June 5, 1934. C. PACK 1,961,941

DIE CASTING

Filed Jan. 2, 1930 2 Sheets-Sheet 1

Fig. 1

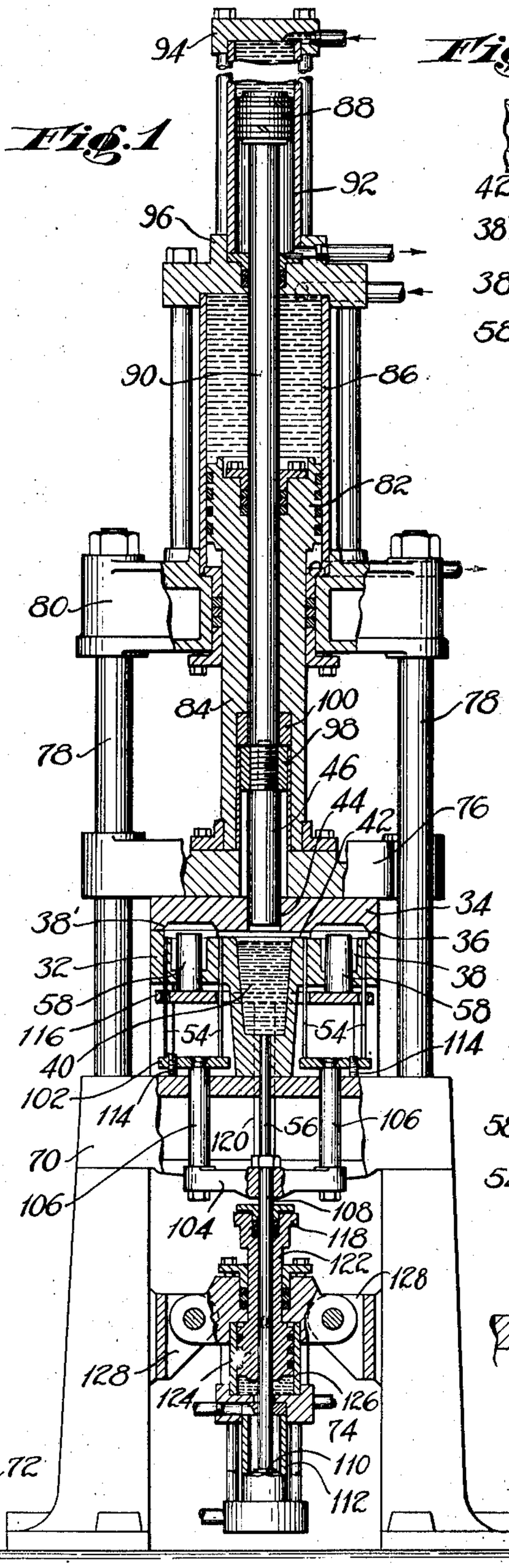

Fig. 4

