

July 5, 1966

L. W. SMITH

3,258,818

METHOD OF CASTING METALS

Filed March 31, 1965

FIG. 1

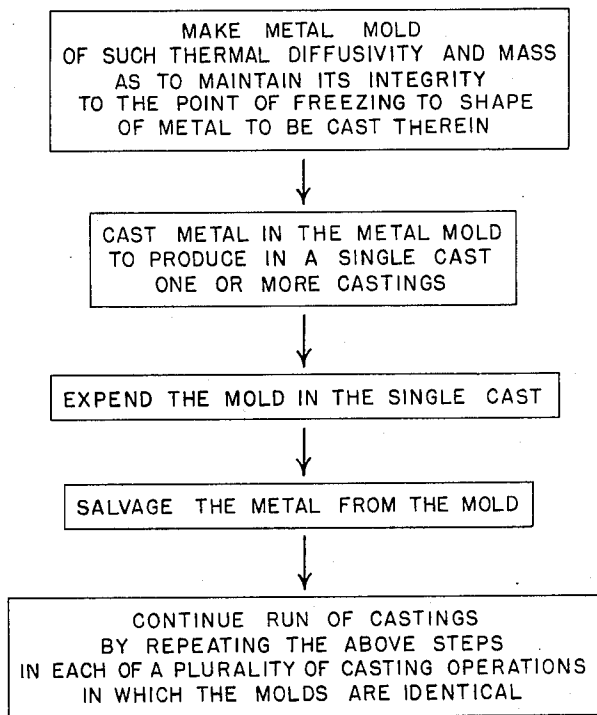
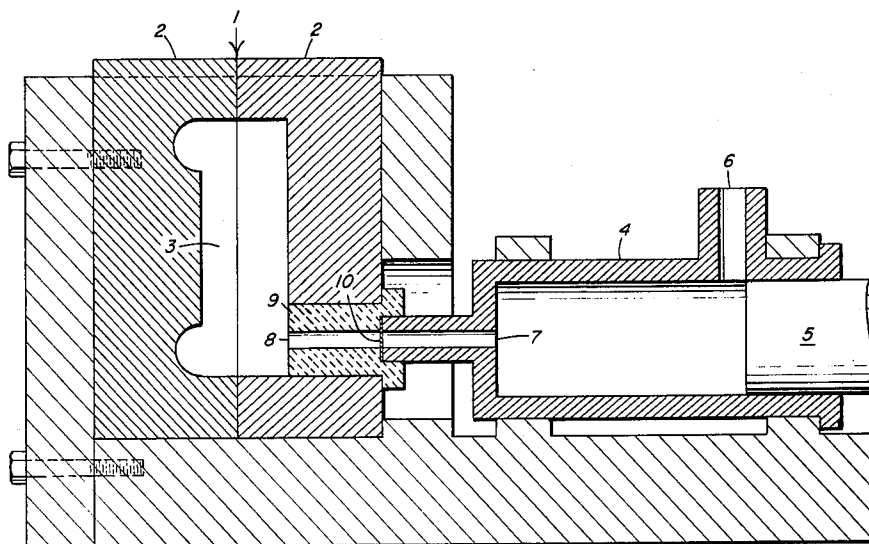


FIG. 2

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3,258,818

METHOD OF CASTING METALS

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Filed Mar. 31, 1965, Ser. No. 444,459

16 Claims. (Cl. 22-216.5)

This invention relates to a method of casting and particularly of die casting metals in metal molds. This application is a continuation-in-part of my now abandoned copending application Serial No. 141,975, filed on October 2, 1961.

Low melting metals, such as aluminum, magnesium and zinc, have been die cast in permanent metal molds and, quite recently, there has been some success in so casting brass. For the low melting metals, the molds usually are made of steel or cast iron, with their cavities machined to configuration, and sometimes are made of aluminum. The practice with the low melting metals has been to introduce them into the metal molds either by gravity or under pressure, the former generally called gravity casting and the latter die casting or sometimes pressure die casting. Where coring is required, the cores are usually made of metal and are either permanent for reuse or expendable, the latter of course being essential if the shape of the cavity formed by the core is such that it cannot be withdrawn intact from the finished casting. However, as to the metal mold, it heretofore has always been considered essential for commercial production that the metal mold itself be permanent in the sense of having an extended die or service life.

