow all loose sand from the mold. Swab, rap and draw the pattern. Cut the gate, which should be about 1¼ in. wide and ⅛ in. deep. Clean all loose sand out of the mold. Figure 58 shows the mold closed, ready for pouring.

EXERCISE 5. MOLDING FROM A SPLIT PATTERN

The pattern used in this exercise, shown in Fig. 59, is split on the parting line. The parts are held together by means of dowel pins on one side and dowel-pin holes on the other. There is to be an opening through the casting made by a dry-sand core. Dry-sand coremaking

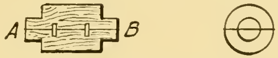

Fig. 59.—Split pattern.

will be taken up later. The pattern has two projections, *A* and *B*, called core prints, used to locate the core and to hold it in place.

Place the drag and the half of the pattern containing the dowel-pin holes on the molding board as shown in Fig. 60. Ram the drag, roll

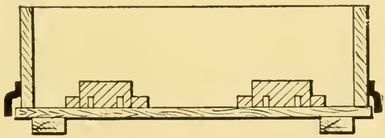

Fig. 60.—Pattern and drag placed on molding board.

it over and make the parting. Place the cope half of the pattern on the drag half with the dowel pins in the dowel-pin holes. Sprinkle parting sand on the drag after the cope patterns are in place. Set

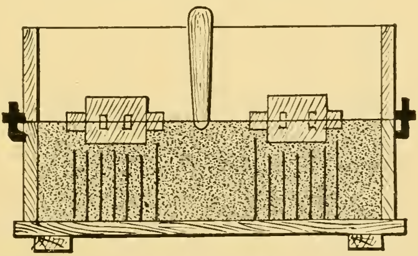

Fig. 61.—Cope, sprue and pattern placed on drag.

the cope and sprue as shown in Fig. 61 Ram the cope, vent it, and draw the sprue pin. Lift the cope and place it on the molding board. Blow all loose sand from the mold. Swab, rap and draw the pattern from the cope and drag. Cut the gate and set the dry-sand core.

The gas, which is freed in the core, can be let out of the mold through holes punched into the cope sand as shown at *AA*, Fig. 62. The gas

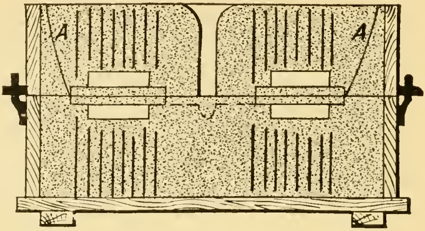

Fig. 62.—Mold closed.

will pass through the hole in the core and out of the holes in the cope. Close the mold and clamp it. Figure 62 shows the mold closed.

EXERCISE 6. MOLDING A PULLEY

The pattern, shown in Fig. 63, is split on the parting line, *AA*.

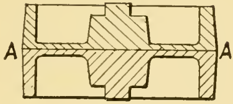

Fig. 63.—Pulley pattern.

Procedure in Molding

Place one half of the pattern and the drag on the molding board as shown in Fig. 64. Sift sand over the pattern and ram the drag. Roll the drag over and make the parting. Place the cope half of the pat-

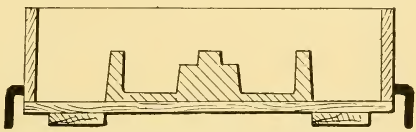

Fig. 64.—Pattern and drag placed on molding board.

tern on the drag half. Set the cope and sprue pin as shown in Fig. 65. Ram the cope, lift it, and place it on the molding board. Swab and rap the pattern in the cope and drag. Draw the pattern and cut the gate. Set the core and make a vent channel through the cope, for the

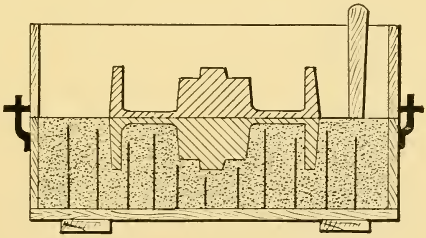

Fig. 65.—Cope, pattern and sprue placed on drag.

escape of the core gas, as shown at *A*, Fig. 66. Close the mold, as shown in Fig. 66, and clamp it.

Note.—The sand on the inside of the pattern in the cope may have to be reinforced, especially if the molding sand is a little weak, so that it will not drop when the mold is closed. Nails, about 1 in. longer than the width of the half-rim, should be used for this purpose. They must be pushed into the sand before the pattern is rapped, until the

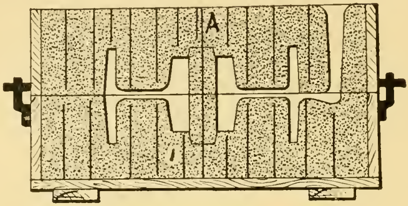

FIG. 66.—Mold closed.

heads are even with the sand. One nail between each two arms usually is sufficient for a small pulley although more may be used.

EXERCISE 7. MOLDING A GOVERNOR PULLEY

The pattern, shown in Fig. 67, is in two parts, split at *AA*. It has two parting lines, one at *B* and one at C. The draft runs from *B* to *A* and from *C* to *A*. While the mold must be made in three parts, it

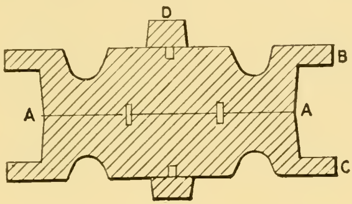

Fig. 67.—Governor pulley pattern.

can be made in either a two- or three-part flask. The three-part flask will be used in this exercise. The core prints *D* should be attached to the pattern by dowel pins.

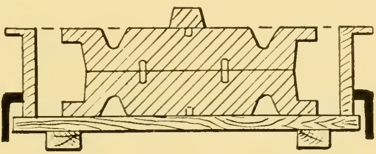

Fig. 68.—Pattern and cheek placed on molding board.

Procedure in Molding

Place the pattern and cheek on the molding board as shown in Fig. 68. Ram the cheek, make the parting, and sprinkle on the parting

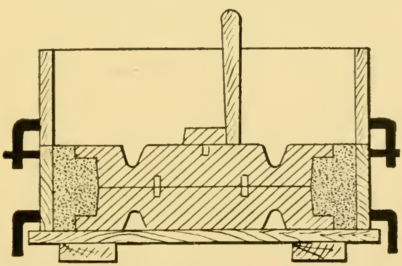

Fig. 69.—Cope and sprue placed on cheek.

sand. Place the cope and sprue as shown in Fig. 69. Ram and vent the cope and draw the sprue pin. Place a bottom board over the cope and roll over the cope and cheek. Remove the molding board, make the parting, and sprinkle on the parting sand.

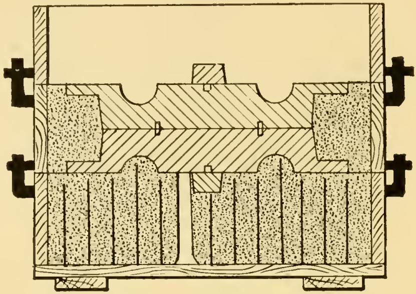

Fig. 70.—Drag placed on cheek.

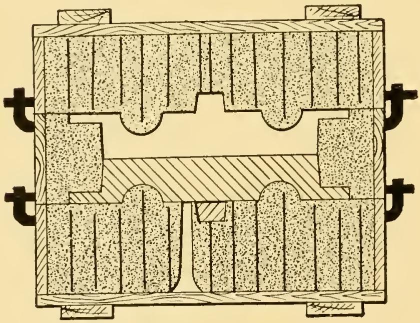

Fig. 71.—Mold ready to roll over.

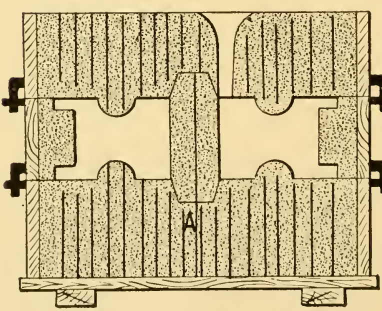

Fig. 72.—Mold closed.

Place the drag and core print as shown in Fig. 70. Ram and vent the drag, lift it, and place it on the bottom board. Swab, rap, and draw the drag half of the pattern. Rap the cope half of the pattern. Place the drag back on the cheek. Sprinkle molding sand which is free from large lumps over the drag and rub the bottom board down. Roll the mold over. Figure 71 shows the mold ready to roll over. Lift the cope and place it on the molding board. Swab and draw the pattern from the cheek. Make the vent hole, *A*, for the escape of core gas. Set the core. Close and clamp the mold, as shown in Fig. 72.

EXERCISE 8. MOLDING A SHEAVE WHEEL

The pattern, Fig. 73, is split at *AA*. The parting lines are at *B* and *C*. The mold must be made in three parts, cope, drag and cheek, using either a two- or a three-part flask. In this exercise it will be shown molded in a two-part flask, with a false cheek, so named because it cannot be seen after the mold is closed.

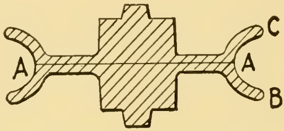

FIG. 73.—Sheave wheel pattern.

Procedure in Molding

Place one half of the pattern and the cope on the molding board. Set the sprue pin as shown in Fig. 74 and sift sand over the pattern. Fill the cope heaping full of sand, ram, vent, and draw the sprue pin.

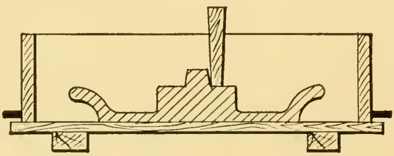

FIG. 74.—Pattern, cope and sprue placed on molding board.

Place a bottom board over the cope and roll it over. Make the parting as shown in Fig. 75, sprinkle on the parting sand, and place the drag half of the pattern. Sift molding sand onto the cope, tucking it

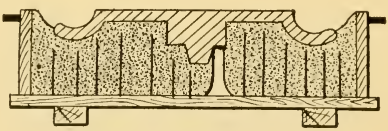

FIG. 75.—Parting made.

firmly into the sheave part of the pattern as shown at *AA*, Fig. 76. Make the parting from the flange, *CC*, to the cope, Fig. 76. Sprinkle parting sand over the cheek (on the parting and the cope but not on the sand above the pattern). Ram the drag, lift it, and place it on the molding board. Swab, rap and draw the drag half of the pattern. Rap the cope half of the pattern. Place the drag back on the cope.

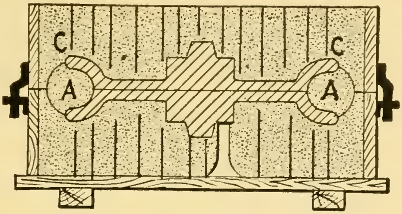

FIG. 76.—Cheek and drag rammed.

Roll over the mold. Lift the cope and place it on the molding board. Swab and draw the cope half of the pattern. Make the vent-hole for

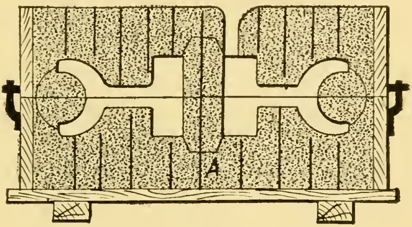

FIG. 77.—Mold closed.

the escape of core gas as shown at *A*, Fig. 77. Set the core. Close and clamp the mold, as shown in Fig. 77.

EXERCISE 9. MOLDING A BEVEL-GEAR BLANK

The pattern, Fig. 78, is in one piece with the parting line at *AA*. A two-part flask is used and the pattern is arranged so that the parting line is even with the joint of the flask. To do that it is necessary to

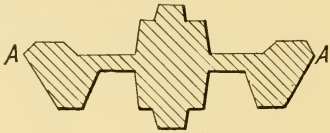

Fig. 78.—Bevel gear blank pattern.

ram a false cope and then embed the pattern to the parting line as shown in Fig. 79.

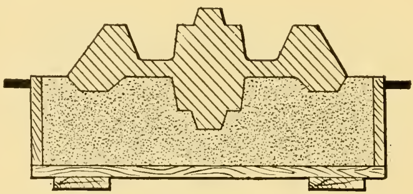

Fig. 79.—Pattern imbedded in false cope.

Procedure in Molding

After the pattern is arranged in the cope, place the drag and sift sand over the pattern. Fill the drag heaping full of sand and ram. Roll the mold over, lift the cope and shake the sand from it.

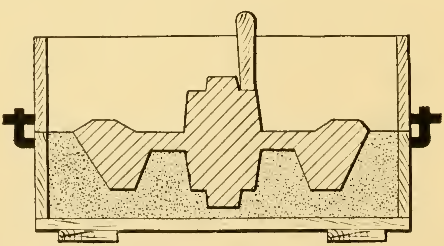

Fig. 80.—Cope and sprue set on drag.

Make the parting and place the cope and sprue as shown in Fig. 80. Ram and vent the cope, remove the sprue and lift the cope. Swab, rap, and draw the pattern. Make the vent hole for the core gas and set the core. Close and clamp the mold.

EXERCISE 10. MOLDING TWO FACE PLATES BY EMBEDDING PATTERNS

In the exercise, the patterns will be embedded in the drag instead of rolling the drag over, a method used under some conditions, frequently resulting in the saving of time.

Procedure in Molding

Place the drag with the pins up on the molding board as shown in Fig. 81. Shovel it level full of unsifted sand. Peen-ram the sand around the flask. Sift sand over the drag and strike it off level with the top. Place the patterns on the sand and press them down even with the top of the drag. With the fingers tuck the sand firmly under the pattern. Peen-ram the sand around the pattern until it is even with the top of the pattern and the drag. Make the parting and sprinkle on the parting sand. Set the sprue and cope as shown in Fig. 82. Ram the cope and finish the mold as in the preceding exercises.

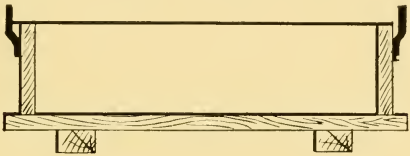

Fig. 81.—Bottom board and drag placed in place for bedding in face plate.

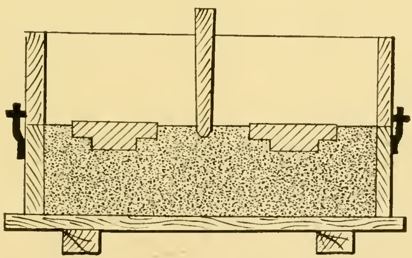

Fig. 82.—Cope and sprue set.

EXERCISE 11. THINNING A PLATE

The pattern is a plate 10 in. square and 1 in. thick. The casting to be made is to be only ½ in. thick. It is necessary to use two strips of wood ½ in. square and as long as the flask.

Procedure in Molding

Place the pattern and drag on the molding board with the pins down. Lay the two strips of wood, *AA*, between the molding board

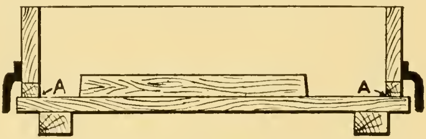

Fig. 83.—Drag and pattern placed on molding board.

and the drag as shown in Fig. 83. Sift sand over the pattern and ram the drag. Roll the drag over, remove the molding board and make the parting. Set the sprue pin and the cope, allowing the strips of wood to remain on the drag and the cope to rest on them as shown in Fig. 84. Make the cope as in the preceding exercises.

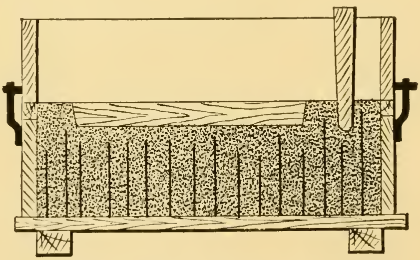

Fig. 84.—Cope and sprue set on drag.

After the cope is lifted, remove the strips of wood, and cut down the sand around the pattern level with the top of the drag as shown in Fig. 85. Swab, rap and draw the pattern. Cut the gate. Before closing the mold, put some parting sand or wheat flour on the drag near the edge of the flask to insure a tight point.

After the mold is closed the cope should be lifted again to observe whether or not the sand in the cope touched the sand in the drag at all points. If there are spots on the cope not marked by the flour, more sand should be added to the drag, and the process repeated until the bearing is complete.

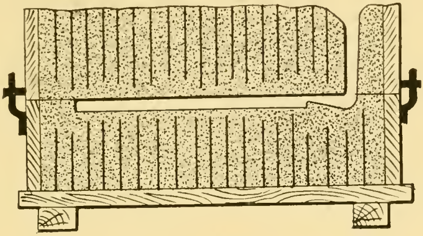

Fig. 85.—Mold closed.

To prevent the metal from running out between the cope and drag, which is likely to happen with this type of mold, tuck wet sand or damp clay into the joint, after the mold is closed, but just before it is clamped.

EXERCISE 12. MOLDING A PULLEY LONGER THAN THE PATTERN

The pattern is the one used in Exercise 6. The rim and the hub of the casting are to be ½ in. longer than the pattern. It is necessary

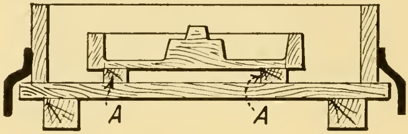

FIG. 86.—Pattern and drag placed on molding board.

to have two wooden strips ½ in. square and as long as the diameter of the pattern.

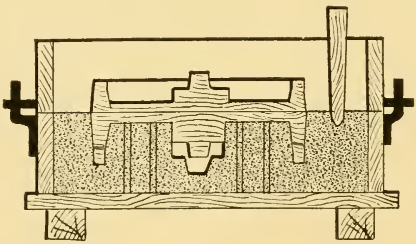

FIG. 87.—Pattern, cope and sprue set on drag.

Procedure in Molding

Place the pattern and the drag on the molding board, with the two strips of wood, *AA*, under the pattern as shown in Fig. 86. Make

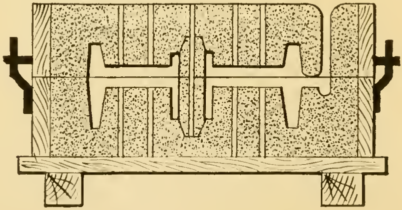

FIG. 88.—Mold closed.

the drag as in the preceding exercises. After the drag is rolled over, take the strips of wood from the pattern. The pattern must now be brought up level with the top of the drag. To hold the pattern up, turn it so that the arms of the pattern rest on the sand which was between them. Build up sifted sand around the pattern. Tuck the sand around the pattern and under the arms with the fingers. The sand must not be tucked too hard or it will be pushed under the pattern. When the pattern is drawn up level with the top of the drag and the sand is packed solidly around it, make the parting. Set the cope half of the pattern on the drag half. Sprinkle parting sand on the drag and set the sprue pin and cope as shown in Fig. 87. The cope is to be made as in Exercise 6. Figure 88 shows the mold closed with the dry-sand core set in place.

CHAPTER XI

FLOOR MOLDING EXERCISES

The term floor molding indicates that the molds are to be made on the foundry floor instead of on the bench. The tools used in bench molding can be used in floor molding with the exception of the rammer. The rammer at *B* shown in Fig. 29, should be used.

EXERCISE 13. MOLDING A CONE PULLEY

The pattern, Fig. 89, is 14 in. in dia. and 7 in. long with the parting line at *A*. The flask should be 16 in. square with the drag 9 in. and the cope 5 in. deep.

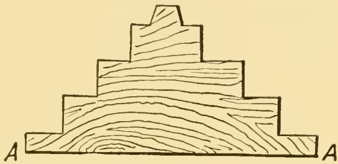

FIG. 89.—Cone pulley pattern.

Procedure in Molding

Place the pattern and drag on the molding board as shown in Fig. 90. Sift sand over the pattern. Fill the drag about half full of sand and peen-ram this layer. Fill the drag heaping full and peen-ram again. This time ram the sand level with the top of the drag. Vent the drag and sprinkle sand free from large lumps over the drag, about ¼ in. deep. Rub the bottom board on the drag, seeing that it lies firmly

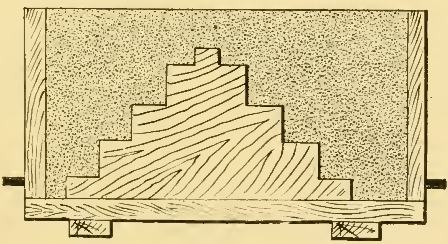

FIG. 90.—Cone pulley drag rammed.

without rocking. Put two clamps on the drag before rolling it over as shown in Fig. 91. Remove the clamps and molding board from the drag and make the parting. Sprinkle on the parting sand and place the cope and sprue as shown in Fig. 92. Sift sand over the pattern and tuck it under the bars with the fingers. Peen-ram between the bars, then fill the cope heaping full and butt-ram the sand level with the to of the cope. Vent the cope and take out the sprue pin. Lift the cope and set it on a wooden box or a pair of trestles as shown in

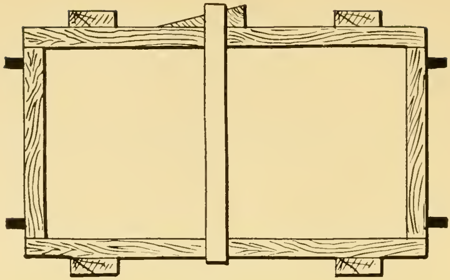

FIG. 91.—Cone pulley drag ready to roll over.

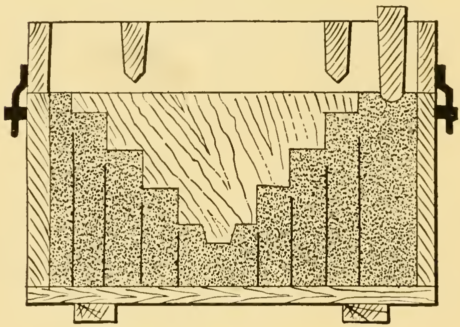

FIG. 92.—Cope and sprue set.

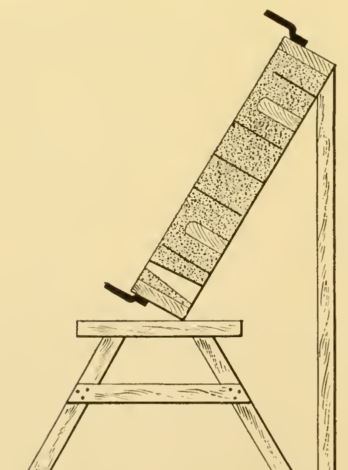

FIG. 93.—Cope placed on trestle.