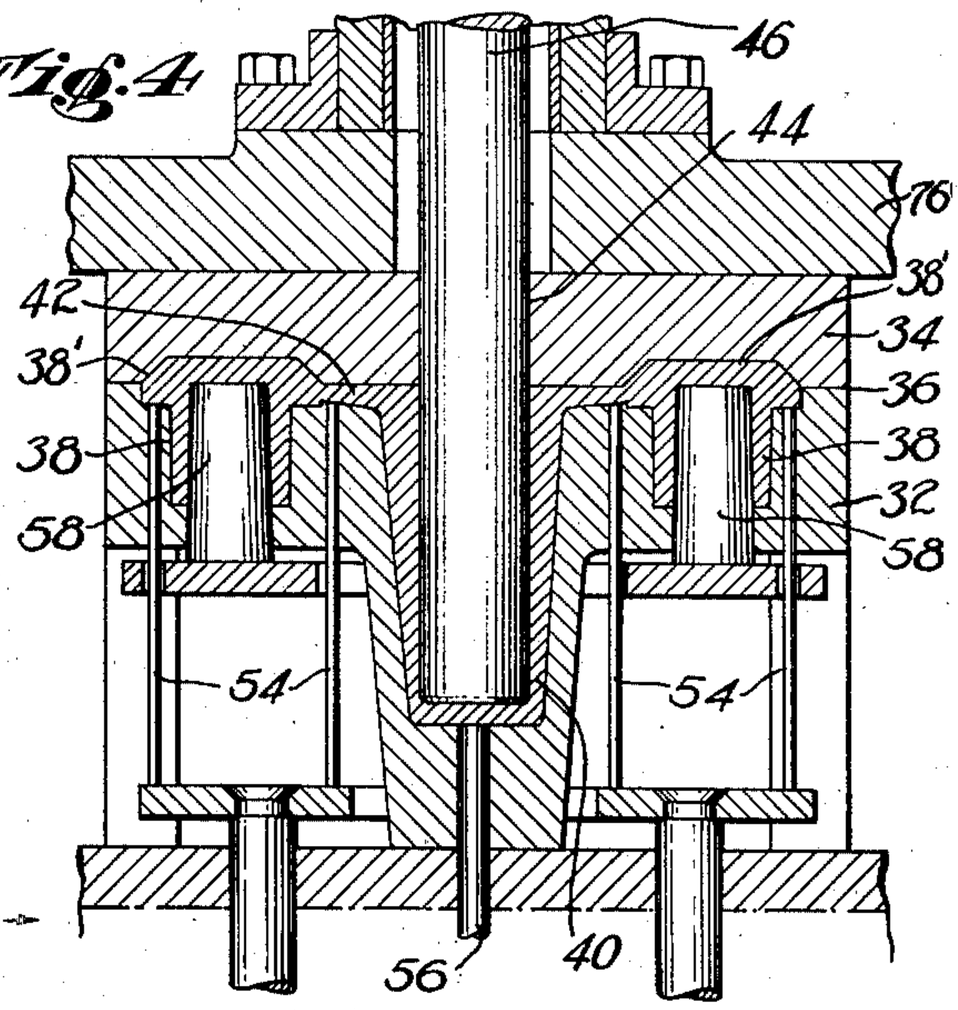

Fig. 5

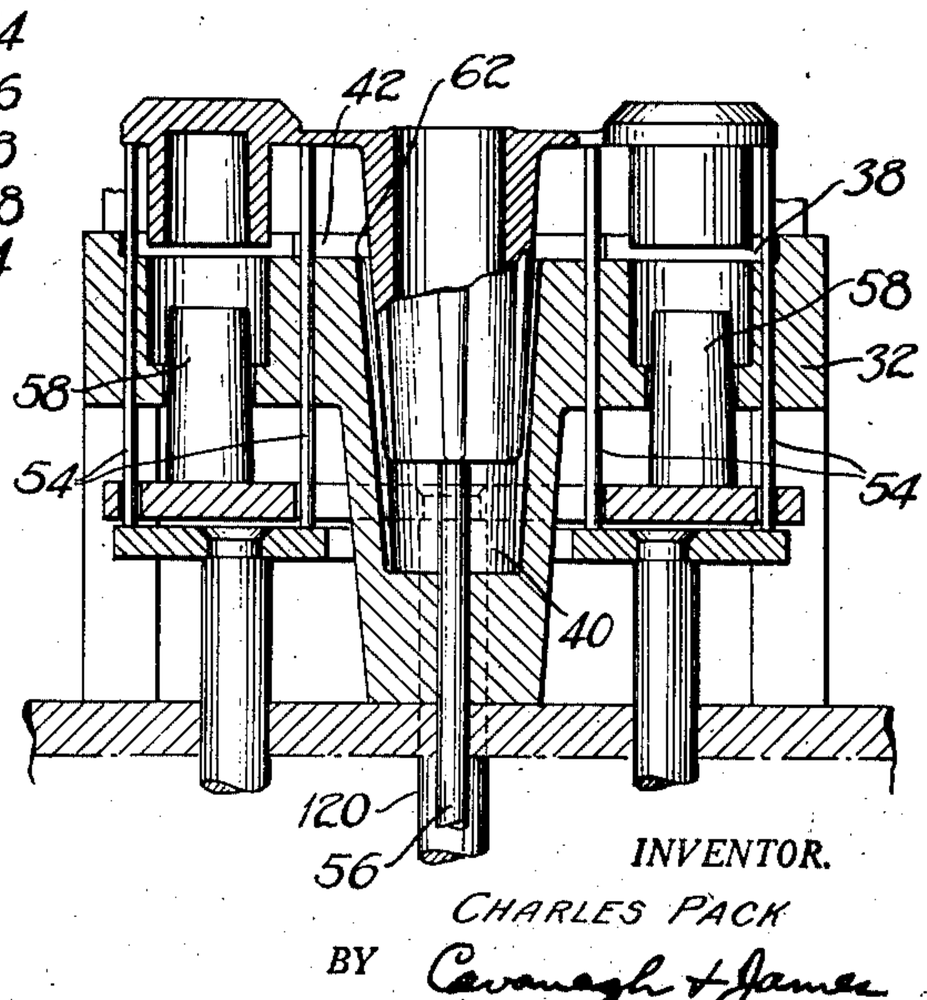

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Fig. 2

