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PLANT REQUIREMENTS TO SET UP AND OPERATE A BRASS FOUNDRY

TECHNICAL AIDS BRANCH
INTERNATIONAL COOPERATION ADMINISTRATION
Washington, D. C.

REVISED
MAY 1959

F O R E W O R D

This manual is a revision of an earlier report of the same type issued in 1955. This revised version includes current costs of labor, machinery, equipment and supplies, as well as additional information relative to engineering, training, safety, markets, sales, financial and economic factors.

* * * * * * * *

This manual is designed to provide a general picture of the factors which must be considered in establishing and operating a small-scale factory of this type. It should prove useful in creating interest in the subject, and serve to give enough understanding of the related considerations to help government officials, other leaders and businessmen to determine whether the potential deserves more-detailed attention.

However, it is important to note that in most cases plans for the actual development and installation of a plant will require expert engineering and financial advice in order to meet specific local situations. For further information and assistance, readers should contact their local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

Mention of the name of any firm, product, or process in this manual is not to be considered a recommendation or endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

* * * * * * * *

The original report was prepared by the Wolf Management Engineering Company, Chicago, Illinois.

Technical information, as well as review, was provided by R. Poliakoff, Industrial Consultant, 126 Eleventh Avenue, New York 11, New York.

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April 1959

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PLANT REQUIREMENTS TO SET UP AND OPERATE A BRASS FOUNDRY

INTRODUCTION

Primarily, this manual will deal with subjects concerning brass foundry operations and techniques. However, matters pertaining to the casting of other metals in the nonferrous category have been included, since it is quite generally the practice in America to utilize identical facilities to cast brass, bronze, zinc, aluminum, magnesium and other nonferrous metals.

COPPER ALLOYS

Copper and its alloys have wide application because of their inherent corrosion resistance properties, particularly where the destructive effects of ocean water and chemicals are involved. Pipe line fittings and valves used by breweries, distilleries, petroleum and chemical plants, as well as utensils employed where corrosive solutions are present, are generally made of copper base alloys. Since applications in these fields are usually of a special nature, where small or moderate quantities of any one part is required, it is less costly, and frequently quicker, to cast the items needed.

The alloys of copper most frequently used in the form of sand castings are called red or low brass, yellow or high brass, and white alloys containing copper and nickel. The alloy which is best suited to a particular requirement may be selected by reference to specifications published by the technical organizations to be subsequently mentioned.

Like nearly every other kind of manufacturing endeavor, a nonferrous foundry operation encounters its peculiar problems. However, when careful attention is given to a relatively few phases of the process, satisfactory copper-base alloy castings may be made in a wide range of alloys and in sizes weighing from a few ounces to large ship propellers weighing as much as 25 tons.

Core and molding technique, gas control, liquid and solidification shrinkage, and the relative affinity of various alloying elements are all subjects well understood, and these topics have been thoroughly dealt with in available technical publications. Therefore, it is reasonable to suppose that persons are to be found in most countries of the world who are capable of utilizing the publications already available and who, by the aid of this information, can become successful foundry operators.

Competition is not nearly so keen in the nonferrous foundry field as it is in the iron and steel foundry industry. Therefore, the price structure for nonferrous castings is generally strong enough to support a healthy gross profit.

Moreover, once a foundry has acquired a reputation for producing quality castings promptly, the prospect is usually quite certain that repeat business, at satisfactory prices, will materialize to assure an ever expanding rate of growth for a well operated enterprise.

Copper-base casting alloys are classified primarily as either bronze or brass. In very general terms, bronze is an alloy of copper and tin, and brass is an alloy of copper and zinc. Both bronze and brass castings are frequently produced containing aluminum, silver, lead, antimony, and cobalt, each alloying agent producing its special effect in the finished casting.

The properties of both bronze and brass are modified by altering the ratio of the basic constituents and also by the introduction of suitable fluxing and scavenging ingredients to achieve a particular grade or type of product. Consequently, there is an impressive number of bronze and brass compositions available.

Generally, however, the ultimate product required is most often produced by adhering to series of specifications published by the American Society for the Testing of Materials, the Society of Automotive Engineers, Bureau of Standards of the United States Government, United States Navy, and the American Foundry Association. The French Government publishes a series of specifications covering architectural and statuary bronzes which are almost universally adhered to by foundries throughout the world who specialize in manufacturing altar and bank grill-work, ornamental doors, and ecclesiastical vessels and adornments.

The foundry producing castings to comply with a customer's specifications can proceed in one of two ways: It can make its own alloys by melting the required constituents of the composition; or it can procure the specification alloy in ingot form from a metal producer. Both of these practices are resorted to by most foundry operators. However, less alloy loss is experienced on small volume production when prepared ingot is melted. The practice of procuring already prepared ingot is especially recommended for the smaller foundry operator, since accurate alloying in a crucible requires close attention to weights of ingredients and the special technique of introducing additional ingredients at proper intervals and at correct temperatures.

This latter recommendation should apply only when a small tonnage of castings is made intermittently. Where an alloy is being utilized in reasonably large quantities, it is presumed that a foundry operator will have acquired the necessary amount of experience melting the initial crucible of alloy to repeat the operation satisfactorily during subsequent meltings.

By producing his own alloy for large tonnage runs, the foundry operator should accrue to himself the profit which a metal vendor would require for his services.

ALUMINUM AND MAGNESIUM ALLOYS

Aluminum alloy castings and, to a lesser extent, magnesium alloy castings are being produced throughout the world at increasing volumes. The foundry facilities required to produce bronze and brass castings may be utilized to manufacture cast aluminum and magnesium objects of various sizes and alloys. As in the case of bronze and brass, standard specifications have already been published covering a wide range of aluminum and magnesium alloys, and literature is available dealing with every phase of the process.

So closely allied has become the processes and methods associated with the production of copper-base and aluminun-base alloys that at times some alloys fall simultaneously into both a copper-base and an aluminum-base category; for instance, aluminum-bronze, a product quite widely used because of its anti-magnetic properties, may have either an aluminum or copper predominating content.

During the present generation, aluminum has acquired a noteworth scope of usefulness, chiefly because of its weight-strength ratio, high thermal conductivity, and its anti-corrosion properties. Thermal conductivity is high for a wide range of aluminum alloys. This fact is reflected in the use of these alloys for food processing equipment and for such parts as pistons and cylinder heads for internal combustion engines.

Where parts are subjected to strains due to subnormal temperatures, aluminum alloy castings display admirable mechanical properties, in many instances superior to those of any other metal. Consequently, aluminum-base alloys are replacing materials which are susceptible to low-temperature embrittlement.

The three distinguishing properties that are combined in magnesium are low specific gravity, a hexagonal lattice in structure and the fact that it is anodic to all other common metals. Aluminum is the chief alloying element used, followed by zinc and manganese. Because of its low specific gravity, it is the lightest of all known structural and engineering metals.

Processing and production machinery possessing rapidly rotating or reciprocating parts - certain textile machines, for example - utilize manganese alloy castings to good advantage. Hand tools, portable electric drills and saws, foundry flasks and bottom boards and many domestic utensils are notable applications for this lightweight alloy.

As in the case of copper-base alloys, both aluminum-base and magnesium-base alloys have been developed for a wide range of applications, and a voluminous amount of technical data, together with a wide selection of standard specifications, are avaiable. When only a small amount of an aluminum or magnesium alloy is needed, it may be procured from metal refiners in ingot form. In instances where a specific alloy is required in large quantities, it should be to the foundry operator's profit to produce the alloy.

GENERAL ASSUMPTIONS

In order to make realistic estimates in this manual, certain assumptions are made. These are:

1. The costs of the building and general facilities are based on United States prices.

2. Material costs are based on sizes and specifications of materials used in the United States.

3. Labor costs are based on the average for the industry as recently published by the United States Bureau of Labor.

4. Adequate power and water are available at the plant site.

5. Adequate transportation facilities are available at the plant site.

6. The plant operates eight hours a day, five days a week, and fifty weeks per year.

7. No special provision is made for the training of new personnel. It is assumed that learner's rates are paid in such cases.

8. The following items cannot be estimated realistically:

   A. Land value
   B. Distribution and selling costs
   C. In-freight and out-freight
   D. Taxes

   While general estimates will be made of each of these items, for the purpose of completing cost estimates, adjustment should be made in accordance with actual local costs.

   In fact, all cost estimates contained in this report should be adjusted to conform to local conditions.

9. Columns are provided in the tables included in this report to facilitate the conversion of cost figures to conform with local costs.

MANUFACTURING PROCESS

The manufacturing process consists essentially of these steps:

1. Use of Patterns
2. Cores and Core Boxes
3. Molding
4. Melting and Pouring
5. Cleaning

Use of Patterns

Since the art of metal casting is one of great antiquity, it is to be expected that the art of pattern making has followed metal casting advancement to a degree where the fundamentals of pattern design are well understood. Qualified pattern makers are versed in such matters as proper filleting and ribbing, provision for adequate draft, correct location of parting lines, shrinkage allowances and, when occasions warrant their use, construction of suitable match plates and mounted patterns.

Pattern making is a trade in itself, and enterprises have been established which restrict their services exclusively to producing, with the use of engineering drawings, wood or metal patterns ready for use. In some instances, jobbing foundries employ qualified pattern makers as an additional service to their customers, but more frequently a customer provides the foundry with the necessary pattern equipment. Generally, customers prefer to own their pattern equipment so that, when occasions require doing so, they are free to transfer this equipment from one foundry to another.

However, when a customer owns the pattern equipment, a foundry operator should carefully examine this equipment before estimating the cost of foundry work to be sure that the equipment may be properlyutilized, and to determine what the cost will be to either modify the patterns or perform the necessary amount of repair work to restore previously used patterns to a usable condition.

By this preliminary examination of the patterns, a foundry operator may more exactly estimate what his molding cost is apt to be. Frequently, in an endeavor to reduce the cost of making patterns, the kind of patterns produced may be such as to increase the cost of handling in a foundry, or to increase the cost of molding, or the cleaning of the finished castings. The latter feature applies expecially when the pattern equipment comprises a quantity of core boxes, or boxes and patterns that are intricate.

It is always advisable for the foundry operator to remember that, if he is requested to estimate the cost of a foundry job using pattern equipment that has not been previously used, he should allow a factor in his estimate to defray whatever additional expense might be occasioned by experimental efforts.

Even with patterns made by experts, it sometimes happens that, during the initial use of the equipment, defects in design develop which require modifications of the patterns; or it may be that the first run of castings may prove to be defective, with its consequent added expense to the foundry operator.

Patterns used to produce medium and large sized castings are usually of the single unit type. Whenever a large quantity of small castings

are required, "gated" patterns are employed. These patterns consist of either a "tree" of individual patterns held together by a connecting area which leaves a void in the mold through which the hot liquid metal runs to fill each casting cavity, or individual patterns securely mounted on a matchplate, making it possible to make a mold cope and drag separately with the assurance that, when the pattern is withdrawn, the two halves of the cavity will match perfectly, thus restricting the area of the parting line and thereby preventing the occurence of malformed castings.

Ordinarily it does not require much additional time to mold a tree or plate of patterns numbering as many as 18 units than it does to mold a single pattern; hence, the molding labor cost per unit is reduced with the gated type of pattern equipment.

Cores and Core Boxes

Core design, and the manner of setting and supporting cores in the molds, are features worthy of careful attention. Proper design of the core boxes is the initial step taken to insure that cores may be ruggedly made to withstand handling and that they can be employed to the best advantage within the molds. When chaplets are necessary to support cores and to prevent their shifting within molds, care should be exercised toward selecting a proper shape and size.

Likewise, whenever chills are required to equalize the cooling rate, care should be exercised in their selection and use, for the tendency of molders is toward an excessive use of such devices. Core chaplets can be obtained in about every conceivable shape and size, and they are usually made of a material that fuses into the casting.

Another means of supporting cores in a mold, which is usually followed whenever possible, is that of adding core prints to a pattern. A core print forms an imprint, or depression, in the sand mold of a shape and size corresponding to the supporting area of a core. Core prints serve the dual purpose of providing core support and vents for gas escapement. The matter of using core prints or chaplets to support cores is usually left to the judgment of a pattern maker.

Cores are used to form the desired depressions, recesses and contours in castings. They may be broadly classified as green-sand or dry-sand cores, depending on the material used to make them. Green-sand cores are made from the same molding sand as that used in the mold; therefore, in most instances, they are an integral part of the mold. Consequently, green-sand cores are

the most economical kind to use, since they require no additionsl materials or processing, and since the material of which they are made is re-usable and may be returned to the sand system to be utilized in the same way that molding sand is re-used.

Dry-sand cores are made from a different kind of material and by a process different from that involved in green-sand cores. Dry-sand cores are composed of types of sharp sand mixed with binding materials selected on thebasis of their imparting desirable mechanical properties to the core. The core mixture is molded in a core box, usually by hand ramming, and after the surplus material is struck off, the core is removed from the core bos and placed on a "core dryer." Where one surface of a core is flat, a steel plate suffices as a core dryer, but when there are no flat surfaces, then a piece of sheet steel is formed to fit the contour of a core.

The next operation consists of placing the core dryer supporting the newly molded core into an oven for baking. Core ovens need be only a simple sheet sttel cabinet containing slat-type shelves, suitable combustion equipment, a thermometer, and an adequate flue system to conduct fumes out of the building. Experience, very largely, is relied on concerning both the degree of temperature and the length of time required to properly bake the cores, the baking process merely being that of carbonizing the oil, dextrin, molasses and lignins used in the sand mixture, to form a rigid structure.

Cores are baked at varying temperatures, depending upon the core binders used and the size of the cores. Ovens may be fired by coal, wood, gas, oil, or electricity, whichever is the cheapest fuel available locally.

Cores frequently require the use of metal rods or wires for reinforcement to impart the necessary strength to resist the pressures developed by the molten metal filling the mold. Experience dictates that extent to which such reinforcing agents may be necessary, but, here again, the tendency on the part of foundry workmen is to utilize reinforcing materials to an excess, resulting in the consumption of an unnecessary amount of material and labor.

Molding

Metal castings are produced from sand molds, principally because of the versatility and economy of this method. There is no other method for shaping metal that offers as much latitude and freedom of expression to the engineering designer.

Molding consists of making the form into which hot liquid metal is poured to cool and thus to be cast into a desired shape. The most common type is sand molding, in which the sand is used either in a "green" or moist state, or in a dry condition. Mass production foundries utilize a variety of casting methods, such as the use of permanent molds, the shell-molding technique, one of a variety of investment casting methods, and the centrifugal casting process, all of which are somewhat intricate advancements in the art of molding especially applicable to mass production requirements.

Green sand molding consists of using a moist mixture of refractory sand which is rammed or squeezed into a foundry flask around a pattern. The following page contains illustrations of foundry flasks most generally used.

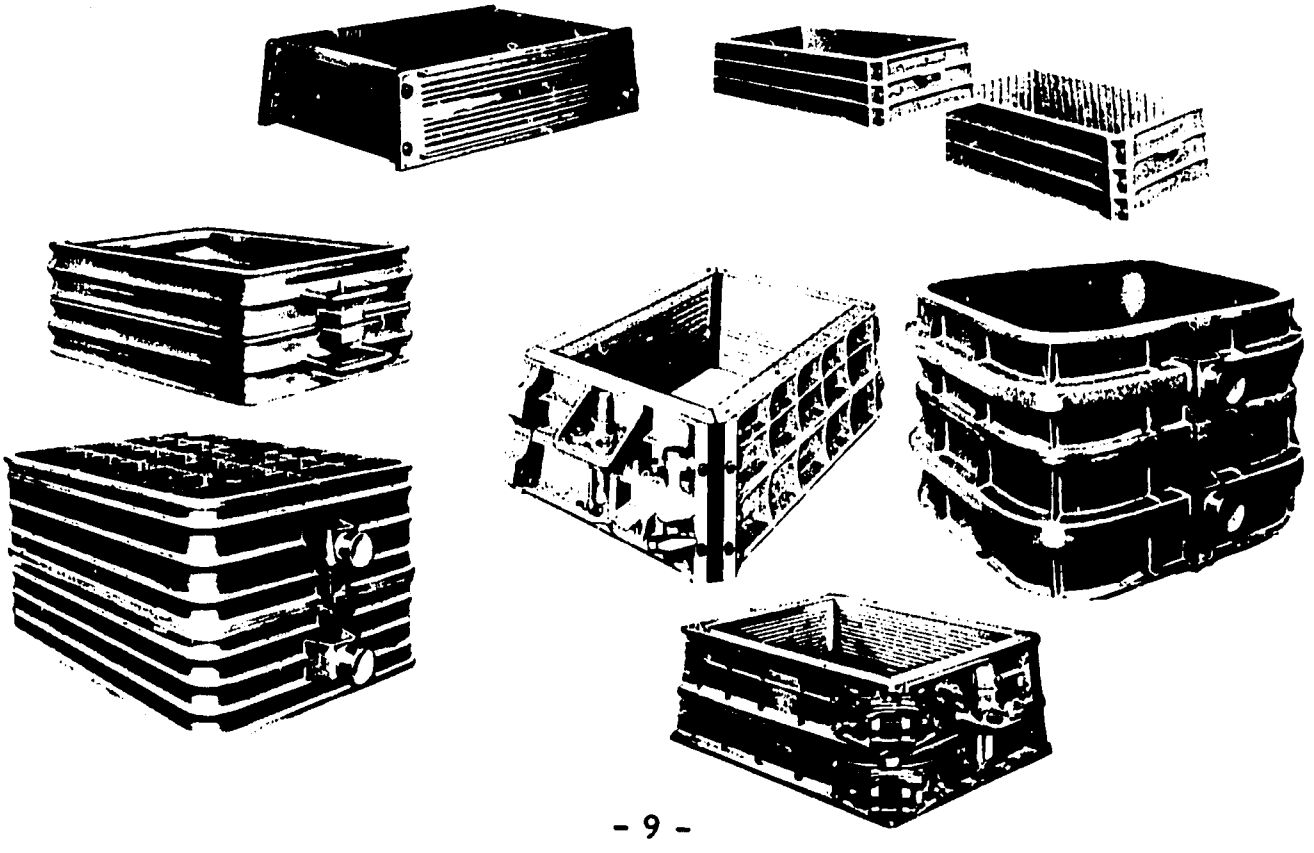
Specifically, the molder carefully packs the sand around the pattern, then he cuts the pouring holes (sprues) and grooves (gates) to act as paths for the molten metal to flow into the cavity of the mold; the holes (risers) which become the medium to insure that the mold can be filled completely; and then he punches additional wire-size holes (vents) to allow for the escape of gas and steam.