Fig. 93. Blow all loose sand from the mold. Swab, rap and draw the pattern. Cut the gate and set the core as shown in Fig. 94. Make

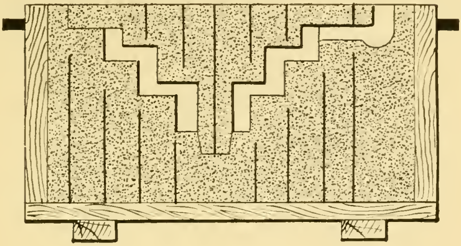

Fig. 94.—Core set in drag.

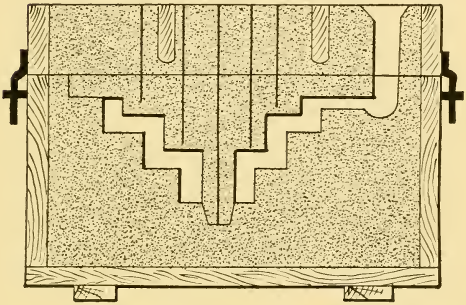

Fig. 95.—Mold closed.

the vent hole through the cope for the escape of core gas. Close the mold as shown in Fig. 95 and clamp it.

EXERCISE 14. MOLDING A GAS ENGINE FLYWHEEL

If the weight of the casting is more than 50 lb., a sea-coal facing composed of one part sea coal and ten parts sand should be put next to the pattern. To feed the casting evenly, use two feeders as shown in Fig. 97. Gate the casting on the hub.

Procedure in Molding

Place the pattern and drag on the molding board as shown in Fig. 96. Sift the facing over the pattern to a depth of about 1 in., then

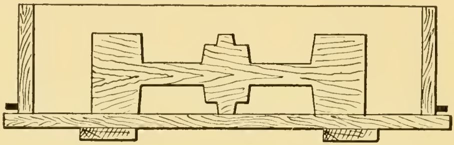

Fig. 96.—Drag and pattern placed on molding board.

fill the drag level with the unsifted heap sand. Peen-ram between the pattern and flask, but not over the pattern. Fill the drag heaping full and step the sand down with the feet, then butt-ram firmly between the pattern and flask and ram lightly over the pattern. Heavy ramming over the pattern may cause the casting to be scabbed.

Strike the sand off level with the drag, vent carefully, and sprinkle on sand free from large lumps. Rub the bottom board down, clamp,

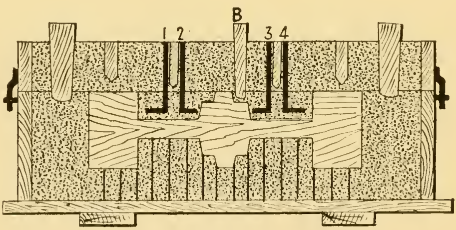

Fig. 97.—Mold rammed up.

and roll the drag over. Remove clamps and molding board. Make the parting, sprinkle on the parting sand and blow all parting sand from the pattern. Sift molding sand over the drag about ¼ in. deep. Clean the molding sand from the flask joint and wet the inside of the cope with a thin clay wash.

Set the cope, sprue, feeders and gaggers as shown in Fig. 97. Sift sand over the pattern and tuck it firmly under the bars with the fingers. Fill the cope level full of sand. First, peen ram between the bars, being careful not to strike the gaggers, then fill the cope heaping full and butt-ram between the bars. Do not strike the tops of the bars. Vent, cut the pouring basin as shown at *D*, Fig. 98, and draw the sprue and feeders.

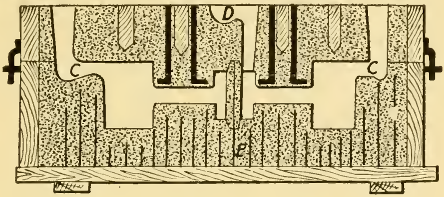

FIG. 98.—Mold closed.

Lift the cope and set it on a pair of trestles or a box. Blow all loose sand from the mold. Swab, rap and draw the pattern. Cut the feeder connections as shown at *CC* in Fig. 98. Put graphite facing on the mold with a camel's hair brush or rub it on with the hand. Set the core in the drag and make the vent channel for the core gas to escape through the drag, as shown at *E*, Fig. 98. Close and clamp the mold.

EXERCISE 15. MOLDING A SUGAR KETTLE

The patterns for the ears must be loose and must be split at *BB*, as shown in Fig. 99. The mold can be made in more than one way, and the casting can be run either from the sides or top. The best way to mold from a pattern of this type is to use a green sand core in the drag, because it insures that the inside of the casting will be clean. By casting the kettle upside down the dirt will flow to the bottom of the kettle (the top of the casting) where it will do no harm unless present in an unusual amount.

Procedure in Molding

Place the pattern and cope on the molding board as shown in Fig. 99, with sifted sand next to the pattern. With the fingers tuck the sand

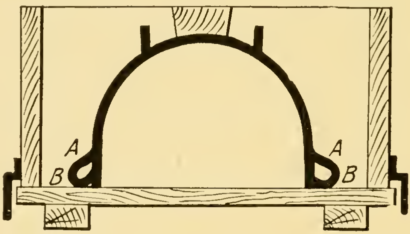

Fig. 99.—Pattern and cope placed on molding board.

firmly around the ears *AA*. Fill the cope with sand to a depth of 5 in. Peen-ram between pattern and flask, being careful not to ram

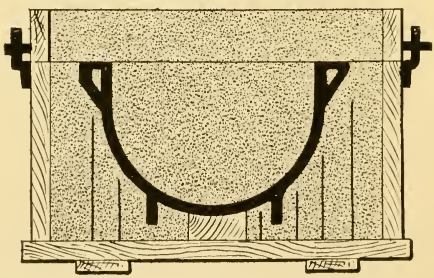

Fig. 100.—Drag set on cope.

the ears out of place. Cover the pattern with sifted sand and set a flat sprue on top of the pattern. Fill the cope level full and peen-ram, then fill the cope heaping full and butt ram. Vent and remove the sprue pin. Sprinkle a bed of sand over the cope, place a board on it, and clamp. Roll the cope over, remove the clamps and molding board. Make the parting, clean all loose sand out of the pattern, sprinkle on parting sand and rap the pattern. Place the drag as shown in Fig. 100. Fill the inside of the pattern with sifted sand and ram it lightly until it is even with the top of the pattern. Vent the sand on the inside of the pattern. Fill the drag full and peen-ram, then fill it

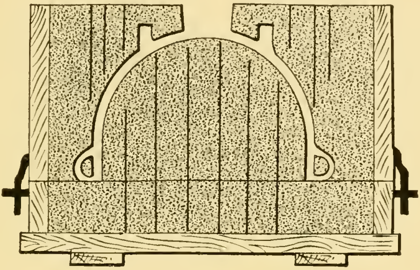

Fig. 101.—Mold closed.

heaping full and butt-ram. Strike the sand off level with the top of the drag and vent it. Sprinkle sand free from large lumps over the the drag and rub down the bottom board. Clamp and roll the mold over. Remove the clamps and board from the cope. Lift the cope and place it on a pair of trestles. Blow all loose sand from the mold. Swab, rap and draw the kettle pattern; then draw the patterns for the ears. Face the mold with graphite. Close and clamp the mold. Figure 101 shows the mold closed.

EXERCISE 16. MOLDING A STEAM ENGINE PISTON

When a casting of this nature weighs more than 50 lb., a sea-coal facing, composed of one part sea coal to ten parts sand should be used next to the pattern. Because the casting must be clean and sound, a skimming gate and feeder should be used.

Procedure in Molding

Place the pattern and drag on the molding board as shown in Fig. 102. Cover the pattern with facing and follow it with a layer of sifted facing

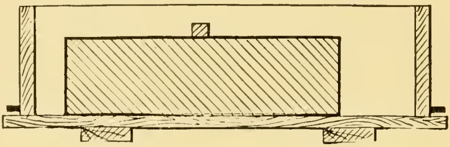

FIG. 102.—Pattern and drag placed on molding board.

sand. Fill the drag level full with unsifted heap sand. Peen-ram between the pattern and flask. Fill the drag heaping full and butt-ram firmly around the pattern, but lightly over the pattern. Strike the sand off level with the drag. Place the bottom board on the drag and clamp. Roll the drag over and remove the clamps and molding board. Make the parting and sprinkle on the parting sand.

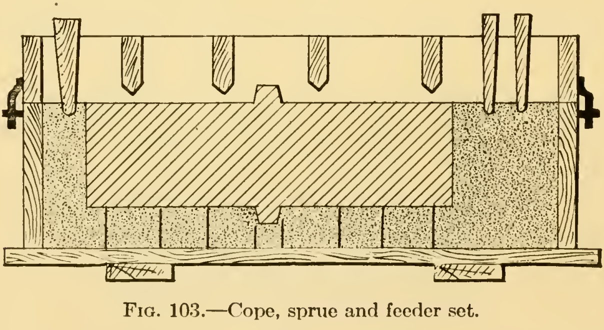

FIG. 103.—Cope, sprue and feeder set.

Set the sprue, skimmer, feeder and cope as shown in Fig. 103. Sift facing sand onto the cope and tuck the sand firmly under the bars. Then fill the cope level full and peen-ram between the bars. After the cope has been peen-rammed, fill it heaping full between the bars and butt-ram even with the tops of the bars. Vent, and draw the sprue, skimmer and feeder. Lift the cope and set it on a pair of trestles or a box.

Swab, rap, and draw the pattern. Cut the gate and connect the feeders in the drag. Rub graphite facing on the mold either with the hand or a camel's hair brush. Cut the drag chaplets, *AA*, Fig. 104, allowing ½ in. to be driven into the bottom board, and point them on

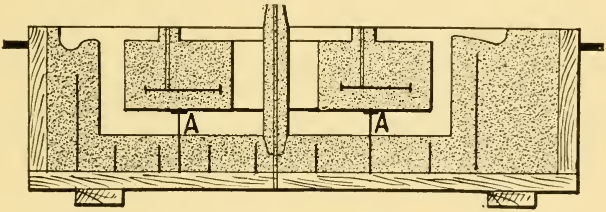

FIG. 104.—Core set in drag.

the grinding wheel. Cut the cope chaplets, *B*, *B*, Fig. 105, long enough so that when they are down on the core, with the mold closed, they will stick out of the cope ¼ in. Place the chaplets in the drag and set the core as shown in Fig. 104. Push the chaplets through the cope and press the sand on the top of the cope firmly around them.

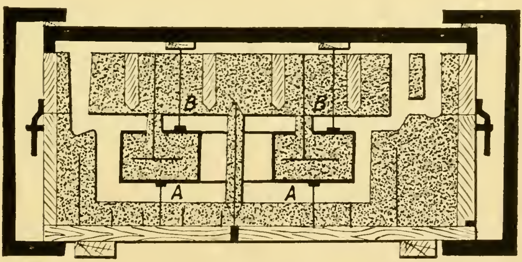

FIG. 105.—Mold closed.

Place the cope on the drag to take an impression of the core prints. Lift the cope again to see that it was bearing on the core prints. (A little wheat flour or paste put on the print will often make a tight joint over the core.) Punch the vent hole fore the dry sand core after the cope has been lifted and make certain that the vent hole through the cope is connected with the hole in the core. Close and clamp the mold. Secure the chaplets in the cope as shown in Fig. 105.

EXERCISE 17. MOLDING A LATHE BED

The weight of the casting is about 75 lb. The parting lines are at *A* and *B*, and the pattern is split at *C*, as shown in Fig. 106. The mold can be made in either a three or a two part flask. In this exercise a three-part flask will be used, and the casting will be gated from the bottom.

Fig. 106.—Lathe bed pattern.

Procedure in Molding

Place the pattern and drag on the molding board as shown in Fig. 107. Lay two strips of wood, *AA*, between the molding board and the drag, to raise the drag even with the parting line of the pattern. Cover the pattern with sifted sand, then fill the drag heaping full of unsifted sand and peen-ram. Again fill the drag heaping full and butt-ram. Strike off the sand level with the drag and vent. Sprinkle on sand, rub down the bottom board, clamp and roll over. Remove the clamps, molding board and strips. Make the parting and sprinkle on the parting sand.

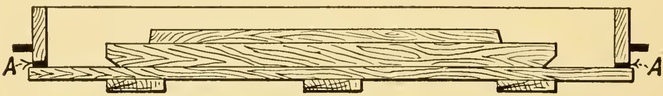

Fig. 107.—Pattern and drag placed on molding board.

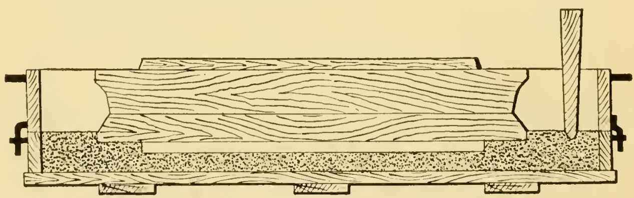

Fig. 108.—Cheek and sprue set on drag.

Set the cheek, sprue and pattern as shown in Fig. 108. Put sifted sand next to the pattern and fill the cheek level full of unsifted sand.

Peen-ram the cheek, then fill it heaping full and butt-ram. Make the parting and apply parting sand. Clay wash the cope and set it on the cheek. Set the riser as shown in Fig. 109. Sift sand into the cope and tuck it firmly under the bars. Fill the cope level full with unsifted sand and peen-ram between the bars, then fill the cope heaping full

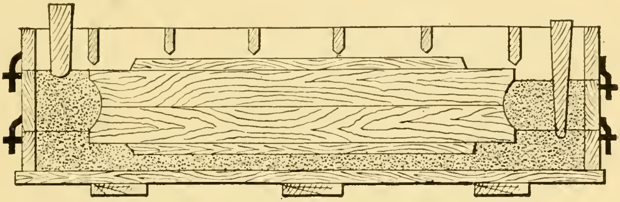

FIG. 109.—Cope placed on drag and cheek.

and butt-ram. Strike off the sand level with the top of the cope and vent. Draw the sprue pin and feeder. Lift the cope and set it on a pair of trestles.

Blow all loose sand from the cheek. Swab, rap and draw half of the pattern from the cheek. Lift the cheek and set it on a pair of trestles.

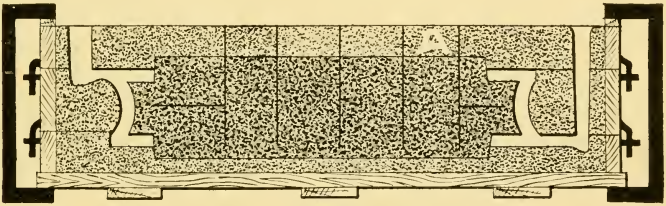

FIG. 110.—Mold closed.

Blow all loose sand from the drag. Swab, rap and draw the pattern from the drag. Cut the gate in the drag, but make the riser connection in the upper part of the cheek as shown in Fig. 110. Brush graphite on the mold and set the cheek back on the drag. Set the core and make the vent holes as shown at *A*. Close and clamp the mold as shown in Fig. 110.

EXERCISE 18. MOLDING A MACHINE BASE

The base casting will be made in this exercise in a three-part flask The pattern has parting lines at *A* and *B*, Fig. 111, and the core print, *C*, is loose. A casting of this type should be poured from the bottom through a step gate, as shown in Fig. 115. If the metal in the casting is more than ¾ in. thick sea coal must be used.

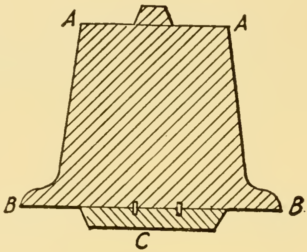

FIG. 111.—Machine base pattern.

Procedure in Molding

Place the core print and the drag on the molding board, as shown in Fig. 112. Cover the core print and molding board with sifted sand, or facing, if facing is being used. Fill the drag heaping full of unsifted sand and peen-ram, then fill it heaping full and butt-ram. Strike off the sand level with the top of the drag. Sprinkle on sand and rub down the bottom board. Clamp and roll the drag over. Remove the clamps

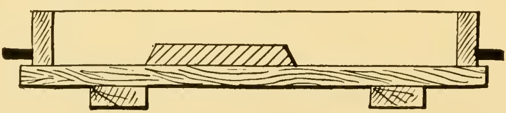

FIG. 112.—Drag and core print placed on molding board.

and molding board. Place the pattern on the core print, as shown in Fig. 113. Make the parting and apply parting sand.

Clay wash the inside of the cheek and place it on the drag. Set into the drag a sprue pin that is long enough to reach to the top of the cheek. Sift sand over the drag about ¼ in. deep and set the gaggers, *A*, around the pattern as shown in Fig. 113. Sift sand or facing over the pattern to a depth of 1 in. Fill in with a layer of sand about 6 in. deep and peen-ram. Put in another layer 6 in. deep, and peen-ram. Continue ramming of layers until the sand is even with the top of the cheek.

The last layer should be heaping full and butt-rammed to make a solid parting. Make the parting and apply the parting sand.

Wet the inside of the cope with clay wash and set the sprue, cope and riser as shown in Fig. 114. Sift sand into the cope and tuck it firmly

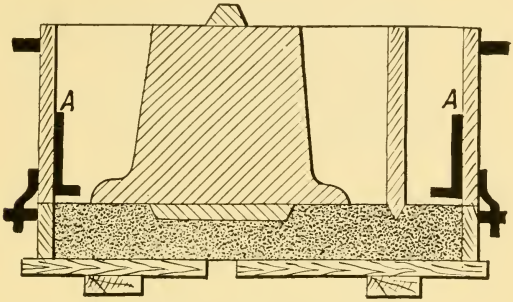

Fig. 113.—Cheek placed on drag.

under the bars. Fill the cope level full and peen-ram, then fill it heaping full and butt-ram. Strike off the sand level with the top, and vent. Draw the sprue pin and riser. Lift the cope and set it on a pair of trestles.

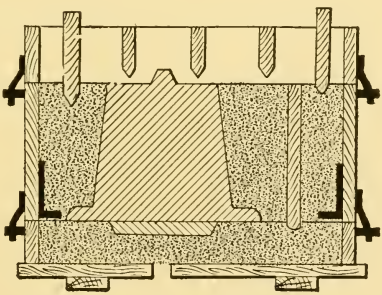

Fig. 114.—Cope and sprue set.

Blow the loose sand from the cheek, swab around the pattern and sprue, rap the pattern, and draw the sprue. Lift the cheek carefully and set it on trestles. The pattern should remain on the drag when the cheek is lifted; if it starts to rise with the cheek, rap it on top until it will stay down.

Draw the pattern and the core print from the drag. Cut the gate on the flange in the bottom of the cheek. Cut the two sprue connections on the top of the cheek. Make the vent hole for the core through the bottom board. Set the core, then face the mold with graphite. Place

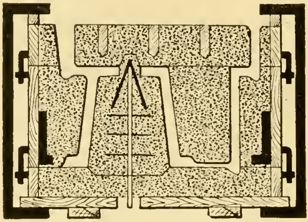

Fig. 115.—Mold closed.

the cheek back on the drag, taking care not to strike the core. Close and clamp the mold as shown in Fig. 115.

EXERCISE 19. LIFTING A DRY-SAND CORE OUT OF THE PATTERN

The mold in this exercise could be made without the use of a dry-sand core, but trouble would be experienced by breaking sand when lifting the cope. This trouble can be eliminated by the use of a dry-sand core lifted out of the pattern with the cope. The core can be made by using the pattern for the core box if desired.

Procedure in Molding

Place the pattern and drag on the molding board, ram, and roll over as in the preceding exercises. Place the core in the pattern. Run

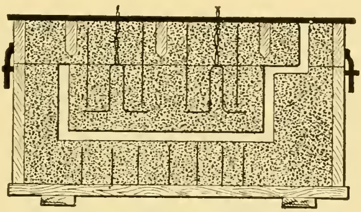

Fig. 116.—Mold closed.

a wire, strong enough to support the core, through the lifting hook in the core, allowing it to stick out of the cope about 4 in. Ram the cope in the usual way.

Before lifting the cope place a bar across it and fasten the wire to this bar. Lift the cope and set it on a pair of trestles, without turning it over. (If the cope is turned over the core may slide to one side.) If there is any work or patching to be done, get under the cope to do it. Draw the pattern and cut the gate. Close the mold as shown in Fig. 116 and clamp it.

EXERCISE 20. MOLDING A PLATE IN OPEN SAND

Plates that require only one smooth surface can be molded in open sand and without the use of pattern or flask. Such molds are called open-sand molds. Their use is limited to a very few shapes. In this exercise only one method of making open-sand molds will be shown. To make this mold it is necessary to have two guide boards, a straight-edge and a spirit level.

Procedure in Molding

Build four mounds of molding sand on the foundry floor as shown in Fig. 117. Place the two guide boards, *B*, on the mounds and

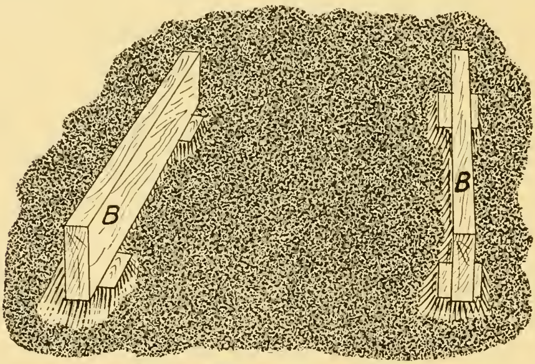

FIG. 117.—Beginning open sand mold.

level them in both directions. Shovel sand between the boards. Ram the sand as in ramming a mold, being careful not to ram the guides out of place.

Sift sand over the bed and ram it lightly not depressing it below the guide boards. Strike off the sand level with the tops of the guides. Test the bed to see that it is level and if it found to be out of level, drive the guide again and again test for level. Repeat until the proper condition is obtained. Sift a little molding sand over the bed through a No. 8 riddle. Slick the sand down with a slick or trowel, being careful not to develop hard spots.