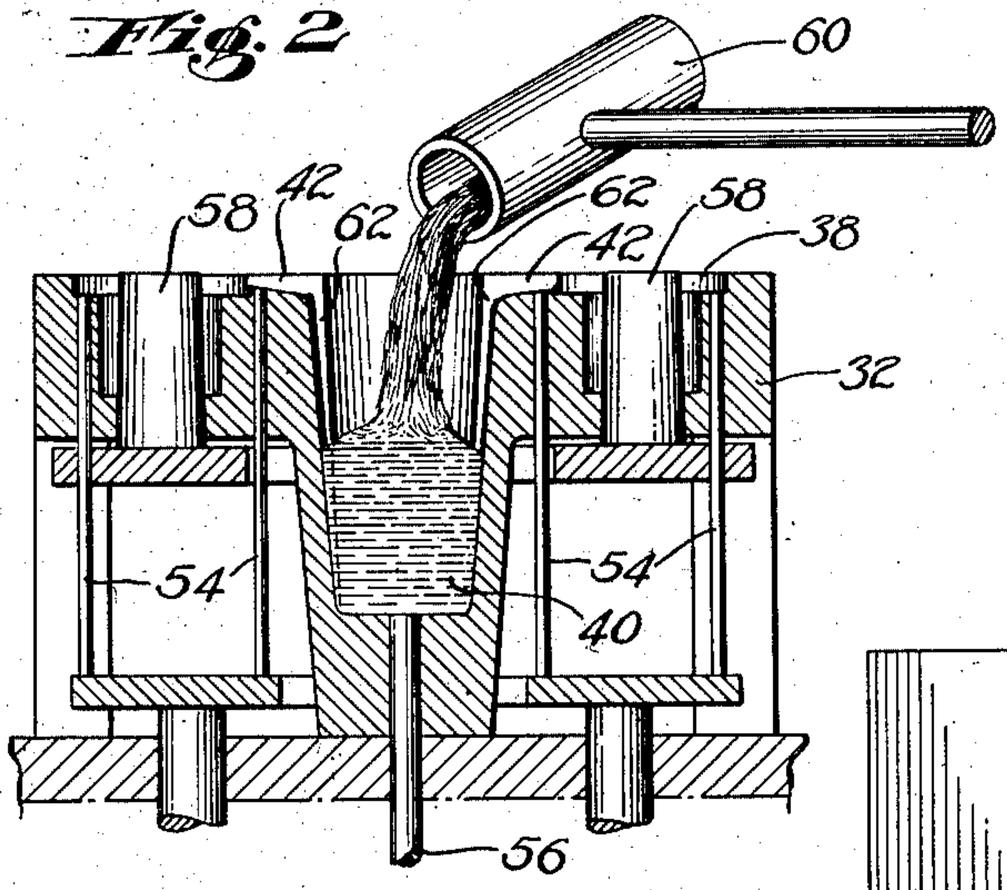


Fig. 3

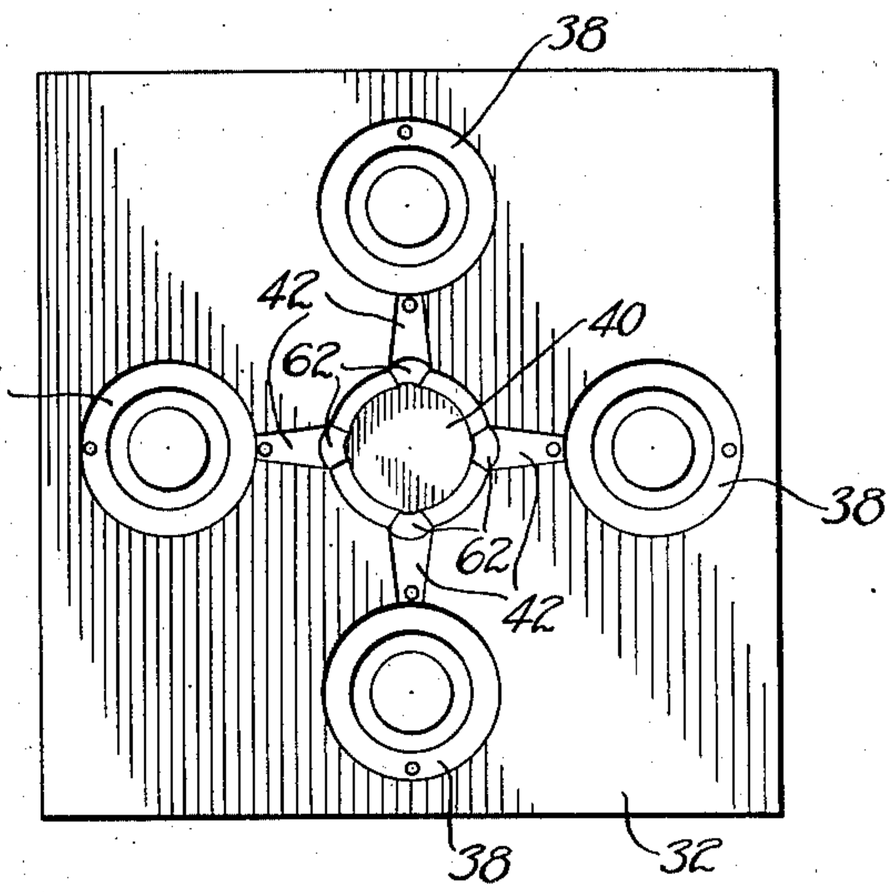
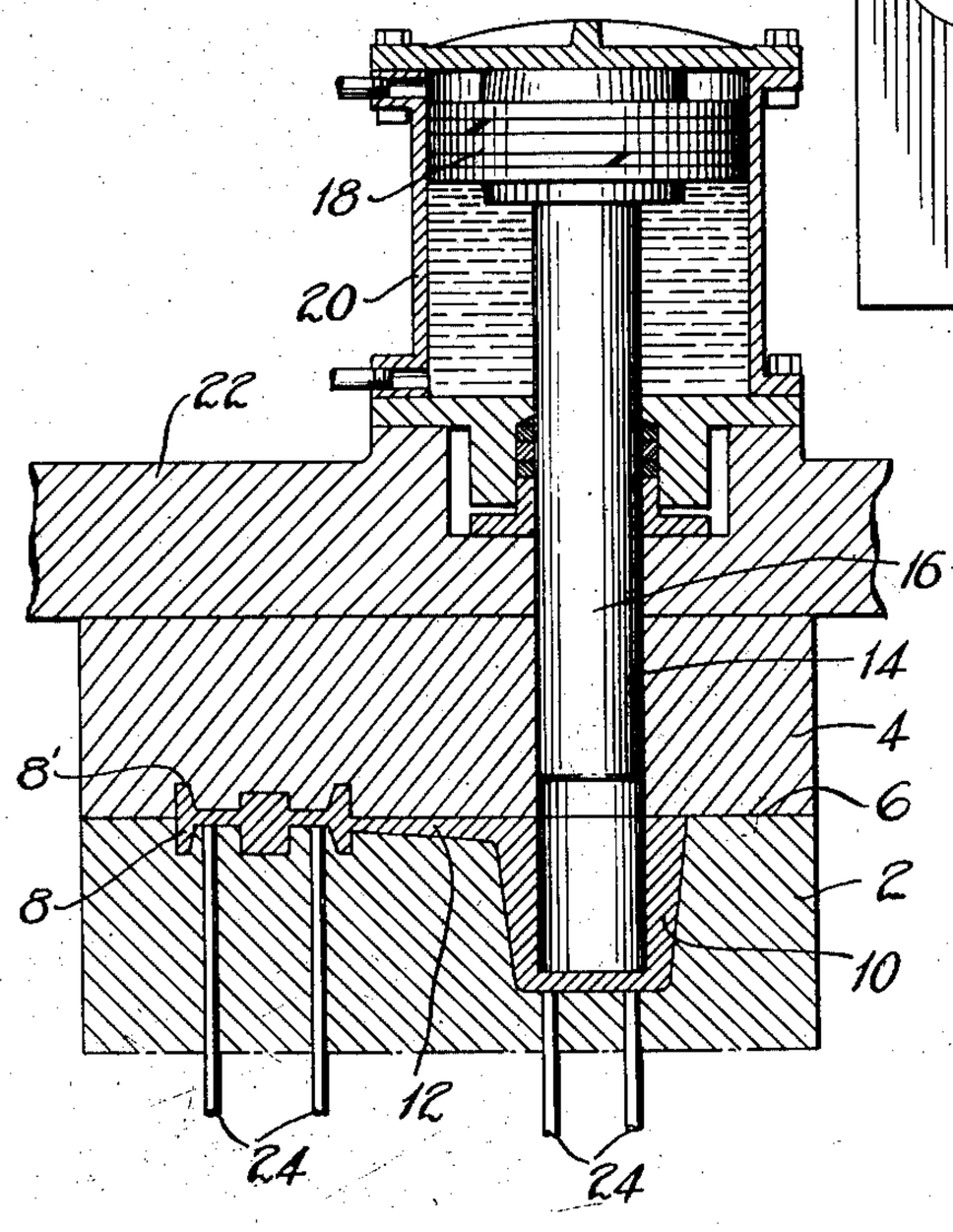