The die life of a permanent metal mold ends the moment it can no longer produce precisely the particular castings for which it was designed. Since, each time it is used, it is exposed to the metal being cast and must both diffuse the heat of the cast metal and permit the casting to be removed intact, such factors as oxidation, heat transfer, dimensional control and thermal expansion differences during the heat diffusion and casting removal thereafter, are vital in the design of a permanent metal mold. For the low melting metals such factors are not a particular problem at the low temperatures at which they are cast and permanent metal molds are in common use, sometimes with ceramic or like coatings applied for protection to their cavities. However, at the much higher temperatures at which high melting metals are cast, the same factors have heretofore been an enormous problem and present almost insurmountable obstacles to the casting of such metals in permanent molds.

For the potential advantage in producing precision metal castings without expensive machining, the castings industry has long sought to die cast the higher melting metals, such as brass, bronze and the ferrous metals. It has recently had some success with brass, as mentioned earlier, using as the metal for the permanent mold a special molybdenum alloy, but the initial cost has been very high and the die life quite short. With this exception, all the published literature that could be found on the subject evidences that, despite the need and intensive research, it heretofore has been considered impossible both in this country and abroad, to commercially die cast high melting metals and especially the ferrous metals, due to the short die life of possible metal molds. This is not surprising in view of the problems raised by the high temperatures involved in the design of the permanent metal molds.

As mentioned in my earlier application, Parlanti Patent No. 2,759,231 purports to disclose a method of commercially casting ferrous metals in aluminum molds. The method the patent describes is gravity casting and, in

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keeping with precedent, the molds are permanent. By anodizing all surfaces of the mold, applying a ceramic coating to the mold cavity and making use of the metal's high thermal conductivity, Parlanti contends that, "surprisingly," the high melting ferrous metals can be cast in permanent molds of relatively low melting aluminum. It would appear that Parlanti has ignored the factors in mold design that, as mentioned earlier, present almost insurmountable obstacles in the casting of high melting metals in permanent molds.

To meet the demands of the space industry, precision ferrous castings have been produced recently in this country in ceramic molds by the investment casting process and a variation of it known as the "Shaw process." While its products are precise, investment casting can only produce very small castings and the cost of \$.75 to \$1.00 per pound is so high as to limit the castings to exotic uses in which cost is no object.

The primary object of the present invention is to provide a method of die casting metals in metal molds, in which, by contrast with prior practice, both actual and proposed, the metal is cast in expendable metal molds which are expended in and the metal of which is salvaged after a single casting operation, thereby avoiding the obstacles in mold design confronting the casting of high melting metals in permanent metal molds.

Another object of the invention is to provide a method of die casting ferrous and other high melting metals in expendable metal molds, whereby, by expending a metal mold in a single use and reusing its metal, it is made feasible to select the mold metal on the basis of the properties desired in freezing or fixing the shape of the cast metal and to disregard such otherwise limiting factors as the initial cost of the mold metal and its melting point relative to that of the cast metal.

A further object of the invention is to provide a method of die casting ferrous and other high melting metals in metal molds, in which the metal mold is expended in and its metal salvaged after a single use and wherein the thermal diffusivity and mass of the mold are such as to enable it to dissipate the heat of the cast metal without loss of integrity to the point at which the casting's shape is fixed.

An additional object of the invention is to provide a method of die casting ferrous and other high melting metals, wherein the high melting metal is cast under pressure in a metal die which is die cast of a relatively low melting, readily die castable metal in a permanent metal mold and is expended in a single use and has its metal reused for die casting new dies, thereby so reducing the cost as to make at least ferrous die castings practical for general industrial use.

Another object of the invention is to provide a method of die casting ferrous and other high melting metals in metal molds which are expended in a single use, wherein, by making the mold of a metal of high thermal diffusivity and non-alloying with the cast metal, a high melting metal can be cast in a relatively low melting metal mold without protective treatment of the mold cavity, thereby obtaining maximum benefit from the thermal diffusivity of the mold and enabling it to be salvaged substantially entirely for making new molds.

Other objects and advantages of the invention will appear hereinafter in the detailed description and be particularly pointed out in the appended claims.