Measure and mark off on the bed the size of the plate wanted. Then use the board *C*, shown in Fig. 118, to build up the sides of the mold. The board should have the thickness of the plate to be made. Figure 118 shows two sides built up. After building up the sides make the pouring basin as shown at *D*, Fig. 119. It should be built up a little higher than the sides of the mold, to give pressure when pouring. Any open sand mold should be poured with hotter metal than molds that are made with a cope, because there is no sprue used to give

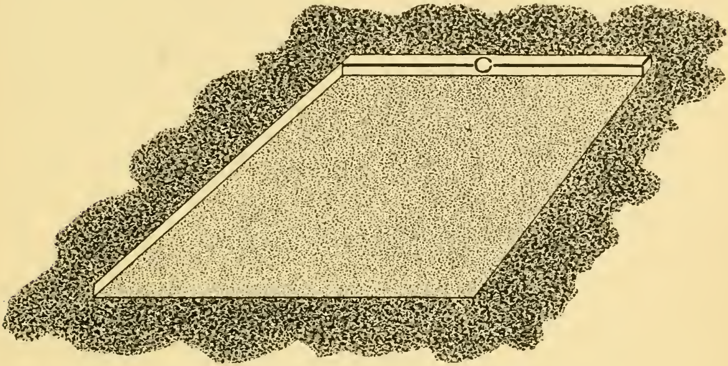

FIG. 118.—Building up sides for open sand mold.

head pressure. Venting is done by running a long wire under the mold. The vent holes should be left open as shown at *E*, Fig. 119.

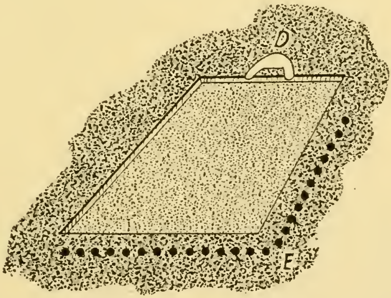

FIG. 119.—Open sand mold ready for pouring.

After the mold is poured and the metal has solidified, the casting should be covered with molding sand which should remain until the casting is removed from the mold.

EXERCISE 21. SWEEP MOLDING

Castings having circular forms can be made with sweeps instead of patterns. When a few castings are to be made, if they are of such nature that sweeps can be used, time in pattern making can be saved. In this exercise a bowl will be molded by using sweeps. To make the mold it is necessary to have the two sweeps, *A* and *B*, the spindle, *C*, and the spindle-seat *D*, as shown in Fig. 120.

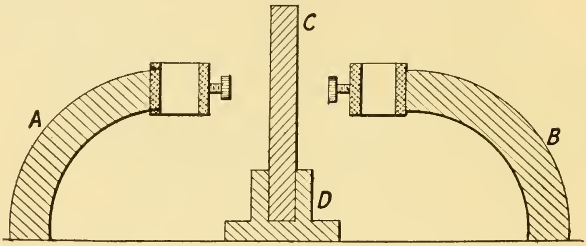

Fig. 120.—Sweeps, spindle and spindle seat.

Procedure in Molding

Place the spindle, in the seat, on the molding floor. Level the seat so that the spindle is vertical. Level the floor with molding sand. Pack molding sand around the spindle and ram it as firmly as a drag is rammed. Place the sweep *A* on the spindle as shown in Fig. 121

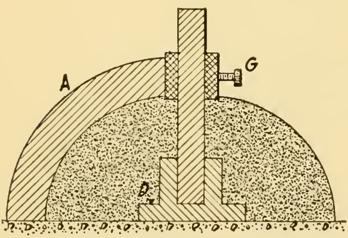

Fig. 121.—Spindle and sweep set to sweep the sand for the outside of the casting.

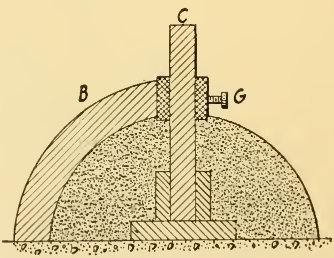

Fig. 122.—Spindle and sweep placed for cutting down the sand to make the inside of the casting.

and revolve it to cut the sand to the desired shape which is the shape of the outside of the casting. Remove the spindle and sweep. Put a plug of wood into the spindle hole to prevent the sand from falling into the seat. If the plug does not come even with the top of the mound, sand can be put over the plug. Put parting sand on the mound of sand.

Clay wash the cope, set it over the mound and drive stakes into the floor against the cope as shown in Fig. 123. These stakes take the place of pins in guiding the cope when it is lifted. Set the gaggers, place a flat sprue on the top of the mound, and ram as in the preceding exercises. Care must be taken in ramming the cope not to ram the mound of sand out of shape. Vent the cope. Lift it and set it on a pair of trestles.

Remove the wood plug and replace the spindle as shown in Fig. 122. Put the sweep *B*, which is smaller than sweep *A*, on the spindle and

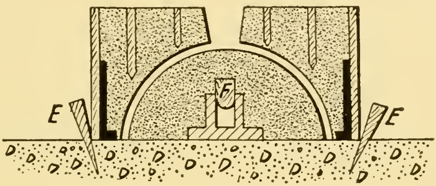

Fig. 123.—Mold closed.

revolve it to cut away the sand to give the required thickness of the metal in the casting. Remove the sweep and spindle. Replace the plug of wood in the spindle seat and fill the hole left by the spindle with molding sand. Slick the sand in the cope and also in the hill, taking care not to cause hard spots. Face the mold with graphite and replace the cope over the drag.

A mold of this type cannot be clamped, but must be weighed down. The amount of weight necessary to be placed on the cope can be computed from the rule given on page 28.

Note.—Sometimes a green-sand core made in this manner will cause blowing. The remedy is to place a cinder or coke bed on the floor under the mold, providing pipes through which the steam and gases can escape.

EXERCISE 22. PIT MOLDING

Castings are sometimes made in a pit, instead of a flask. In some cases the entire mold is made in the pit. In others only the drag half is so made, an ordinary cope being used above ground. The practice of pit molding is carried on chiefly in making large castings and in jobbing shops where the cost of building flasks would not be justified.

Complete patterns may or may not be used. Some molds are formed by the use of sweeps and parts of patterns. Others are built up entirely of dry sand cores.

Shops that practice pit molding regularly make permanent pits, lining the sides with common brick. Shops that make only an occasional pit mold usually fill the pit with molding sand after the job is finished and use the space for molding floor.

The cross section of a pit mold is shown in Fig. 124. The drag half only is made in the pit. The casting is to be a large collar or sleeve.

PROCEDURE IN MAKING THE MOLD

A pit is dug in the foundry floor, large enough to allow for making the mold and for making a vent bed of cinders or coke 6 in. deep, as shown at *A*, under the mold. After the bed is prepared, vent pipes are placed as shown at *B*, extending out of the pit from 4 to 6 in. The upper ends are filled with waste to exclude sand when making the mold.

A layer of molding sand is put on the vent bed and rammed. Vent holes are then run through the sand into the bed as shown at *C*. Next the pattern is embedded in the molding sand with the top even with the foundry floor. The gate core, *D*, is put in place and a sprue pin, long enough to come even with the top of the pattern, is set into the gate hole in the core. The sides of the mold are rammed in the usual way, the parting is made and the parting sand applied. The cope, sprue and feeder are placed and the guides *E* are driven. The cope is then finished in the usual way. The pattern and sprue pin are drawn from the pit, the runner, *F,* and the feeder connection, *G,* are cut, and the drag is finished as in floor molding. The core, *H,* is set and the pipes running from the vent bed must be opened.

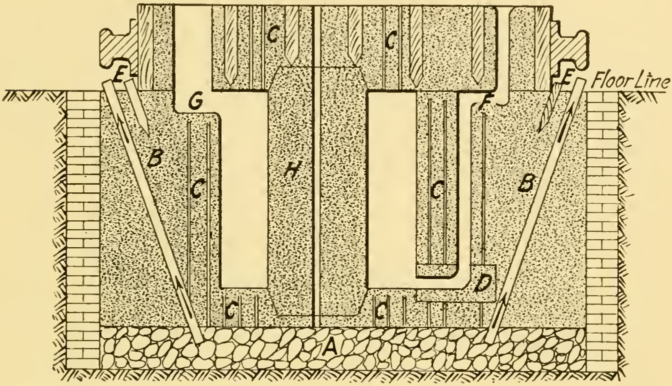

FIG. 124.—Pit mold closed.

FOUNDRY PROBLEMS

Some schools wish to go deeper into foundry practice than the making of molds and dry sand cores and the pouring of metals, by taking up problems from an executive point of view. The following are examples of important problems that must be solved by foundry executives. They have been and are being used by the author in teaching foundry practice.

Problem 1.—To lay out a floor plan for a small commercial foundry. Some of the information can be had from the plan shown in Fig. 3. The instructor should discuss, with the student, the departments of the foundry and require him to show in the plan where some of the principal pieces of equipment are to be placed. He should also impress upon the student the necessity for the plan to be practical and to provide for efficient operation.

Problem 2.—Cupola practice. The student should be given dimensions for a cupola with the task of showing by cross-section drawing how the cupola is to be charged when ready for the blast. The method of charging should be specified by the instructor.

Problem 3.—To compute the weight of a casting from a drawing, to show by cross-section drawing how the casting is to be molded, and to compute the weight necessary to hold down the cope.

Problem 4.—To compute an iron mixture from chemical analysis. To make up charges to fit the cupola shown in Exercise 2. To compute the summary after the heat has been poured, taking into consideration: The amounts of the different kinds of metal used; the good and bad castings made; the amount of metal in the sprues and risers; the iron loss in melting; the iron and coke recovered from the dump; and the melting ratio. To test the metal for strength, deflection, shrinkage and chill. To compute the cost per pound of the castings. The data are obtained from the exercise.

Note.—The data in regard to good and bad castings, the iron in sprues and risers, and the iron and coke in the dump must be furnished the student. They can be taken from general practice, but it is preferable if the heat actually can be run by the student.

Problem 5.—The student should be given a pattern with the task of designing a flask that will be suitable for making the mold, and of showing, by cross-section drawing, the mold ready for pouring.

Problem 6.—Defective casting report. For this exercise the instructor should collect a group of defective castings and have the student make a report on them. The student should state the causes of the defects and tell how to prevent such defects.

Problem 7.—The student is to show in graphic form how the organization is going to function when the foundry that he planned is put into operation, and to select some of the principal pieces of equipment.

Note.—The information necessary in selecting equipment can be had from trade catalogues.

Problem 8.—The student is given a pattern and is required to calculate the weight of the casting to be made from it. He is then to check his calculation by weighing the pattern.

FIRST EXERCISE—FOUNDRY LAYOUT

Rooms, Storage Bins and Yards Required

Molding room for twelve molders
Cupola room
Cleaning room for cleaning castings
Core room for making dry-sand cores
Pattern storage room
Tool and supply room
Motor and blower room
Office

Coke shed
Molding sand shed
Core sand shed
Clay shed
Sea coal facing shed

Iron yard
Flask yard
Railroad siding

Specifications

(a) Base the molding floor space on 800 sq. ft. to 1 ton of good castings.

(b) One molder should make 500 lb. of good castings per day.

(c) One molder will need a molding floor 25 ft. long and 8 ft. wide.

(d) The main gangways in the molding room should be from 6 to 8 ft. wide.

(e) When laying out the floor plan use a scale of $\frac{1}{16}$ in. to 1 ft.

Notes

The layout specified is that of a typical small commercial shop.

Any additional rooms, sheds, or yards may be added if thought to be desirable and practical.

In this layout it is very important that considerable attention be given to the routing of the iron from the storage yard to the finished casting.

SECOND EXERCISE—CUPOLA PRACTICE

Cupola Dimensions

Diameter of cupola shell	52 in.
Thickness of lining	7½ in.
Inside diameter at tuyeres	37 in.
Height from bottom plate to bottom of charging door	12 ft.
Height from bottom plate to bottom of tuyeres	15 in.
Height from sand bottom (back side) to bottom of tuyeres	9 in.
Height from sand bottom (at spout) to bottom of tuyeres	11 in.
Number of tuyeres in cupola	6
Size of tuyeres at inside of lining	4½ in. high, 8 in. wide

Notes and Instructions

1. 1 lb. of coke will occupy about 65 cu. in. when charged in a cupola.
2. 1 lb. of iron will occupy about 9 cu. in. when charged in a cupola.
3. Make the first charge or bed of coke 22 in. above the top of the tuyeres.
4. Charge 2½ lb. of iron to 1 lb. of coke on the first charge, or bed.
5. Use a 9 in. layer of coke between layers of iron.
6. Charge 10 lb. of iron to 1 lb. of coke on the charges above the bed.
7. A "charge" means a layer of coke, together with the layer of iron directly above it.
8. In computing a coke charge make it the nearest multiple of 10 lb. Example: If the result obtained is 128 lb. make it 130 lb.
9. In computing an iron charge make it the nearest multiple of 25 lb. Example: If the result obtained is 910 lb., make it 900 lb.
10. In computing the thickness of an iron charge, make it the nearest multiple of a half-inch.
11. Compute and enter on the drawing the additional amounts of iron and coke required to complete the heat of five tons of iron.
12. In making the cupola sketch use a scale: ½ in.–1 ft.

Note.—The dimensions and figures given here may be varied at the discretion of the instructor.

THIRD EXERCISE

1. The drawing gives the dimensions of a casting and of the flask in which it is molded. Make a drawing similar to that shown, using the scale given.

2. Compute the weight of the casting and enter it on the drawing. A cubic inch of cast iron weighs 0.26 lb.

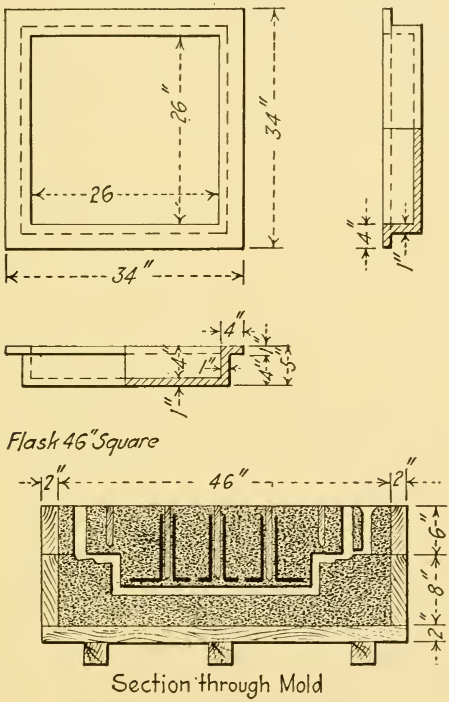

Fig. 124A.—Pattern and mold.

3. Compute the weight required to hold down the cope while the mold is poured, and enter it on the drawing.

When a mold is poured, the fluid metal exerts a pressure similar to a hydraulic pressure and can be expressed in the same way (in pounds per square inch). Obviously the pressure which will tend to raise the cope is that exerted on the top surface of the mold, hence the pressure on the bottom and sides of the mold may be disregarded.

The pressure per square inch on any surface of the mold is equal to the distance in inches from the given surface to the top of the cope, multiplied by 0.26. The total force lifting up on any surface is then equal to the pressure per square inch multiplied by the number of square inches of surface. The total force lifting up on the cope is the total of the lifting forces on all the top surfaces of the mold. This total force may be computed in another way, by obtaining the total volume in cubic inches of the space between the pattern and the top of the cope, and multiplying this figure by 0.26.

The upward force may be partly or entirely balanced by the weight of the cope. This weight may be computed by obtaining the number of cubic inches of sand in the cope and multiplying this number by 0.06 lb., the weight of a cubic inch of rammed molding sand. Use the inside dimensions of the flask, neglecting the weight of the flask itself, and figure the cope as solid sand, disregarding the sprue and riser, bars, and gaggers.

The weight required is the total upward pressure minus the weight of the cope.

FOURTH EXERCISE

1. Compute mixture.

2. Fill in cupola dimensions from Exercise 2.

3. Compute the ratio of tuyere area to area of the cupola.

The combined tuyere area equals the product of the number of tuyeres times the height, times the width of each tuyere.

The horizontal cross-sectional area of the cupola is the area of a circle whose diameter is the inside diameter of the cupola.

4. Fill in charging sheet according to iron mixture and cupola charges computed in Exercise 2. Start charging flux on the fourth charge.

5. When computing the summary the iron recovered from the dump is regarded as iron not melted. The percentages of iron taken from the dump, good and bad castings, sprues and risers, and iron lost in melting, should total 100 per cent, and the percentages are based on total metal charged as 100 per cent. The iron taken from the cupola and the iron lost in melting should also total 100 per cent, and their percentages are also based on total metal charged.

The melting ratio is obtained by dividing the number of pounds total metal melted by the number of pounds of coke burned in melting.

6. Break the test bars to obtain the breaking load and deflection. Average the results for the two bars. To find the transverse strength in pounds per square inch divide the breaking load by the area of the fracture in square inches.

To find the shrinkage measure the difference between the lengths of the pattern or shrinkage clamp and the casting.

To find the depth of chill measure the thickness of the white portion in the fracture of the chilled bar.

7. Compute the various items of cost on the basis of one day's operation, and from these the cost of the castings per pound.

8. Fill in your name, bench number, period, hours spent on the exercise, and date in the spaces provided at the bottom of the sheet.

FOURTH EXERCISE

Sheet 1

Analyses of Iron in Stock

No. 1 Pig Iron	Per cent	No. 2 Pig Iron	Per cent	Scrap Iron	Per cent
Carbon	4	Carbon	3.75	Carbon	3.5
Silicon	3.1	Silicon	2.75	Silicon	2.1
Manganese	0.8	Manganese	0.6	Manganese	0.5
Phosphorus	0.9	Phosphorus	0.5	Phosphorus	0.6
Sulphur	0.03	Sulphur	0.05	Sulphur	0.07

Analysis Required in Castings

	Per cent
Carbon	from 3.6 to 3.8
Silicon	from 2.25 to 2.5
Manganese	from 0.5 to 0.6
Phosphorus	from 0.6 to 0.7
Sulphur	not over 0.1

Silicon loss in melting about 0.25
Manganese loss in melting about 0.1
Sulphur increase in melting about 0.03
Carbon and phosphorus remain approximately constant.

Mixtures Computed in 1,000 Lb. Charges

Carbon

No. 1 Pig Iron..........lb.   C..........lb.
No. 2 Pig Iron..........lb.   C..........lb.
Scrap Iron..............lb.   C..........lb.
Total...................lb.   C..........lb. = ...Per cent

Silicon

No. 1 Pig Iron..........lb.   Si..........lb.
No. 2 Pig Iron..........lb.   Si..........lb.
Scrap Iron..............lb.   Si..........lb.
Total...................lb.   Si..........lb. = ...Per cent
Loss in melting..Per cent
.......Per cent

Manganese

No. 1 Pig Iron..........lb. Mn........lb
No. 2 Pig Iron..........lb. Mn........lb.
Scrap Iron..............lb. Mn........lb.
Total..................lb. Mn........lb. = ...Per cent
Loss in melting..Per cent
.......Per cent

Phosphorus

No. 1 Pig Iron..........lb. P..........lb.
No. 2 Pig Iron..........lb. P..........lb.
Scrap Iron..............lb. P..........lb.
Total. ....lb. P..........lb. = ...Per cent

Sulphur

No. 1 Pig Iron..........lb. S..........lb.
No. 2 Pig Iron..........lb. S..........lb.
Scrap Iron..............lb. S..........lb.
Total..................lb. S..........lb. = ...Per cent
Gain in melting..Per cent
.......Per cent

Name.............................

FOURTH EXERCISE

Sheet 2

Dimensions of Cupola

Size of cupola shell....................................
Thickness of lining.....................................
Inside diameter at tuyeres..............................
Height from bottom plate to bottom of charging door..............
Height from bottom plate to bottom of tuyeres....................
Height from sand bottom (back side) to bottom of tuyeres..........
Height from sand bottom (at spout) to bottom of tuyeres...........
Number of tuyeres in cupola.............................6
Size of tuyeres at inside of lining........in. high; ....in. wide
What is the ratio in per cent of the combined tuyere area to the horizontal cross-sectional area of the cupola...............per cent

Weight of Charges in Pounds

No. of Charges	Fuel Coke	No. 1 Pig	No. 2 Pig	Scrap Iron	Flux
1st or bed					
2nd					
3rd					
4th					
5th					
6th					
7th					
8th					
9th					
10th					
Total					

Summary

	Lb.	Per cent		Lb.	Per cent
No. 1 pig iron charged.	.....	.....	Iron taken from cupola	.....	.....
No. 2 pig iron charged.	.....	.....	Iron lost in melting...	.....	.....
Scrap iron charged...	.....	.....	*Fuel*		
Total metal charged..	.....	.....	Coke charged........	.....	
Iron recovered frum dump.............	.....	3.0	Coke recovered from dump............	100	
Total iron melted....	.....	.....	Coke burnt in melting	.....	
Good castings made..	.....	60.0	Melting ratio..lb. iron to 1 lb. coke..	.....	
Bad castings made...	.....	2.5			
Returned sprues, risers, etc..............	.....	26.5			

Test of Iron

Size of bar, 1.25 in. in dia., 15 in. long. Tested 12 in. between supports.
Load applied in center. Bar broke at...........................lb.
Transverse strength..........lb. per sq. in. Deflection..........in.
Shrinkage: Bar 1 in. square, 12 in. long. Shrinkage........in. per ft.
Chill: Bar 1 in. square, 6 in. long. Depth of chill................in.

Name..............................

FOURTH EXERCISE

Sheet 3

Cost of Metals, Coke, and Flux

No. 1 pig iron..............................	per ton of 2,240 lb.
No. 2 pig iron..............................	per ton of 2,240 lb.
Scrap iron.................................	per ton of 2,000 lb.
Coke.......................................	per ton of 2,000 lb.
Flux.......................................	per ton of 2,000 lb.

Cost of Iron in Heat

........lb. No. 1 pig iron at........¢ per lb. $.........
........lb. No. 2 pig iron at........¢ per lb. $.........
........lb. scrap iron at........¢ per lb. $.........
Total $.........

Deduct the value of iron returned as sprues, bad castings, and iron in dump, at the price of scrap iron, ...lb. at........¢ per lb................................$.........
Net cost of metal in castings........................$.........

Cost of Melting

........lb. coke to melt iron, at........¢ per lb........$.........
........lb. flux, at........¢ per lb........$.........
1 melter at per day....................................$.........
1 man to make up charges at per day................$.........
Total cost of melting..........................$.........

Cost of Molding, Coremaking, and Cleaning Castings

12 molders at per day.................$.........
2 coremakers at per day.................$.........
4 laborers at per day.................$.........
Total labor.............$.........
Overhead: allow 100% of labor cost... ......$.........
Total..$.........

Cost of Castings

Metal.......................................$.........
Melting.....................................$.........
Molding, coremaking, cleaning, and overhead...$.........
Total..$.........
Cost of castings per ton of 2,000 lb............$.........
Cost of castings per lb.........................$.........