Fig. 6



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UNITED STATES PATENT OFFICE

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DIE-CASTING

Charles Pack, Jackson Heights, N. Y.

Application January 2, 1930, Serial No. 417,849

18 Claims. (Cl. 22—68)

This invention relates to die-casting, and more particularly to a method and means for die-casting any metal under any desired high pressure.

A common type of die-casting machine is the plunger type, in which a reciprocable plunger and cylinder are immersed in a reservoir of molten metal, from which the plunger operates to pump some of the metal into a die. This type of die-casting machine has the advantage of making it possible to attain relatively high pressures in the casting operation. However, its use is limited to alloys having a comparatively low melting point, say 800 degrees Fahrenheit, because at higher temperatures difficulty is experienced due to expansion and freezing of the plunger in the cylinder.

This difficulty has led to the development of the direct air type of die-casting machine, a common form of which employs an enclosed gooseneck ladle, which is filled with metal by being immersed in a reservoir of molten metal, and to which compressed air is subsequently admitted in order to eject the metal therefrom into the die. With this machine almost all metals may be cast except those having so very high a melting temperature that the strength of the ladle against the air pressure is weakened, but the air machine suffers from the disadvantage that the maximum pressure obtainable is relatively low.

The primary object of the present invention is to combine the advantages and overcome the disadvantages of both the plunger and the air types of die-casting machines, and thereby to make it possible to cast any metal at any desired pressure.

Even when working with low temperature alloys the plunger type of machine heretofore employed could not attain extremely high pressures owing to difficulties arising with the fit between the cylinder and the piston or plunger. It is very difficult to maintain close tolerances between these parts when they are completely immersed in molten metal or when the cylinder carries molten metal, because of the large temperature changes to which the parts are subjected between the cold and the heated state; because of the abrasion between the plunger and cylinder when working on a molten metal constantly tending to solidify; and because of the solubility of the material of the piston and cylinder in the molten metal. One important object of my invention is to overcome the foregoing difficulties and to make possible the attainment of extremely high pressures without necessitating close fits and, in fact, allowing for solidification of metal on the walls of the cylinder.

In die-casting machines of either the plunger or the air type there is a constant tendency for the working parts of the machine to go into solution in the reservoir of molten metal. This leads to a constant loss of metal in the form of a discarded dross-like substance and, more importantly, causes contamination of the metal being cast and necessitates recurring replacement of the immersed machine parts. A further object of the present invention resides in the provision of a die-casting machine not subject to these difficulties and disadvantages, and thereby making possible the casting of pure metal.

It sometimes is desired to make a certain number of castings of a given metal and an additional quantity of similar castings of a different metal. With the prior machines it has been necessary in such cases to drain the reservoir of metal and melt the desired second metal, or to change machines, or, in the case of metals of widely different melting point, to change from one to another kind of machine. Still another object of this invention is to make possible the manufacture of successive castings out of different metals, the change being made at will and even in alternation.

Other objects of this invention are to provide a die-casting machine which, in addition to fulfilling the various foregoing objects, will require substantially smaller floor space than machines heretofore used, and which may be manufactured at a relatively low cost.