In the drawings:

FIGURE 1 is a flow sheet of a preferred embodiment of the present invention in which the mold metal is salvaged; and

FIGURE 2 is a somewhat schematic side view of apparatus suitable for die casting metal in accordance with

the method of this invention, in which, as opposed to the expandable mold, the charging cylinder is permanent and thermally insulated from the mold.

Basically, the method of this invention is for casting or die casting a run of metal castings in metal molds in a plurality of casting operations each producing in a single cast, fill or injection one or more castings each identical with a casting of every other operation. Each casting operation comprises the steps of making a metal mold, die casting a metal in the mold and expending the mold in a single use or operation. To reduce the cost of the method, the mold metal from the expended mold should be salvaged or recovered and, most conveniently, can be used in making additional molds. In carrying out the method, the liquid metal is pressure cast or, as generally termed, die cast by being introduced or injected under pressure into the metal mold. The method is applicable equally to high and low melting metals, but, as applied to low melting metals, such as aluminum, magnesium and zinc, usually will have no particular advantage over the present practice of die casting such metals in permanent steel, iron or even aluminum molds. It, therefore, can be expected to be applied principally, if not entirely, to the die casting of high melting metals, such as the ferrous metals, bronze and brass, with only one of which, brass, there has heretofore been even limited commercial success in die casting in the permanent metal molds of prior practice. While the exemplary high melting metals can and ordinarily will be cast in the presence of a normal ambient atmosphere, any special conditions, such as a partial vacuum or an inert atmosphere, can be provided to suit the basic method to a particular high melting metal such as titanium or zirconium.

The expendable or single use or operation metal mold in which the metal is cast may be made in a plurality of parts to facilitate removal of the finished casting, but, if the melting point of the mold metal is sufficiently below that of the cast metal, can be made in one part and melted off after the casting operation to free the finished casting. Too, if permitted by the shape of the particular casting to be produced, the benefits in preciseness and rapid heat dissipation of a metal mold, can be substantially fully obtained by making the expendable metal mold the part or die in which the mold cavity is principally formed and, to complete the cavity, closing that part or die against a companion part or die, which, since not depended upon for heat dissipation, may conveniently be made of or coated with a low conductivity ceramic inert to the cast metal.

Permanency of the metal mold is neither required nor desired. On the contrary, the expendable metal mold of this invention need maintain its integrity only to the point at which the cast metal is fixed or frozen in the shape imparted to it by the mold cavity and thereafter may disintegrate or otherwise be expended, even though the interior of the casting is still liquid. Since in addition the mold metal is salvaged and reused, a far wider range of metals is available for selection as the mold metal for a particular cast metal than has heretofore been possible. The metal mold must, of course, have sufficient thermal diffusivity to diffuse rapidly through its mass the heat transmitted to it at the interface by the cast metal so that at any given moment the temperature of the mold metal throughout the mold will be substantially the same. The other requirement of the disposable metal mold is as to its mass. If a surrounding water jacket or other suitable provision is made for rapid dissipation of heat from the mold during the die casting, the mass of the mold is not critical. However, absent forced circulation of a cooling medium, the heat loss from the mold to the surrounding atmosphere, in the short interval required for die casting, ordinarily will be so small relative to the total that it should be disregarded and the mass of the mold be made sufficient to absorb the heat loss in the cast metal from introduction or injection to the point of freezing to shape

without in process having its own temperature raised to the melting or, if lower, softening point of the mold metal.

So long as it meets the foregoing requirements as to its metal and mass, a metal mold can be used in a given casting operation in accordance with this invention and, since the mold metal is salvaged and reused indefinitely, even silver is available for use as the mold metal, whenever the advantage derivable from its very high thermal diffusivity outweighs its initial high cost. Although there will be some attendant reduction in the rate of heat transfer from the cast metal to the mold metal, if fusion or the formation of intermetallic compounds at the interface is likely for the particular cast and mold metals, this can be prevented by giving the mold cavity a suitable pretreatment, as by applying to it a coating inert to the cast metal. If desired, a release agent, such as used in conventional die casting, can be applied to the cavity beforehand to facilitate removal of the finished casting from the mold.