Overhead Expense

Overhead expense includes cost of power, heat, light, water, taxes, insurance, interest on investment, depreciation on buildings and equipment, repairs, office salaries, office supplies, telephone charges, supervision of labor, trucking, express, freight, miscellaneous foundry supplies such as sands, sea coal, graphite, clays, and core-binders, tools for molding and coremaking, and miscellaneous materials.

FIFTH EXERCISE—FLASK DESIGN

1. Design a flask suitable for molding the casting specified, making proper allowance of space for gating and for sand between the pattern and flask on the sides, top, and bottom.
2. Show in the sketch one end view and one side view of the flask.
3. Name each part of the flask and enter dimensions on the sketch.
4. Show a cross-section of the mold ready for pouring, with gates cut and core set in place.

SIXTH EXERCISE—DEFECTIVE CASTING REPORT

1. Rule up a sheet of paper similar to the one posted, and list the castings as shown there.

2. Examine each casting carefully and determine the cause of its defect.

3. After analyzing the defect explain how to prevent it.

SEVENTH EXERCISE

1. Form a working organization to operate the foundry that you planned.
2. Show in a graphic way how it operates.
3. Select the principal equipment needed for operating the foundry.

EIGHTH EXERCISE

Compute the weight of the casting when cast in gray iron. Hand in the computations on a sheet of ruled paper like that mentioned in Exercise 6. Multiplications need not be carried out in full, but may be indicated on this sheet.

1. Compute the weight by the method of Exercise 3.
2. Compute the weight from the weight of the pattern. First weigh the pattern. A cubic inch of white pine weighs about 0.0144 lb. Gray cast iron is about eighteen times as heavy as white pine. In this method of computation, deduction must be made for cored holes and for core prints on the pattern.

CHAPTER XII

METAL PATTERNS, FOLLOW BOARDS, MATCH PLATES

The molds described in Chaps. X and XI were made by hand, partings and gates had to be cut, and the patterns were drawn one at a time. Those methods are slow and are used only when a few castings are to be made from a pattern or when fundamental principles are to be taught.

The method of molding by hand, called the Egyptian method, has been in use many years and still is being used. One might think that there has been no progress made in the manufacture of castings, but such is not the case. There have been quite extensive improvements over the few-castings method, in making castings on a "production" scale. However, the pattern equipments are expensive and it would not be practical to fit up patterns for the production method when only a few castings are wanted.

Metal Patterns.—Metal patterns give better service than wooden patterns, especially when in continuous use. They not only will last longer but they will keep their shape better and remain smoother than wooden patterns, advantages that are important in production work. Metal patterns may be made of aluminum, brass, white-metal or iron. The best kind of metal to use for a given kind of pattern depends upon the size and shape of the pattern. Alloys with aluminum predominating are good metals to use for making small patterns, because they are not heavy and are easy to finish.

When making metal patterns a master pattern must be made first, either of wood or of some other material that can be shaped without much expense. From the master pattern the metal pattern is molded. After the metal patterns are made they can be attached to gates as shown in Fig. 125.

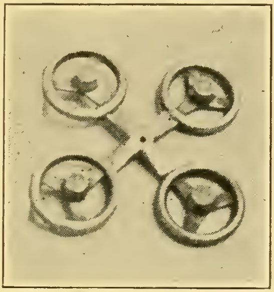

FIG. 125.—Gated metal patterns.

Follow Boards.—Much time can be saved by using follow boards instead of flat molding boards. Figure 126 shows the follow board to use with pattern shown in Fig. 125. If a flat molding board were used with a pattern of this type, much time would have to be spent in making

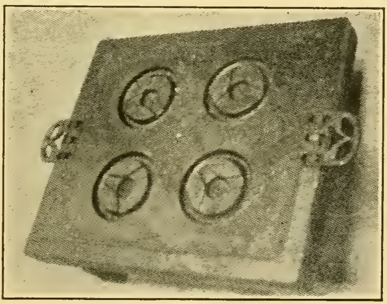

FIG. 126.—Follow board.

the parting. With the use of the follow board, no parting need be cut, because the patterns lie in the board only as far as the parting line. When using a follow board, the patterns are placed on it and the drag is rammed in the usual way. After the drag is rolled over, the follow board is lifted off and the parting is ready. The mold is then completed in the usual manner.

Follow boards may be made of wood by carving the board in such a manner that the patterns will lie in it to the parting line, or they can be made of oil sand or plaster of Paris. For small patterns oil-sand followers are usually used.

To make the follower shown in Fig. 126. A frame that has the required depth for the pattern must be made first as must a board to fit the frame. Place the pattern and drag on a flat molding board with the drag raised to be even with the parting line. Ram the drag a little harder than is necessary in making a mold. Roll the drag over and cut down the sand around the pattern to the parting line. Dust some parting material on the pattern and drag. Lycopodium makes the best parting material for oil-sand work.

A good sand to use for making the follower is burned sand that has been rattled from castings. Measure out the required amount of sand and mix it with the litharge in the ratio of one part of litharge to from twenty to thirty parts of sand. Moisten the mixture with linseed oil, making it slightly damper than sand ordinarily used for molding, taking care not to get it too wet.

Place the frame on the drag and sift the oil-sand mixture over the patterns to cover them. Then fill the frame heaping full with the oil sand and ram it about as hard as a mold is rammed. Strike off the sand even with the frame and fasten the board to the frame, with wood screws. Clamp the follower and drag together and roll them over. Lift the drag from the follower and clean all loose sand from the patterns. Should the oil sand be rammed below or above the parting line on the pattern, build it up or cut it down. Rap the patterns and draw them from the follower carefully, so that the sand around them will not break. Slick down the sand that may have been loosened.

The follower should be set in a warm place, where it will dry in about 24 hr. After it is dry, give it two or three coats of thin shellac, which will make the sand stronger and more capable of withstanding wear. Oil-sand followers will last for many years in continual use if they are handled carefully. They can be kept in storage successfully.

Match Plates.—The mounting of patterns and gates on plates is another method used to increase production. Patterns fastened on plates not only will increase production but will hold their shape better than loose patterns, and usually the castings made from them are more uniform in size. The objection to plated patterns is the high cost of

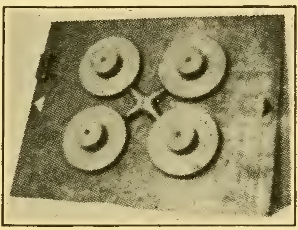

Fig. 127.—Face plate patterns mounted on plate.

mounting them, and therefore they are made only when a large number of castings is wanted.

The patterns may be mounted on boards, but wood is not very serviceable for the work because of its tendency to warp. Steel plates about $\frac{3}{16}$ in. thick or aluminum plates about $\frac{1}{4}$ in. thick are much more serviceable. The mounting is a very particular job and is usually done by metal pattern makers.

A plate with the patterns and gates on one side is shown in Fig. 127. The fact that the patterns are drafted in one direction makes possible their mounting on one side of the plate. The pattern side should be used in the drag and the flat side in the cope.

A plate with patterns mounted on both sides is shown in Figs. 128 and 129. The patterns are split on the parting line, one half being fastened to one side and the other half to the opposite side of the plate. The gate is on the drag side.

When mounting patterns on both sides of the plate, the two halves must be directly opposite; otherwise there will be a shift in the castings.

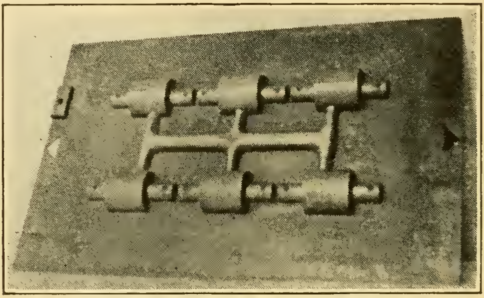

FIG. 128.—Drag side of match plate.

A pattern with an irregular parting line, mounted on a plate, is shown in Fig. 130. To mount this pattern, it is necessary to mold the pattern and plate in one casting and then finish the casting for a pattern.

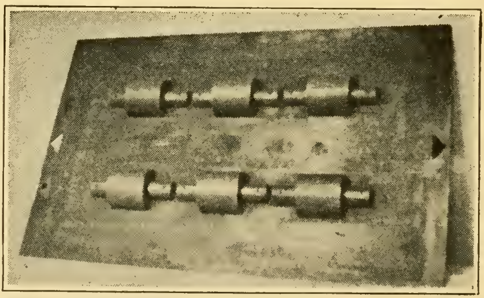

FIG. 129.—Cope side of match plate.

To Mold the Plate.—Select a flask with good, smooth joints, about 4 in. wider and 12 in. longer than the plate to be made. The pins must fit in the guides. Place the cope on a board with the pins up. Fill the cope with sand and ram it about as hard as in ramming a mold. Strike off the sand level with the joint of the flask. Embed the pattern in the sand to the parting line, centering it with respects to the sides and ends of the core.

Place the drag on the cope and ram it in the usual way. After the drag is rolled over, remove the cope and shake

Fig. 130.—Propeller match plate.

it out. Carefully make the parting. Dust some parting material (lycopodium is the best) on the drag. Place the cope and set one sprue at each end of the pattern about 3 in. from the end of the flask. Ram the cope, being careful not to ram the sand in the drag out of place. Lift the cope

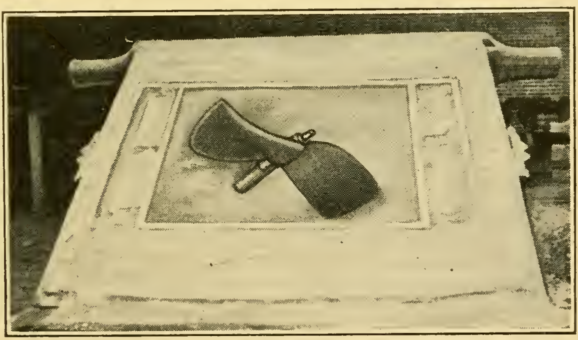

Fig. 131.

and set it on a board. If any of the sand sticks down when the cope is lifted, another cope should be rammed, instead of patching the broken one.

Make a frame the size of the plate and lay it on the drag. Build up the sand around the frame as shown in

Fig. 131. Swab the sand around the frame and draw the frame from the drag. Blow all the loose sand from the mold. Then swab around the pattern and draw it from the drag. Cut the gate that is to run the casting to be made from the plate, in the drag. Cut the gates that are to run the plate at the ends of the mold. Put a little thin flour paste on the sand that was built up around the frame, to help make a tight joint when the mold is closed. Close the mold, but before clamping it, wet the outside of the flask at the joint and tuck some wet molding sand between the cope and the drag to further improve the tightness of the joint.

CHAPTER XIII

MOLDING MACHINES

Molding machines are used extensively by foundries carrying on production work. The castings made on them are usually more uniform in size and shape than those made by hand. Production often is increased 100 per cent by their use. Less skill is required with machines and unskilled labor can be better employed, in itself an important factor on production work. While there are many special machines in use, it may be considered that there

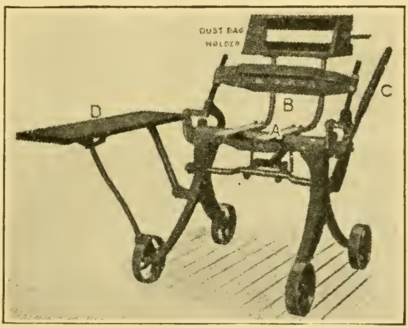

Fig. 132.—Hand squeezer type molding machine.

are four general types, which will be considered in this chapter.

Squeezer Machines.—The machines generally used to make small castings are called "squeezers." They are built in stationary and portable types, operated either by hand or by air. A portable hand-operated machine is shown in Fig. 132 in which *A* indicates the squeezer table, *B* the head or yoke, *C* the handle used in squeezing the mold, and *D* the shelf upon which the flask and patterns are set.

The squeezer and bottom boards should be made smaller than the inside of the flask by 1/4 in., so that they will enter the flask freely. Snap flasks are used on the squeezer as a rule, although other types may be employed. A button correctly located and of the proper shape and size to leave a funnel-shaped depression where the sprue hole is to be cut, should be fastened to the squeezer board.

Almost any one can learn to operate a squeezer in a very short time and to do good work, especially when the patterns are mounted on a plate.

To Make a Mold on the Machines.—Place the match-plate between the cope and the drag on the table, *A*. Cover the pattern with sifted sand. Tuck the sand around the flask next to the match-plate. Then fill the drag level full of sand and place the bottom board. Tap the bottom board down a little, making certain that it enters the flask. Roll the drag over, without squeezing.

Cover the pattern in the cope with sifted sand and fill the cope level full of heap sand. Place the squeezer board on the top of the mold. Pull the yoke, *B*, over the flask and squeeze the mold by pulling down the handle, *C*. Remove the squeezer board and cut the sprue hole. Rap the plate on the corners with either a wooden or raw-hide mallet. Lift the cope and set it on the shelf. Rap the plate and draw it from the drag.

Close the mold and remove the flask. Set the mold on the floor where it is to be poured. Brush off with the hand the rough edge of sand left around the top of the mold. Before pouring slip a jacket over the mold and weight it down.

Stripping-plate Machines.—Stripping-plate machines are adapted to a great variety of castings. They are exceedingly simple to operate which is an advantage when using inexperienced men. Stripping a pattern through a plate is one of the best methods known for producing castings true to pattern. In order to make some castings these machines must be worked in pairs. A pair of machines used to make brake shoes is shown in Fig. 133, where *B* indicates the machine used to make the cope.

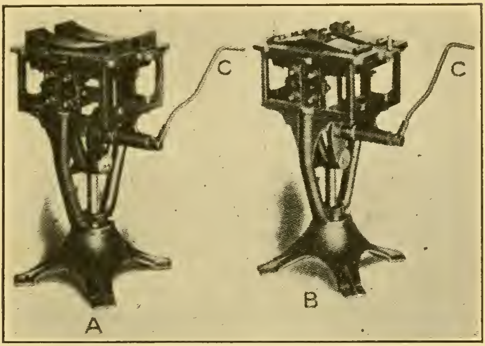

FIG. 133.—Stripping plate molding machines. A for making drag and B for making cope.

To Make the Mold.—Place a drag on machine *A* and ram it as in hand molding. Then draw the pattern by

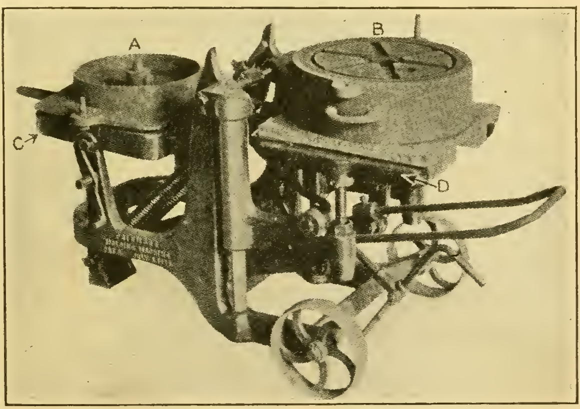

FIG. 134.—Hand roll-over molding machine.

pulling down the lever *C*. Lift the drag from the machine and set it where it is to be poured. Place the cope on machine *B*, ram it, and draw the pattern by pulling down on the lever *C*. Lift the cope from the machine and set it on the drag. Clamp the mold and it is ready for pouring.

Roll-over Machine.—A roll-over, or rock-over machine with the pattern of a pulley ready to be molded is shown in Fig. 134.

To Make the Mold.—Place the drag over the pattern, *A*, supported on the plate, *C*, and ram it. Put a bottom board on the drag and clamp board and drag to plate. Roll the plate and drag over to the other side of the machine where the bottom board will rest on the stand, *D*, which has been adjusted to the depth of the flask. Remove the clamps and

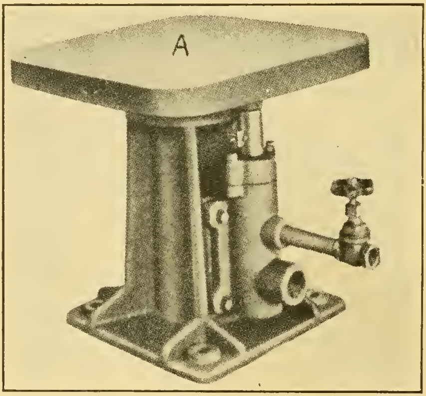

FIG. 135.—Air power jar molding machine.

drop the stand, thereby withdrawing the mold, *B*, from the pattern. Place the drag where it is to be poured and set the dry-sand core in it. Roll the pattern back to its first position. Place the cope over the pattern and set the sprue either on the hub or between the arms. Ram the cope and roll it over as the drag was rolled. Draw the cope from the pattern, place it on the drag, and clamp the two. Roll the pattern back to the first position, and it is ready for the next mold.

Jarring Machines.—A simple jarring machine, that can be used for ramming either molds or cores is shown in Fig.

135. Jarring machines are usually set on a solid foundation in a pit, with the table, *A*, raised slightly above the floor level. The machine shown is operated by air.

Ramming a mold on a jarring machine is very simple and requires no skill. The pattern and flask are set on the table. Then the pattern is covered with sifted sand and the drag is filled heaping full of unsifted sand. The air is then turned on. When it enters the cylinder the table is raised and when it exhausts the table falls. The result of the rising and falling motion is to jar the mold. The constant repetition of the jarring action for a short time produces a mold evenly rammed.

The number of strokes, the length of the strokes and the time required to pack the sand to sufficient density depend upon the size of the mold and the shape of the casting, and a knowledge of them must be gained by experience in actual practice.

CHAPTER XIV

DRY-SAND CORE MAKING

Dry-sand core making is a branch of foundry business and is more important than molding in the manufacture of some castings. It is regarded as a trade in itself. Dry-sand cores are used to make any desired hole or cavity in castings that cannot be made with green-sand cores.

COMPOSITION OF CORES

Cores are made of different kinds of sands mixed with a binder which holds the individual sand grains together and hardens under the application of heat. The chief qualities to be sought after in cores are: strength, to retain the original form when submitted to the high temperatures of the molten metal; porosity, to permit a free vent for the gases formed when the melted metal comes in contact with the core surface; and smoothness, to leave the surface on the casting as nearly as possible in a finished condition.

The strength of the core depends upon the sharpness of the corners of the individual grains of sand and the cementing quality of the binder. Sand grains with rounded corners are an aid to porosity but weaken the core through the absence of the locking effect of sharp corners. Sand that is too coarse makes a core with a rough surface and hence a casting that is not very smooth. A fine sharp sand, therefore, held together by a binder which does not form a solid mass, makes the best core. A binder such as referred to will collect at the contact points of the grains while hardening, thus making a porous interior. Some of the mixtures that have proved satisfactory are as follows:

Mixture 1.—For small castings. Vents freely. Forty parts fine sharp sand to one part linseed core oil.

Mixture 2.—For small castings. Vents well but not as freely as Mixture 1.
Fifteen parts new fine-grained molding sand,
Five parts fine-grained sand.
Twenty parts of the above sand mixture to one part of linseed oil, or one and one-half parts resin. Wet with water.

Mixture 3.—For medium-sized castings.
Ten parts sharp sand
Five parts new molding sand
One part wheat flour or one part core compound. Wet with thin clay wash.

Mixture 4.—For heavy castings.
Thirty parts sharp sand
Ten parts new molding sand
One part dry core compound, one part "glutrin."*
Wet with clay wash.

It is assumed that the sharp sand for small castings mixtures has the quality of Lake Michigan sand found around Michigan City, Ind. For larger castings a sand of coarser grain should be used. In general a sharp sand requires less binder than a dull sand.

The proportions of all of the mixtures noted above are given by volume.

In some foundries equal parts of old core sand are added to the mixture of new sharp and new molding sand, thus: To fifteen parts sharp sand and ten parts of new molding sand, there would be added twenty-five parts old core sand.

In some localities sand is found that has the proper proportion of sharp sand and clay, and no sharp or new molding sand need be added to it for a core mixture.

* Trade name.

Binders may be divided into two general classifications: First, those that do not flow to the contact points of the grains. These are sometimes called pastes. Flour and dextrine mixtures are of this type. Second, those that flow to the contact point of the grain. They are sometimes called binders. Molasses, "glutrin"* and certain oils are examples.

Resin and pitch also are used occasionally as binders. Oils make the most satisfactory binders for small cores. They are strong and do not absorb moisture.

A baking temperature that is too low does not harden the binder, while a temperature that is too high burns it and weakens the core.

Care must be taken in the amount of binder used. Too much binder makes a hard core, which frequently causes defective castings. Too little binder makes the core soft and a soft core will crumble.

Cores may be surfaced by coating them with graphite, which assists them in withstanding the temperatures to which they are subjected. It also improves the surface of the core and therefore the surface of the hole in the casting. To make the graphite-paint mixture, add water to the powdered graphite to form a paste, then thin down with water to a paint, after which add one teaspoonful of molasses per pint. The cores may be dipped, brushed or sprayed.

CORE BOXES, SWEEPS AND CORE PLATES

Cores are shaped by any one or a combination of three methods, *i.e.*, by the use of specially prepared core boxes; by employing sweeps; and by means of patterns used as core boxes.

The use of specially prepared core boxes is the most common method for small cores. The boxes generally are made of wood, iron, aluminum, brass or plaster of paris.

* Trade name.

Cores of cylindrical shape may be made by using sweeps. When the expense of making a special core box is too great and the pattern is of the proper form and strength, it may be used as a core box.

CORE PLATES

Iron core plates, such as shown at *A*, Fig. 136, are used for handling and baking cores. Straight plates are common for cores that have a flat side to rest on, such as cylinder cores made in halves, but forms of special shapes are required for irregular cores. Sometimes flat plates may be used where the irregularities can be supported during the

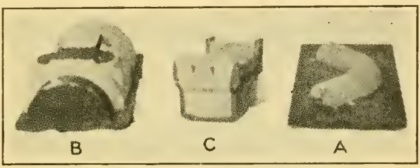

Fig. 136.—Core plates and core dryer.

baking process by green molding sand, built up under or around the core as shown at *B*. When the core is baked the molding sand peels off easily.

If molding sand is not packed under the cores, core dryers are used. The illustration, at *C*, shows a core resting in a dryer. Core dryers are made of iron and they must have the exact shape of the cores with which they are used.

RAMMING

Some core mixtures may be rammed harder than others. The amount of ramming will depend upon the amount of loam in the mixture, size of the core, and the size of the individual sand grains. Loam mixtures pack harder and vent less freely than sand mixtures. Therefore mixture 1, consisting entirely of sharp sand, may be rammed harder than mixture 2, without causing any bad results. Ramming the sand too hard causes it to stick to the boxes and makes drawing difficult. If the core is too lightly rammed, it will be porous and the metal will eat into it, causing a rough surface on the casting. The ideal core is one with a smooth, reasonably firm surface and a porous interior.