To the accomplishment of the foregoing and such other objects as will hereinafter appear, my invention consists in the die-casting method and machine elements and their relation one to the other as hereinafter are more particularly described in the specification and sought to be defined in the claims. The specification is accompanied by drawings in which:

Fig. 1 is a partially sectioned vertical elevation through a machine embodying the present invention;

Fig. 2 illustrates a die receptacle being loaded with metal to be cast;

Fig. 3 is a plan view of a lower die portion including a fluted receptacle;

Fig. 4 illustrates the casting operation;

Fig. 5 shows the ejection of the castings and gate from the lower die portion; and

Fig. 6 is a section through a modified die-casting machine.

Referring first to Fig. 6, there is a die con-

sisting of a lower die portion 2 and an upper die portion 4, separable on a parting line 6. The lower die portion is provided, in addition to the usual mold impression 8, with a receptacle 10 for receiving the molten metal to be cast, and a gate 12 connecting the mold impression 8 with the receptacle 10. The upper die portion 4 is provided with a mold impression 8', mating with the mold impression 8, and with a cylindrical opening 14 closely fitting a plunger 16 smaller in diameter than the receptacle 10 and located thereabove. The plunger 16 may be reciprocated by any suitable means, here exemplified by a hydraulically operated piston 18 reciprocable in a cylinder 20 mounted on a clamping plate 22.

In operation the separable die portions are separated and a preferably, though not necessarily, measured quantity of molten metal is transferred by means of a ladle from a reservoir of molten metal and poured into the receptacle 10. The upper die portion 4 is then clamped upon the lower die portion 2, and the plunger 16 forced into the receptacle 10. This kind of casting may be conveniently referred to as "press-coating". The receptacle 10 being larger in diameter than the plunger 16, solidification of metal around the walls of the receptacle does not affect the descent of the plunger. In effect, the latter displaces the center or heart of the metal from the receptacle 10 through the gate 12 and into the mold impressions 8, 8'. The plunger 16 may be quickly reciprocated before the metal remaining in the receptacle 10 freezes to the plunger. The die portions may then be separated and the casting and the remaining metal in the receptacle be ejected from the lower die portion by means of ejector fingers 24. The casting may then be broken from the gate in the customary manner, and the gate remelted for further use.

With this arrangement it is obvious that the reservoir of metal may be kept molten in a refractory crucible, thereby avoiding contamination. Extremely high pressures may be obtained because a close tolerance may be provided between the plunger 16 and the upper die portion 4, inasmuch as these parts are not steadily immersed in metal and, in fact, may, if desired, be artificially cooled. The plunger is smaller than the receptacle 10, thereby allowing for solidification of metal around the walls of the receptacle, and consequently preventing injury and wear of the plunger. The apparatus may be of extreme simplicity for any form of press may be used to clamp the die portions together and to apply movement to the plunger.

The machine so far described has been selected for preliminary explanation of the invention because of its simplicity. Identically similar principles are made use of in the more complex machine next described with reference to Figs. 1 through 5 of the drawings. In this machine there is a die including a lower or ejector die portion 32 and an upper or cover die portion 34, these die portions being separable on a parting line 36. The lower die portion 32 is provided with a plurality of mold impressions 38, there being four similar impressions illustrated in the present example. It will be understood, of course, that any suitable number of mold impressions may be provided and that these may be different, as well as alike.

The lower die portion 32 is also provided with a receptacle 40 which is preferably located as shown in central relation with respect to the mold impressions 38. The latter are connected with the receptacle 40 by appropriate gates 42.

The upper die portion 34 is provided with mold impressions 38' which mate suitably with the mold impressions 38 in the lower die portion 32. The upper die portion is also provided with a cylindrical opening 44 closely fitting a reciprocable plunger 46 which is smaller in diameter than the receptacle 40.

The lower die portion 32 is provided with ejector fingers 54 for ejecting the finished castings, and with an ejector finger 56 for ejecting the metal remaining in the receptacle 40.

In the case of the particular castings here being manufactured it is necessary to provide cores or core pieces 58 projecting into the mold impressions. To prevent freezing of the cast metal to the core pieces it is desirable to not only give them a slight taper, but also to make them reciprocable so that they may be quickly retracted from the castings.

The method of the present invention may next be explained with particular reference to Figs. 2, 4, and 5 of the drawings. In Fig. 2 the upper die portion has been separated from the lower die portion, thereby exposing the receptacle 40. The ejector fingers 54 and 56 have meanwhile been retracted, and the cores 58 have been elevated to their proper positions. A quantity of molten metal is dipped from a reservoir of pure molten metal by a ladle 60 and transferred to the receptacle 40. The ladle 60 is preferably of proper size to measure out approximately the necessary quantity of metal for one casting operation, but this quantity is not critical. Obviously, the receptacle 40, in the case of any particular die, is likewise made of sufficient depth to permit the ejection therefrom of sufficient metal for the castings being made without permitting the plunger 46 to reach the bottom of the receptacle.

Referring next to Fig. 4, the upper die portion 34 has been clamped in proper position on the lower die portion 32, and the plunger 46 has been forced downwardly into the receptacle 40, thereby causing the center metal to be displaced therefrom, and through the gates 42 into the mold impressions 38, 38'. The casting operation may be run at any desired pressure, the pressure being determined by the force with which the plunger 46 is forced downwardly into the receptacle 40. The descent of the plunger 46 is not obstructed by solidified metal on the walls of the receptacle owing to the fact that sufficient clearance is allowed between the diameters of the plunger and the receptacle to prevent this from happening.