When the molding operation has been accomplished, the pattern is withdrawn from the sand, thus leaving a void of the shape it is intended that the final casting should be. Before putting the upper (cope) and the lower (drag) of the flask together, the molder carefully repairs any damage done to the mold when he withdrew the pattern; and when there are any hollow apertures in the casting, the molder sets the necessary cores in place to produce these.

Normally, in a production operation, a molder prepares flasks about five hours per day and spends the balance of the day pouring. This keeps the responsibility of good castings in the hands of one individual in an effort to control defective work. In a nonferrous job foundry, melting and pouring operations may be conducted throughout the day; therefore, a separate crew is usually employed to pour the metal, thus allowing molders to confine their work to the preparation of molds.

Molders closing a mold - showing cores in place in mold.

Miscellaneous types of flasks



Dry sand molding consists merely of drying a green sand mold before the pouring operation takes place. This method is employed chiefly when it is necessary to preserve smooth and accurate contours. By "dusting" a green sand mold with finely pulverized facing materials before a mold is dried, it is possible to produce slick skin surfaces on castings, which kind of surface minimizes the amount of cleaning time necessary.

Sand casting makes it possible to produce a large number of castings from a pattern, the quantity being limited only by the life of a pattern. Molds may be made by manual or machine methods. The manual method consists of shovelling the required amount of sand into a foundry flask, and by the use of suitable hand tools, ramming the sand firmly into place, then striking off the surplus sand to insure a level surface on both the top and bottom of the mold.

There is a variety of molding machines made which essentially provide a power means of compressing sand into a flask around a pattern. The sand compressing operation is sometimes achieved by mechanical means or by the force exerted by pneumatic or hydraulic pressure. Machine molding is capable of producing a greater output than is usually possible by manual molding methods, chiefly for the reason that human energy is not repeatedly required to perform the laborious task of ramming the sand.

Molds for small or gated patterns are usually made on a bench of a suitable surface height to suit the physical stature of the individual molder. Relatively larger molds are made on the floor of the foundry, while molds of extreme size and weight, such as ship propellers, are made in a pit. Both of the latter methods make it possible to utilize the services of two or more molders as a crew; and in the case of pit molding, it is possible to submerge the mold sufficiently below the foundry floor grade to permit convenient mold construction, as well as to provide for accessibility in pouring the casting and in controlling the cycle of cooling.

The gating system employed in molding essentially serves the purpose of providing channels through which molten metal from the ladle may flow to every part of a void in a mold, as well as to provide suitable passages for the escapement of gases generated within the mold at the time of pouring. Gating, together with the risers, also perform the important function of providing suitable head pressures.

Since the molding is a process dating from antiquity, and because its development has been shared by many nations, there is an absence of standardized terminology covering the subject; therefore, there is no assurance that the nomenclature used by one nation of foundry men is accorded general acceptance throughout the world. It is therefore necessary for some to devise their own definitions of terms to understand the functions of such items as gates, sprues, and risers.

The most simple gating system is the one where metal is poured through a vertical opening that leads directly to the mold cavity, the opening being called either a sprue or a riser, depending upon the details of its functioning and upon local terminology. The more generally used gating system is designed to lead the molten metal into the side, rather than from the top of the mold cavity. In some types of castings, the molten metal is introduced into the mold cavity at the bottom.

Sprues may be of circular, oval, square, or oblong shape. However, a square shape tends to reduce the amount of turbulence when pouring, thereby eliminating one source of the inclusion of oxides in the metal stream; and the square design is preferable for use when casting nonferrous metals, particularly those bearing bronze, light brass and aluminum.

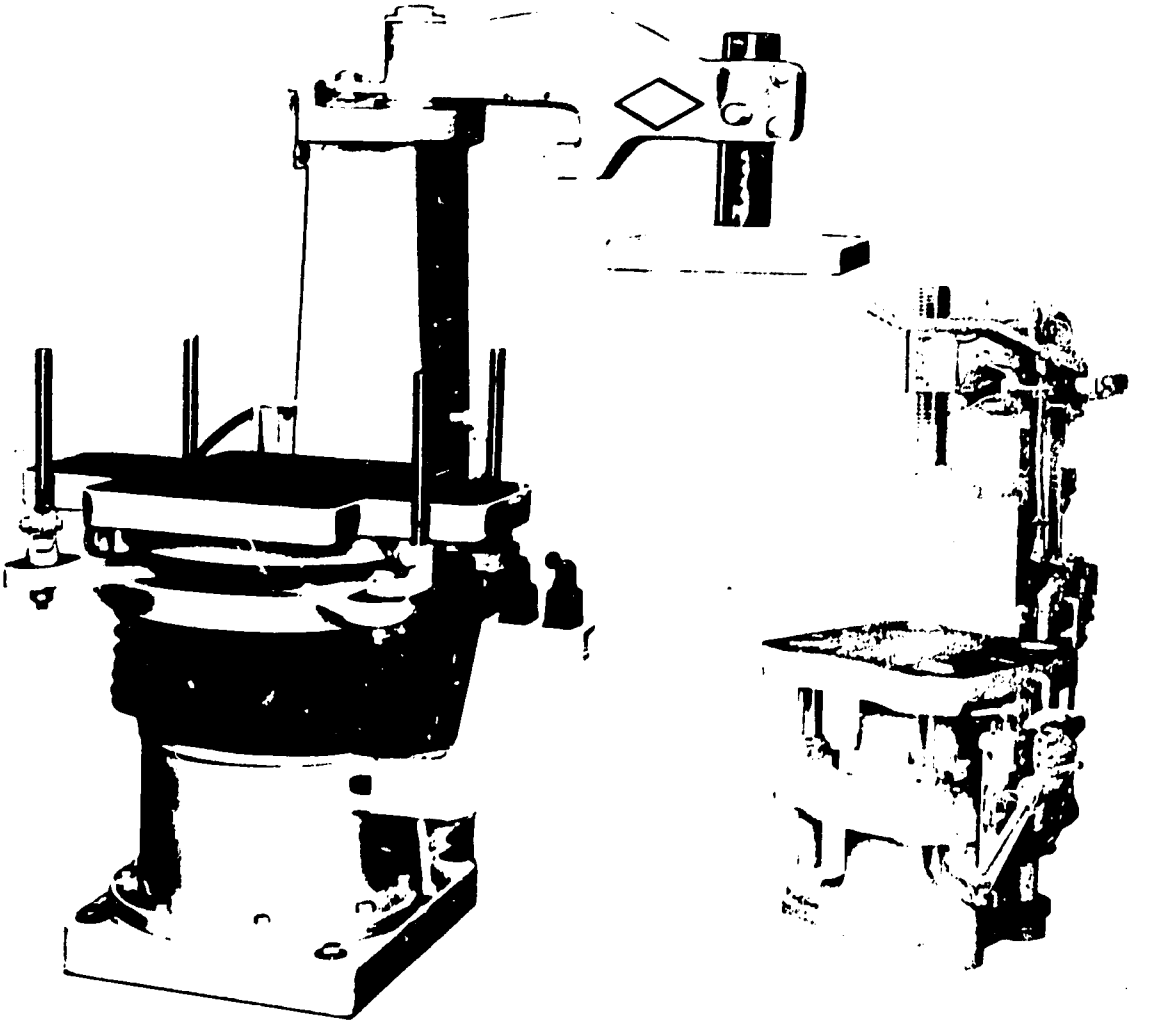
Care should be exercised when determining the cross-sectional area of sprues and risers to maintain a satisfactory ratio between the weight of the sprue and the casting itself. The tendency of molders is to provide themselves with only a few sizes of sprue cutters, resulting in using one so large that the weight of the sprue may equal or exceed the weight of a casting.

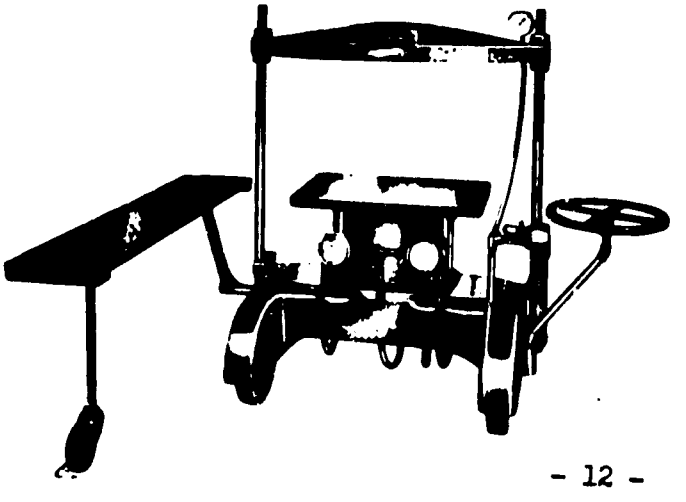
Sand is a basic foundry material. It is ued, in some form, in every foundry activity from core making to molding to cleaning, and these diverse applications require a variety of physical, as well as mechanical, properties. Foundry sands include such materials as pit sand, beach sand, sharp sand, blended sand, and refractory clays.

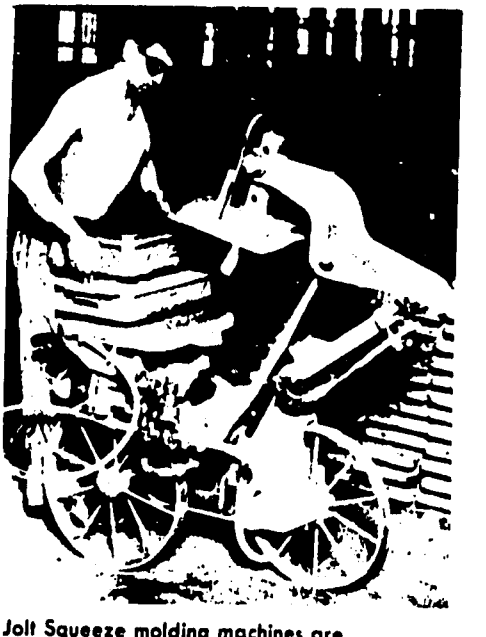
The investment material used in molding is a naturally bonded sand which, in many instances, may be used in the condition in which it is mined. This material is "tempered" by the introduction of water to impart sufficient moisture to give the sand the desirable degree of plasticity, and when sand, as received, lacks certain essential properties, additives may be used to blend the mixture. A considerable amount of research has been conducted which has lead to the establishment of standards to be used as a basis for the selection of the proper blend or mixture for specific applications. The Foundry Sand Handbook published by the American Foundrymen's Society, deals fully with this matter.

It is always well to remember that when the moisture condition of the investment sand is excessive, high pressure steam may be generated at the time of pouring the melt, which is apt to cause blow-holes and rough surface castings, and increase the liability of porosity. Too low a moisture content results in improper dry bond strength which may cause cuts, washes, and dirty castings. Proper moisture content is therefore important.

TYPES OF MOLDING MACHINERY AND SQUEEZERS

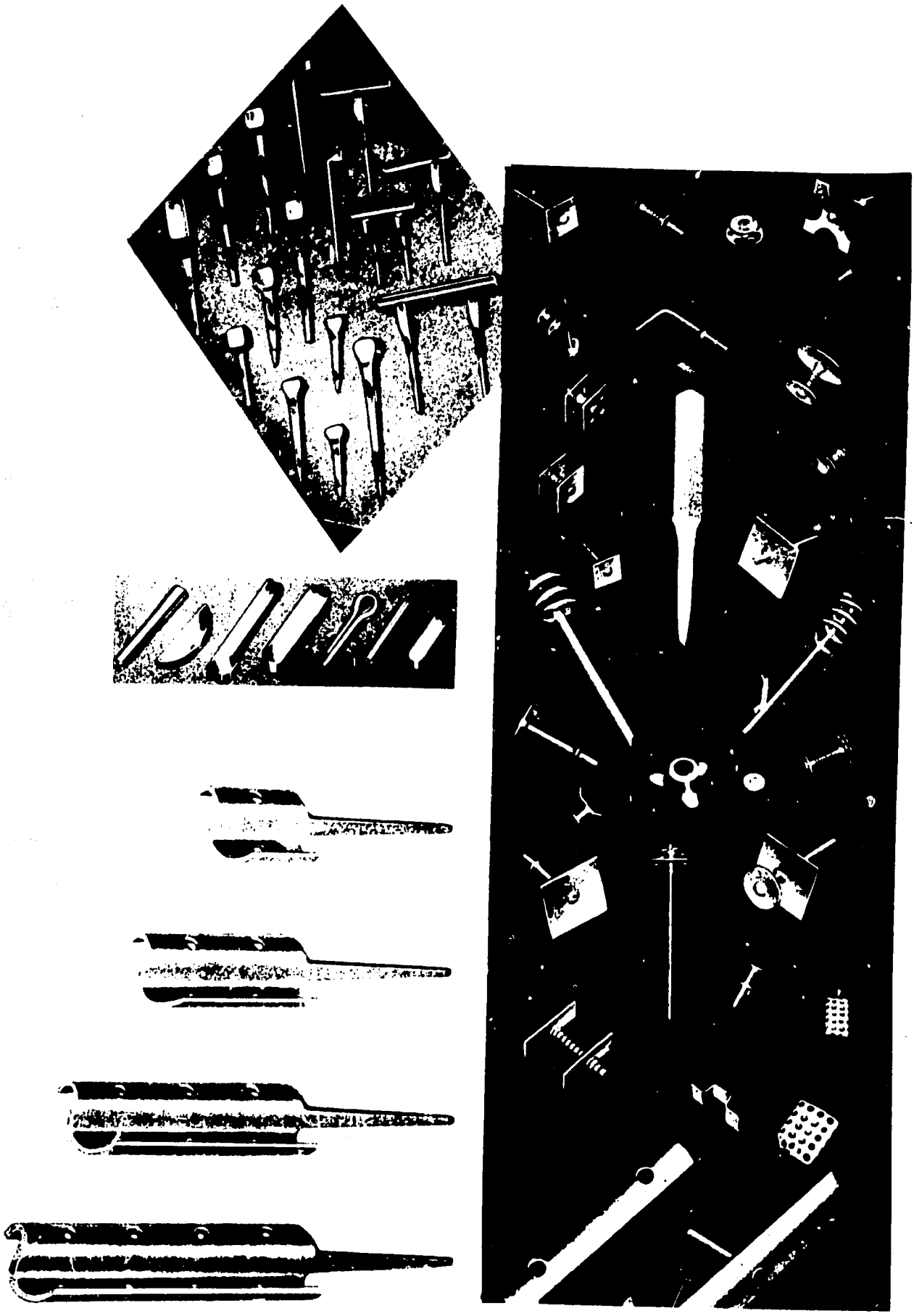






Jolt Squeeze molding machines are with wheels or pedestal base.

VARIOUS TYPES OF CHILLS AND CHAPLETS



Clay materials are prevalent in sufficient volume in most naturally bonded molding sands to work satisfactorily in their as-received condition. However, when sand undergoes the casting cycle, some portion of the bonding elements may be affected adversely by high temperatures; they may become vitrified or burned out, so that they no longer possess adequate bonding properties. When this condition is encountered, bonding clay may be mullered into the investment material in sufficient quantity to restore the mixture to a usable condition.

Where problems arise that demand high dry strength bonds, cereal binders, such as corn flour, may be mullered into the mixture; and when extremely high bond strength is required, Portland cement may be used. Such additions exert a profound effect by increasing the hot strength of the sand, and at the same time making the sand more workable during the molding operation.