VENTING CORES

One of the most important features of the core is its venting qualities. When the metal comes in contact with them, all dry-sand cores give off gas, which must be led out of the mold, for reasons previously given. The amount of gas liberated depends largely upon the sand and the binder

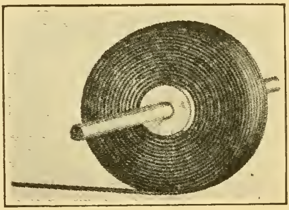

FIG. 137.—Shows a roll of vent wax.

used. Wheat flour is a gaseous binder, while resin and oils are less so.

In some of the simple cores venting is easily done, but on the more intricate ones it becomes a difficult problem. A small round core made in a round box may be vented by running a vent rod through its center after ramming. A core made in halves may be vented by cutting a channel through the center of each face of the main section, and laterals in the lesser sections, leading from the channel to the surfaces of the core. When the halves are pasted, the channels must match.

In some intricate cores where a wire cannot be used, or where a channel cannot be made, a vent wax, as shown in Fig. 137, is used. Vent wax may be purchased from the foundry supply houses. It is embedded in the sand along the line or lines that the escaping gas is to follow. When the core is baked, the wax melts and disappears between the sand grains, leaving the vent channels desired.

Where it can be used, a perforated pipe, such as described under "Rodding," makes one of the best possible vent channels.

Many large cores are made with center of coke, cinders, or some similar material. These substances give porosity and lightness to the core and save much sand, which in large castings is a point of considerable importance.

RODDING CORES

Some cores are subjected to more or less bending during the setting and pouring processes. Vertical cores undergo

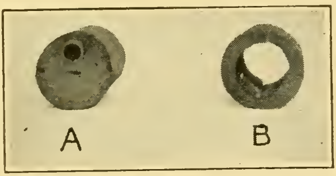

Fig. 138.—Shows dry sand cores supported with a pipe at A and a core arbor on the inside of the core at B.

the least strain and horizontal cores the greatest. Assuming careful handling in setting, deflection may be caused by the weight of the core; the floating action of the metal; or by the dynamic force of the metal when a mold is filled quickly.

The exact pressure exerted in any mold cannot be determined, but to insure a core that will retain its shape under all conditions, the core-maker reinforces his core by rodding it. What size of rod to use is something that must be learned by experience. The rods may vary between $\frac{1}{16}$ in. and 3 in. in diameter. Figure 138 shows at *A*, a core rodded with a pipe perforated by small holes, which makes an ideal stiffener and at the same time provides excellent channels for outlet of gas.

In some large cores, arbors are used. They are shaped to suit the core and serve not only to strengthen but to save sand. A cylindrical core made with an arbor is shown at *B*. Rods or pipes will hold the sand better if coated with clay wash or flour paste.

LIFTING HOOKS

Some cores are of such shape and weight that it would be impossible to handle and set them in the mold if they were not provided with lifting hooks or eyes. The core maker must inform himself before making the core just how it is intended to be handled. There are many kinds of hooks used. Generally they are made of iron and the

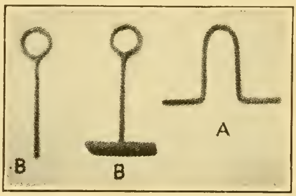

Fig. 139.—Lifting hooks and lifting plate for lifting core.

size depends upon the weight of the core to be supported. A U-shaped hook used extensively for small and medium sized cores, is shown at *A*, Fig. 139. The lifting plate and screw, shown at *BB*, are used for larger cores.

Hooks and plates must be so placed that the core will balance when it is lifted. All depressions made to accommodate the hooks must be filled after the core is set.

PASTING AND DAUBING CORES

When cores are made in sections, the parts must be assembled before they are set in the mold. In the assembling process the sections are cemented together at the jointed surfaces with a good coat of thin paste, the sections being rubbed together to secure a good face contact, or tied together by wire or other fastening if necessary. The cores are then inserted in the oven during a period of time for the paste to dry.

A number of good commercial core pastes may be obtained but an inexpensive and very satisfactory paste is made of wheat flour dissolved in cold water.

After cores are assembled and baked all open joints should be filled to insure a smooth casting. This process is called daubing. A good daubing substance can be made by mixing graphite in water to the consistency of a stiff paste. A little molasses put into the water will add to

Fig. 140.—Two half core pasted together.

the sticking qualities. A better mixture consists of graphite in oil. Figure 140 shows the halves of a core before and after pasting. The assembled core has the joints daubed and is ready to be set in the mold.

CORE OVENS AND BAKING

Core ovens are of many types and may be portable or stationary. The kind to be used depends upon the size of the cores to be made. For baking small cores, ovens of the type shown in Fig. 141 have worked out successfully. They are portable, with built-in fire boxes. The shelves are connected with the doors, so that when the doors are opened the cores are drawn out. A plate attached to the back of each shelf closes the opening to the fire box, preventing the waste of heat when the cores are taken from the oven.

A stationary combination type of oven is shown in Fig. 142. It is an oven that can be used for either small or large cores. One side contains the roller type of shelves and the other side is arranged to accommodate a truck. Large cores are usually made on the truck, which is then pushed

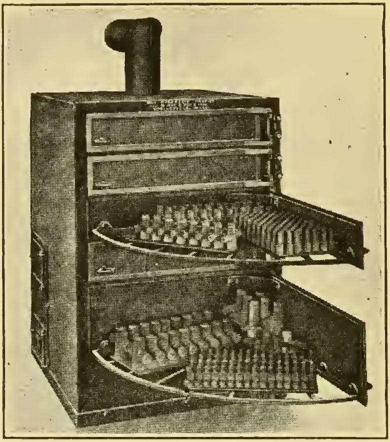

FIG. 141.—Core oven for baking small cores.

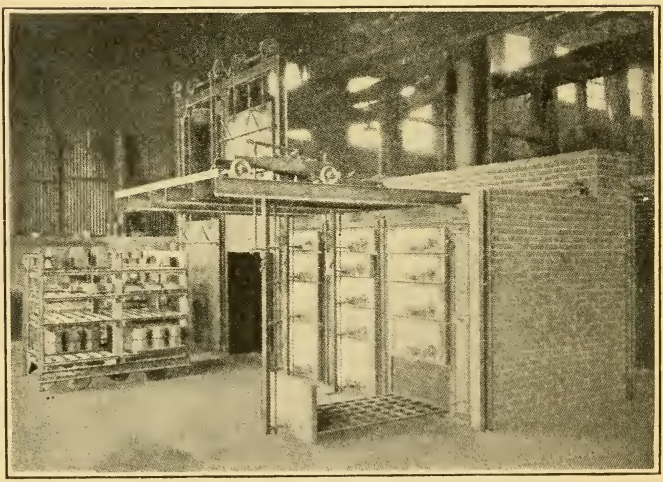

FIG. 142.—Core oven for baking small or large cores.

into the oven. The truck may be used to hold a large quantity of small cores. The combination oven can be purchased in any size desired.

All core ovens should be connected to chimneys. Coke, coal, gas, crude oil, or electricity may be used for heating them. Coke is the most economical fuel.

Core ovens are generally heated from 300 to 600 deg. F. With temperatures above 600 deg. there is much danger of burning the cores. A small core will bake in one hour or less, but large cores may have to be baked several days and nights. The amount of heat to use depends for one thing upon the binder used in the core. Oil binders require more and quicker heat than flour, resin, or glutrin binders.

Cores should be baked as soon as possible after they are made, at least the same day or night. If not, they will partially air-dry, and a poor core will be the result after baking.

CORE MAKING BENCHES

Small cores are usually made on benches. Any school can build its own benches, which should be substantial

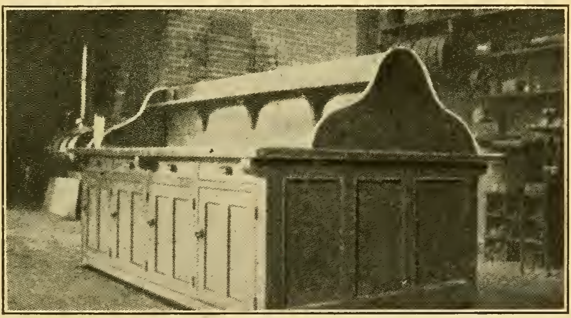

Fig. 143.—Bench for dry sand core making.

rather than elaborate. However, having a good bench to work on is frequently a matter of pride with a core maker.

The bench shown in Fig. 143 is conveniently arranged. It has a good solid top, and drawers in which to keep tools and rods. Under the drawers are shelves for the storage of core boxes.

CHAPTER XV

EXERCISES IN DRY-SAND CORE MAKING

EXERCISE 1. MAKING ROUND CORES

All of the round cores needed in the molding exercises can be made in core boxes such as shown in Fig. 144. Core mixtures 1 and 2 can be used. A round core is made in the following manner: Clamp the two halves of the core box together and set the box on end. Drop a little sand into the box and ram it with an iron rod.

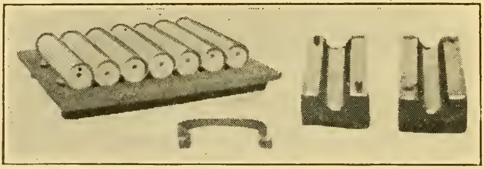

Fig. 144.—Core box and plate with small round cores.

Add a little at a time, and ram, until the box is filled. Punch a vent hole through the center of the rammed sand.

Remove the clamp and rap the box on all sides. Remove the half-box that carries the dowel pins and roll the core out of the other half onto the plate. After the plate is filled put it into the oven. If necessary, a core of this kind can be reinforced with a rod before the clamp is taken from the box.

EXERCISE 2. MAKING A CONE PULLEY CORE

The core made in this exercise is used in molding the cone pulley, Exercise 13. Either core-sand mixture No. 1 or No. 2 is suitable. Figure 145 shows the core and box

To make the core clamp the two half-boxes together and set them on the small end. Ram the box full of sand. Slick the sand even with

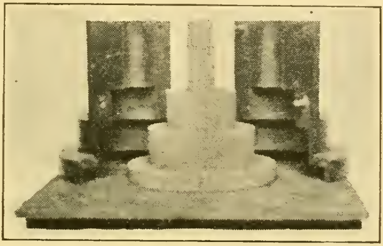

Fig. 145.—Cone pulley core box and core.

the large end. Punch a few vent holes and place a plate of the proper size over the large end. Then hold the plate and box together firmly and roll them over. Push into the core, somewhat to one side of center, a rod, long enough to pass through the part of small diameter into the main body, leaving it even with the small end. Punch a vent hold at the center entirely through the core. Remove the clamps and rap the box. Draw the box from the core as shown in the illustration. Set the core in the oven to bake.

EXERCISE 3. MAKING A CORE FOR A LATHE BED

The core is used in molding the lathe bed, Exercise 17. Use core-sand mixture 1, 2, or 3. In Fig. 146, *A* indicates the half core before it is baked, *B* the core box, and *C* the loose strip.

Lay the loose strip of wood into the box in its proper place. Put a little sand into the box and tuck it under the strip. Fill the box half full of sand, tucking it into the corners. Place a stiff reinforcing rod in the middle. Fill the box heaping full of sand and butt-ram, taking

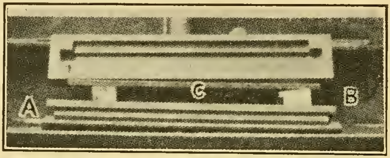

Fig. 146.—Lathe bed core box and core.

care not to ram too hard. Strike off the sand level with the box and slick it down even with the top. Cut the vent channels about 3 in. apart, ⅛ in. deep and ½ in. wide. Clamp a plate to the box, make the roll-over, and rap on all sides. Remove the clamps and draw the box from the core. The loose strip will not draw out with the box, but must be drawn out sidewise after the box is drawn. Repair the core if broken, and place it in the oven to bake. Make a second half-core in the same way. After the two halves are baked, paste them together and daub the joints as explained in the sections "Pasting" and "Daubing."

EXERCISE 4. MOLDING THE CORE FOR A MACHINE BASE

The core is used in molding the machine base, Exercise 18. Use mixture 3 or 4. Figure 147 shows the box and the half-core. Since the core is symmetrical, a box for making only half of it is needed.

Fill the box about half full of sand and peen-ram. Put a rod in the small end, heap the box with sand, and butt-ram. Strike off the sand level with the top of the box, and slick it with a trowel. Cut the vent

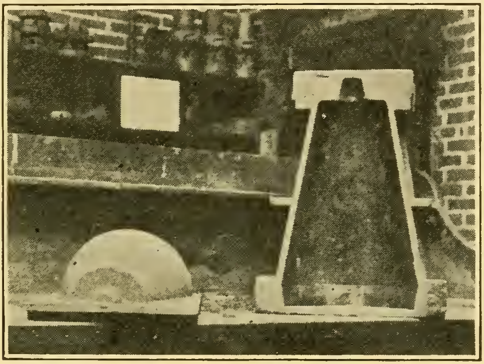

FIG. 147.—Machine base core box and core.

channel beginning it a short distance from the small end and leading it out of the large end. Punch a few vent holes from the channel to the sides of the box.

Clamp a plate to the box, make the roll-over, and rap on all sides. Remove the clamps and draw the box from the core. Make any necessary repairs and place the core in the oven to bake. Make the second half. After the two halves are baked, paste them together and daub the joints.

EXERCISE 5. MAKING A CORE TO BE LIFTED OUT OF THE PATTERN

The core is similar to the core used in Exercise 19. Use mixture 2 or 3. Use the pattern instead of a core box. As this core must be lifted out of the pattern, put in two lifting hooks. Figure 148 shows the pattern and core.

Fill the pattern half full of sand and peen-ram. Set the hooks so that the eyes are even with the top of the pattern. Ram the pattern

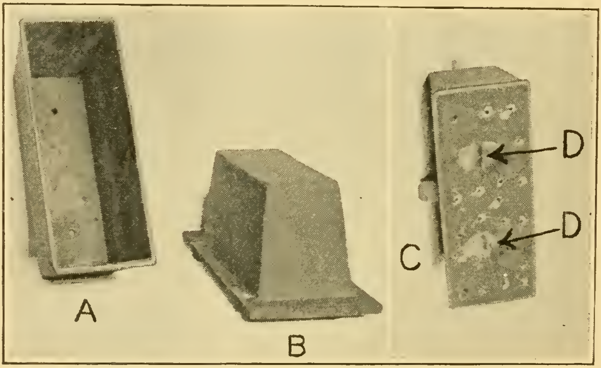

FIG. 148.—Pattern used for core box, and core.

level full of sand and trowel down the surface. Punch some vent holes, place the plate, make the roll-over, and rap the pattern on all sides. Draw the pattern from the core and place the core in the oven to bake.

Note.—The core must be set back into the pattern when the mold is made, and on that account the pattern must be rapped rather hard to make the core a trifle small. If this is not done, filing will be necessary to make the core fit the pattern after baking, which causes expansion.

CORE-MAKING MACHINES

Dry-sand core-making machines of which there are several types, are not used as much as molding machines, but they are being used more every year. Figure 149 shows a machine for making round cores as long as 24 in.

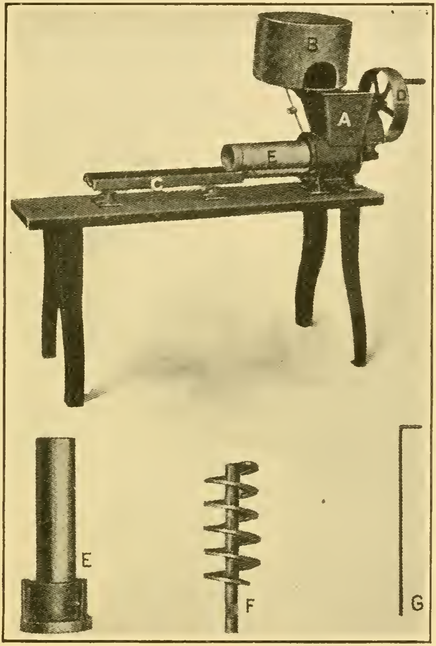

FIG. 149.—Machine for making small round core.

and from 3/8 to 3 in. in dia. The "screw" and "die" control the diameter.

In setting up the machine, select die and screw according to the diameter of core wanted. Attach the screw, *F*, and the die, *E*, in the machine body, *A*. Run the vent wire, *G*, through the screw from the rear end of the machine. Set the core tray, *C*, on the machine bed, and the machine is ready for use.

The two mixtures given below are suitable for use in the machine. To operate the machine, mix up a batch of sand first. Mixture A is for cores ranging in size from 3/8 to 1½ in. in diameter. Mixture B should be used for cores from 1½ to 3 in. in diameter.

Mixture A	Mixture B
8 quarts sharp sand	8 quarts sharp sand
1 quart wheat flour	2 quarts new molding sand
¼ pint core oil	1 quart wheat flour
	¼ pint core oil

Wet the mixture sparingly with water. The mixtures given must be a little dryer when run through the machine than if they were used in making cores by hand. If the sand is too wet, it will pack in the die.

After the sand is mixed, put it into the hopper, *B*, and feed it into the machine. Place one hand against the front of the die and hold it there while turning the wheel, *D*, until the sand in the die is packed to the right consistency. Then remove the hand, but continue to feed sand into the machine and to turn the wheel. The core will be pushed out onto the plate. When the length wanted has been made, cut it off. Before setting the core in the oven to bake, spray it with water mixed with a little glutrin, to make the surface firmer.

QUESTIONS

1. What is bench molding?
2. What is floor molding?
3. When should metal patterns be used?
4. Name at least two metals used in gated patterns?
5. Should metal patterns be made when only a few castings are wanted?
6. What is a follow board?
7. Should a follow board be made for a few castings?
8. What are some of the advantages in using a follow board?
9. What is a match plate?
10. Give some of the reasons for using match plates.
11. Is it a good plan to make match plates for only a few castings? If your answer is yes, give your reason. If no, why not?
12. Name at least three metals used in making match plates.

13. What is a squeezer molding machine?
14. For what class of castings are squeezers mostly used?
15. What is a roll-over machine, and how does it operate?
16. What is a stripping-plate machine, and how does it operate?
17. What is a jolter or jarring machine, and how does it operate?
18. What is a combination molding machine?
19. What is a dry-sand core and why are dry-sand cores used?
20. Explain the difference between a dry-sand and a green-sand core.
21. Name some of the essential properties of a good core sand.
22. What are core binders and why are they used?
23. Name at least three core binders.
24. How are dry-sand cores vented?
25. What is vent wax and when and why is it used?
26. What is meant by rodding cores and why is it done?
27. What is meant by pasting and daubing cores?
28. How are dry sand cores treated to make smooth castings?
29. What is an assembled core and how is it assembled?
30. What are lifting hooks and plates and why are they used?
31. Why must core plates be used?
32. How does a core binder differ from a core paste?
33. Why are coke and cinders used inside of cores at times?
34. What core binders give off the least gas?
35. At about what temperature should a core be baked?
36. Can cores be baked too much or too little? What will be the result in either case?
37. If a core is too hard what will be the result?
38. How are cores removed from the castings?
39. What fuels are most used for baking cores?
40. Name two types of core ovens.

PART III

MELTING AND MIXING METALS

CHAPTER XVI

FURNACES, GENERAL CONSTRUCTION OF CUPOLA, TUYERES, CUPOLA LININGS, AND LINING THE CUPOLA

Melting metals is one of the most important branches of the foundry business. A careful study of furnaces and metals is necessary to success in making castings.

Different types of furnaces are used to melt different kinds of metal. The cupola furnace is used to melt iron for gray-iron and semi-steel castings. Open-hearth and air furnaces are used to melt iron for malleable iron, steel, semi-steel and high grades of gray-iron castings. Crucible, non-crucible, pit and tilting furnaces are used to melt metals for steel, brass, bronze and aluminum castings. Electric furnaces are rapidly coming into use. Some of the best steels and non-ferrous metals are melted in the electric furnace. Coke, coal, crude oil, gas and electricity are used as sources of heat.

The cupola and crucible furnaces will be the only ones taken up in detail.

GENERAL CONSTRUCTION OF CUPOLA

A modern cupola furnace is shown in Fig. 150. The shell, *A,* is constructed of steel plate from $3/16$ to $3/8$ in. thick. The foundation, *B,* is made of brick, stone or concrete. Columns or legs, *C,* support the cupola, which with the windbox, *D,* rests on the bottom plate, *E.* There are two sets of tuyeres, the lower, shown at *F,* and the upper shown at *G.* The bottom doors, *H,* hang on hinges so that they can be dropped and raised. All material charged into the cupola passes through the charging door, *I.* Melted metal is run from the cupola through the spout, *J,* into ladles. Slag is drawn off through the slag spout, *K*. The blast pipe inlet is shown at *L*, and the blast gage at *M*. A section through the safety tuyere is shown at *N* in the small drawing.

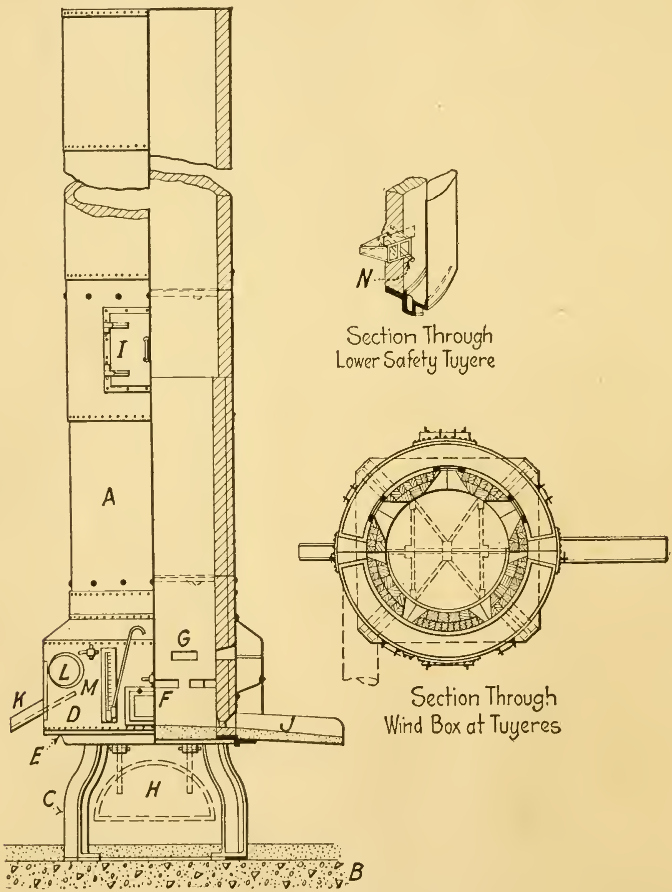

Fig. 150.—Cupola furnace.