Almost instantly after the plunger has been depressed it may be retracted and the core pieces 58 retracted, inasmuch as only a relatively small quantity of metal is being brought into considerable intimate surface contact with die portions, core pieces, and a plunger, which are all in a relatively cool state. As is clear from Fig. 5, the upper die portion is next elevated and separated from the lower die portion, and the ejector fingers 54 and 56 are raised, thereby freeing the castings and the cup-shaped metal remaining in the receptacle from the die. The castings may readily be broken free at the gate in the usual manner, and the cup-shaped remaining metal may be re-melted and again used for casting.

Referring again to Figs. 2 through 5, and more particularly to Figs. 3 and 5, it will be noted that the receptacle 40 may be provided with a flute or groove 62 at each of the gates 42. These flutes

facilitate the ready discharge of metal from the receptacle 40 upward through the gates 42 when the plunger descends. From another viewpoint, it may be explained that the excess diameter of the receptacle relative to that of the plunger is necessitated by two component increases, one due to solidification of metal around the walls of the receptacle, and the other due to clearance desired to permit upward flow of the displaced metal. The flutes or grooves 62 permit the receptacle 40 to be designed with a closer clearance because only the first component need be provided for, the second component being taken care of by the flutes. In this manner the weight of metal which must be handled and re-melted because of the metal remaining in the receptacle at each casting operation is greatly reduced. In fact, while I have suggested that in the practice of my invention the plunger displaces only the center portion or heart of the metal in the receptacle, and while I propose to use this terminology in the claims appended hereto, I wish it to be clearly understood that I do not intend by this terminology to convey the impression that only a small portion of the metal in the receptacle is displaced. As a matter of fact, quite the opposite is true, and with an automatic machine such as is disclosed in Fig. 1 of the drawings, opening and closing of the die portions may be proceeded with so rapidly that only a slight solidification of metal takes place around the walls of the receptacle, and consequently a small clearance may be used. This clearance, however, is in every case quite large compared with the close fit obtained between the plunger and the opening in the upper die portion, and also is quite large compared with the clearances used in the ordinary plunger type of die-casting machine. Consequently, by the statement in the claims that the plunger is substantially smaller in diameter than the receptacle, I do not mean that it is only a fraction of the diameter of the receptacle, for it is nearly equal to the same, but rather that the clearance is several or many times that normally employed between a plunger and cylinder used for ejecting molten metal.

In the foregoing description it has been assumed that suitable means are available for opening or closing the die portions and for reciprocating the plunger, the core pieces, and the ejector fingers. Suitable means for the performance of these several functions are next described with particular reference to Fig. 1. The lower die portion 32 is carried by a frame or bed portion 70 mounted upon a suitable foundation 72. The frame 70 also carries means generally indicated at 74 for operating the ejector fingers 54 and 56, and the core pieces 58. The upper die portion 34 is carried upon a cross head 76 reciprocably mounted on four vertical pillars or rods 78 which are fixed at their lower ends to the machine frame 70. A fixed cross head 80 is bolted to the upper ends of the rods 78 and carries means for operating the cross head 76 and the plunger 46.

The present machine is hydraulically operated, preferably by oil supplied under a suitably high pressure. The movable cross head 76 is reciprocated by a piston 82 connected thereto by a piston rod in the form of a tube 84. The piston 82 reciprocates within a fixed cylinder 86 and, if desired, oil may be selectively admitted and discharged from either end of the cylinder in order to move the piston 82 in either direction, and thereby to open or close the die portion 34 attached to the cross head 76. However, as will be subsequently explained, the piston 82 and cylinder 86 may be made only uni-directionally operative for clamping the die portions together, but not for separating them.

The plunger 46 is reciprocated by means of a piston 88 to which it is connected by a piston rod 90. The piston rod 90 passes through the tubular opening in the piston rod 84, thereby making it possible for the pistons 82 and 88 to be concentric and their forces to be applied symmetrically. The piston 88 reciprocates in a fixed cylinder 92 bolted between an upper cylinder head 94 and a lower cylinder head 96 which, in turn, acts as the upper cylinder head of cylinder 86, and is bolted to the fixed frame member 80. The cylinder 92 is longer than the cylinder 86 because the stroke of piston 88 must exceed that of piston 82 by the amount of immersion of plunger 46 desired in the receptacle 40. This, in turn, depends upon the displacement of metal needed in relation to the diameter of the particular plunger then being employed. In practice, of course, the stroke of piston 88 is made larger than that of piston 82 by an amount equal to the largest stroke of plunger 46 which, it is anticipated, will be desired in the operation of the machine.

During the casting operation the cross head 76 must be forced downwardly with sufficient pressure to prevent leakage through the parting line between the die portions. On the other hand, a relatively slight force is sufficient to elevate the cross head and the upper die portion between casting operations. It is desirable to retract the plunger 46 almost immediately after it has descended for reasons previously explained, whereas the upper die portion 34 is preferably elevated only after the plunger 46 has been retracted. These facts may be taken advantage of by providing a collar 98 between the plunger 46 and the piston rod 90, which engages a shoulder 100 in the hollow piston rod 84 during the upward motion of the plunger 46. The oil pressure employed is very high in order to obtain the desired casting pressure and the desired commensurate clamping pressure between the die portions, and this pressure, applied solely to the underside of piston 88 and not to the underside of piston 82, is sufficient to retract the plunger, and upon collar 98 reaching the shoulder 100 to raise cross head 76 and the upper die portion 34, the pressure on the upper side of piston 82 having meanwhile been released.