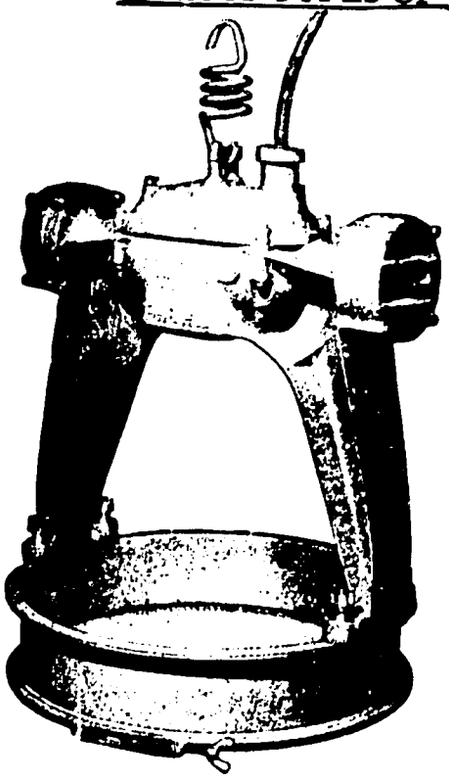
Facing sand, the sand used against, or for dusting, the pattern, is usually a specially prepared sea coal used to insure a clean and smooth surface on the casting. This material also functions in a manner to generate a reducing-type of gas when exposed to casting temperatures, which not only improves the skin portion of castings, but also acts as a thermal conductor to accelerate the rate of cooling.

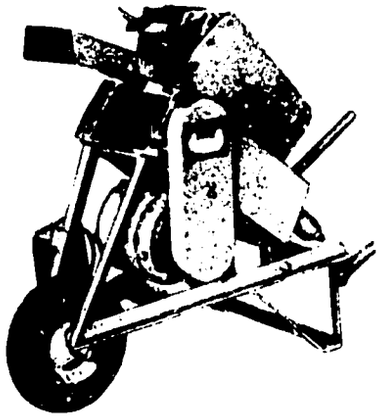
System sand, i.e., the backing sand or investment material used to make up the bulk of a mold, may be "conditioned" by the utilization of simple or relatively elaborate mulling equipment; or the conditioning operation may be accomplished by the "cutting" process. This latter process consists of heaping the system sand in knee-high drifts along the foundry floor and sprinkling these drifts with the necessary quantity of water to moisten the surface of the sand particles. While the sand is still in the heaped condition, additional ingredients, such as clay or cereal binders, may be necessary to restore the sand to usable condition and can be scattered along the drifts.

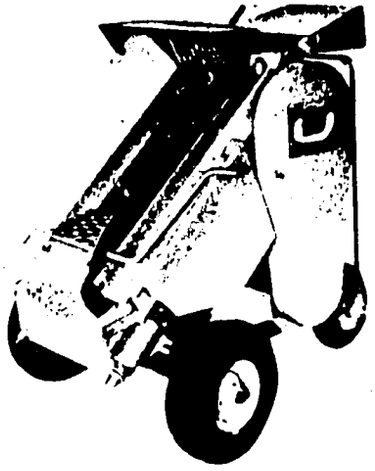
Following this, either by manual shovelling or by the utilization of a power-driven sand cutter, the material in the drifts is "turned over," i.e., the material is thoroughly mixed. This operation should be done sufficiently ahead of time to allow the drifts to be left undisturbed for at least four hours before the sand is used by the molders in order to insure that the mixture is properly "tempered."

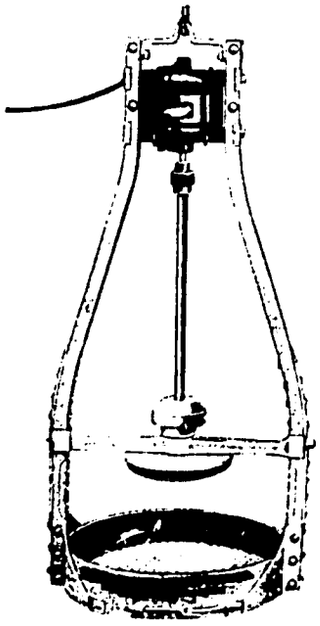
Core sand is usually free of, or low in, natural bond, and consequently it has to be mixed with a "binder." Binders consist of linseed oil, molasses, dextrin, lignins, and mineral oil. There are certain essential requirements for a satisfactory core binder.

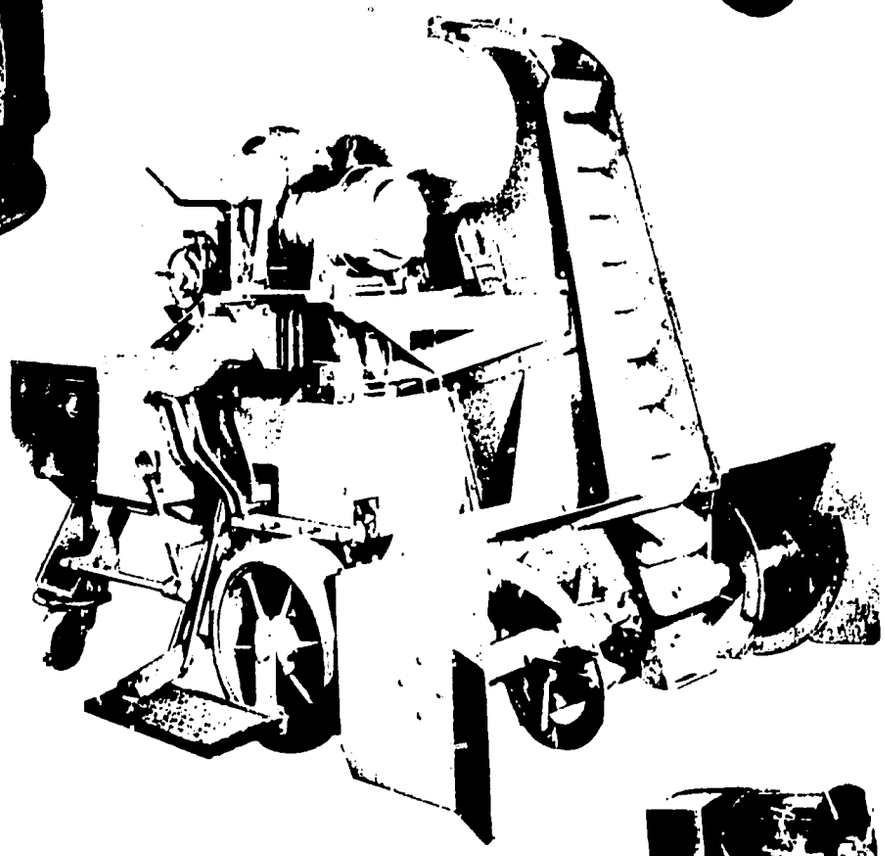
VARIOUS TYPES OF SAND CONDITIONING EQUIPMENT

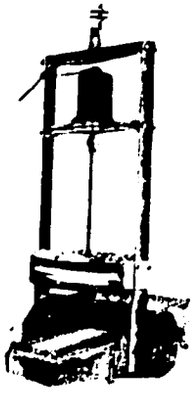


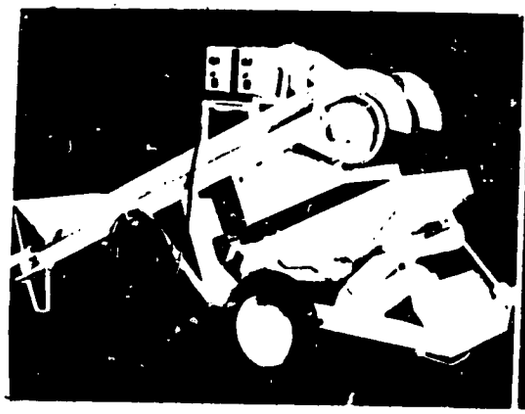


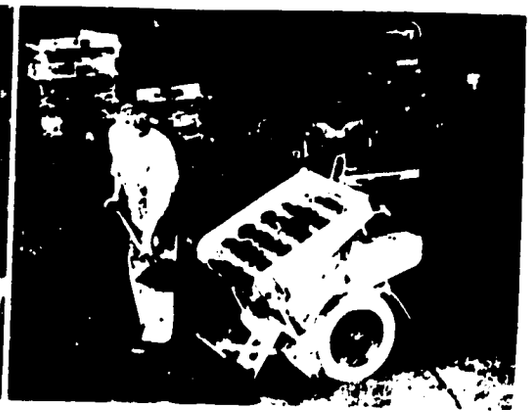












It should:

(a) be capable of holding the core to shape while "green";

(b) impart sufficient mechanical strength to withstand casting conditions;

(c) generate a minimum amount of gas during casting;

(d) cause the baked core to be nonhygroscopic;

(e) afford sufficient strength to withstand necessary handling;

(f) burn out for easy removal from the casting.

A jobbing foundry rarely ever finds it necessary to use more than one standard formula to produce a satisfactory core material; therefore, when a satisfactory mixture has once been devised, further experimentation seldom becomes necessary.

Unlike molding sand, core sand is not recoverable for re-use. When used core material is removed from finished castings, it should be thrown away.

Cleaning sand may consist of any flinty abrasive material, with a grain size depending upon whether it is used in connection with blast guns or in tumbling barrels. Some natural beach sands, or find sharp river bed gravel, is suitable for most cleaning work, provided the sand, or gravel, is kept clean and free of dust and metal particles.

Melting and Pouring

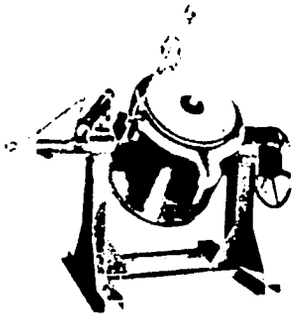
The function of the melt shop is to produce the necessary molten metal in a suitable condition, of the proper alloy, and in sufficient quantity. Many melting operations include some type of alloying for analysis adjustment, applied either during the actual melting in a crucible, or by subsequent ladle treatment.

Regardless of the type of furnace or fuel used, the fundamental of converting the potential energy of the fuel into heat units effective for melting is of primary importance. Transferring heat units into metal in order to bring about its fusion is the basis of foundry melting.

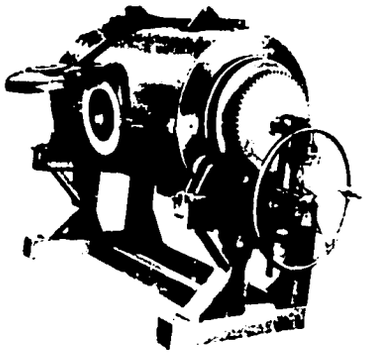
Nonferrous metals are usually poured in small volume castings, with the result that melting equipment is generally of the indirect flame type containing a crucible.

Nonferrous Melting and Holding Furnaces

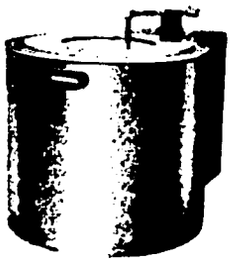
Stationary crucible furnace used for general melting requirements. Available in capacities of from 30 to 400 pounds. Obtainable equipped to utilize either gas or oil as fuel. Crucible removable.



Hand-tilt crucible furnace used for general melting requirements. Has nonremovable pouring lip crucible. Obtainable in capacities of from 50 to 400 pounds, either gas or oil fired.



Rotary open-flame furnace. Obtainable in capacities for 2,400 pounds of aluminum or 6,000 pounds of copper-base alloys. Either gas or oil fired.



Electric resistence furnace. Gives uniform distribution and control of heat. Removable or stationary crucibles. Capacity from 250 to 1,000 pounds of copper-base alloy.

A crucible furnace usually consists of a cylindrical steel shell having a rammed or bricked lining. It may consist of a single unit or it may be a dual, triplicate or quadruplicate arrangement. Each furnace has a separate cover faced with refractory material designed to be either tilted, lifted, or swung, to afford access to the crucible.

Heat is supplied through burners using either gas or oil by a separate combustion furnace when solid fuels are used, or by radiant heating elements when electricity is used.

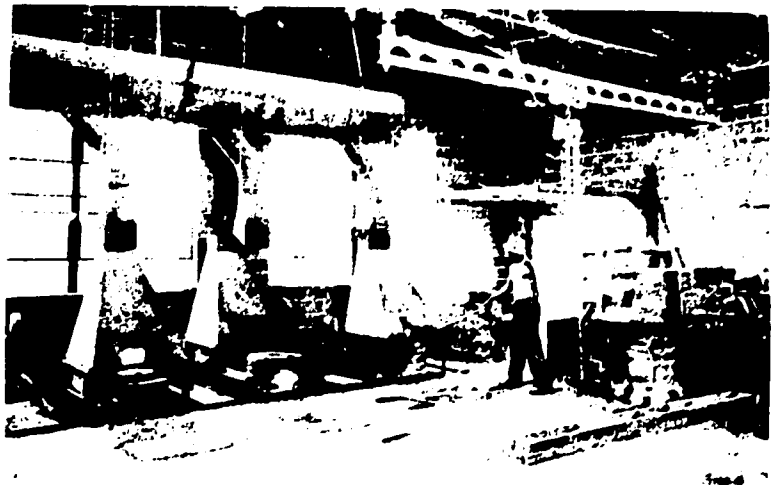
Furnaces are made for tilting on trunnions, or they may be stationary, in which case the crucible must be lifted out of the furnace. Stationary furnaces are usually installed in a pit sufficiently deep so that the level of the top of the furnace is at a convenient height above the floor grade. The pit should be of dimensions that afford accessibility to the combustion appliances, and the floor area between the crucible furnace and the walls of the pit should consist of substantial grill flooring.

When a large melting capacity is required for copper-base alloys, some form of tilting or reverberating furnace may be used. Crucibles are not used in tilting furnaces; instead the cold metal is deposited directly into the furnace where it is subjected to the action of a direct flame. Where the melting facilities of a foundry do not include sufficient ordinary furnace capacity to melt enough metal to cast large items like a ship's propeller, a furnace of the open-flame type may be constructed.

By exercising care in the introduction of ingredients and by properly regulating temperature, it is possible to control the melting process in this type of furnace to exactly provide specification metal.

Where the bulk of the foundry volume consists of heavy castings and where low-cost electrical energy is available, a rocking-type arc furnace may be utilized to advantage. Melting cost with a furnace of this type usually is very low, chiefly for the reason that conduction of heat to the furnace surroundings is greatly restricted, and because the furnace remains in heat for the entire duration of a day's operation.

This type of arc furnace may be designed to prevent the arc impinging directly on the charge, thereby preventing carbon pick-up by the melt from the electrodes. Another outstanding feature of this type is that the rocking action of the furnace continually agitates the molten bath, thereby promoting homogeneity. The rocking motion may be controlled automatically over a wide range of oscillations, making it possible to melt not only all copper-base alloys, but also the nickel alloys.



Well arranged three furnace melting setup. These furnaces are fired with coke and are equipped with automatic air blast control.

Tilting electric furnace suitable for small melts of special alloys

Typical three furnace arrangement. These furnaces use natural gas for fuel.

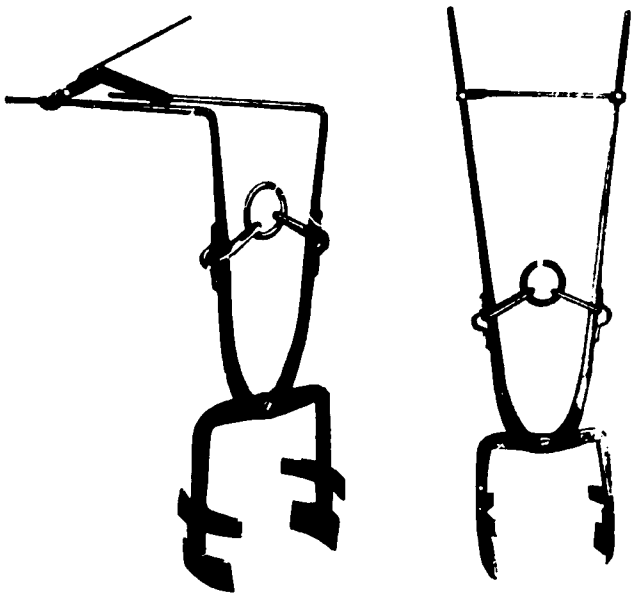
Where the foundry output is extremely great, the induction type will produce at low melting cost, and the process is one which will insure melts entirely free of contamination. Every phase of the melting cycle may be automatically controlled with an induction furnace. There are several American, German, and French manufacturers of this type of furnace, and capacities available may range from a few hundredweight to several tons per charge.

Fuels most generally used in foundry melting furnaces, together with their calorific values expressed in Btu., are as follows:

Fuel	Average Gross Calorific Value -- Btu.	Unit
Coke	13,000	pound
Natural gas	950	cubic foot
Coal gas	500	cubic foot
Fuel oil	140,000	gallon
Electricity	3,415	kilowatt hour

To conserve radiation losses and to reduce deterioration of furnace linings, it is necessary to provide an adequate amount of furnace insulation. While the proper amount of insulation may add to the initial cost of a furnace, it should be remembered that heat radiating losses continue for the life of a furnace. Quite likely during the first few months of operation, fuel loss due to poor insulation will amount to more than an initial investment for an adequate insulation. Moreover, when fuel consumption is excessive, the melting cycle time is usually lengthened.