SIZES OF CUPOLAS

Cupolas range in size from 16 to 120 in. in diameter on the inside of the lining and from 8 to 20 ft. in height from the bottom plate to the bottom of the charging door. The total height depends upon the height of the roof of the building, and varies from 25 to 35 ft. All cupola stacks should extend out of the building so that the fumes and gases can be discharged into the atmosphere. The size of cupola to use depends upon the amount of metal to be run through during a heat and upon the rapidity with which the men in the department can take care of the metal.

TUYERES

The openings used to convey air from the wind box into the cupola are called tuyeres. Tuyeres of many shapes, forms and sizes have been used, but in modern cupola practice the tuyere shown in Fig. 151 has proved to be the best and is generally used. It is flaring in shape and admits

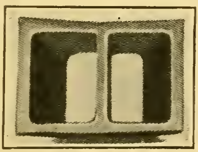

Fig. 151.—A cupola tuyere.

the blast through the small area permitting the air to spread evenly inside the cupola. The tuyeres are independent of each other and on account of their shape are easily held between the bricks. Most cupolas have a row of lower and a row of upper tuyeres.

There are usually six tuyeres in a row, separated by equal distances, with a combined area at the smallest section of from 15 to 25 per cent of the cross-sectional area of the inside of the cupola. They are generally placed from 10 to 30 in. from the bottom plate, the distance depending upon the amount of metal to be collected in the cupola for a tap. In some cupolas the tap hole is left open, the metal running out as fast as it melts, and the tuyeres may be very near the sand bottom. Other cupolas are tapped at intervals and a large amount of metal must be collected before tapping. In such cases the tuyeres must be well up.

Upper Tuyeres.—Upper tuyeres are similar in construction to lower tuyeres, and are from 18 to 24 in. above them. They are to supply air to utilize any escaping gas that may be used as fuel, and are of great service in quick melting and in keeping the cupola in blast. Upper tuyeres are operated independently of lower tuyeres and may be closed for small heats.

Safety Tuyeres.—The safety tuyere, shown at *N*, Fig. 150, is a great help in operating a cupola. When the iron rises too high it will run into the safety tuyere, and thence down to a hole located under the safety tuyere, in the bottom of the windbox. The hole is covered with cardboard, which the metal burns, thereby escaping to the ground and automatically warning the cupola tender that it is time to tap.

Tuyere Peep Holes.—Hinged frames fitted with mica are placed opposite the tuyeres. The cupola tender can look through the mica into the cupola and watch the operation of the furnace. If the tuyeres become closed the peep holes can be opened to permit the removal of the obstruction.

Slag Holes.—A cupola that is to be kept in operation more than 1½ hr. at a time should be provided with a hole for the removal of slag, which accumulates when the cupola is in blast. If the slag is not removed, it clogs the cupola and retards melting. The slag hole is from 2 to 3 in. in diameter and is usually located in the back of the cupola opposite the tap hole, from 4 to 5 in. below the lower level of the tuyeres. When slag holes are too near the tuyeres, the cold blast chills the slag so that it will not run.

CUPOLA LININGS

Cupolas are lined with either a single or a double course of fire brick. A single lining is satisfactory in cupolas that measure less than 36 in. in diameter. Although the first cost of a double lining is more than that of a single lining, the double lining is more economical to keep up when used in cupolas that measure 36 in. and more. In a double lining, the brick next to the shell need not be of as good quality as the brick on the inside. Some foundrymen use common red brick for the shell layer. The advantages of a double lining are that there is less risk that the lining will burn through to the shell, and that the inner lining

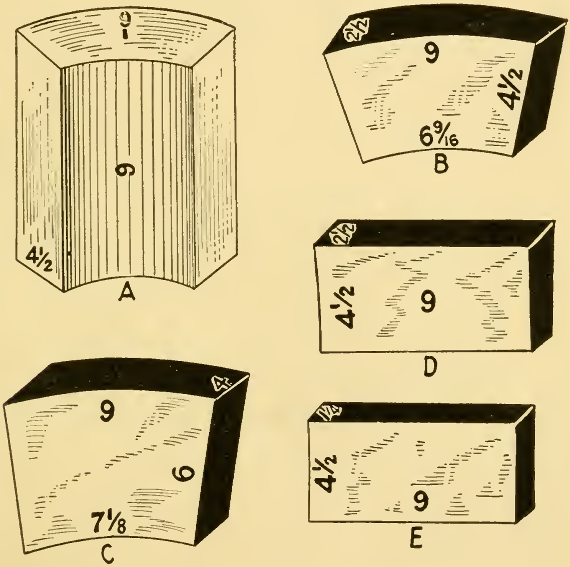

FIG. 152.—Cupola fire bricks.

can be used more completely than if only a single lining were employed.

Fire Brick.—Cupola fire brick may be obtained to fit any size of cupola. Some of the common forms are shown in Fig. 152. Bricks *A, B* and *C* are known as cupola blocks, *A* and *B* for cupolas up to 36 in. in dia. and *C* for larger sizes. The wedge-shaped brick, *D,* is sometimes used as lining and sometimes as a wedge between cupola blocks. The square brick, *E,* is used next to the shell.

LINING THE CUPOLA

A diagram of the lining in a cupola is shown in Fig. 153. The single lining is indicated at *A*, the double lining at *B*. The closer the joints can be made the better the lining will be, because the bricks cut and burn out at the joints more than at any other place. Once the joints are open, the gases and blast enter between the bricks, increasing their

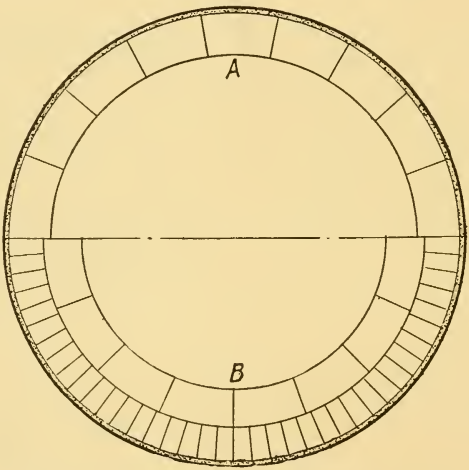

Fig. 153.—Diagram of the lining in a cupola.

destruction. A thin grouting, made by mixing fire clay with water, should be put between the bricks. The mixture should be so thin that it can be poured on the bricks, or bricks dipped into it. The bricks should be handled rapidly, so that the grouting will not dry before they are in position, and each brick should be tapped with a hammer as soon as it is laid, to improve the tightness of the joints. Fire bricks expand when heated, and to prevent possible injury to the cupola shell from expansion, they should be set from ½ to 1½ in. from shell. The space between the shell and the bricks should be filled by pouring in a mixture of equal parts of clay and sand mixed with water.

Drying the Lining.—After the cupola is lined, it should be dried slowly. The bottom doors are put up and covered with a protecting layer of molding sand about 3 or 4 in. deep. Shavings and kindling are then placed on the sand and are in turn covered by a layer of coke 20 to 30 in. high. The fire is lighted and when the coke has caught the drafts are closed and the coke is allowed to burn out. The bottom doors are then dropped.

After the bottom has been dropped and the cupola is cool enough for a man to get inside, the lining should be gone over with a thin grouting, composed of about ½ pint of salt to 3 gal. of fire clay, mixed with water until it is so thin that it can be rubbed into the joints with a brush. The salt in the mixture will help to glaze the bricks, adding to the life of the lining. When the first heat is run from a newly-lined cupola, the fire should be allowed to burn as long as possible before starting the blast, the blast pressure should not be stronger than is necessary, and the heat should be small.

LADLES

Ladles are used to receive the metal from the cupola, in transporting it, and in pouring it into the molds. They vary in size and shape, their capacities ranging from 25 lb. to 100 tons. Bowls for small ladles are made of cast-iron or sheet iron, and for large ladles, of steel plate. The shanks, which hold the bowls, are made of wrought iron. The ladle shown in Fig. 154 is an example of the type known as hand ladles, which hold from 40 to 80 lb. of iron and are handled by one man. The shank is indicated by the letter *A*, and the bowl by *B*.

Bull Ladles, as shown in Fig. 155, vary in capacity from 100 to 300 lb. and are usually handled by two men. A crane ladle is shown in Fig. 156. The capacities of crane ladles vary from 500 lb. to 25 tons or more. The ladle shown has a gear controlling device provided to facilitate pouring.

Linings.—The linings of ladles vary in material and thickness, according to sizes. Hand ladles can be lined with strong molding sand from ¼ to ½ in. thick. Linings

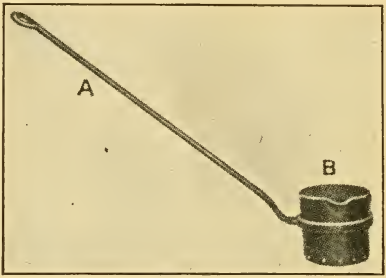

FIG. 154.—Hand ladle and shank.

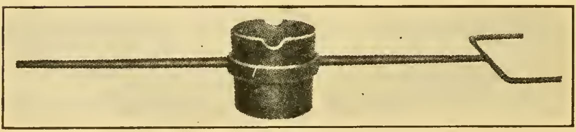

FIG. 155.—Bull ladle and shank.

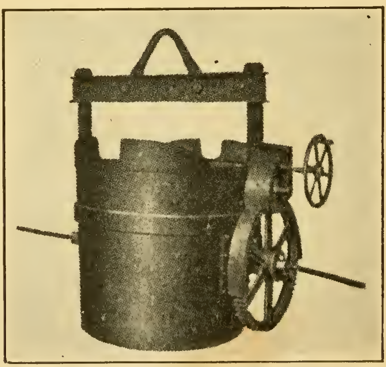

FIG. 156.—Crane ladle.

for bull and crane ladles must be made of a more refractory material. A composition of two-thirds fire clay, and one-third sharp sand, mixed with water, makes a good material for the linings of ladles that have capacities of from 100 lb. to 3 tons. The mixture should be just wet enough that it can be worked easily. Linings for bull and crane ladles are made from ½ to 2 in. thick, very large ladles being lined with fire brick.

Before applying the linings, the inside of the bowl should be wet with a thin clay wash. The lining should be dried before the ladle is used to prevent the usual bad results when hot iron is brought into contact with moisture. The lining can be dried by putting the ladle into the core oven, or by making a fire inside of the ladle.

BLOWERS AND FANS

There are two types of blowers used to supply air to the cupola. The one shown in Fig. 157 is shown as a "rotary

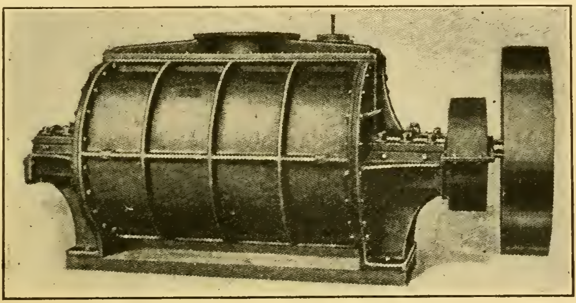

FIG. 157.—Rotary positive pressure blower.

positive pressure blower," and the one shown in Fig. 159 is called a fan blower. The rotary positive pressure blower supplies a constant volume of air to the cupola, but the fan may not.

In the positive blower, the air intake is usually at the bottom and the outlet is at the top as shown by the diagram in Fig. 158. The impellers, *A* and *B*, do not touch each other, nor do they touch the case, but they fit so closely that there is little chance for the air to pass back when once taken into the blower.

The air intake for the fan is on the sides and the outlet is at the bottom. The impellers or blades do not fit closely, on that account affording opportunity for the air to pass back.

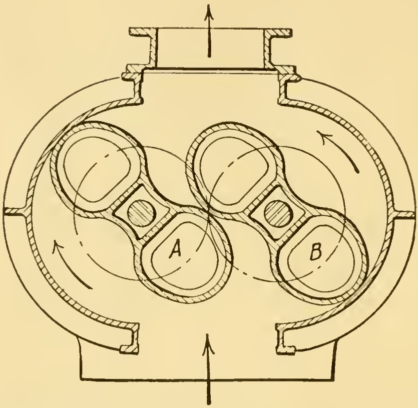

FIG. 158.—Diagram of positive pressure blower.

The size of blower or fan to be selected for the cupola in use can be determined by referring to either cupola or blower catalogues.

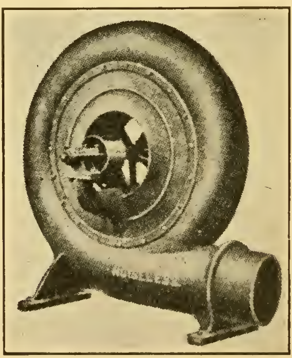

FIG. 159.—A fan blower.

Blowers and fans should be set on solid foundations and bolted down. They should be placed as near to the cupola as practicable. The connecting pipes should have as few elbows as possible, because elbows retard the pressure of the blast.

Blast gauges on the cupola to determine the air pressure may be used successfully, if the tuyeres are kept open. The pressure to be maintained depends upon the size of the cupola. For cupolas 24 in. in dia., the pressure should be from 5 to 7 oz. A 36 in. cupola requires about 10 oz. and a 48 in. cupola from 12 to 14 oz. Although the blast gage shows pressure, it does not indicate volume, and if the tuyeres become clogged, the cupola may not be supplied with the proper amount of air.

A blast meter is sometimes placed on the main blast pipe to measure the volume of air passing through. About 30,000 cubic ft. of air are required to melt one ton of iron.

CHAPTER XVII

PREPARING, CHARGING AND OPERATING THE CUPOLA

Bottom Doors.—When preparing the cupola for a heat, the bottom doors must be raised and propped as shown at *A*, Fig. 160. The prop should rest on an iron plate embedded in the cupola foundation. Only one prop is needed for cupolas under 42 in. in diameter, but two are necessary for cupolas 42 in. or more in diameter. The props are made of wrought-iron and are from 2 to 5 in. in diameter. All openings between the doors and the bottom plate should be filled with clay.

Materials for the Bottom.—The material for the bottom should be of such a nature that it will not wash when the metal runs over it or when the blast is on. Molding sand or sand cleaned from gang-ways in the molding room can be used. The sand should bake a little when the fire is burning, but must not bake so hard that it will not fall readily when the doors are dropped. Some foundrymen wet the sand with a thin clay wash when it is weak.

Putting in the Bottom.—The sand should be as wet as that used for green-sand molding. After it is mixed, it should be sifted through a ½ in. riddle. It can be put into the cupola by being shoveled into the spout and pushed through the breast opening, or by being taken to the charging floor and dumped in through the charging door. When the sand is in, the tender enters the cupola through the charging door, spreads the sand, rams it and gives it the proper slope. The sand should be rammed about as hard as for a mold. Sand that is rammed too hard or too soft will give the same troubles that it gives in a mold with the additional trouble, in the case of soft ramming, that the force of the blast may blow the sand out.

Slope of the Bottom.—The sand bottom should be sloped so that all the metal will run out of the tap hole.

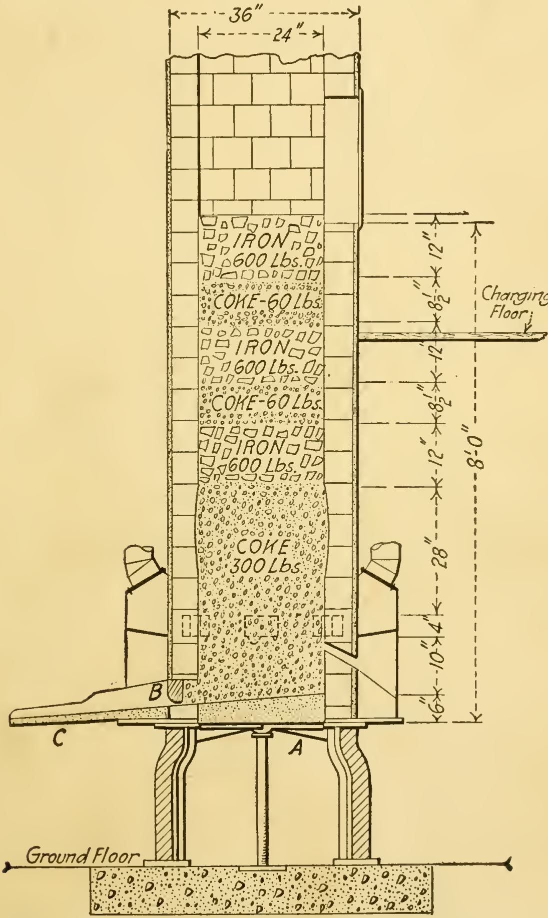

Fig. 160.—Cross section of cupola showing method of lining and charging

A slope of about ½ to 1½ in. to the foot is usually given. Too steep a slope will cause the metal to run out too rapidly and will cause undue pressure against the breast when stopping against a stream of iron. When the slope is too gradual, the metal will not run out rapidly enough when the cupola is drained to drop the bottom.

Kindling.—After the sand bottom is made, some shavings or oiled waste should be put in followed by kindling large enough to start a coke fire.

Instead of wood, crude oil or gas may be used, with the advantage that they leave no ash. When oil is used, a pipe 4 or 5 in. in diameter, with a number of holes 2 in. in diameter and 3 in. apart, is used to carry the flame. It should reach from the breast to a point about three-fourths of the way across the bottom. The oil burner is inserted through the outer end. After the coke is burning, the pipe is taken out and put away for the next heat. A similar piping arrangement is made when gas is used.

Coke Charges.—Every melter must decide how much coke to put into the cupola for the bed. There is no fast rule to follow. Common practice is to have it from 20 to 30 in. above the top of the tuyeres after the kindling has burned out and the coke has settled.

Various methods are used to determine the amount of coke needed for the bed. Some melters make a mark on the lining and build the coke up to it after the kindling has burned. Others measure with a stick from the charging door. Others compute the amount of coke needed by finding the volume of the cupola from the sand to the top of the bed in cubic inches, and dividing by 65, the volume of one pound of coke (approximately).

Example.—The cupola shown in Fig. 160 is 24 in. in diameter, measured on the inside of the lining. The distance from the sand bottom of the tuyeres is 10 in. at the back and 12 in. at the front, an average height (in the center) of 11 in. The tuyeres are 4 in. high and the coke bed is to be 28 in. above the top of the tuyeres. The total height from sand bottom is therefore 43 in. (11+4+28). The area (radius squared x π) of a 24 in. cupola is 452 square inches ($12 \times 12 \times 3.1416$). The volume (area of base or section times height) to be filled with coke is 19,436 cubic inches (43×452). 19,436÷65=299 (say 300) lb. of coke needed for the bed. About 25 lb. should be held back and not charged until the other has burned through.

The succeeding layers of coke are usually made from 4 to 10 in. deep. The amounts by weight can be computed in the same manner as for the bed. A layer 8.5 in. deep in a cupola 24 in. in diameter weighs approximately 60 lb.

Iron Charges.—The first iron charge is called a Bed Charge. Its size depends upon the quality of the coke used, the height of the tuyeres from the sand bottom, and how hot the metal must be to run the castings. There is no fast rule to follow. Some melters charge 1 lb. of iron to 1 lb. of coke, others charge 4 lb. of iron to 1 lb. of coke. Cupolas which might have the tuyeres placed from 8 to 12 in. above the sand bottom may be charged with 2 lb. of iron to 1 lb. of coke. At that ratio, the iron charge for the cupola shown in Fig. 160 would weigh 600 lb.

The iron should be put into the cupola as soon as the coke bed has burned through, but not before. By delay, after the bed is ready, heat is lost, and dull iron results.

The size of succeeding iron charges is regulated by the size of the coke charges. Ordinarily 10 lb. of iron are charged to 1 lb. of coke. Following that rule, the succeeding iron charges, in the furnace being dealt with, would be 600 lb. of iron to 60 lb. of coke.

Lighting Up.—The fire is lighted at the breast and is allowed to burn through the coke bed slowly to heat up the cupola. The draft is regulated by means of the tuyere peep-hole covers. From 1 to 3 hrs. are required for the bed to burn through, the time depending upon the size of the cupola and the height of the stack. The bed in a 24-in. cupola will burn through in about 1 hr. while 1½ hr. will be required in a 36-in. cupola.

Breast.—The large hole in the front of the cupola is called the breast opening. It is usually left open to give draft to the fire until the coke bed has burned through. Then it is closed, as shown at *B*, in Fig. 160. Closing the opening is called "putting in the breast." The material used for the breast should be refractory. A mixture of equal parts of strong molding sand and refractory clay may be used. This mixture should be wet with water and made about as damp as the sand used for green-sand molding. When everything is ready for the breast to be put in, all loose sand and ashes are brushed out of the hole, and the sides are wet with clay wash. Short pieces of coke or a board may be jammed into the opening to form a backing for the clay. The clay is then put in and rammed against the coke or board.

Tap Hole.—The tap hole is made when the breast is put in. A rod from 1 to 1½ in. in diameter is laid in the spout and on the sand bottom before the breast is put in. After the breast is rammed, the clay is cut to a funnel shape, around the rod, and the rod is drawn out, leaving the tap hole.

Spout.—The spout is lined, as shown at *C*, in Fig. 160, with the same clay mixture as used for the breast. The lining must not be raised above the bottom of the tap hole.

Before starting the blast, the breast and spout linings must be dried.

Starting the Blast.—After the cupola has been prepared, the coke bed has burned through, and the first iron charge is in, the tuyere peep holes are closed and the blast started.

After blowing the air into the cupola from 8 to 12 min., the metal will begin to run out of the tap hole. The first 10 to 25 lb. is too cold to use for pouring, and is allowed to run into dry sand on the floor. The tap hole is then closed and the iron accumulated for a tap.

Tapping.—After the metal has accumulated, it is drawn off at intervals. Tapping a cupola is dangerous work and must be done carefully.

The tools needed for tapping consist of round iron bars, from ¾ to 1¼ in. in dia. and from 3 to 10 ft. long, pointed, as shown in Fig. 161. There should be from one to three bars on hand. The clay bott is picked out of the tap hole carefully. It must not be removed by driving the bar into it. By driving the bott a sudden rush of iron, impossible to control, would be caused. The point of the bar is cooled and hardened by being dipped into water as soon as the iron is running. In that way it is prepared for the next tap.