The ejector fingers 54 are positioned in advantageous location in the lower die portion, dependent upon the particular castings being made. The lower ends of the ejector fingers are fixed to an ejector plate 102 in corresponding locations. The ejector plate 102 is connected to a cross rod 104 through posts 106. Cross rod 104 is rigidly fixed on a piston rod 108, the upper end of which acts as the ejector finger 56. Piston rod 108 is connected to a piston 110 reciprocating in a cylinder 112. Accurate location of the upper ends of the ejector fingers 54 during the casting operation is insured by stop screws 114 located in the ejector plate 102. It will be clear from the description thus far that upon the application of pressure on the underside of piston 110 the ejector fingers 54 and 56 may all be simultaneously raised, and thereby serve to eject the castings and the cup-shaped gate from the lower die portion, as is indicated in Fig. 5.

The core pieces 58 are located in positions necessitated by the particular castings being manufactured, and are fastened in similar locations to a core plate 116. This core plate is

provided with suitable apertures to permit the free passage therethrough of the ejector fingers 54. The core plate is related to a cross head 118, just as the ejector plate 102 is related to the cross head 104. But the cross head 118 is positioned at right angles to the cross head 104, that is, it is perpendicular to the plane of the drawings and is connected to the core plate 116 by two vertical posts, one of which is shown at 120. The cross head 118 is fixedly mounted on a tubular piston rod 122 fixed at its inner end to a piston 124 which is reciprocable in a cylinder 126. The piston rod 122 is hollow in order to permit the passage therethrough of piston rod 108. The cylinder 126 is anchored to the frame 70 through brackets 128, and the cylinder 112 is fixed to the end of cylinder 126 and through it to the frame 70. It will be clear that during the casting operation the core plate 116 is held upwardly by pressure exerted on the lower side of piston 124 and that immediately after the casting operation the piston 124 may be forced downwardly, thereby retracting the core pieces 58, as is indicated in Fig. 5. It will be noted that the ejector plate 102 and the core plate 116 approach each other at the end of the casting operation, but the permissible travel thereof is properly limited to prevent interference. It will also be clear that with certain castings the core pieces and core plate may be dispensed with, and that in other castings it may be necessary to use horizontally reciprocable core pieces which, with the present machine, would have to be operated manually. It also may not be amiss at this point to mention that in the case of certain complex castings it may be necessary to use a die consisting of more than two die portions, but all these special problems belong to the province of the artisan skilled in the preparation of dies for die-casting, and need not be entered into here. It will also be understood that while I have not disclosed the precise piping and valve mechanism to be used for controlling the oil supplied to the cylinders 86, 92, 112, and 126, these may be of conventional type and may be and preferably are suitably interconnected to make the operation of the machine depend simply upon the movement of a single manually operable control member. This is readily accomplished in the case of the present machine because so many of the movements may take place simultaneously.

My die-casting or press-casting method and its application to the die-casting or press-casting machines here set forth will be understood from the foregoing description thereof. The method and the machine possess numerous advantages which, for the most part, will already be apparent. Any alloy may be used regardless of its melting point. Zinc alloy, which ordinarily must have added thereto aluminum to prevent freezing, may be used in a pure state or in alloys containing no aluminum. High pressures may be obtained equal to an even substantially greater than those now obtainable in plunger type machines and while working with any desired metal or alloy. The pressure obtainable is not dependent upon maintaining a close fit between a plunger and a cylinder containing molten metal. The plunger is not forced against solidified metal and therefore is capable of indefinite wear. There is no need to use asbestos cups or the like to prevent solidification of metal while press-casting.

It is possible to obtain castings of great purity for the metal may be kept molten in a refractory crucible. A number of machines may be operated from a single crucible. A single machine may be operated from a number of crucibles, thereby making it possible to change the metal being cast at will. No machine parts being immersed in molten metal, the replacement cost, due to solution of immersed parts, is eliminated.

The machine in simple form may be applied to take advantage of any pressure mechanism which happens to be anyway available, for all that is essential is a die provided with a suitable receptacle and plunger. The machine in the form here disclosed is economical of floor space and is relatively economical to build. The machine is not connected to a melting furnace or reservoir of metal, and therefore remains relatively cool, so that close tolerance may be provided in the various moving parts which, in turn, makes for increased length of life of the machine.

It will be apparent that while I have shown and described my invention in the preferred forms, many changes and modifications may be made in the structures disclosed without departing from the spirit of the invention, defined in the following claims.

I claim:

1. In die-casting under pressure the method which includes pouring a quantity of molten metal into a receptacle in enclosed communication with a mold, causing a slight solidification of metal on the walls of the receptacle, and displacing the molten center portion only of the metal out of the receptacle and forcing the said molten metal into the mold under pressure.

2. A die-casting machine comprising a receptacle for molten metal, a mold in communication therewith, means to force the molten center portion only of the metal out of the receptacle and into the mold, and means to remove the solidified remaining metal from the receptacle.

3. A die-casting machine comprising a receptacle for receiving a measured quantity of molten metal from a reservoir, a mold in communication with said receptacle, means to cover the receptacle, means to displace the molten center portion only of the metal out of the receptacle and to force said molten metal into the mold, and means to remove the casting from the mold and the remaining metal from the receptacle in a solid state.