Crucibles are refractory containers, somewhat barrel-shaped, open at the top where the pouring lip is located. They may be procured from many manufacturers and are made of a mixture of fire-clay and graphite. Since crucibles are susceptible to moisture pick-up, they should be heated slowly and long enough to drive off absorbed moisture prior to their use in a furnace. Pouring ladles likewise are made of refractory materials and should be well dried before hot metal is poured into them.

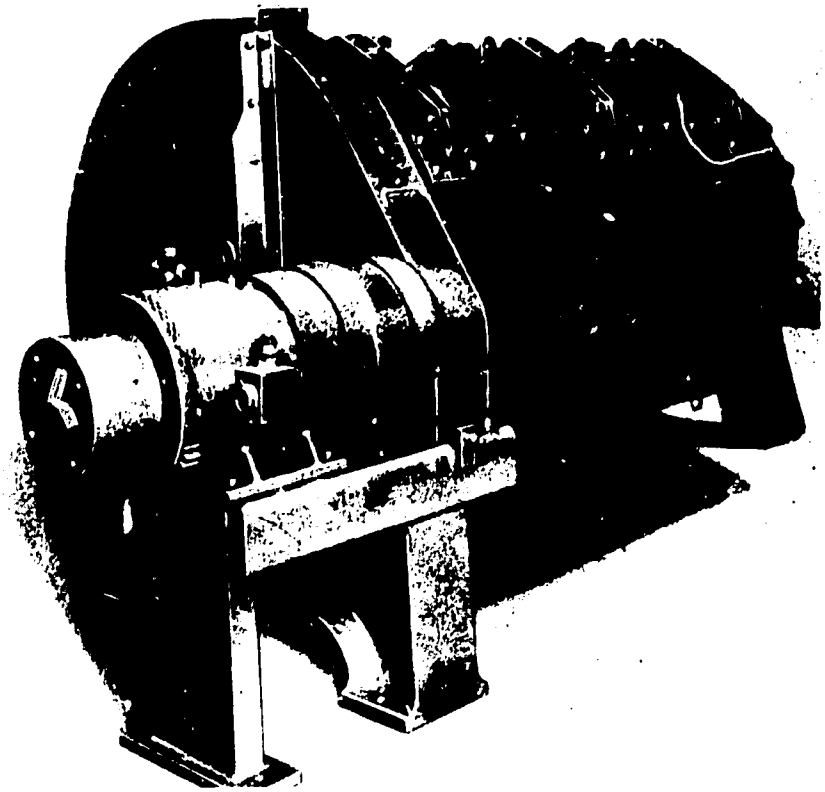


Two styles of crucible tongs

Pouring ladle with double-end ladle shank

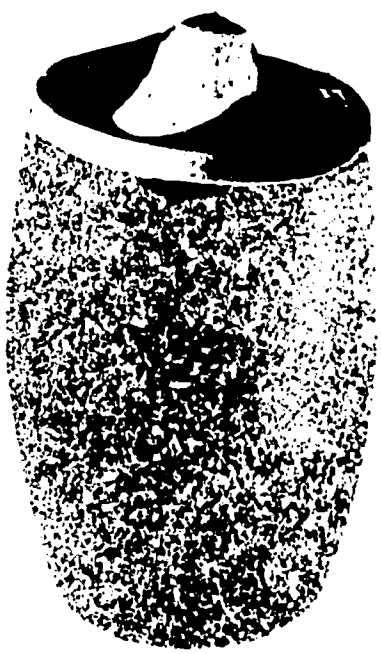
Single-end bull ladle shank

Double-end bull ladle shank

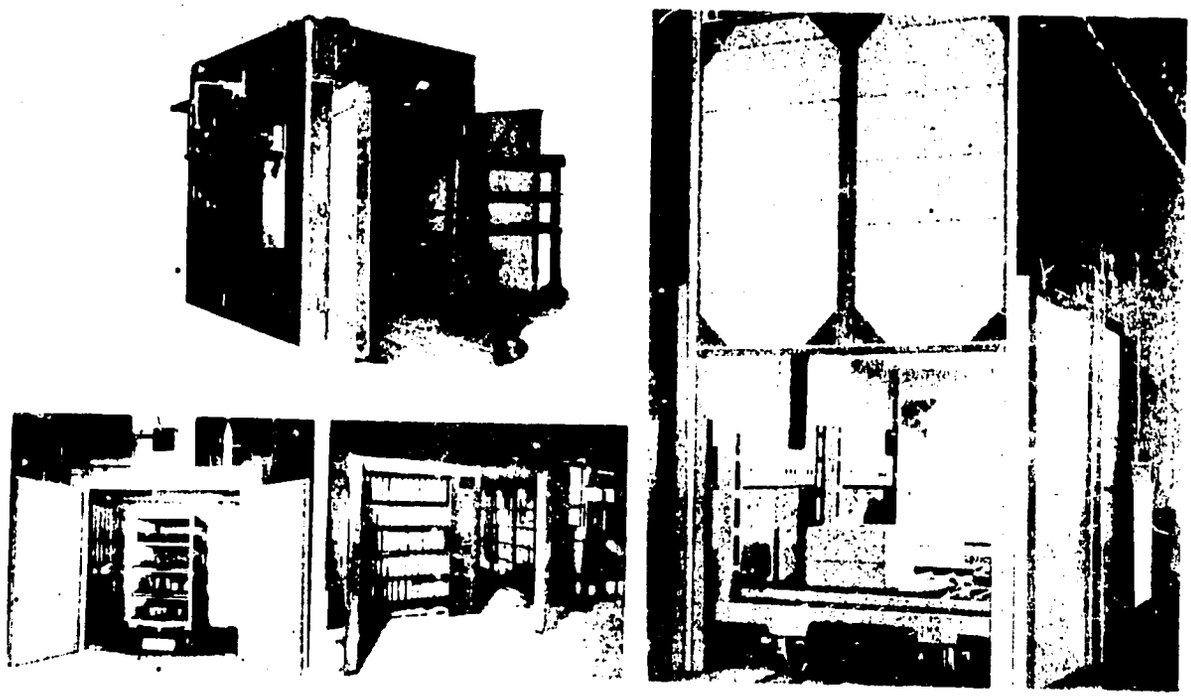


Rotary tumbling barrel equipped with direct motor drive and speed-changing device.

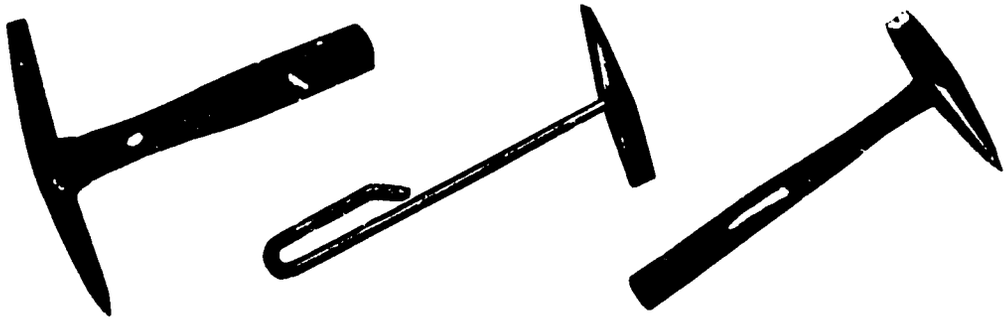
Tilting furnace lip crucible.



Furnace crucible with cover.



Modern Types of Core Ovens



Cleaning Hammers

Surface Pyrometer

Optical Pyrometer

Immersion Pyrometer

Instruments For Precision Temperature Measurement

Cleaning Castings

Usually the cleaning crew's function commences with the removal of castings from the broken-open molds on the pouring floor. The castings are retrieved from the sand, usually with the larger sections of the cores intact, and, by wheelbarrow, the castings are conveyed to an area of the foundry reserved for cleaning purposes.

Here the core material is removed, and the sprues, gates, risers and much of the flash and fin metal are broken off by blows of a heavy cross-peen hammer. The flashing is further removed by using a cold-chisel, after which the chiseled portion of the casting is ground by using a suitable abrasive wheel.

A wire scratch-brush, either of the hand type or electrically driven, is used to remove adhering sand, or the castings are "tumbled." This latter operation consists of putting castings into a steel shell cylindrical device which slowly rotates. Coarse sharp sand, small particle-size washed river bed gravel, and bits of metal are put into the tumbling barrel along with the casting.

When the castings are freed of adhering sand, they are removed from the tumbler; core wires are extracted, and unwanted surface projections are ground off. At this stage the castings are usually ready for delivery to the customer.

FOUNDRY PROCESS

Reviewing the above text briefly, a nonferrous alloy foundry process consists of the following steps:

(a) Core and investment mixtures are prepared for use by core makers and molders.

(b) Cores are made and baked, then delivered to the molding floor.

(c) Using pattern equipment, molders make up the number of flasks that may be needed to produce the number of individual castings required.

(d) The melting crew weights out the required amounts of ingredients to obtain the desired amounts of an alloy specified by the customer. Each batch of ingredients is placed into a crucible and is melted.

(e) When the heat is ready for pouring, the melting crew withdraws the crucible from the furnace, adds any scavenging materials necessary, then stirs and skims the molten metal to remove the dross, using the pyrometer to insure that the metal is of the correct temperature for pouring.

(f) The hot metal may be taken directly to the pouring floor in the furnace crucible, or it may be poured into smaller ladles for "hand" pouring.

(g) Flask weights are used while pouring hot metal into molds, these weights being shifted from a poured to an unpoured mold while the pouring operation goes on.

(h) After the molds have cooled sufficiently to solidify the castings, the molds are "broken," to accelerate cooling.

(i) When castings are cool enough to handle, the shake-out crew separates them from the molding sand and removes them to the cleaning room, where sprues, gates and risers are broken off, and where cores are removed, after which the castings go through the cleaning operation.

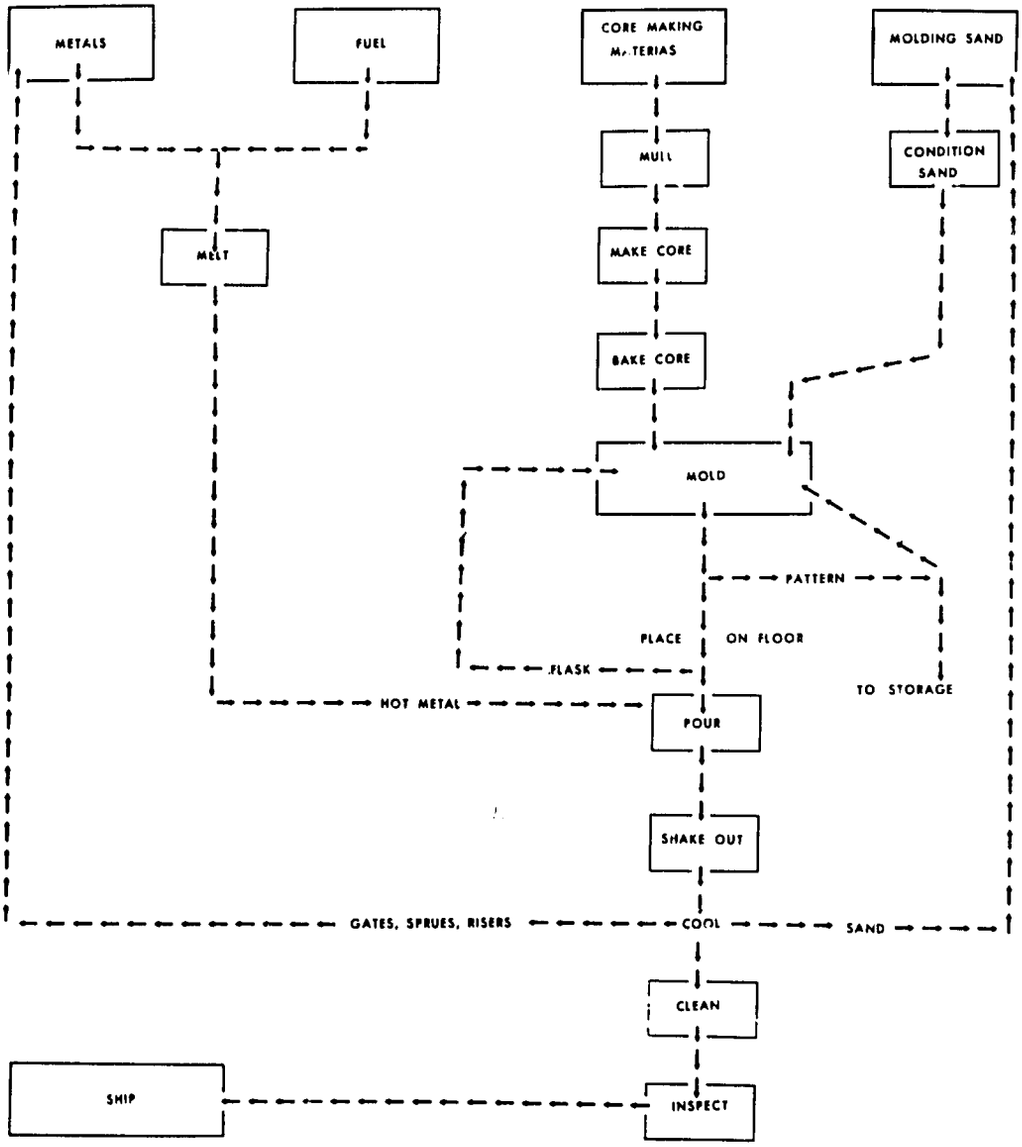
(j) As soon as all the castings have been removed from the foundry, the shake-out crew, by the use of a lawn sprinkling can or hose, moistens down the system sand which is still hot, after which the crew piles the sand into drifts along the molding floor. Later on, the crew adds the necessary amount of restorative ingredients to the sand, moistens it sufficiently, then performs the "cutting" operation, which consists of thoroughly mixing the investment material.

(k) Flask equipment is removed from the pouring area to locations convenient to molders. Broken-off sprues, gates and risers are removed from the cleaning room to appropriate scrap bins for remelting. The cleaned castings are delivered to the shipping area.

(l) On the following page is a flow chart of a conventional nonferrous foundry that depicts the simple nature of this particular field of manufacturing endeavor.

FLOW CHART

NON-FERROUS FOUNDRY



HOUSING REQUIREMENTS

The type of construction required for a building to house a nonferrous foundry operation depends a good deal on climate. In warm and tropical climates, the building may be limited to merely a roof which will offer protection from the rain, and fencing to protect the property from thieves, since nonferrous foundry materials are expensive. Such a structure, if constructed in the United States, would not cost more than $3.00 per square foot, including illumination, sanitation, water supply, and fencing.

When a foundry is located in a cold climate, provision has to be made to insulate the interior of the building from cold, and to heat the working area. Investment material drifts are quite apt to freeze in cold climates unless heating is provided, and a drift is an exceedingly bothersome thing to have to thaw out once it becomes frozen.

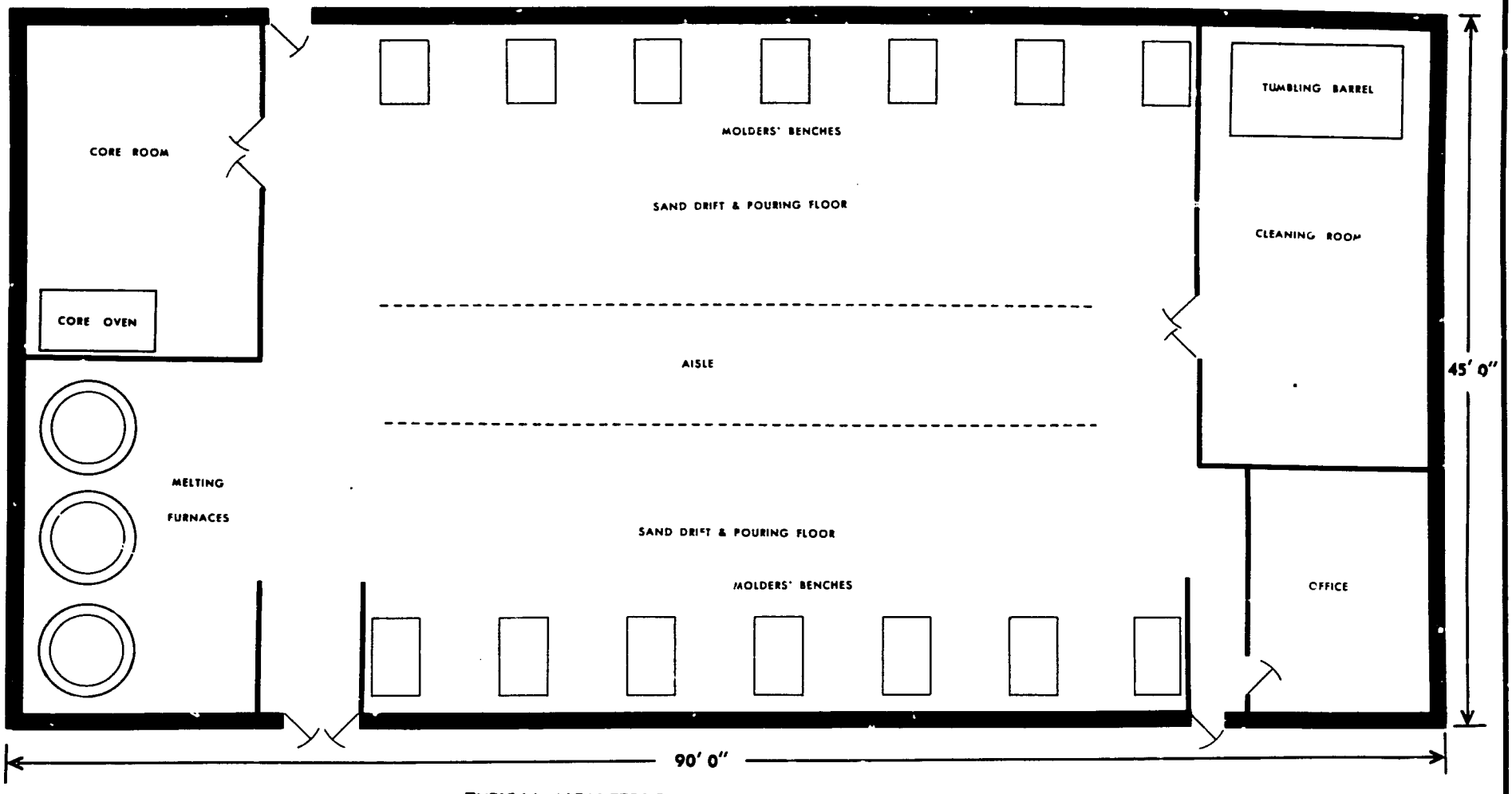
During working periods there usually is a sufficient amount of heat from the melting area to prevent water pipes and sand piles from freezing, but at night a suitable source for building heating is required. Such heating equipment in the United States might consist of anything from open salamanders to modern convection heating units.