Commercial practicability generally will dictate the selection of the mold metal from the many possible mold metals on the basis of at least two factors and, where feasible, a third. The first two are its thermal diffusivity, as determined by its specific heat and heat conductivity, and die castability. As its thermal diffusivity measures its capacity to absorb and dissipate or carry away the heat from the cast metal during the cooling of the latter from a liquid to the freezing point at which it is frozen or fixed in shape, the mold metal most desirable is one having a high thermal diffusivity so that the cast metal will reach the point of freezing to shape without impairment to that point of the integrity of the mold. The second factor, die castability, is of prime importance if the single use molds are to be supplied at a rate sufficient for the high output of precision metal castings of which die casting is capable. Over a high melting metal, a low melting metal that can readily be die cast in a permanent metal mold would, therefore, be the preferred mold metal. The third factor is the relative reactivity or inertness of the mold metal to the cast metal. Lack of inertness can be compensated for by applying an inert coating or other protective treatment to the mold cavity before casting, but only at the expense of the thermal conductivity of the metal mold. Of mold metals that compare favorably on the basis of the other two factors, the one more inert to or non-alloying with the cast metal thus usually will be preferred as enabling prior protective treatment of the mold cavity to be minimized or eliminated entirely.

While the selection of the mold metal for die casting a high melting metal in accordance with the method of the present invention may lead to different mold metals for different cast metals, it leads, in the case of the ferrous metals to aluminum and its alloys, hereinafter termed collectively "aluminum," as the preferred mold metal. As explained in my earlier application, not only is aluminum a low melting metal which is readily die castable by conventional die casting techniques in permanent molds of steel, iron or even aluminum, but it has a thermal diffusivity below only silver, copper and gold and a low initial cost and is substantially inert to the ferrous metals. Its inertness to the ferrous metals permitting its direct exposure thereto during casting, aluminum has the further attraction in die casting ferrous metals of eliminating the need for an inert coating or other preliminary protective treatment of the mold cavity and thus enabling the mold wholly or entirely to be salvaged after the single use for use in die casting new molds. Of all possible mold metals, aluminum, therefore, is the most practical for the commercial die casting of the ferrous metals by the method of this invention. Not only is aluminum the most practical mold metal, but, as indicated by the cost analysis on file in my application Serial No. 141,975, its use enables steel to be die cast at a cost of about 15 cents a pound, a cost so low as for the first time to make steel die castings practical for common industrial use, by contrast with the limited exotic market

for precision steel castings produced by investment casting.

The method of this invention is applied to the die casting of ferrous metals in expendable or single use aluminum molds in the manner described in my earlier application. Conventional die casting practice may be followed not only in die casting the aluminum molds in suitable permanent molds but also, as shown in FIGURE 2, in making each aluminum mold 1 into two parts as a pair of mating dies 2 which during casting are adapted to be held in mated relation on a suitable holding machine. Also conventionally, the dies of each aluminum mold will have impressed or formed in them their parts of the mold cavity 3, any core prints, the pouring cavity and other necessary cavities, including vents or vent holds for escape of air from the top and any blind or trapped areas of the mold cavity.

As in die casting non-ferrous metals, it is contemplated in this exemplary application of the method of this invention, to force the liquid ferrous metal under pressure into the mold cavity in the amount required to produce the particular casting and to maintain the metal under pressure until it has solidified. This entails the use of a charging cylinder 4 fitted with a ram or piston 5 and having axially spaced feed or inlet and discharge or outlet ports 6 and 7, respectively, with the capacity of the cylinder such that, on closing or sealing off of the inlet port in the advance stroke of the ram, the required metered charge of the liquid metal will be expressed or forced from the outlet port through a connecting passage 8 into the mold cavity. Were the mold permanent, the charging cylinder should be made integral with it. However, for the temporary or expendable mold of this invention, the cylinder, as desired, may be integral or separate and, in the latter case, adapted either to be mounted on a side of or fitted into a suitable cavity in the mold. Consequently, although the mold itself is temporary, the associated charging cylinder may be permanent and, particularly if arranged to enable the ram to push out any residual metal on completion of each operation, can readily be used with different molds for a long run of castings.