4. A press-castings machine comprising a receptacle for molten metal to be cast, a mold in enclosed communication therewith, and a plunger for displacing the metal from the receptacle into the mold under pressure, said plunger being substantially smaller in diameter than the diameter of the body of metal in the receptacle.

5. A die-casting machine comprising upper and lower die portions having a mold impression and a receptacle for molten metal, a gate connecting the mold impression with the receptacle, and a plunger reciprocable through one of said die portions for displacing solely the central portion of the metal out of the receptacle through the gate and into the mold impression.

6. A die-casting machine comprising a lower die portion having a plurality of mold impressions and a receptacle for molten metal, a gate connecting each of the mold impressions with the receptacle, an upper die portion, and a plunger reciprocable through said upper die portion for displacing the central portion only of the metal in the receptacle through the gates and into the mold impressions under pressure.

7. A die-casting machine comprising a lower die portion having a mold impression and a receptacle for molten metal, a gate connecting the mold impression with the receptacle, said receptacle being downwardly tapered and provided with a flute at the gate to facilitate flow of metal upwardly therethrough, an upper die portion, and a plunger reciprocable through said upper die portion for displacing the central portion only of the metal in the receptacle through the flute and gate and into the mold impression.

8. A die-casting machine comprising a lower die portion having a plurality of mold impressions and a receptacle for molten metal, a gate connecting each of the mold impressions with the receptacle, said receptacle being downwardly tapered and provided with flutes at each of the gates to facilitate flow of metal upwardly therethrough, an upper die portion, and a plunger reciprocable through said upper die portion for displacing the metal in the receptacle through the flutes and gates and into the mold impressions.

9. A die-casting machine comprising a lower die portion having a mold impression and a receptacle for molten metal, a gate connecting the mold impression with the receptacle, an upper die portion, and a plunger substantially smaller in diameter than the body of metal in the receptacle reciprocable through said upper die portion for displacing the central portion of the metal in the receptacle through the gate and into the mold impression.

10. A die-casting machine comprising a mold having a plurality of mold impressions and a receptacle for molten metal, a gate connecting each of the mold impressions with the receptacle, said receptacle being downwardly tapered, and a plunger substantially smaller in diameter than the receptacle reciprocable into said receptacle for displacing metal from the receptacle through the gates and into the mold impressions.

11. A die-casting machine comprising separable die portions provided with a mold impression, a receptacle in flow communication with the mold impression, reciprocable core pieces, reciprocable ejector fingers for the finished casting and receptacle residue, and a reciprocable plunger smaller in diameter than the receptacle for displacing metal therefrom into the mold impression.

12. A die-casting machine comprising separable die portions provided with a mold impression, a receptacle in flow communication with the mold impression, reciprocable core pieces, reciprocable ejector fingers for the finished casting and receptacle residue, and a reciprocable plunger smaller in diameter than the receptacle for displacing metal therefrom into the mold impression, means to open or close the die portions, means to reciprocate the plunger, means to reciprocate the core pieces, and means to reciprocate the ejector fingers.

13. A die-casting machine comprising separable die portions provided with a mold impression, a receptacle in flow communication with the mold impression, reciprocable core pieces, reciprocable ejector fingers for the finished casting and receptacle residue, and a reciprocable plunger smaller in diameter than the receptacle for displacing metal therefrom into the mold impression, means to open or close the die portions, means to reciprocate the plunger, means to reciprocate the core pieces, and means to reciprocate the ejector fingers, said means including pistons reciprocable in cylinders under hydraulic pressure.

14. In die-casting apparatus, the combination of two die members providing a well having in its side a channel extending upwardly from its bottom, a casting cavity between said die members, and an inlet for said casting cavity connected with the channel above the bottom of the well, a plunger guided for downward movement into said well, and means for depressing said plunger into said well and thereby displacing hot metal therein upwardly through the channel and through said inlet to the casting cavity.

15. In die-casting apparatus, the combination of a die including two die members providing a casting cavity therebetween and a well in said die communicating at a point above its bottom with said casting cavity, a plunger of smaller cross section than said well slidably supported above said well, and means to depress said plunger into said well and thereby displace hot metal therein upwardly and through such comunication to the casting cavity.

16. A press-casting machine comprising separable die portions provided with a receptacle, a mold impression, and a gate leading from the upper portion of the receptacle to the mold impression, said receptacle being adapted to receive a single charge of molten metal to be cast in the mold impression, a plunger substantially smaller in diameter than the body of metal in the receptacle and reciprocable into the receptacle, said plunger having a clearance between it and the receptacle which at its minimum is substantially larger than the maximum clearance used between the plunger and cylinder of conventional die casting machines, and means to simultaneously eject the solidified residue in the receptacle, the gate, and the casting when the die portions are separated.

17. A die-casting machine comprising a downwardly tapered receptacle for molten metal, a mold in communication therewith, means to force the molten center portion only of the metal out of the receptacle and into the mold, and means to remove the solidified residue of metal from the receptacle.

18. A press-casting machine comprising separable die portions provided with a downwardly tapering receptacle, a mold impression, and a gate leading from the upper portion of the receptacle to the mold impression, said receptacle being adapted to receive a single charge of molten metal to be cast in the mold impression, a plunger substantially smaller in diameter than the minimum diameter of the body of metal in the receptacle and reciprocable into said receptacle, said plunger having a clearance between it and the receptacle which at its minimum is substantially larger than the maximum clearance used between the plunger and the cylinder of conventional die-casting machines, and means to eject the casting, the gate, and the solidified receptacle residue when the die portions are separated.

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