The minimum cost for constructing a building in the United States to provide suitable protection from cold would amount to $8.00 per square foot, including water supply, illumination and open salamanders for heating. A modern building with a central heating plant or unit heaters, and one complying with building code requirements of most United States cities, would cost at least $12.00 per square foot.

A nonferrous foundry operation equipped for a daily production of three tons of the usual type of small and medium-sized job-shop castings should require a building 45 x 90 feet, or an area of 4,050 square feet, including a small office space. It is presumed that raw metal, scrap and sand inventory will be stored in inexpensively constructed detached sheds.

Therefore, the lowest possible cost for a building in a warm climate in the United States would cost (4,050 square feet x $3.00) approximately $12,150.00. A suitable building located in a cold climate would cost (4,050 square feet x $8.00) $32,400.00; and if constructed to comply with building code requirements, the building might cost as much as (4,050 square feet x $12.00) $48,600.00.

Generally, most nonferrous foundry buildings in the United States have concrete floors, and such floors cost a minimum of $1.25 per square foot, which amount should be added to the above cost figures, except for the code compliance building when a concrete floor is obligatory, in which case the cost is included in the $12.00 per square foot cost.



TYPICAL NON-FERROUS FOUNDRY FLOOR PLAN

PLANT SITE

To provide for eventual expansion, the land for the plant site should contain at least 12,000 square feet. The site should be level, well drained, and should be located as advantageously as possible with respect to transportation, power, water, fuel, sources of markets and labor. The cost of such a site is estimated at $1,000.

BUILDING

A one-story building 45 feet x 90 feet, or 4,050 square feet, will provide ample space for all operations, including an office. It may be constructed with any suitable building materials. It is estimated that the complete building, including adequate plumbing and wiring, will cost about $3.50 per square foot, or a total of about $14,200.

In addition, a detached one-story shed 30 feet by 40 feet or 1,200 square feet will be required for storage. The cost of the shed is estimated at $2.50 per square foot or $3,000. Total cost of buildings $17,200.

POWER

About 830 kilowatt hours per day of power will be required. Based on a cost of $.025 per kilowatt hour, the annual cost of power for all purposes is estimated at $1,200.

FUEL

It is estimated that the fuel consumption for production, heating and sanitary purposes will amount to about $7,800 per year.

WATER

Very little water is required for production purposes. Water requirements for the purposes of heat, sanitary facilities, drinking purposes and fire protection is estimated at $300 per year.

TRUCK

A one-ton cab pick-up and delivery truck is included in Production Tools and Equipment. The maintenance and operating cost is included in Supplies, and the cost of the truck driver is included in the Indirect Labor.

PRODUCTION TOOLS AND EQUIPMENT

Description	Number Required	Estimated Unit Cost	Estimated Total Cost	Actual Cost
Crucible tongs	1	$ 100	$ 100	
Crucible ladle	3	40	120	
Skimmer	2	8	16	
Crucibles	12	20	240	
Ladles	12	9	108	
Chain hoist	1	100	100	
Pyrometer	1	115	115	
Flask weights	15	1	15	
Flask boards	100	1	100	
Sprue cracker	2	7	14	
Sprayer	10	4	40	
Riddles	10	3	30	
Shovels	15	4	60	
Forks	2	9	18	
Goggles	6	3	18	
Safety shoes	6 pair	7	42	
Sprinkler can	2	4	8	
Garden hose	200 feet		20	
Sand trimmer	1	465	465	
Platform scale	1	1,000	1,000	
Tumbling barrel	1	2,000	2,000	
Portable grinder	1	250	250	
Wheelbarrows	6	20	120	
Molder's hand tools			60	
Melting furnace - oil	2	1,500	3,000	
Snap flasks	15	20	300	
Wood flasks	35	6	210	
Molders' benches	14	10	140	
Core benches	4	15	60	
Core oven	1	1,000	1,000	
Tram rail	1	200	200	
Spare parts			1,000	
Export packaging, freight, cartage and insurance on tools and equipment			1,031	
Total			$ 12,000	
One-ton pick-up truck			$ 2,500	

FURNITURE AND FIXTURES

Description	Number Required	Estimated Unit Cost	Estimated Total Cost	Actual Cost
Desks and Chairs	4	$ 115	$ 460	_____
Filing Cabinets	3	80	240	_____
Typewriter	1	150	150	_____
Adding Machine	1	150	150	_____
Total			$1,000	_____

DIRECT MATERIALS

The prices of metals and foundry supplies fluctuate daily in the source markets throughout the world, but metal refiners and supply dealers in the large business centers of America and Europe quote daily spot prices for the generally used base metals, alloys and melting scrap, as well as prices of foundry supplies. Quantities are the estimated amounts required for one month's production.

Item	Price Per Pound	Quantity Required	Estimated Cost	Actual Cost
Copper - ingot	$ .29	30,000	$ 8,700	_____
Copper - melting scrap	.24	50,000	12,000	_____
Zinc - ingot	.11	16,000	1,760	_____
Zinc - melting scrap	.09	10,000	900	_____
Tin - ingot	.99	6,000	5,940	_____
Brass - melting scrap	.18	8,000	1,440	_____
Aluminum - ingot	.25	4,000	1,000	_____
Magnesium - ingot	.32	2,000	640	_____
Alloying briquettes			820	_____
Total - One Month			$33,200	_____
Total - One Year			$ 398,400	_____

SUPPLIES

Item	Unit	Unit Price	Quantity Required	Estimated Cost	Actual Cost
Molding sand	ton	$ 5.27	50	$ 263.50	_____
Core sand	ton	6.14	50	307.00	_____
Parting sand	ton	13.77	10	137.70	_____
Sea coal	ton	34.05	10	340.50	_____
Pitch	pound	0.0858	200	17.16	_____
Corn flour	pound	0.076	400	30.40	_____
Core oil	pound	0.1725	355	61.24	_____
Molasses	gallon	0.19	100	19.00	_____
Fuel oil	barrel	2.90	50	145.00	_____
Core wires, rods, and chaplets				228.50	_____
Maintenance and hand tools				75.00	_____
Office supplies				25.00	_____
Truck operation				50.00	_____
Total - One Month				$ 1,700.00	_____
Total - One Year				$20,400.00	_____

DIRECT LABOR

Occupation	Personnel Needed	Hourly Rate	Estimated Annual Cost	Actual Cost
Molder	14	$ 2.30	$ 64,400	_____
Molder helper	5	1.70	17,000	_____
Core maker	6	2.00	24,000	_____
Core room helper	3	1.70	10,200	_____
Shake-out crew	4	1.70	13,600	_____
Cleaner	3	1.70	10,200	_____
Cleaner - foreman	1	2.30	4,600	_____
Pattern repair	1	2.30	4,600	_____
Melting crew	3	2.00	12,000	_____
Total	40		$ 160,600	_____

INDIRECT LABOR

Description	Personnel Required	Hourly Rate	Estimated Annual Cost	Actual Cost
Manager	1		$ 10,000	_____
Foreman	1		6,000	_____
Bookkeeper	1		5,000	_____
Secretary	1		3,000	_____
Maintenance	1	$ 2.50	5,000	_____
Truck Driver	1	1.50	3,000	_____
Total	6		$ 32,000	_____

This work-force, if every worker is properly employed for the full time each day, should produce 6,000 pounds of small and medium-sized single or gated job-shop castings each eight hours.

DEPRECIATION

Description	Estimated Cost	Years Life	Estimated Per Year	Actual Per Year
Building	$17,200	20	$ 860	_____
Production Tools and Equipment	12,000	10	1,200	_____
Furniture and Fixtures	1,000	10	100	_____
Pick-up Truck	2,500	4	625	_____
Total			$ 2,785	_____

MANUFACTURING OVERHEAD

Item	Estimated Cost	Actual Cost
Indirect Labor	$ 32,000	_____
Power	1,200	_____
Fuel	7,800	_____
Water	300	_____
Supplies	20,400	_____
Depreciation	2,785	_____
Total	$ 64,485	_____

MANUFACTURING COST

Direct Labor	$ 160,600	_____
Materials	398,400	_____
Manufacturing Overhead	64,485	_____
Total	$ 623,485	_____

FIXED ASSETS

Building	$ 17,200	_____
Production Tools and Equipment	12,000	_____
Furniture and Fixtures	1,000	_____
Pick-up Truck	2,500	_____
Total	$ 32,700	_____

WORKING CAPITAL

Item		Estimated Cost	Actual Cost
Direct Materials	- 60 days	$ 66,400	_____
Direct Labor	- 30 days	13,400	_____
Manufacturing Overhead	- 30 days	5,400	_____
Reserve - Sales Collections	- 30 days	70,000	_____
Total		$ 155,200	_____

CAPITAL REQUIREMENTS

Item	Estimated Cost	Actual Cost
Fixed Assets	$ 32,700	_____
Working Capital	155,200	_____
Total	$ 187,900	_____

SALES REVENUE

Experience shows that $0.80 per pound is a conservative average price for brass foundry products. This average is for small and medium sized castings, both gated and single units, in various quantities.

Assuming that the foundry is able to operate at 70% of the daily rated capacity, which for the foundry under consideration is 6,000 pounds, average production would be 4,200 pounds per day. The annual production would be 1,050,000 pounds, assuming full normal operations. On this basis the annual sales would amount to 1,050,000 x $0.80 or $840,000.

RECAPITULATION OF COSTS, SALES AND PROFITS

Item	Estimated Cost		Actual Cost
Direct Materials	$ 398,400		_____
Direct Labor	160,600		_____
Manufacturing Overhead	64,485		_____
Total Manufacturing Cost		$ 623,485	_____
Interest on Loans	$ 5,000		_____
Insurance	800		_____
Legal	1,200		_____
Auditing	2,400		_____
Unforeseen Expense	6,000		_____
Total Administrative Cost		15,400	_____
Sales Commissions, Travel Freight Out, Bad Debts, Discounts and Allowances		60,000	_____
Profit before Taxes		141,115	_____
Total Annual Gross Sales		$ 840,000	_____

BUDGET CONTROL

A requisition form designed to provide accurate records of procurement and indicate the purpose of procurement with the least amount of time and effort is shown on the following page.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power and water, are usually under contract and are easily checked by reference to monthly bills. For simplification, items (marked with an asterisk below) are omitted from the purchase requisition. Variations in the labor costs are easily reviewed by examination of the payroll vouchers. The simplified type of control thus provided makes certain that the manager can control expenditures promptly.

Following the requisition form, a sample voucher check is shown. Voucher checks should be used for the payment of all expenditures and the appropriate book account number placed on each voucher.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts. If the expenditures exceed the budgeted monthly allowances of any of the accounts, the bookkeeper will furnish the manager with a break-down of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions and the check vouchers. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If at any time during each month it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

BUDGET CONTROL ACCOUNTS

Account Number		Monthly Expense	Monthly Budget	Annual Budget	Actual
10	Administrative	$_____	$ 788	$ 9,400	$_____
20	Sales	_____	5,000	60,000	_____
30	Direct Materials	_____	33,200	398,400	_____
40	Supplies	_____	1,700	20,400	_____
51	Power*	_____	100	1,200	_____
52	Water*	_____	25	300	_____
53	Fuel	_____	650	7,800	_____
60	Unforeseen Expense (Reserve Account)	_____	500	6,000	_____
71	Direct Labor*	_____	13,383	160,600	_____
72	Indirect Labor*	_____	2,666	32,000	_____
80	Depreciation (Reserve Account)	_____	---	2,785	_____

Note: Administrative includes interest on loans, insurance, legal and auditing.

PURCHASE REQUISITION	COMPANY NAME	DATE

☐ 10 ADMINISTRATION ☐ 40 SUPPLIES

☐ 20 SALES ☐ 50 UTILITIES

☐ 30 MATERIALS ☐ 60 UNFORESEEN EXPENSE

INDICATE BELOW THE USE OF MATERIALS

☐ DIRECT MATERIALS ☐ MAINTENANCE SERVICES

☐ MAINTENANCE MATERIALS ☐ OPERATING SUPPLIES

	PLEASE ORDER THESE MATERIALS OR SERVICES	DELIVERY WANTED		
QUANTITY	DESCRIPTION	UNIT	TOTAL	

QUOTES FROM		REQUISITIONED BY	
QUOTES FROM		APPROVED BY	
QUOTES FROM		ORDER NO.	ORDER DATE

R. W. MITCHELL MANUFACTURING COMPANY
1422 BOSWORTH STREET, S. E.

65-22
514

ANYWHERE, U. S. A._____19____ No. 10000

PAY _____ DOLLARS $ _____
TO THE ORDER OF

R. W. MITCHELL MANUFACTURING COMPANY

TO FIRST NATIONAL BANK
ANYWHERE, U. S. A.

BY SAMPLE CHECK
VICE PRESIDENT

ACCOUNT NUMBER

Sample voucher check to be used for the payment of all expenditures in connection with Budget Control.

R. W. MITCHELL MANUFACTURING COMPANY

ENGINEERS

The services of professional engineers are desirable in the design of this plant, even though the proposed plant is small.

A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers
2029 K Street, Northwest,
Washington 6, D. C.

Manufacturers of industrial equipment employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed project.

The equipment manufacturers also know, and can recommend, professional engineers in private practice, who are willing and able to provide appropriate consulting services.

TRAINING

Manufacturing an inferior quality of product during the training period could create sales resistance that might be difficult to cope with later. To avoid such possibilities, the quality of the product should be maintained at all times, including the training period.

In some areas skilled operators may be available locally. In other areas all the operators may have to be trained.

If skilled operators are not available, adequate training would be assured by using one or more of the following methods:

A. If the plant is designed and installed by a competent engineering firm, the contract should be negotiated, if possible, on a turn-key basis. On this basis the contractor agrees to operate the plant and produce the quality and quantity of the product stated in the contract for an agreed period of time. Such a contract would assure adequate personnel training, since full quantity and quality could not be produced with an untrained organization.

B. The engineering firm that designs and installs the plant can usually make training arrangements to have key personnel placed, for training purposes, in a foreign industry that produces the same type of product. This would provide training for the key personnel while the plant is being installed.

C. If neither of the above methods is possible, then qualified and experienced individuals should be employed for the key positions, either permanently or temporarily, to perform the key operations and assist in training the organization, even if they must be secured outside the country.

D. The manager should have years of successful experience in this type of business and be fully qualified in all phases of management, including the training of employees.

SAFETY

There is always danger of accident and injury in any industrial plant. Because of this, the manager should take specific action to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

Practically all machines have safety appliances, and the manager should see that these are in good working condition and that the operators are making full use of them.

In addition to constant watchfulness to make sure that all practicable safety precautions are taken, first aid supplies should be readily available. One complete first aid kit should be maintained near the manager's office, and others at appropriate places throughout the plant. Some of the employees should be trained to provide first aid service.

The use of accident posters in the plant have proved to be of value in reducing accidents. It is recommended that such posters be used, and that some direct special action be taken by the manager, at least once each month, to bring to the attention of all personnel the importance of safety precautions.

A fire brigade should be established and each member trained as to his responsibility in case of fire. Fire drills should be conducted periodically.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.

SUMMARY

A small plant, built and operated according to the assumptions made in this manual would be a profitable undertaking.

There are some determinations, however, that should be made before a decision is reached to build and operate such a plant. Among the necessary determinations to be made are those with respect to the following items:

MATERIALS AND SUPPLIES

1. Are all materials and supplies available locally?
2. Is the local material market competitive?
3. Are satisfactory delivery of local materials assured at reasonable prices?
4. What materials and supplies must be imported?
5. Are they available in world markets at competitive prices?
6. Would prompt delivery of imported materials and supplies be assured so that large inventories would not be required?