Stopping.—When enough metal has been drawn, the tap hole is closed with a conical clay bott, stuck on the tip of a stopping bar such as shown at *B*, Fig. 161. Stopping is another dangerous job and the bott must be pushed into the tap hole without splashing any of the metal. Stopping bars are iron rods, or they may be made of wrought-iron pipe 1 in. in diameter. In either case the tip is an iron disk,

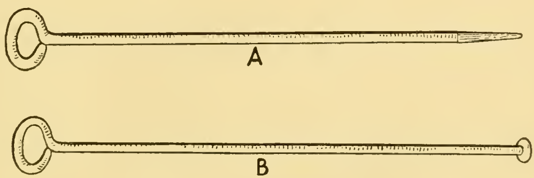

Fig. 161.—Tapping and stopping bar.

securely fastened. From one to three extra bars, with botts stuck on should always be ready for instant use.

The materials used for the bott should be refractory and plastic, and of such nature that the bott will bake slightly. A mixture of seven parts new molding sand, three parts common yellow clay, one part wheat flour and water serves the purpose very well. A bott that is too wet will cause the metal to splash and blow, and one that is too dry will not stay in the tap hole.

Pouring.—The metal is conveyed from the cupola to the molding floors in ladles, transported by hand, overhead trolleys, industrial trucks, or cranes. When pouring molds the ladles should not be held higher than necessary. The scum, floating on top of the metal, can be skimmed off with an iron rod called the skimmer. When pouring, the gates, sprue, and pouring basins should be filled quickly and kept full.

The temperature of the metal should be right before pouring. Light thin castings must be poured with very hot metal. Heavy castings should not be poured with such hot metal, because a large amount will cut the sand. Hot metal will also cause more shrinkage trouble than dull metal. It is important that the mold be filled by continuous pouring. If pouring is stopped too soon, the castings will be "poured short."

There is usually some metal remaining after the molds are filled, which is poured into pigs of suitable size, to be used in later heats. The pigs may be made in sand, or in cast-iron molds washed with thin clay wash.

Dropping the Bottom.—When enough metal to pour the molds, or all the metal in the cupola has been melted, the blast is shut off. After the last tap has been made, all metal remaining in the cupola is drained out, the tuyere peep holes are opened, and the bottom doors are dropped by pulling away the prop. The material that drops out of the cupola, called the "dump," is spread out and sprinkled with water to avoid danger of fire and to save any unconsumed coke.

If the slag that accumulates in front of the tuyeres is broken off as soon as the bottom is dropped, it is easily removed and the cupola cools the more quickly.

When the dump is cool enough to be handled, it is removed. The large pieces of coke and iron are picked out by hand and the small pieces of iron, coke and slag are put into a cinder mill where the slag is broken and the iron freed for reclamation. The reclaimed coke is usually used for baking cores, but may be mixed with new coke and used in the cupola. All the iron taken from the dump is used when making up the charges for later heats.

Chipping the Cupola.—After each heat the slag sticking to the lining must be removed and slag and cinders hanging over the tuyeres must be chipped off. Due care must be taken not to break the lining. The tools used are shown in Fig. 162. The cupola tender must be on the inside of the cupola to do the work. The job is dirty and dusty and hard on the eyes. Much of the dust can be eliminated by sprinkling water on the lining and the workman's eyes should be protected by goggles.

Melting Zone.—The lining in a cupola is usually built in a straight line from the tuyeres up. After a few heats it is burned from the top of the tuyeres upward for a distance of from 2 to 3 ft. It is in this section called the melting zone, where the temperature is highest, and where nearly all the metal melts.

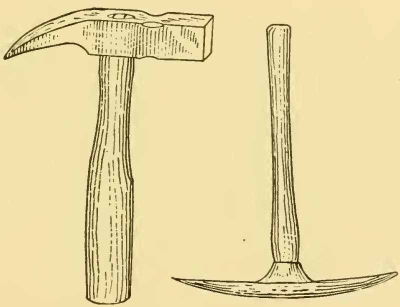

Fig. 162.—Cupola picks.

The inside diameter of the cupola is increased by the burning of the lining in the melting zone, but the increase should never exceed, by more than 4 to 6 in. the diameter at the tuyeres. The cupola tender secures the best results by keeping the melting zone in a good condition.

Daubing the Cupola.—The lining must be repaired by daubing, after each heat, or it will quickly burn out. The life of the lining depends upon the material used for the daubing and upon how well the work is done. Some cupola men are able to use a lining for a long time, while others have to reline the melting zone quite often.

The material used to daub a cupola should be highly refractory. Cupola men differ as to the best daubing material. A mixture that serves the purpose very well is composed of two parts fire clay and one part sharp sand. The fire clay and sand should be mixed dry and then wet with water. If the daubing is too wet and thin, it does not stick well, cracks when it dries, and falls off when the cupola is in blast. Experience will show how thick the mixture must be and how thick a coat must be applied. If the mixture is made and put to soak the day before it is used, it will be better than if mixed just before using.

The lining should be clay-washed before daubing. If there are large holes burned in the lining, they should be filled with small pieces of fire brick. The patching can be done by hand better than with tools.

Breaking-up Molds.—After the molds have been poured, the loose iron on the tops of the molds should be taken off with an old shovel and put into a pile to be used again.

The clamps and weights can be removed and the molds broken up as soon as the metal has solidified. Thin castings solidify within a few minutes after they are poured, but the metal in large castings may remain in a fluid state for hours.

Snap flask molds are much easier to break up than any other kind. They are simply dumped from the boards. The boards, and jackets, if used, are returned to the molding bench.

Some of the larger molds are not so easy to break up, especially if the copes have bars. The sides of the cope can be rapped with a hammer or sledge to loosen the sand. Bars should not be rapped. When the cope is lifted the casting should remain in the drag. The cope, after the sand is removed, is placed on the floor with the pins up. The drag is then rapped, removed from around the casting, and set on the cope. The casting may be dumped from the board while hot or left on the board to cool, the procedure being governed by the size and shape of the casting. Castings with a tendency toward warping are allowed to cool on the boards.

Cleaning Castings.—The castings are conveyed from the molding floors to the cleaning room. The burned sand is cleaned from them by hand or by machinery. The sprues, gates, and feeders are broken off by means of sledge or hammer. The fins and small pieces of the gates are removed by grinding or chipping. Small- and medium-sized castings are cleaned and polished in a machine called a tumbling mill or rattler, as shown in Fig. 163. A rattler from 20 to 24 in. in dia. and from 24 to 36 in. long provides a barrel of the proper size for school foundries.

The rattler is filled with castings and small scrap or "milling stars" and revolved for an hour or two at a rate

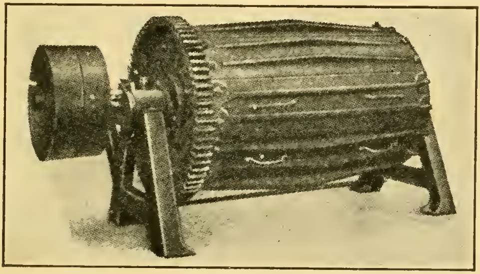

Fig. 163.—Tumbling mill or rattler.

of about 75 r. p. m. When taken out, the castings are free from sand and present a polished appearance.

Thin castings must not be put into the rattler with large ones, nor must castings be packed too tightly or too loosely. Tight packing will result in improper cleaning and loose packing will cause breakage.

Large castings are cleaned by hand or by sand blasting. In hand cleaning the sand is removed by means of wire brushes and the castings are rubbed with abrasive stones or coke.

The cleaning room is usually a dirty and noisy place. The noise is unavoidable, but much of the dirt and dust can be eliminated by using either an exhaust or dust collecting system.

CHAPTER XVIII

RECORD FORMS

School foundries as well as commercial foundries should keep accurate records of the work done. The keeping of records may require extra effort, but the time is well spent, if the record keeping is not too complicated. Keeping records and comparing them will help to make the work more efficient. Every foundryman should know the time taken for the cupola operations and the blast pressure used. He should also know the percentage of good castings, the iron loss in melting, and the melting ratio.

The form shown in Fig. 164 can be used when making up the charges. The size of the form and the number of charges can be determined by each foundryman in charge of the work.

The form shown in Fig. 165 may be used in timing the operations when taking off the heat and for the blast pressure.

The summary form in Fig. 166 can be used to keep a record of the work done. The percentages of good and bad castings are computed in three ways: On the total metal charged; on the total number of castings made, or on the total pounds of castings made. Any one, or all three methods may be used, depending upon the information desired.

If the percentage of good castings to the total metal charged is wanted, the weights of the metal in the following groups must be taken into consideration: Good castings; bad castings; dump; sprues; risers; loss in melting. Their total weight is taken as 100 per cent. If a check on the quality of the molds is wanted, the percentage must be based on the total castings made. The total of good and bad castings equals 100 per cent. The pound method of computing the percentage is preferred to the piece method.

The percentage of good castings that a school can pro-

Weight of Charges in Pounds					
Charges	Coke	No. 1 Pig Iron	No. 2 Pig Iron	Scrap Iron	Flux
1st, or Bed					
2nd.					
3rd.					
4th.					
5th.					
6th.					
7th.					
8th.					
9th.					
Total					
Heat No........	Date..........	Signed....................			

Fig. 164—Chart for Making up Charges.

duce, computed by the pound method, depends upon the age of the students, the length of time the students spend in the course, and the complexity of the work. Students with no previous foundry training, who are given a course of from 72 to 100 hr., should obtain an average of about 90 per cent good castings based on total castings made, if the castings are of the kind treated in this course.

The amount of iron lost during melting depends upon how clean and how large the pieces are when charged. The dirtier the iron and the smaller the pieces, the greater will be the loss. The average loss in melting is about 8 per cent.

Running Log		
Operations	Hours	Minutes
Time of lighting kindling		
Time of placing iron bed charge		
Time of starting blast		
Time of molten metal first appearing		
Time of stopping blast		
Time of dropping bottom		
...... ounces of blast pressure at		
...... ounces of blast pressure at		
Length of heat		
Heat No......... Date.......... Signed....................		

Fig. 165—Chart for Timing Cupola Operations.

The melting ratio is obtained by dividing the total amount of iron melted by the total coke burned in melting. The amount of iron that can be melted with 1 lb. of coke depends greatly upon the size of the heat and the size of the cupola. With long heats in large cupolas higher melting ratios can be obtained than with small heats in small cupolas.

Summary of Heat		
Materials	Pounds	Percentages
No. 1 pig iron charged		
No. 2 pig iron charged		
Scrap iron charged		
Total iron charged		
Iron recovered from dump		
Total iron melted		
Good castings made		
Bad castings made		
Iron in sprues, risers, etc.		
Total iron taken from cupola		
Iron lost in melting		
Fuel		
Coke charged		
Coke recovered from dump		
Coke burnt in melting		

Melting ratio.......... (Lbs. of iron melted to 1 lb. of coke)

Heat No......... Date.......... Signed...................

Fig. 166—Chart for Computing Summary of Heat.

CHAPTER XIX

FOUNDRY IRONS

Pig Iron.—The pig iron that the foundryman uses in making gray-iron castings is a "blast furnace" product. It is cast in shapes convenient for cupola melting. The pigs are cast either in "sand molds" or "pig machines." The iron is analyzed and graded according to chemical analysis, and put on the market as Nos. 1, 2, 3, and 4, or various grades of either northern or southern iron. The northern irons are mined in the northern part of the United States, and the southern irons in the southern part.

Pig iron is sold on the long-ton basis, 2,240 lb. The 240 lb. is an allowance made by the blast furnace men to make up for the sand and slag adhering to the pigs.

Gray foundry irons contain many impurities such as carbon, silicon, phosphorus, manganese and sulphur. These impurities will be found in different proportions. If they were removed, the iron would not be suitable for the manufacture of gray-iron castings.

Carbon.—Foundry irons contain from 3 to 4 per cent of carbon, one of the most important elements in iron. The condition of the carbon in iron determines its hardness or softness. Carbon is usually found in two forms, known to foundrymen as combined and graphitic. When the iron is in a molten state the carbon is in a combined form. As the iron solidifies, much of the carbon will pass from the combined to the graphitic form. The amount of carbon that changes from the combined to the graphitic form depends upon the time required for the iron to solidify. When the carbon is in the graphitic form, the iron is open grained and soft.

In Fig. 167 is shown a photomicrograph of gray cast iron, magnified 100 times. The black portions show the graphitic carbon and the white portions show the iron and combined carbon.

Silicon.—Gray cast iron usually contains from 1 to 3.5 per cent of silicon. It is a very important element and is known as a softener. When the iron is solidifying, the silicon assists the carbon in changing from the combined to the graphitic form, and therefore it is a good element to adopt as a base for general iron mixtures. However, silicon will cause large castings to be weak and open grained, with a tendency to leak when subjected to steam, air, or water pressure.

Fig. 167.—A photomicrograph of gray cast iron. Black shows the graphitic carbon. White shows the iron and combined carbon. Magnified 100 times.

When small machineable castings are to be made, the silicon should range from 2.5 to 3 per cent. For large castings, it should be kept below 2.5 per cent and often as low as 1 per cent.

Manganese.—Manganese usually ranges from 0.2 to 1 per cent in foundry irons. It is a beneficial element because it closes the grain of the iron. Manganese is known as a strengthener. It holds the carbon in a combined state, without impairing the machining quality, if it is used in the proper proportion.

A high manganese iron will give soft castings by absorbing sulphur and carrying it in to the slag. For light and thin castings, the manganese should be kept below 0.5 per cent, but for large castings it is often used in amounts above 1 per cent.

Phosphorus.—From 0.20 to 2 per cent of phosphorus is found in gray cast iron. It acts indirectly on the carbon by its influence in keeping the metal in a molten state, allowing the carbon to change from the combined to the graphitic form. An excessive amount of phosphorus in large castings will cause sponginess and high shrinkage, and will weaken them, but in small castings, which solidify quickly, it does not have the weakening effect. Phosphorus will cause the metal to flow more freely and is therefore used in amounts as high as 1 per cent in thin castings. It is usually kept below 0.5 per cent in large castings.

Sulphur.—Sulphur is one of the most undesirable elements in cast iron, and should be kept as low as possible. Its action is to keep the carbon combined, in a white glazed state, making the iron very weak, brittle and hard to machine.

Sulphur exists in the iron as iron sulphide, which melts at a lower temperature than the iron and remains fluid longer, so much so that it separates from the iron, causing blow holes and cracks. It also causes great shrinkage and dirty castings. Sulphur is absorbed from the fuel when the iron is melting, and therefore a high sulphur fuel should never be used. It is a very powerful agent and causes serious results.

When making up mixtures, the sulphur should never run higher than 0.1 per cent for large castings. For small castings, it should be kept below 0.08 per cent if possible.

Scrap Iron.—Pig iron that has been melted in the cupola, and is to be melted again, is known as scrap iron. Machinery, stove plate, and car wheel scrap are usually classed as "cast scrap." Sprues, risers, bad castings and left-over iron are known as "scrap." Bought scrap is called "foreign iron."

The composition of "home" scrap is generally known, but that of foreign scrap is not. It would not be practicable to try to analyze all scrap. Machinery scrap averages from 2 to 2.5 per cent silicon, 0.5 to 0.7 per cent manganese, 0.5 to 0.7 per cent phosphorus, and 0.05 to 0.15 per cent sulphur.

Remelting Iron.—Iron usually becomes harder each time it is remelted, due to a decrease in the elements that soften the iron and an increase in the elements that harden it. There is not much change in the total amount of carbon in the iron when it is melted in the cupola, but there is an increase in the percentage of combined carbon.

The loss of silicon averages about one-tenth of the amount present each time the iron is melted and that amount of loss should be used in computing mixtures.

In the same way the loss of manganese is about one-fifth.

It is not necessary to make any allowance for phosphorous because the amount of that element remains practically constant.

The gain in sulphur depends upon the quality of the coke, usually being equal to about 4 per cent of the sulphur in the coke. The increase depends somewhat upon the amount of manganese in the iron and how the cupola is fluxed. Manganese usually absorbs some of the sulphur and carries it into the slag.

MIXING IRONS BY FRACTURE AND CHEMICAL ANALYSIS

When making up mixtures of different pig irons and scrap irons the class of casting to be made and the kind of iron on hand must be considered. Castings that are to be machined must be soft. Those that do not need to be machined may be either soft or hard. Some castings must be strong and close grained while others may be weak and open grained, depending upon the use to which they are to be put.

It is wise to use a soft pig iron in school foundries, one that will carry at least 50 per cent of scrap, because students are certain to make scrap.

Fracture Mixing.—An iron that has a very open, coarse grain with a silvery gray color is weak and soft. As the grain becomes finer and the color lighter, the iron becomes harder and stronger. The quality of an iron can be judged by the texture and color of the fracture. When the fracture has a white color and a very fine and dense grain, the iron is usually hard, but weak. A fairly good mixture may be made by studying the fracture of irons, but mixing by analysis is the more accurate method.

Mixing by Analysis.—The analyses of pig irons can be obtained from the manufacturers. For ordinary castings such analyses are accurate enough, but many foundries have their own chemical laboratories and analyze the iron before making up mixtures.

In the following a concrete example will be taken up to compute a mixture suitable for small castings that are to be machined. The charges will fit the cupola shown in Fig. 160. The mixture will carry 50 per cent of scrap.

Suppose that three grades of iron are at hand, two of pig and one of scrap, and they analyze as follows:

	No. 1 Pig Iron %	No. 2 Pig Iron %	Scrap Iron %
Silicon..........	3.5	3.	2.25
Manganese......	0.6	0.8	.6
Phosphorus......	0.8	0.6	7
Sulphur.........	0.03	0.04	.08

The castings to be made are to have the following analysis: Silicon, from 2.50 to 2.75%; manganese, between 0.5 and 0.7%; phosphorus, between 0.60 and 0.80%; sulphur, not over 0.10%.

SILICON

200 lb. of No. 1 pig iron	contain	7.00	lb. of silicon
100 lb. of No. 2 pig iron	contain	3.00	lb. of silicon
300 lb. of scrap iron	contain	6.75	lb. of silicon
600 lb. of the mixture	contain	16.75	lb. of silicon
100 lb. of the mixture	contain	2.79	lb. of silicon
Loss in melting (1/10 of the above)		0.28	lb. of silicon
Remaining in castings made from 100 lb. of mixture		2.51	lb. of silicon

The percentage of silicon is therefore 2.51.

MANGANESE

200 lb. of No. 1 pig iron	contain	1.2	lb. of manganese
100 lb. of No. 2 pig iron	contain	0.8	lb. of manganese
300 lb. of scrap iron	contain	1.8	lb. of manganese
600 lb. of the mixture	contain	3.8	lb. of manganese
100 lb. of the mixture	contain	0.633	lb. of manganese
Loss in melting (1/5 of the above)		0.127	lb. of manganese
Remaining in castings made from 100 lb. of mixture		0.506	lb. of manganese

The percentage of manganese is therefore 0.506, say 0.51

PHOSPHORUS

200 lb. of No. 1 pig iron	contain	1.60	lb. of phosphorus
100 lb. of No. 2 pig iron	contain	0.60	lb. of phosphorus
300 lb. of scrap iron	contain	2.10	lb. of phosphorus
600 lb. of the mixture	contain	4.30	lb. of phosphorus
100 lb. of the mixture	contain	0.72	lb. of phosphorus

The percentage of phosphorus is therefore 0.72.

SULPHUR

200 lb. of No. 1 pig iron	contain	0.06	lb. of sulphur
100 lb. of No. 2 pig iron	contain	0.04	lb. of sulphur
300 lb. of scrap iron	contain	0.24	lb. of sulphur
600 lb. of the mixture	contain	0.34	lb. of sulphur
100 lb. of the mixture	contain	0.057	lb. of sulphur
Gain in melting (4 per cent of sulphur in coke, assuming a coke containing .75 per cent sulphur)		0.03	lb. of sulphur.
Existing in castings made from 100 lb. of mixture		0.087	lb. of sulphur

The percentage of sulphur is therefore 0.087, say 0.09.

GENERAL PURPOSE MIXTURES

Light Castings.—When the metal is not more than ½ in. thick in any section, castings are known as light castings. A mixture suitable for light castings is: Silicon 2.50 to 2.75, manganese 0.40 to 0.70, phosphorus 0.60 to 0.8, sulphur not over 0.08.

Medium Castings.—Castings that have sections thicker than ½ in. and up to 2 in. thick are called medium castings. A mixture suitable for medium castings is: Silicon 1.75 to 2.00, manganese 0.60 to 1.00, phosphorus 0.40 to 0.60, sulphur not over 0.10.

Heavy Castings.—Any castings having no section less than 2 in. thick are called heavy castings. A mixture suitable for heavy castings is: Silicon 1.00 to 1.50, manganese 0.70 to 1.00, phosphorus 0.20 to 0.50, sulphur not over 0.12.

TESTING GRAY CAST IRON

The main tests to which gray cast iron is subjected are those for transverse strength, flexure, shrinkage, chill and hardness.

Testing Machines.—There are many types of testing machines that have capacities from 50,000 to 100,000 lb. Small shops and school foundries usually have small testing machines which they operate by hand.

Test Bars.—The bars used in making the transverse-strength test may be either round or square, ranging in size from ½ to 1¼ in. in diameter or ½ to 1½ in. square. The bar that is as nearly standard as any is 1¼ in. in diameter and 15 in. long. It is known as the Arbitration Test Bar.

The transverse-strength test is made by placing the bar on knife edges 12 in. apart and applying the load in the center until the bar breaks. To find the transverse strength of the bar in pounds per square inch, the breaking load in pounds is divided by the area of the bar in square inches.

For example, the area of the arbitration bar is $0.625 \times 0.625 \times 3.1416 = 1.225$ sq. in. If the bar breaks at 3,500 lb., the transverse strength is $3{,}500 \div 1.225 = 2{,}857$ lb. per square inch.

There is great variation in the strength of gray cast iron, due to its composition. The transverse strength per square inch of any cast iron should not be under:

For light castings, 2,100 lb.

For medium castings, 2,400 lb.

For heavy castings, 2,700 lb.

Iron of some compositions and grades will have greater transverse strength, sometimes as high as 3,500 lb.