Although not so important in die casting low melting non-ferrous metals, it is very important for the high melting ferrous metals of this example that the charging cylinder be spaced or otherwise thermally insulated from the mold cavity, as by a ceramic spacer 9, so as not to detract from the high thermal diffusivity of the mold metal upon which the desired rapid solidification of the casting is dependent and, to prevent interference with escape of air through the vents, that the liquid ferrous metal enter the mold cavity from a side or the bottom. It also is important to prevent the liquid metal from entering the mold cavity prematurely and to guard against cold shuts as the cavity is being filled. Since the molds are temporary, entrance of liquid metal into the mold cavity, except during the pressure stroke or cycle of the ram, is readily preventable by inserting a controlled burst diaphragm 10 in the passage between the charging cylinder and the mold cavity in the course of assembling the mold sections for a casting operation. If the shape of a particular ferrous casting is found or deemed likely to cause cold shuts, they can be effectively eliminated by a limited preheating of the molds, with the consequent loss in the heat absorption capacity of the molds compensated, as necessary, by increasing their mass.

As mentioned earlier, any necessary core prints are included among the cavities impressed in the mold sections as they are cast, preferably by die casting. The coring required for a particular ferrous casting and fittable into these prints as part of the mold in assembling the mold sections, also preferable is die cast metal and ordinarily will be of the same analysis as the metal of which the molds are made. However, the cores can and, under certain circumstances, should be of different metal analysis

than the molds themselves. Thus, if it is desired that the cores be meltable out of the castings more readily than were they made of mold metal and any resulting decrease in the relative thermal diffusivity of the coring is acceptable, the cores can be made of a lower melting metal than the dies.

Using the preferred die cast aluminum expendable molds and cores, the method of this invention in this exemplary form involves but few steps. After the first in which the sections of the mold and the cores are die cast from aluminum in permanent molds of aluminum or other suitable metal, the mold sections and cores are assembled. With the controlled burst diaphragm and charging cylinder in position and the mold held in a holding machine, the charging cylinder is then charged with liquid ferrous metal. Actuation of the ram completes the casting operation. Next the mold sections are separated to enable the ferrous casting to be removed and any otherwise inaccessible cores are melted out of the casting. Thereafter, the mold metal and the metal from the cores is remelted for die casting into new mold sections or dies and cores.

As opposed to the only prior known commercial production of precision ferrous castings, in which they have been produced by investment casting in ceramic molds, the exemplary application of the present method to ferrous metals, in addition to the far lower cost, has advantage in being applicable to the production of castings of a much wider size range. It also can produce castings to as close or closer tolerances and, due to the high thermal diffusivity of the aluminum molds, of better physical properties than can be produced in non-metallic molds. Both in the exemplary application and in general, the present method, by eliminating the dependence of prior practice upon permanent metal molds in favor of expendable or single use metal molds, of course, eliminates the problems in the design of permanent metal molds, raised by factors such as oxidation, heat transfer, dimensional control, thermal expansion differences and casting removal, that, save for brass, have heretofore barred the commercial die casting of high melting metals.

From the above detailed description, it will be apparent that there has been provided a method of die casting metals in metal molds, which, by expending the metal mold in a single use and salvaging the mold metal, in the main for the first time, provides a commercially practicable way of die casting high melting metals. It should be understood that the described embodiment is merely exemplary of the invention, and that all modifications are intended to be included that do not depart from the spirit of the invention and the scope of the appended claims.

Having described my invention, I claim:

1. A method of casting a run of metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more castings each identical with a casting of every other operation, comprising in each casting operation making a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of metal to be cast therein, casting said metal in said mold, and expending said mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended.

2. A method of die casting a run of metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more castings each identical with a casting of every other operation, comprising in each casting operation making a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of metal to be cast therein, casting said metal under pressure in said mold, and expending said mold in said casting operation to free the run of castings from dependency for

preciseness upon any life of a mold beyond the operation in which it is expended.

3. A method of die casting a run of metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more castings each identical with a casting of every other operation, comprising in each casting operation making a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of metal to be cast therein, casting said metal under pressure in said mold, expending said mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and salvaging the metal of said mold.

4. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation making a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of high melting metal to be cast therein, casting said metal under pressure in said mold, and expending said mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended.

5. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation making a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of high melting metal to be cast therein, casting said metal under pressure in said mold, expending said mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and salvaging the metal of said mold.

6. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting a relatively low melting metal to make a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of high melting metal to be cast therein, casting the high melting metal under pressure into said metal mold, expending said metal mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and using the metal of said metal mold to die cast new molds.

7. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting a relatively low melting metal in a permanent mold to make a metal mold of such thermal diffusivity and mass relative to high melting metal to be cast therein as to maintain its integrity in absorbing the heat of the high melting metal to the point of freezing to shape, casting the high melting metal under pressure in said metal mold, expending said metal mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and using the metal of said metal mold to die cast new molds.

8. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting a relatively low melting metal in a permanent mold to make a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of high melting metal to be cast therein, injecting a measured quantity of the high melting metal under pressure into said metal mold for casting said metal therein, expending the metal mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and using the metal of said metal mold to die cast new molds.

9. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting a relatively low melting metal in a permanent mold to make a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of high melting metal to be cast therein, injecting a measured quantity of the high melting metal under pressure into said metal mold, maintaining pressure on said cast metal to said point, expending the metal mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and using the metal of said metal mold to die cast new molds.

10. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting in a permanent metal mold a metal inert and low melting relative to a high melting metal to be cast to make a metal mold of such thermal diffusivity and mass as to maintain its integrity to the point of freezing to shape of high melting metal to be cast therein, presenting said metal mold for casting without protective treatment of any mold cavity therein, casting said high melting metal under pressure in said mold cavity, expending said metal mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and using the metal of said metal mold to die cast new molds.

11. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting a metal low melting relative to a high melting metal to be cast to make a metal mold and any required metal coring each of such thermal diffusivity and mass relative to the mass of said high melting metal to be cast in said mold as to maintain its integrity in absorbing the heat of said high melting metal transmitted thereto to the point of freezing to shape, inserting said coring in any mold cavity in said mold, casting said high melting metal under pressure in said cavity, expending said mold and coring in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and using the metal of said mold and coring to make new molds and coring.

12. A method of die casting a run of ferrous and other high melting metal castings in metal molds in a plurality of casting operations each producing in a single cast one

or more of said high melting metal castings each identical with a casting of every other operation, comprising in each casting operation die casting a relatively low melting metal to make a metal mold of such thermal diffusivity and mass as to maintain its integrity in dissipating the heat of high melting metal to be cast therein to the point of freezing to shape, thermal insulatedly connecting a charging cylinder to said mold, filling said cylinder with said high melting metal, ramming said metal in said cylinder into said metal mold for casting said metal therein, expending said metal mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and recovering and reusing the metal of said metal mold to make new molds.

13. A method of die casting a run of ferrous metal castings in aluminum molds in a plurality of casting operations each producing in a single cast one or more ferrous metal castings each identical with a casting of every other operation, comprising in each casting operation making an aluminum mold, casting said ferrous metal under pressure in said mold, expending said mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and reusing the aluminum from said mold to make new molds.

14. A method of die casting a run of ferrous metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more ferrous metal castings each identical with a casting of every other operation, comprising in each casting operation die casting in a permanent mold a plural die aluminum mold of such mass relative to ferrous metal to be cast therein as to maintain its integrity in absorbing the heat of said ferrous metal to the point of freezing to shape, casting said ferrous metal under pressure in said aluminum mold, expending said aluminum mold in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and reusing the aluminum from said aluminum mold to make new molds.

15. A method of die casting a run of ferrous metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more ferrous metal castings each identical with a casting of every other operation, comprising in each casting operation die casting aluminum in a permanent aluminum mold to make an aluminum die of such mass relative to ferrous

metal to be cast therein as to maintain its integrity in dissipating the heat of said ferrous metal to the point of freezing to shape, casting said ferrous metal under pressure in said die, expending said die in said casting operation to free the run of castings from dependency for preciseness upon any life of a mold beyond the operation in which it is expended, and reusing the aluminum from said die to cast new dies.

16. A method of die casting a run of ferrous metal castings in metal molds in a plurality of casting operations each producing in a single cast one or more ferrous metal castings each identical with a casting of every other operation, comprising in each casting operation die casting aluminum to make an aluminum die and any required coring, inserting said coring in a mold cavity in said die, presenting said die for casting without protective treatment of said cavity and coring, casting ferrous metal under pressure in said die, expending said die and coring in said casting operation to free the run of castings from dependency for preciseness upon any life of the mold beyond the operation in which it is expended, and reusing the aluminum from said die and coring to die cast new dies and coring.

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J. SPENCER OVERHOLSER, *Primary Examiner*.

V. K. RISING, *Assistant Examiner*.