MARKET FACTORS

1. Is there already a demand for the product?
   A. Who are the principal consumers?
   B. Who are possible new consumers?

2. How is demand for the product now satisfied?
   A. By local production? If so, what is the volume of annual production?
   B. What percentage of consumption is filled by local production?
   C. By imports? If so, what is the volume of annual imports?
   D. What percentage of consumption is met by imports?
   E. From what areas are imports derived?

3. What is the estimated annual increase in local consumption over the next five years?
   A. How were such estimates made?
   B. By reference to official figures on population growth, family budgets, imports, etc.?
   C. By consultation with trade or industry, ministries, associations, bankers, commercial houses, wholesalers, retailers, industrial consumers, etc.?

4. If the product is already being manufactured, can the existing and estimated future local market absorb production of the new plant without price-cutting or other dislocations?

5. Would the estimated sales price and quality of the new product make it competitive with an imported equivalent?
   A. After adjusting cost to local conditions, is the estimated sales price of the product so high that tariff protection is necessary to protect it from imports?

EXPORT MARKETS

1. Could the product compete in export markets on the basis of price, quality and dependability of supply?
2. Can export markets for the product be developed?
3. If so, in what areas and in what annual volume?
4. What procedures would be necessary to develop export markets?
5. What would it cost?

MARKETING PROBLEMS

1. In calculating costs of the product, has adequate allowance been made for the expense of a sales department, advertising and promotion that might be required?

2. Do consumer prejudices against locally manufactured products exist?
   A. If so, why?
   B. Would they apply to the new product?
   C. If so, how could they be overcome and what would it cost to do so?

3. Do marketing and distribution facilities for the product exist?
   A. If not, can they be set up?
   B. What would it cost to do so?

4. Will the product be sold to:
   A. Wholesalers?
   B. Retailers?
   C. Direct to consumer?
   D. Other industries?
   E. Government?

ECONOMIC FACTORS

1. How much foreign exchange (and in what currency) is required to import machinery, equipment and supplies:
   A. How much foreign exchange (and in what currency) is required for annual interest payments and amortization of any loans contracted to import machinery and equipment, or for payment of royalties and technical services?
   B. How much foreign exchange (and in what currency) is required for annual import of raw materials and supplies?
   C. What are estimated annual foreign exchange earnings and in what currencies?
   D. Has careful consideration been given to the possibility of depreciation in the foreign exchange value of the local currency?
   E. Has careful consideration been given to the possibility of import controls, or restrictions on availabilities of foreign exchange necessary to operate the business?
   F. What benefits would the new business bring to the economy in the use of local raw materials: in employment and in technology?
   G. Do dependable facilities exist for transportation, power, fuel, water and sewage?
      (1) If not, can existing deficiencies be eliminated satisfactorily?
      (2) What would be the cost to do so?

PERSONNEL

1. Is there an adequate labor supply near the plant location?
   A. If not, how can the problem be solved?

2. Can the problem of training competent management and supervisory personnel be solved?
   A. Also, the training of skilled labor?
   B. Is technical advice available in the locality?
   C. If not, where can it be obtained and what will it cost?

LAWS AND REGULATIONS

1. Do existing labor laws, government regulations, laws and taxes favor establishment of new business?
   A. If not, can existing obstacles be removed?
   B. If so, how and when?

FINANCIAL FACTORS

1. Technical advice on selection of machinery and equipment.
   A. In selecting the machinery and equipment for the new plant, have reputable and competent engineers and technicians been consulted?
   B. Have they been asked for advice on the most suitable types of machinery and equipment for the process and locality?
   C. Have they carefully compared costs of various suppliers?
   D. Credit terms offered purchasers?

FINANCIAL REQUIREMENTS OF THE PROJECT

1. In estimating the cost of the project, has careful consideration been given to:
   A. The effect on costs of delays in construction schedules?
   B. In delivery and installation of machinery and equipment?
   C. In import of essential raw materials and supplies?

2. In calculating cash flow and working capital requirements, has careful consideration been given to:
   A. Maintaining adequate inventories of raw materials?
   B. Supplies and spare parts?
   C. Seasonal fluctuations in the business?
   D. The time required to liquidate credit sales to customers and bad debts?
   E. The period necessary to get the plant into production?
   F. Cash required to amortize its principle loans?

3. If the economy is in a period of inflation, has full allowance been made for the influence of rising prices and wages on the cost of the project and on working capital requirements?

SHORT TERM BANK CREDITS

1. Has it been possible to make arrangements with local banks to finance short-time working capital requirements of the business?

FINANCIAL PLAN

1. Has a definite plan to finance the project been worked out?
   A. Is sufficient capital available locally?
   B. If not, what is the plan to obtain the required capital?

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ABBREVIATIONS

'	Foot or feet
"	Inch or inches
%	Percent
lb	Pound
lbs	Pounds
^{o}F	Degree Fahrenheit
Btu.	British thermal unit or units

GLOSSARY OF FOUNDRY TERMS

Air Hammer - Chipping hammer operated by compressed air.

Air Hoist - Lifting device operated by compressed air.

Air Hole - Hole in a casting caused by air or gas trapped in the metal during solidification.

Alloy - A metallic material formed by mixing two or more chemical elements. Usually possesses properties different from those of the components.

Alloying - Procedure of adding other elements than those usually comprising a metal or alloy to change its characteristics and properties.

Alloying Elements - Elements added to nonferrous and ferrous metals and alloys to change their characteristics and properties.

Angle Sleeker - Molder's tool for sleeking or smoothing the inside and outside corners of a mold.

Annealing - A process involving heating and cooling usually applied to induce softening. The term also is used to cover treatments intended to (a) remove stresses (b) alter mechanical or physical properties (c) produce a definite microstructure, and (d) remove gases.

Backing Plate or Board - A second bottom board where molds are opened.

Back (Backing) Sand - Sand between the facing sand and the flask.

Bail - Connection between crane hook and ladle.

Baked Core - One which has been subjected to heating or baking until it is thoroughly dry as opposed to a green sand core which is used in the moist state.

Glossary

Baked Permeability - Property of a molded mass of sand heated at a temperature above 230° F. until dry and cooled to room temperature, to permit passage of gases through it; particularly those generated during pouring of molten metal into a mold.

Band, Inside - A steel frame placed inside a removable flask to reinforce the sand.

Bar - A rib in the cope to help hold the sand.

Basin - A cavity on top of the cope into which metal is poured before it enters the sprue.

Batch - Amount or quantity of core or mold sand or other material prepared at one time.

Battens - Strips attached to a bottom or follow board.

Bayberry Wax - Wax made from bayberries, used as a coating on patterns.

Beam and Sling - Tackle used in conjunction with a crane for turning over a cope or drag mold prior to assembly.

Bed-In - Method of ramming the drag mold without rolling it over.

Bellows (Pl.) - A device operated with both hands for producing a current of air.

Bench Rammer - A short rammer used by bench molder.

Bentonite - A widely distributed and peculiar type of clay which is considered to be the result of devitrification and chemical alteration of the glassy particles of volcanic ash or tuff. Used in foundry to bond sand.

Binder - Material to hold the grains of sand together in molds or cores. May be cereal, oil, clay, resin, pitch, etc.

Blacking - Carbonaceous material for coating mold or core surfaces.

Blast Cleaning - Removal of sand or oxide scale from castings by the impinging action of sand, metal shot or grit projected under air, water or centrifugal pressure.

Blended Sand - Mixture of sands of different grain sizes, clay content, etc. to produce one possessing more suitable characteristics for foundry use.

Blind Riser - An internal riser which does not reach to the exterior of the mold.

Blister - Defect on surface of a casting appearing as a shallow blow with a thin film of metal over it.

Blow - A casting defect due to trapping of gas in molten or partially molten metal.

Blow Hole - The hole or void left in a casting by trapped gas.

Blower - Machine or device for supplying air under pressure to the melting unit.

Body Core - The main core.

Boil - Agitation of molten metal by steam or gas.

Bond - Cohesive material in sand.

Bond Strength - Resistance of foundry sand to deformation.

Bond Clay - Any clay suitable for use as a bonding material in molding sand.

Booking - Method of assembling or bringing together two halves of a core in a manner similar to closing a book.

Boric Acid - Inhibitor used in facing sand for magnesium-base and aluminum-base alloys high in magnesium to prevent reaction with moisture in the sand.

Boron - One of the elements whose chemical symbol is B, and atomic weight is 10.82. In the form of borax and boric oxide used as a flux in nonferrous metallurgy, and in form of an alloy with other elements as an addition agent to ferrous alloys.

Boron Trichloride - A product used for degasification of aluminum alloys.

Bottom Board - Board supporting the mold.

Bottom Pour Mold - Mold gated at the bottom.

Branch Gate - Two or more gates leading into the casting cavity.

Brass - Copper-base alloy with zinc as the major alloying element.

Brinell Hardness - Value of hardness of a metal or alloy, tested by measuring the diameter of an impression made by a ball of given diameter applied under a known load. Values are expressed in Brinell hardness numbers.

Bronze - Copper-base alloy with tin as the major alloying element.

Buckle - Defect on a casting surface appearing as an indentation resulting from an expansion scab.

Bumper - Machine for ramming sand in a flask by repeated jarring or jolting action.

Built-Up Plate - A pattern plate with the cope pattern mounted or attached to one side with the drag on the other.

Burner - A device which mixes fuel and air intimately to provide perfect combustion when the mixture is burned. Types include acetylene, oil, gas, powdered coal, stoker, etc.

Butt Rammer - The flat end of the molder's rammer.

Calcium Boride - An alloy of calcium and boron corresponding when pure to the formula CaB_6 containing about 61% boron and 39% calcium, and used in deoxidation and degasification of nonferrous metals and alloys.

Casting (Noun) - Metal poured into a mold to form an object.

Casting, Open Sand (Noun) - Casting poured into an uncovered mold.

Casting Strains - Strains resulting from internal stresses created during cooling of a casting.

Cast Plate - Metal plate, usually aluminum, cast with the cope pattern on one side and the drag pattern on the other.

Cement, Refractory - Highly refractory material in paste or dry form ready to be mixed with water which may be used as a mortar, a patching material, or to form a complete lining in a furnace or other unit where high temperatures are encountered.

Chalk Test - Method of crack detection which consists of applying a penetrating liquid to the part, removing the excess from the surface which then is coated with whiting or chalk. After a short period of time the penetrant seeps out of the cracks into the whiting, causing an appreciable difference in whiteness.

Chaplet - A metallic insert or support to hold a core in position in the mold.

Chaplet, Curved - A chaplet with a curved face.

Chaplet, Double Head - A chaplet with a bearing plate at each end.

Chaplet, Flat - A chaplet with a straight face.

Chaplet, Perforated - A chaplet made from tin-coated sheet metal punched full of small holes, and bent to shape.

Chaplet, Shell - A cup-shape chaplet.

Chaplet, Single Head - A chaplet with a bearing plate at only one end.

Chaplet, Stud - A solid block chaplet or one with a bearing plate at each end.

Charpy Test - A pendulum type of impact test in which a specimen supported at both ends as a simple beam, is broken by the impact of the falling pendulum. Energy absorbed in breaking the specimen as determined by the decreased rise of the pendulum, is a measure of the impact strength of the metal.

Cheek - Intermediate sections of a flask inserted between cope and drag. Necessitated by difficulty of molding unusual shapes, or in cases where more than one parting line is required.

Chip (Verb) - To remove extraneous metal from a casting with hand or pneumatically operated chisels.

Chlorination - A refining or degasification process wherein dry chlorine gas is passed through molten aluminum-base and magnesium-base alloys to remove entrapped oxides and dissolved gases.

Churn - Moving a metal rod up and down in the riser of a large casting to prevent freezing over the top.

Glossary

Clamp - A device for holding parts of a mold, flask, corebox, etc. together.

Clay, Refractory - A clay which in addition to its capability to resist high temperatures also possesses strong bonding power.

Cohesion - Force by which particles are held together. Varies with different metals and alloys, and depends on hot or cold working as well as upon molecular arrangement due to heat treatment.

Columnar Structure - Coarse structure of parallel columns of grains caused by highly directional solidification resulting from sharp thermal gradients.

Compressive Strength - The maximum compressive strength which a material is capable of developing.

Controlled cooling - Process by which a metal object is cooled from an elevated temperature in a predetermined manner of cooling to avoid hardening, cracking, or internal damage.

Cope - The upper or topmost section of a flask,mold or pattern.

Core - Separable part of the mold, usually made of sand and generally baked, to create openings and various shaped cavities in the castings. Also is used to designate the interior portion of an iron-base alloy which after casehardening is substantially softer than the surface layer or case.

Core Bar - A piece of iron or steel to strengthen a core.

Core Binder - Any material used to hold the grains of core sand together.

Corebox - Box with an opening in which the core is formed.

Core Drier - Sand or metal supports to keep cores in shape during baking.

Core Gum - A pitchy material used as a core binder.

Coremaker- A person who makes cores.

Core Oil - Linseed-base or other oil used as a core binder.

Core Oven - An oven for baking cores.

Core Paste - Material in paste form used as an adhesive to join sectional cores.

Core Plate - A plate or board made of metal or heat resisting material on which certain types of cores are baked.

Core Print - An extension of the pattern for locating the core or an extension of the mold cavity for locating the core.

Core Raise - Casting defect caused by core moving upward toward cope surface.

Core Rod - Iron or steel in rod form used to stiffen or support a core internally.

Core Room - That part of the foundry in which cores are made.

Core Sand - Sand for making cores.

Core Sand Mixer - Equipment in which core sand is mixed.

Core Shift - Defect resulting from movement of the core from its proper position in the mold cavity.

Core Spindle - A shaft on which a core barrel is rotated in making cylindrical cores.

Core Strickle or Templet - Device of wood or metal to give shape to certain types of cores or molds.

Core Truck - Truck or carriage used for transporting cores.

Core Vents - A wax product round or oval in form used to form the vent passage in a core. Also refers to a metal screen or slotted piece used to form the vent passage in the corebox employed in a core blowing machine.

Core Wash - Refractory coating for a core.

Crack, Cold - Appears in a casting after solidification and cooling due to excessive strain generally resulting from nonuniform cooling.

Crack, Hot - Developed in a casting before it has cooled completely, and usually due to some part of the mold restraining solid contraction of the metal.

Critical Points (Temperatures) - Temperatures at which changes in the phase of a metal take place, and are determined by liberation of heat when the metal is cooled and by the absorption of heat when the metal is heated, resulting in halts or arrests on cooling and heating curves.

Glossary

Crucible - A ceramic pot or receptacle of graphite-clay, clay or other refractory material in which metal is melted. Term sometimes is applied to pots of cast iron, cast or wrought steel.

Crucible Furnace - Furnace in which metal is melted in crucibles.

Crucible Lifter - A device for lifting and holding a crucible.

Crucible Pouring Device - An apparatus for holding a crucible during the pouring operation.

Cutoff Machines, Abrasive - A machine using a thin abrasive wheel and employed in cutting off gates and risers from castings or similar operations.

Cutter, Gate - A piece of sheet metal or other tool for removing a portion of the sand in a mold to form the gate or metal entrance into the casting cavity.

Cutter, Sprue - A piece of metal tubing or other tool used to remove a portion of the sand from a mold to form the sprue or passage from the exterior of the mold to the gate. Also a machine used for shearing sprues and gates from castings.

Cuts - Defects in castings resulting from erosion of the sand by the molten metal pouring over the mold or core surface.

Degasifier - A material employed for removing gases from metals and alloys.

Dendrite - A crystal formed during the solidification of a metal or alloy characterized by a branching structure like that of a fir tree.

Deoxidizer - A material used to remove oxygen or oxides from metals and alloys.

Desulphurizer - A material used to remove sulphur from molten metals and alloys.

Devil's Claw - A hook for rapid attachment to a chain.

Diffusion - Movements of atoms within a solution. Net movement is usually from regions of high concentration to regions of low concentration to achieve homogeneity of the solution which may be a solid, gas or liquid.

Dowell - A short pin of metal, wood, etc. used to join two pieces of material together.

Draft - Taper allowed on the vertical faces of a pattern to permit removal from the sand mold without excessive rapping and tearing of the mold walls.

Drag - The lower or bottom section of a mold or pattern.

Drawback - Section of a mold lifted away on a plate or arbor to facilitate removal of the pattern.

Draw Bar - A bar used for lifting the pattern from the mold.

Drop Out - Sand falling from the cope of a mold.

Dross - Metal oxides, etc. on or in a metal or alloy.

Dry Permeability - Property of a molded mass of sand dried at 221° to 230° F. and cooled to room temperature, to permit passage of gases through it.

Dry Sand Mold - A mold made of prepared molding sand dried thoroughly before being filled with metal.

Ductility - The property permitting permanent deformation by stress in tension without rupture.

Elastic Limit - The greatest stress which a material can withstand without permanent deformation after complete release of the stress. For commercial purposes elastic limit is considered as yield strength.

Elongation - The amount of permanent stretch before rupture; usually expressed as a percentage of the original gage length such as 15 percent in 2 inches.

Endurance Limit - A limiting stress below which the material will withstand without rupture an indefinitely large number of cycles of stress.