Flexure Test.—The flexure test, usually conducted in connection with the transverse test, shows how much the iron will bend before it breaks, an indication of whether or not it is suitable for castings that have to withstand many jars and shocks. A bar 1¼ in. in diameter with 12

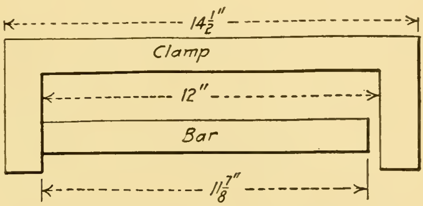

FIG. 168.—Shrinkage clamp and bar.

in. between supports, should bend at least 0.1 in. before breaking, and in many cases the deflection will be as much as 0.15 in.

Shrinkage.—For some castings, such as pulleys and gears, it is important to know the rate of contraction of the iron. In gray cast iron it ranges from 1/12 to 1/6 in, to the foot. The average is usually given at ⅛ in.

When making the test bar to be used in measuring contraction, a pattern 12 in. long and 1 in. square may be used. A good and simple way to mold the bar is to lay the pattern in a clamp as shown in Fig. 168, and build the mold around it. The inside dimension of the clamp is 12 in. When a clamp is used there is no danger that the mold will be longer than 12 in., due to rapping the pattern.

After the bar has been poured and is cool, it is measured and the contraction noted.

Hardness Test.—To test the castings for hardness either a sample casting or a test bar can be used. The pieces of the bar in the transverse test will do very well. The hardness is determined by drilling holes in the iron and observing the speed of cutting, or by filing it. Either test can be made very accurately after a little practice.

There are two tests for hardness that are made with special testing machines. They are known as the Brinell test and the Scleroscope test.

CHAPTER XX

NON-FERROUS METAL FOUNDING

The making of molds for brass and aluminum castings is similar to the making of molds for iron castings. Any one who understands making molds for iron castings can soon learn to make molds for brass castings. The molding exercises given in the book can be poured in brass as well as iron.

Light brass and aluminum castings should be very smooth, a fact that necessitates the use of a fine-grained sand. The tendency of molten brass is to eat into the sand, thereby causing the castings to be rough and streaky. Care in selecting a sand from among the several grades and kinds in the market will pay.

In foundries where only a few brass castings are made, and fully equipping for them would not be justified, fairly good castings can be made by using the regular molding sand and facing the pattern with a fine-grained sand to a depth of about ½ inch.

Another way to secure a comparatively smooth surface is with cement, which is dusted on from a bag after the pattern is drawn. Then the pattern is "printed back" (see Chap. IV). The pattern must not remain in the sand more than a minute or so, because the cement becomes damp and will stick to it.

The sand for non-ferrous casting must be kept free of all foreign matter and any material that will cause it to become coarse. Such small pieces as burned dry-sand core and nails should be carefully picked out.

Parting Material.—Common parting sand is seldom used in brass molding, because it is too coarse. There are on the market many commercial parting compounds that can be used without harming the sand. One of the best materials is lycopodium, to which the only objection is its high price. The parting compounds, or the lycopodium, should be dusted onto pattern and mold from bags.

Furnaces.—Furnaces used to melt non-ferrous metals, of which there are many types, range from the coke-fired, crucible pit furnace to the electric furnace. In some foundries the metal is melted in crucibles, and in others in the hearth of the furnace.

The crucible pit furnace is probably the cheapest to install and is the furnace most used by school foundries.

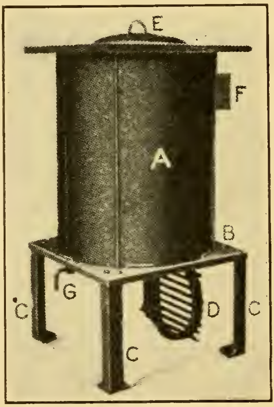

Fig. 169.—Crucible pit furnace.

For those reasons it has been selected for treatment in this course. Its construction is shown in Fig. 169. The shell, *A*, is made of steel plate $3/16$ in. thick. It rests on plate, *B*, made of cast iron. The legs, *C*, support the furnace high enough from the floor to allow for draft and ashes. The grate, *D*, works on hinges so that it can be raised and dropped. It is turned by the handle, *G*. The cover, *E*, holds down the flame. The furnace should be connected by the flue, *F*, with a chimney.

Crucible pit furnaces are built in sizes ranging from 23 to 36 in. in diameter and from 24 to 36 in. high. Their melting capacities are from 20 to 200 lb. of brass or from 10 to 70 lb. of aluminum per heat. Linings are made of fire brick as in the cupola furnace. Sometimes the furnace is set on the floor, but it is much more easily operated when set in a pit as shown in Fig. 172.

Crucibles.—The crucibles, shown in Fig. 170, are made of graphite and a special clay, known as German clay. They are made in standard sizes and are numbered from 1 to 400. To find the amount that a crucible will hold, multiply its number by three for brass, and by one for aluminum. For example, No. 20 crucible has a capacity of 60 lb. of brass or 20 lb. of aluminum. The No. 20 is the best size to use in the furnace shown in Fig. 172.

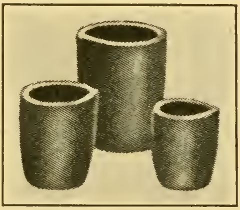

Fig. 170.—Crucibles.

Care of Crucibles.—A new crucible should be annealed and then heated up gradually to about 600 deg. F. before the first heat is taken. Heating up a new crucible too rapidly will cause it to crack or flake off (known as "scalping"). Crucibles must be kept in a warm place free from moisture. The shank and tongs must fit properly, and when the crucible is removed from the furnace, it should never be placed in wet sand.

A few "don'ts" to be observed in the care of crucibles are:

Don't put a damp crucible into a hot furnace.

Don't use wet coke to melt metals.

Don't wedge the metal into a crucible.

Don't leave the crucible in the fire after the metal is ready to pour.

Don't leave the metal in the crucible to cool.

Don't drop cold metal into the crucible from a distance.

Don't set hot crucibles in cold drafts, or near an open door during the winter.

Tongs.—In Fig. 171 three tongs are shown: *A*, the crucible tong, used to lift the crucible from the furnace; *B*, the pick-out tong, used to pick the coke from around the crucible to make possible getting a firm hold with the crucible tongs; and *C*, the shake-out tong, used to shake the castings out of the sand after the molds are broken up.

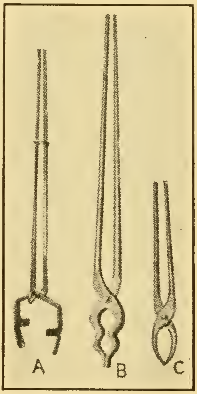

Fig. 171.—Crucible, pick out and shake out tongs.

Operating the Furnace.—To operate the furnace shown in Fig. 172: Place shavings and kindling on the grate, and about 50 lb. of coke on the kindling. Light the shavings. After the coke is well lighted, build up the coke bed so that the top of the crucible, *A*, when put on, will be even with the top of the flue, *B*. Place the metal in the crucible and the crucible on the coke bed. Fill in around the crucible with small pieces of coke up to the level of the top of the crucible. These pieces of coke should not be larger than hen eggs. Close the cover.

No further attention need be paid to the furnace for about an hour except to see that the fire is burning. From

1 to 2 hr. are required for the furnace to become hot enough to melt any of the metal, especially brass.

It sometimes happens that the coke burns out around the crucible before the metal is melted or hot enough to pour. In such a case the crucible must be raised and new coke put around it. To lessen the tendency of the crucible to sink to the grate. it is a good plan to put a brick, *C*, about 4 in. thick, on the grate before charging the furnace.

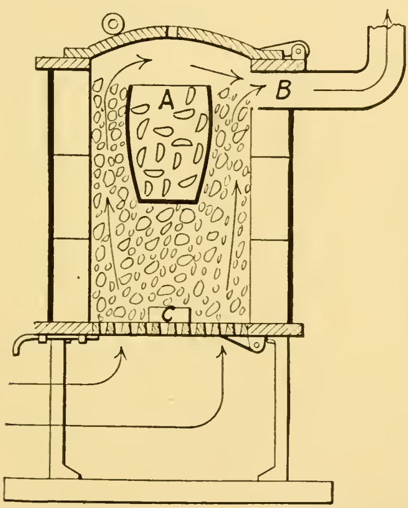

Fig. 172.—Cross-section of crucible furnace.

As soon as the metal is hot enough to run the castings, the crucible should be taken from the furnace, and set into the shank, and the metal poured.

If only one heat is to be taken out of the furnace in a day, the coke should be dumped and the crucible put in a warm place to cool. If more than one heat is to be run, more coke should be put on the bed, the crucible recharged and set into the furnace, and more coke placed around it.

A heat from a cold furnace requires from 3 to 4 hr. Following heats can be taken in from 1 to 3 hr. When preparing the furnace for the second and following heats, all ashes and unburned coke should be removed from under the grate and any unburned coke should be used again.

ALLOYING NON-FERROUS METALS

The metals most frequently used to make non-ferrous metal castings are copper, tin, zinc, lead and aluminum. These five metals may be mixed in varying proportions to form many alloys, chief among them "red brass," "yellow brass," "bronze," "bearing metals" and alloys of aluminum.

When alloying, the metal with the highest melting point should be melted first, then the one with the next highest melting point, and so on until all of the metals that are to make up the alloy are melted together. For example, in making a red brass alloy, the copper is melted first, then the zinc, then the lead, and last the tin. As soon as the mixture is hot enough to run the castings, it should be taken out of the furnace, or the zinc, tin and lead may burn away.

Red brass is usually a mixture of copper, tin, zinc and lead. The proportions of the metals are not always the same. Two mixtures often used are as follows:

RED BRASS

Mixture 1		Mixture 2	
Copper	85 per cent	Copper	60 per cent
Tin	5 per cent	Tin	4 per cent
Zinc	5 per cent	Zinc	4 per cent
Lead	5 per cent	Lead	2 per cent
		Red brass scrap	30 per cent

Yellow brass is usually a mixture of copper and zinc, although many of the yellow brass alloys contain a small percentage of tin and lead. The following are typical yellow-brass mixtures:

YELLOW BRASS

Mixture 1		Mixture 2	
Copper	70 per cent	Copper	73 per cent
Zinc	30 per cent	Zinc	23 per cent
		Tin	2 per cent
		Lead	2 per cent

There are many alloys called bronze. The most common ones are known as "straight bronze," "phosphor bronze" and "manganese bronze."

Straight bronze is usually a mixture of copper and tin, but there are many bronzes that contain zinc and lead, especially the cheaper mixtures. The following mixtures are known as straight bronze:

BRONZE

Mixture 1		Mixture 2	
Copper	90 per cent	Copper	89 per cent
Tin	10 per cent	Tin	8 per cent
		Zinc	1.5 per cent
		Lead	1.5 per cent

Phosphor bronze castings may be made by adding a little phosphorus to the mixture. If phosphor-tin is used, and alloyed with the copper, better results will be obtained than if the phosphorus is mixed with the copper. The following mixtures are called phosphor bronze:

PHOSPHOR BRONZE

Mixture 1		Mixture 2	
Copper	90 per cent	Copper	65 per cent
Phosphor tin	10 per cent	Phosphor tin	5 per cent
		Zinc	2 per cent
		Lead	3 per cent
		Scrap phosphor bronze	25 per cent

Manganese bronze alloys are usually made by using both copper that contains from 5 to 15 per cent of manganese, and copper that contains no manganese. The following mixtures make typical manganest bronze:

MANGANESE BRONZE

Mixture 1		Mixture 2	
Copper that contains 15 per cent of manganese	3 per cent	Copper that contains 5 per cent manganese	8 per cent
Copper that contains no manganese	58 per cent	Copper that contains no manganese	51 per cent
Zinc	38 per cent	Zinc	40 per cent
Aluminum	1 per cent	Aluminum	1 per cent

Bearing Metals are made according to formulas. The following are two typical mixtures:

BEARING METAL

Mixture 1		Mixture 2	
Copper	76 per cent	Copper	38 per cent
Tin	8 per cent	Tin	4.5 per cent
Lead	15 per cent	Lead	7.5 per cent
Phosphorus-copper	1 per cent	Scrap bearing metal	50 per cent

For metal pattern and match plate mixtures, the following formulas may be used:

METAL PATTERNS

Mixture 1		Mixture 2	
Copper	8 per cent	Antimony	10 per cent
Aluminum	92 per cent	Zinc	5 per cent
		Tin	25 per cent
		Lead	60 per cent

Aluminum alloys are used extensively for castings that are to be light in weight, because pure aluminum is too soft. Usually the aluminum predominates. To obtain a well-mixed alloy, it is necessary to make a primary alloy known as a hardener which ordinarily contains 50 per cent of aluminum and 50 per cent of copper or zinc. The hardener is cast into pigs suitable for handling. When the alloy for the casting is to be made, a certain percentage of the hardener is mixed with the pure aluminum. For example, in making the mixture known as No. 12 aluminum alloy, which contains 8 per cent of copper, 84 per cent of pure aluminum and 16 per cent of the hardener are used.

QUESTIONS

1. Name three types of furnaces used for melting metals.

2. Why are cupolas lined, and how?

3. After cupolas are lined how should the lining be treated before taking off the first heat?

4. Why are tuyeres used in a cupola?

5. What is a slag hole, what is its object, and how should it be located?

6. What materials are used for making the sand bottom?

7. What is meant by the melting zone of a cupola? Where is it located in relation to the tuyeres?

8. What is meant by the bed in a cupola?

9. How is the amount of coke for the bed determined?

10. If the iron charges are too heavy for the coke charges, what will be the effect on the iron?

11. Should the fire in a cupola be started before or after charging the iron, and why?

12. If too little fuel is put between charges of iron what will be the result?

13. How must a cupola be taken care of after a heat has been taken?

14. Describe one method of making breast and tap hole for a cupola.

15. What two classes of machines are most commonly used for producing the blast for a cupola, and in what respect do they differ?

16. Name the two kinds of coke used to melt iron in a cupola.

17. What materials are used to line ladles, and why are they lined?

18. What will be the result if the ladle linings are not dry?

19. If the metal is poured too cold what will be the result?

20. How are the molds broken up after they are poured?

21. How are the castings cleaned?

22. What is meant by the melting ratio and how is it computed?

23. What is meant by the loss in melting and how is it computed?

24. Describe a safety tuyere and safety drain, and explain their use.

25. How many pounds of iron will a pound of coke melt in a cupola?

26. How thick should the charges of coke be between the charges of iron?

27. What is gray cast iron and how does it differ from pure iron?

28. Name the "big five" impurities in gray cast iron.

29. What effect has carbon on gray cast iron, and in what form is it found in the iron?

30. Which of the impurities make gray cast iron harder?

31. Which of the impurities make gray cast iron softer?

32. What effect has remelting on cast iron? Does it make it harder or softer?

33. What effect has the chilling of iron on the casting?

34. What are the important tests usually used on gray iron castings?

35. What is meant by the "arbitration test bar"?

36. What kind of molding sand is used in making brass castings?

37. What types of furnaces are used to melt non-ferrous metals?

38. What care should be used in handling crucibles?

39. What is brass? Give a mixture.

40. What is bronze? Give a mixture.

TABLE I.—MELTING POINT, SPECIFIC GRAVITY, WEIGHT AND TENSILE STRENGTH OF METALS

Name	Melting Point Deg. F.	Specific Gravity	Wt. per Cu. In. in Lb.	Wt. per Cu. Ft. in Lb.	Tensile Strength Lb. per Sq. In.
Aluminum	1,300	2.6	0.089	162	23,000
Aluminum bronze	1,700	7.56	0.28	485	80,000
Brass (common)	1,800	8.3	0.31	539	24,000
Bronze	1,900	8.4	0.31.5	545	32,000
Copper	2,000	8.6	0.31.8	550	24,000
Gray cast iron	2,200	7.2	0.26	450	20,000
Lead	620	11.3	0.41	712	1,800
Malleable iron	2,100	7.2	0.20	450	64,000
Manganese bronze	2,000	8.4	0.3	525	57,000
Phosphor bronze	2,000	8.4	0.3	525	40,000
Cast steel	2,800	7.9	0.28	485	70,000
Tin	512	7.3	0.26	460	4,600
Zinc	775	6.86	0.25	455	2,900

TABLE II.—SHRINKAGE OF CASTINGS

	In. per Ft.		In. per Ft.
Bismuth	5/32	Tin castings	1/4
Brass castings	3/16	Lead	5/16
Copper castings	3/16	Zinc	5/16
Gray iron castings	1/10		

TABLE III.—CUBIC FEET TO A TON OF EARTH

	Cu. Ft.		Cu. Ft.
Sand, river (loaded in wagon)	21	Gravel, coarse (loaded in wagon)	23
Sand, pit (loaded in wagon)	22	Clay, stiff (loaded in wagon)	28

One cubic yard of sand weighs about 3,000 lb.

FOUNDRY BOOKS FOR GENERAL READING

BELT, ROBERT E., "Foundry Cost Accounting." Penton Publishing Co., Cleveland, O.

BUCHANAN, JOHN F., "Practical Alloying." Penton Publishing Co., Cleveland, O.

CARMAN, EDWIN S., "Foundry Molding Machines." Penton Publishing Co., Cleveland, O.

HALL, JOHN HOWE, "The Steel Foundry." McGraw-Hill Book Co., New York, N. Y.

KIRK, EDWARD, "The Cupola Furnace." Henry Carey Baird & Co., New York, N. Y.

MOLDENKE, RICHARD, "The Production of Malleable Castings." Penton Publishing Co., Cleveland, O.

MOLDENKE, RICHARD, "The Principles of Iron Founding." McGraw-Hill Book Co., New York, N. Y.

PALMER, R. H., "Foundry Practice." John Wiley & Sons, New York, N. Y.

PAYNE, DAVID W., "Founder's Manual." D. Van Nostrand Co., New York, N. Y.

WEST, THOMAS D., "American Foundry Practice." John Wiley & Sons, New York, N. Y.

WEST, THOMAS D., "Moulder's Text Book." John Wiley & Sons, New York, N. Y.

GLOSSARY OF FOUNDRY TERMS

Air-dried	Refers to a core that has dried or partially dried in the air before baking.
Alloys	A combination of metals melted together.
Anchor	Appliance used to hold cores in place in molds.
Annealing	Softening, by heat.
Bed charge	The first charge of coke put into the cupola.
Bedding-in	Sinking a pattern into the sand.
Bench molding	Making molds on a bench.
Binder	Material used to hold sand together.
Blast	A current of air blown into the cupola by blower or fan.
Blow hole	Hole in the casting caused by trapped air or gas.
Bott	The chunk of clay stuck on the end of a stopping bar, and used to stop the flow of metal from the cupola.
Bottom board	The board that the mold rests on.
Breast	The clay put into the opening, above the spout, to form the tap hole.
Butt-ramming	Ramming with flat end of the rammer.
Bull ladle	A two-man ladle used for carrying metal.
Casting	The iron, brass, or alloy article, or part, that is obtained as a result of pouring metal into the molds.
Chaplet	A metal support used to hold a core in place.
Cheek	The middle part of a three-part flask.
Chill	Iron placed against a pattern when making a mold.
Chilled casting	A casting that was cooled very rapidly.
Churning	Feeding metal into a casting with an iron rod, through the feeder or riser.
Cinder bed	A layer of cinders placed beneath a mold. Gas, from the mold, escapes through the cinders and is led out through pipes.
Clay wash	Clay, thinned with water, and used as a coating for gaggers and flasks.
Clamping iron	An iron bar used to tighten clamps on flasks.
Cold shut	The junction where two streams of metal run together and do not fuse.

Contraction	Decrease in volume due to cooling.
Cope	The upper part of a flask or mold.
Core	A body of sand used to form holes or openings through castings.
Core box	A box in which a core is formed.
Core oven	An oven in which cores are baked.
Core plate	An iron plate on which a core is baked.
Core driers	A form which holds the core in shape while it is baking.
Core print	A projection on a pattern which forms in the sand an impression used in locating a core and in holding it in place.
Core wash	A blackening mixture with which cores are painted.
Crushing	The pushing out of shape of core or mold, when two parts of the mold that do not fit properly meet.
Daubing	Filling cracks in cores or plastering a cupola after heat.
Draft	The taper on a pattern that makes drawing it from the sand possible.
Drag	The bottom part of a flask or mold.
Draw plate	A plate put into a pattern to be used for drawing the pattern.
Drop-out	The falling-away of part of a mold.
Dull iron	Iron not as hot as it should be for best pouring.
Facing	A material put next to the pattern when making the mold.
Feeding	Pouring metal into the feeder while the casting is solidifying.
Fin	Metal that has run into an imperfect joint in the mold.
Flow-off gate.	An opening through which the metal flows after the mold is filled.
Floor molding	Making molds on the foundry floor.
Flux	A material charged into the cupola to thin the slag.
Follow board	A board in which the pattern lies to the parting line.
Gaggers	Metal support used to reinforce the sand in the cope.
Green sand	Sand that is in a damp state.
Green core	A core that is not baked.
Green ladle	A ladle with a lining that is not dry.
Hand ladle	A small ladle carried by one man.

Hot metal	Metal hot enough to flow easily.
Loam	A mixture of sand and clay used in loam molding.
Melting zone	The portion of the cupola above the tuyeres, where the metal melts.
Match plates	A plate to which the pattern is fastened at the parting line.
Molding board	The board on which the pattern is placed when beginning to make the mold.
New sand	Sand that has not been used for molding.
Old sand	Sand in which castings have been poured.
Patching	Repairing broken parts of the mold.
Peeling	The ready dropping away of sand from the casting.
Peen-ramming	Ramming with the wedge end of the rammer.
Pit molding	Making molds in pits in the foundry floor.
Rapping	Striking the pattern to loosen it in the sand.
Scabbed castings	Castings having rough surfaces.
Scrap iron	Metal to be remelted.
Sea coal	Soft coal, finely ground.
Skimmer	A piece of iron used to prevent the dirt from flowing into the mold when pouring a casting.
Skimming	Holding back the dirt on the iron when pouring.
Skin drying	Drying only the face of the mold.
Slag	Impurities fluxed from the cupola.
Soldiers	Wooden blocks used to reinforce sand when molding.
Spongy castings	Castings in which the iron is very open-grained.
Spout	A trough through which the metal flows from the cupola to the ladle.
Swab	A sponge or piece of waste used to wet the sand around the pattern before drawing it from the sand.
Sweep work	Making molds with sweeps instead of patterns.
Tuyere	An opening through which the air passes from the wind box into the cupola.
Weak sand	Sand that will not hold together.

INDEX