Endurance Ratio - The ratio of endurance limit to the ultimate tensile strength of the material.

Erosion Scab - Casting defect occurring where the metal has been agitated, boiled, or has partially eroded away the sand, leaving a solid mass of sand and metal at that particular spot.

Expansion Scabs - Rough thin layers of metal partially separated from the body of the casting by a thin layer of sand, and held in place by a thin vein of metal.

Facing - Refractory material applied to the face of a mold.

Facing Sand - Specially prepared sand in the mold adjacent to the pattern to produce a smooth casting surface.

False Cheek - A cheek used in making a three-part mold in a two-part mold.

False Cope - Temporary cope used only in forming the parting, and therefore not a part of the finished mold.

Fatigue - Tendency for a metal to break under conditions of repeated cyclic stressing considerably below the ultimate tensile strength.

Fatigue Crack - A fracture starting from a nucleus where there is an abnormal concentration of cyclic stress and propagating through the metal. Surface is smooth and frequently shows concentric markings with a nucleus as the center.

Feed Head - A reservoir of molten metal provided to compensate for contraction of metal as it solidifies, by the feeding down of liquid metal to prevent voids. Also called a riser.

Fillet - A concave junction formed where two surfaces meet by use of a preformed strip of leather or wax.

Filling Frame - Placed on top of a flask to hold an extra quantity of sand while the mold is being rammed on a machine.

Fin - A thin piece of metal projecting from a casting at the parting line or at the junction of cores, or of cores and mold, etc.

Finish (Verb) - The hand work on a mold after the pattern has been withdrawn.

Firebrick - Brick made of refractory clay or other material which will resist high temperatures.

Fireclay - A type of clay which is resistant to high temperatures.

Fire Sand - A refractory sand which resists high temperatures.

Flask - Container in which a mold is made.

Flask, Slip - A removable flask to be stripped vertically from the mold.

Flask, Snap - A hinged flask can be removed from the mold after completion.

Flask, Tight - Flask remains on the mold.

Flask Pins - Assure proper alignment of cope and drag molds after the pattern is withdrawn.

Flowability - Property of a foundry sand mixture which enables it to fill pattern recesses and move in any direction against pattern surfaces under pressure.

Fluidity - Ability of molten metal to flow readily; usually measured by the length of a standard spiral casting.

Flux - Any substance used to promote fusion. Also any material which reduces, oxidizes or decomposes impurities so that they are carried off as slags or gases.

Follow Board - Board shaped to fit the pattern and form the joint.

Gagger (Jagger) - An L-shaped rod used for reinforcing sand in the cope mold.

Gas Holes - Rounded cavities caused by generation or accumulation of gas or entrapped air in a casting; holes may be spherical, flattened or elongated.

Gate - Specifically, the point where molten metal enters the casting cavity. Sometimes employed as a general term to indicate the entire assembly of connected columns and channels carrying the metal from the top of the mold to that part forming the casting cavity proper. Term also applied to pattern parts which form the passages, or to the metal that fills them.

Gated Patterns - One or more patterns with gating systems attached.

Grain Refiner - Any material added to a liquid metal or alloy or a treatment which produces a finer grain size in the subsequent solid.

Graphite - Native carbon in hexagonal crystals, also foliated or granular massive, of black color with metallic lustr and soft. Used for crucibles, foundry facings, lubricant, etc. Also made artificially by passing alternating current through a mixture of petroleum coke and coal tar pitch.

Green Permeability - Property of a molded mass of sand in its tempered condition which is a measure of its ability to permit the passage of gases through it.

Green Sand - Prepared molding sand in the moist or "as-mixed" condition.

Green Sand Core - Core used in the green state; not baked.

Grinding - Removing gate stubs, fins and other projections on castings by an abrasive wheel.

Grinding Wheel - Abrasive materials such as silicon carbide, aluminum oxide, corundum, emery, etc., which are bonded with clays, rubber, synthetic resins and formed into wheels under pressure. The wheels then are vitrified or baked depending upon the bond.

Grit, Abrasive - Crushed ferrous or synthetic abrasive material in various mesh sizes is used in abrasive blasting equipment for cleaning of castings.

Guide - The strip or other suitable device used to locate the cope in the proper place on the drag.

Guide Pin - The pin used to locate the cope in the proper place on the drag.

Gypsum Cement - Calcined calcium sulphate commonly called plaster of paris.

Hand Ladle or Shank - A small ladle carried by one man.

Hard Sand Match (Matchplate) - A body of sand shaped to conform to the parting line upon which a pattern is laid in starting to make a mold. Sand is made hard by addition of linseed oil and litharge, portland cement, etc. See match.

Head - Pressure exerted by a fluid such as molten metal. Also used as a term for riser.

Heap Sand - Sand on piles on the foundry floor.

Hindered Contraction - The prevention of the free contraction of a metal or alloy by mold conditions or casting design.

Horn Gate - Curved gate in the shape of a horn arranged to permit entry of molten metal at the bottom of the casting cavity.

Hot Spots - Localized areas of a mold or casting where high temperatures are reached and maintained for a period of time.

Hot Spruing - Removing castings from gates before the metal has completely solidified. The operation is particularly necessary on light-section or intricate castings which might be cracked if removed in the cold state.

Hot Tears - Cracks in castings formed at elevated temperatures; usually by contraction stresses.

Humectant - A material which has the ability of retaining moisture.

Impact Test - A test in which one or more blows are applied suddenly to a specimen. Results usually are expressed to terms of energy absorbed or number of blows (of a given intensity) required to break the specimen. Izod impact or Charpy impact are the common methods of studying impact resistance.

Inclusions - Particles of slag, sand or other impurities such as oxides, sulphides, silicates, etc., trapped mechanically during solidification or formed by subsequent reaction of the solid metal.

Ingot - Commercial pig or block in which copper, copper-base, aluminum, aluminum alloys, magnesium, magnesium alloys, and other nonferrous materials is made available to the foundry field.

Internal Stress - A system of balanced forces existing within a casting not subjected to a working load.

Isotope - One of two or more chemical elements occupying the same position in the periodic table, identical in chemical behavior, and distinguishable only by radioactive transformations or small differences in atomic weight.

Izod Test - Pendulum-type impact test in which the specimen is supported at one end as a cantilever beam and the energy required to break off the free end is used as a measure of impact strength.

Glossary

Jack Star - A piece of hard metal for use in a tumbling barrel.

Jacket, Mold - A wood or metal form slipped over a mold made in a snap or slip flask, to support the four sides of the mold during pouring. Jackets and mold weights are shifted from one row of molds to another during the pouring period.

Jarring Machine - Molding machine which rams the sand by rapid jolting.

Jig - Fixture or template employed to insure exact location of one part in relation to another.

Jobbing Foundry - Foundry which is not a part of a manufacturing plant, and produces castings for sale. Usually makes a wide variety of castings in small lots or quantities.

Knock Out - To remove sand and casting from a flask.

Ladle - Metal receptacle lined with refractory for transportation of molten metal. Types include hand, bull, sulky, trolley, crane, bottom evolved, and teapot.

Launder - Channel for conducting molten metal.

Leaker - Foundry term for castings which leak under liquid or gaseous pressure.

Lifter - An L-shape molder's tool with a long shank and short arm. It is used to lift sand from the bottom of a mold.

Lining - Inside refractory layer of firebrick, clay, sand or other material in a furnace or ladle.

Liquid contraction - Shrinkage or contraction in molten metal as it cools from one temperature to another while in the liquid state.

Liquidus - The temperature at which solidifcation of metal begins on cooling and the temperature at which the last portion of solid metal becomes liquid on heating.

Loam - A coarse, strongly bonded molding sand used for loam and dry sand molding.

Loose Piece - Part of a pattern so attached that it remains in the mold, and is removed after the body of the pattern is drawn.

Lute - To seal with clay or other plastic material.

Macrostructure - Structure of metals as revealed by the eye or a magnification of less than 10 diameters.

Magnesia - Magnesium oxide, a basic refractory.

Master Pattern - The pattern from which the working pattern is cast.

Match - A form of wood, plaster of paris, sand or other material on which an irregular pattern is laid or supported while the drag is being rammed.

Matchplate - A metal or other plate on which patterns split along the parting line are mounted back to back with the gating system to form an integral piece.

Melting Pot - Metal, graphite-clay, or ceramic vessel in which metal is melted.

Melting Loss - Difference between the amount of metal charged into, and the amount removed from a melting unit.

Melting Rate - Amount of metal melted in a given period of time, usually one hour.

Metal Penetration - Casting surface defect which appears as if the metal has filled the voids between the sand grains without displacing them.

Metallography - That branch of science which relates to the constitution and structure, and their relation to the properties of metals and alloys.

Metallurgy - Science dealing with the constitution, structure and properties of metals and alloys, and the processes by which they are obtained from ore and adapted to the use of man.

Microporosity - Extremely fine porosity in castings caused by shrinkage or gas evolution and apparent on radiographic film as mottling.

Microstructure - The structure and characteristic condition of metals as revealed on a ground and polished (etched or unetched) specimen at magnifications above 10 diameters.

Misrun - A casting not fully formed.

Modification - Treatment of aluminum-silicon alloys in the molten state with a small percentage of an alkaline metal or salt such as sodium fluoride to develop maximum mechanical properties in the solid metal.

Modulus of Elasticity - The ratio, within the limit of elasticity, of the stress to the corresponding strain.

Mold - The form, usually sand, containing the cavity into which molten metal is poured to make the casting.

Mold Cavity - Impression left in the sand mold by the pattern.

Mold Clamps - Devices used to lock or hold cope and drag together.

Mold Shift - Casting defect resulting when the two cavities in the cope and drag molds do not match properly.

Mold Wash - Usually an aqueous emulsion containing various organic or inorganic compounds or both which is used to coat the face of a mold cavity. Materials include graphite, silica flour, etc.

Mold Weights - Weights placed on top of molds to offset internal or ferrostatic pressure.

Molder - An operator who makes molds.

Molder's Bench - Table or bench on which small molds are produced.

Molder's Tools - Used by a molder in making a mold.

Molding - The act of making molds.

Molding, Machine - Making sand molds from production patterns on molding machines.

Molding Sand - Mixture of sand and clay suitable for mold making.

Monorail System - Single overhead rail from which a trolley is suspended to transport ladles, molds, materials, etc. around the foundry.

Mud - Wet sand or clay to close the joint of a flask or the joint between a core and sand of the mold. Also mortar in loam molding.

Muller - Type of foundry sand mixing machine.

Nail, Chill - Steel nail with a heavy head which is inserted in the mold wall to hasten cooling of the metal at that point.

Open-Grain Structure - Coarse or open grain structure usually revealed after a machining operation.

Oil Core - A core bonded with oil.

Open Sand Casting - A casting poured in a mold which has no cope or other covering.

Oven - Furnace or chamber heated by coal, gas, oil, coke, or electrically which may be used for heat treating purposes, drying cores and molds, etc.

Oxidation - Any reaction whereby an element reacts with oxygen.

Parting - Where sections of a mold are separated.

Parting Compound - Material dusted or sprayed on a pattern or mold to prevent adherence of sand.

Parting Line - The line along which a pattern is divided for molding, or along which the sections of a mold separate.

Parting Sand - Sharp or burned sand sprinkled on the joint of the mold to prevent the sand cope and drag from adhering.

Pattern - Model of wood, metal, plaster or other material used in making a mold.

Pattern Coating - Coating material applied to wood patterns to protect them against moisture and abrasion of molding sand.

Pattern Letters - Metal letters and figures in various sizes which are affixed to patterns for identification purposes.

Patternmaker's Shrinkage - Shrinkage allowance made on all patterns to compensate for the change in dimensions as the solidified casting cools in the mold from freezing temperature of the metal to room temperature. Pattern is made larger by the amount of shrinkage characteristic of the particular metal in the casting and the amount of hindered contraction to be encountered. Rules or scales are available for use.

Permeability - The property in sand molds which permits the passage of gases.

Pins, Flask - Hardened steel locating pins used on flasks to insure proper register of cope and drag molds.

Plates, Bottom - Usually metal plates on which molds are set for pouring.

Plates, Core Drying - Straight, flat plates of metal or heat resisting composition on which cores are placed for baking.

Plumbago - Graphite in powder form.

Pneumatic Tools - Grinders, rammers, drills, etc. operated by compressed air.

Porosity - Unsoundness in castings appearing as blowholes and shrinkage cavities.

Pour - Discharge of molten metal from the ladle into the mold.

Poured Short - Casting which lacks completeness due to the cavity not being filled with molten metal.

Pouring Basin - Reservoir on top of the mold to receive molten metal.

Print Back - After the surface of a mold is dusted with graphite facing, the pattern is replaced, rapped into position and again removed.

Production Foundry - Highly mechanized foundry for manufacturing large quantities of repetitive castings.

Proportional Limit - The greatest stress which a material is capable of developing without deviation from the law of proportionality of stress to strain.

Pull Down - Sand buckle in cope sometimes severe enough to cause a scab.

Push-Up - Anindentation in the casting surface due to displacement (expansion) of the sand in the mold.

Purifiers, Flux - Various materials added to molten metals and alloys for the purpose of removing impurities, gases, etc.

Pyrometer - An instrument for determining elevated temperatures.

Quaternary Alloy - One which contains four principal elements.

Rammer - Tool for ramming the sand.

Ram-Off - Casting defect caused by improper ramming.

Rapping Plate - Metal plate attached to a pattern to permit rapping for removal from the sand.

Rat Tail - Minor sand buckle occurring as a small irregular line or series of lines.

Reduction of Area - Difference between the original cross sectional area of a tension test bar and that of the smallest area at the point of rupture. Usually expressed as a percentage of the original area.

Refractory - Usually a ceramic material resistant to high temperatures, molten metal and slag attack.

Reverberatory Furnace - Melting unit with roof arranged to deflect the flame and heat toward the hearth on which the metal to be melted rests.

Riddle - Hand or power operated device for removing large particles of sand or foreign material from foundry sand.

Riser - Reservoir of molten metal attached to the casting to compensate for the internal contraction of the casting as it solidifies.

Rockwell Hardness Testing - Method of determining the indentation hardness by measuring the depth of residual penetration by a steel ball or a diamond cone.

Rolling Over - Operation of reversing the position of the mold so that the pattern faces upward to be removed.

Rollover Board - Wood or metal plate on which the pattern is laid face down for ramming of the mold.

Rollover Machine - Molding machine on which the mold is rolled over before the pattern is drawn.

Run-Out - Metal flowing through a defect in the mold.

Runner - That portion of the gate assembly connecting the downgate or sprue with the casting.

Glossary

Sand, Backing - Sand in mold back of the facing.

Sand, Blast - Sand used in an abrasive blasting machine for cleaning castings.

Sand Castings - Metal castings produced in sand molds.

Sand Control - Procedure whereby various properties of sand such as fineness, permeability, green strength, moisture content, etc. are adjusted to obtain castings free from such defects as blows, scabs, rat tails, veins, etc.

Sand, Core - Sand used in making cores.

Sand Cutter - A machin used to mix sand by use of a blade device which cuts the sand over.

Sand Cutting - Preparing sand for molding either by hand or by machine.

Sand, Dune - A sharp, wind-blown sand from the shores of lakes or ocean.

Sand, Facing - Prepares sand used next to the pattern.

Sand, Fat - Sand with a high percentage of clay.

Sand Holes - Cavities of irregular shape and size whose inner surfaces plainly show the imprint of granular material.

Sand, Lake - Sharp sand from vicinity of lakes.

Sand, Lean - Sand low in bond or clay.

Sand, Molding - Sand used to make molds.

Sand Muller - A machine for mixing sand by a kneading and squeezing action.

Sand, Open - Sand through which gases can pass freely.

Sand, Silica - Sand composed of almost pure silica.

Sand Strip - A strip along the lower inside edge of a flask.

Sand Tempering - Adding sufficient moisture to core or molding sand to make it workable.

Scab - A blemish on a casting caused by eruption of gas from the mold face.

Sea Coal - Finely ground bituminous coal.

Seam - Surface defect on a casting similar to a cold shut, but not as severe.

Shakeout (Shake Out) - The operation of removing castings from the mold.

Shank - The handle attached to a small ladle.

Sharp Sand - Sand that is substantially free of bond; term does not refer to grain shape.

Shift - A casting defect resulting from a mismatch of cope and drag.

Shot - Abrasive blast cleaning material.

Shrink Hole - A hole or cavity in a casting resulting from contraction and insufficient feed metal, and formed during the time the metal changed from the liquid to the solid state.

Shrink Rule - Patternmaker's rule graded to allow for metal contraction.

Sieve - A device with meshes of wire or other material for separating fine material from coarse material.

Silica - Silicon dioxide, SiO_2, occurring in nature as quartz, opal, etc. Molding and core sands are impure silica.

Silica Wash - Silica flour mixed with water and other materials to form a brushable or sprayable facing material.

Silicon - One of the elements with the chemical symbol Si whose formula weight is 28.06; specific gravity 2.4, and melting point 1420°C.

Silicon-Aluminum - An alloy of 50 per cent Si and 50 percent Al used for making silicon additions to aluminum alloys, and often termed an intermediate or hardener alloy. Melting point is 1070°F.

Silicon Brass - A series of alloys containing from 0.5 to 6 percent Si, 1 to 19 percent Zn, and remainder substantially copper.

Silicon Bronze - A series of alloys containing from 1 to 5 percent Si, 0.5 to 3 percent Fe, under 5 percent Zn, under 1.5 percent Mn, and remainder substantially copper.

Silicon-Copper - An alloy of silicon and copper available in two types containing 10 to 20 percent silicon. The 10 percent grade has a melting point of 1500°F while the 20 percent grade melts at 1650°F. Used as a deoxidizer and hardener in copper-base alloys.

Silt - Extremely fine sand particles that pass through a 270-mesh sieve but which are not plastic or sticky when wet.

Skeleton Pattern - A pattern made in outline to reduce cost.

Skim Gate - An arrangement which changes the direction of flow of molten metal in the gating system and thereby prevents the passage of slag and other extraneous materials beyond that point.

Skimmer - A device or tool for removing slag and dross from surface of molten metal.

Skin Drying - Drying of the mold surface by direct application of heat.

Skull - Film of metal or dross remaining in the ladle after the metal has been poured out.

Slab Core - Flat, plain core.

Slag - A nonmetallic covering on molten metal as the result of the combining of impurities contained in the original charge, some ash from the fuel, any silica and clay eroded from the refractory lining. Except in bottom pour ladles it is skimmed off prior to pouring the metal.

Sleek - A term applied to various molder's tools used to impart smoothness to the mold face.

Slurry - Thin loam.

Snag - Removal by grinding, of fins and rough places on a casting.

Solid Contraction - Shrinkage or contraction as a metal cools from the solidifying temperature to room temperature.

Solidifying Contraction - Shrinkage or contraction as a metal solidifies.

Solidus - Temperature at which freezing is completed. Below that temperature all metals are completely solid.

Spongy - A porous area in a casting.

Sprue - The vertical portion of the gating system where the molten metal first enters the mold.

Sprue Button - Attached to the cope pattern to indicate where the sprue should be cut.

Sprue Cutter - A piece of tubing cuts the sprue hole through the cope. Also a shear-type machine for removing the sprue and gates from the casting.

Spruing - Removing gates and risers from castings after the metal has solidifed.

Stop Off - To shorten or change a mold.

Stop Off Strip - Reinforcing members on frail patterns. Impressions later filled with sand.

Strain - The change per unit length in a linear dimension of a body, which change accompanies a stress. Strain is measured in inches per inch of length (millimeters per millimeter) or in per cent.

Strained Castings - Molten metal poured into the mold too fast, raises the cope slightly from the drag and produces an oversize casting with protruding fins. Also over size casting from weak mold.

Strainer Core - A small perforated core in the sprue, runner or gate to prevent entrance of slag and other extraneous material into the mold cavity.

Strains, Casting - Strains produced by internal stresses, resulting from unequal contraction of the metal as the casting cools.

Stress Relieving - Heat treatment to remove stresses or casting strains.

Strickle - Wood or metal form for imparting shape to part of a mold or core.

Strike Off - A straight edge to cut the sand level with the top of the drag or cope flask.

Swell - An enlargement on the face of a casting, due to yielding mold face.

Tear, Hot - Same as crack, hot, but developing before the casting has solidifed completely.

Tempering (Sand) - Addition of water to and mixing molding sand to obtain uniform distribution of moisture.

Template - A guide, gage or pattern for checking dimensions or locations.

Tensile Strength - The greatest load per square inch of original cross-sectional area carried during a tension test.

Ternary Alloy - One which contains three principal elements.

Test Bar - Bar cast of a standard shape and size to determine the physical and chemical properties of the metal.

Thermal Contraction - Decrease in linear dimensions of a material which accompanies a change in temperature.

Thermal Expansion - Increase in linear dimensions of a material which accompanies a change in temperature.

Thermocouple - A bi-metallic device capable of producing an electromotive force roughly proportional to temperature differences on its hot and cold junction ends and used in the measurement of elevated temperatures.

Tin Sweat - Beads or exudations of a tin-rich low-melting phase found on the surface of or on risers of bronze castings; usually caused from absorption of hydrogen by the molten metal.

Tongs - Metal instrument with two legs joined by a hinger for grasping and holding things; such as crucible tongs.

Top Board - A wood board on the cope half of the mold to permit squeezing the mold.

Transfer Ladle - Container used to carry molten metal from melting furnace to holding furnace, or from furnace to pouring ladles.

Trimming - Removing fins, gates, etc. from castings.

Trowel - Tool for sleeking, patching and finishing a mold.

Tucking - Pressing sand with the fingers under the flask bars, around gaggers, and other places to insure firm placement.

Undercut - Part of a mold requiring a drawback.

Upset (Frame) - Frame to increase the depth of a flask.

Vent - An opening in a mold or core to permit escape of steam and gases. Also called a vent hole.

Vent Rod - A piece of wire or bar to form the vents in sand.

Vent Wax - Wax in rod shape placed in the core during manufacture. In the oven the wax is melted out leaving a vent or passage.

Vibrator - A device which jars or vibrates the pattern or matchplate as it is withdrawn from the sand.

Wash - Casting defect resulting from erosion of sand by flowing metal. Also a term for coating materials applied to molds, cores, etc.

Weak Sand - Sand lacking in the proper amount of bond.

Weephole - A hole placed in a casting to permit drainage of moisture.

Whirl Gate - Gating system in which the metal enters a circular reservoir at a tangent, and so whirls around, leaving dirt and slag behind before passing into the mold cavity.

Yield Point - The load per unit of original cross section at which a marked increase in deformation occurs without increase in load.

Yield Strength - The stress at which a material exhibits a specified limiting permanent stress.

Figure I - Making cores.

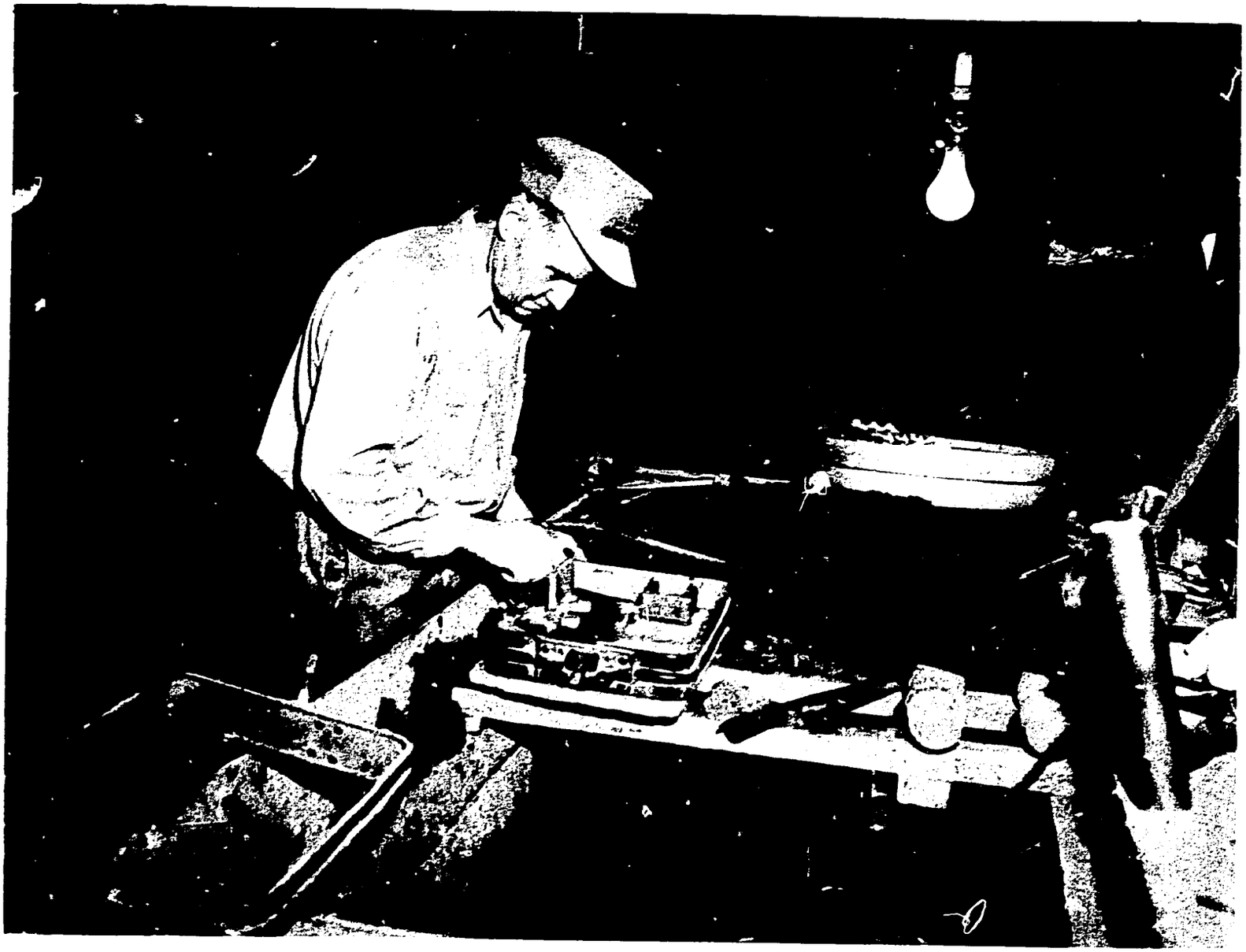

Figure 2 - Bench molding.

Figure 3 - Pneumatic Roll-Over Molding Machine.

Figure 4 - Removing pot of molten brass from furnace.

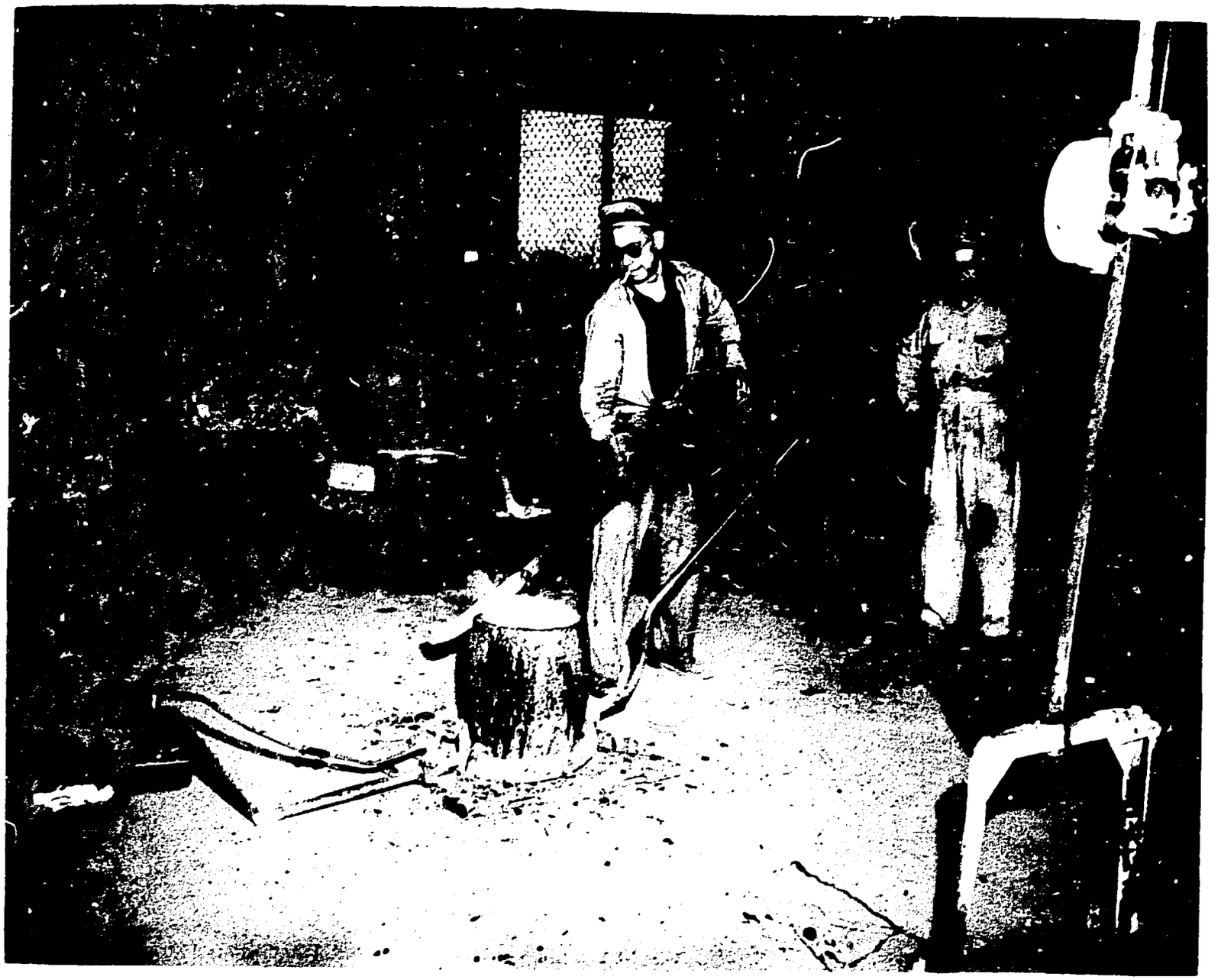

Figure 5 - Skimming dross from ladle.

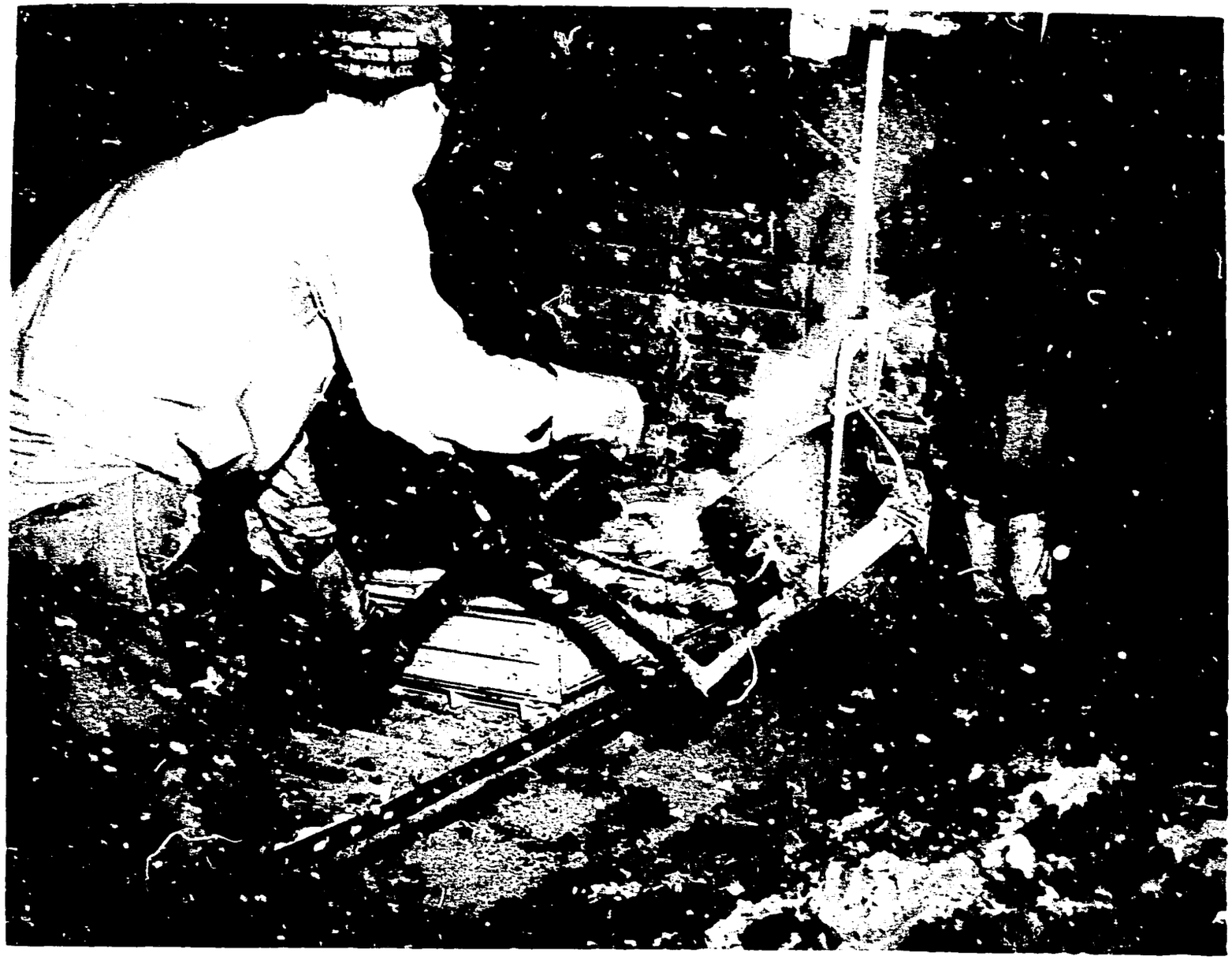

Figure 6 - Pouring.

Figure 7 - Grinding castings.

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