Dec. 9, 1952 J. DE STERNBERG 2,620,528

DIE CASTING MACHINE

Filed Nov. 30, 1948 6 Sheets-Sheet 1

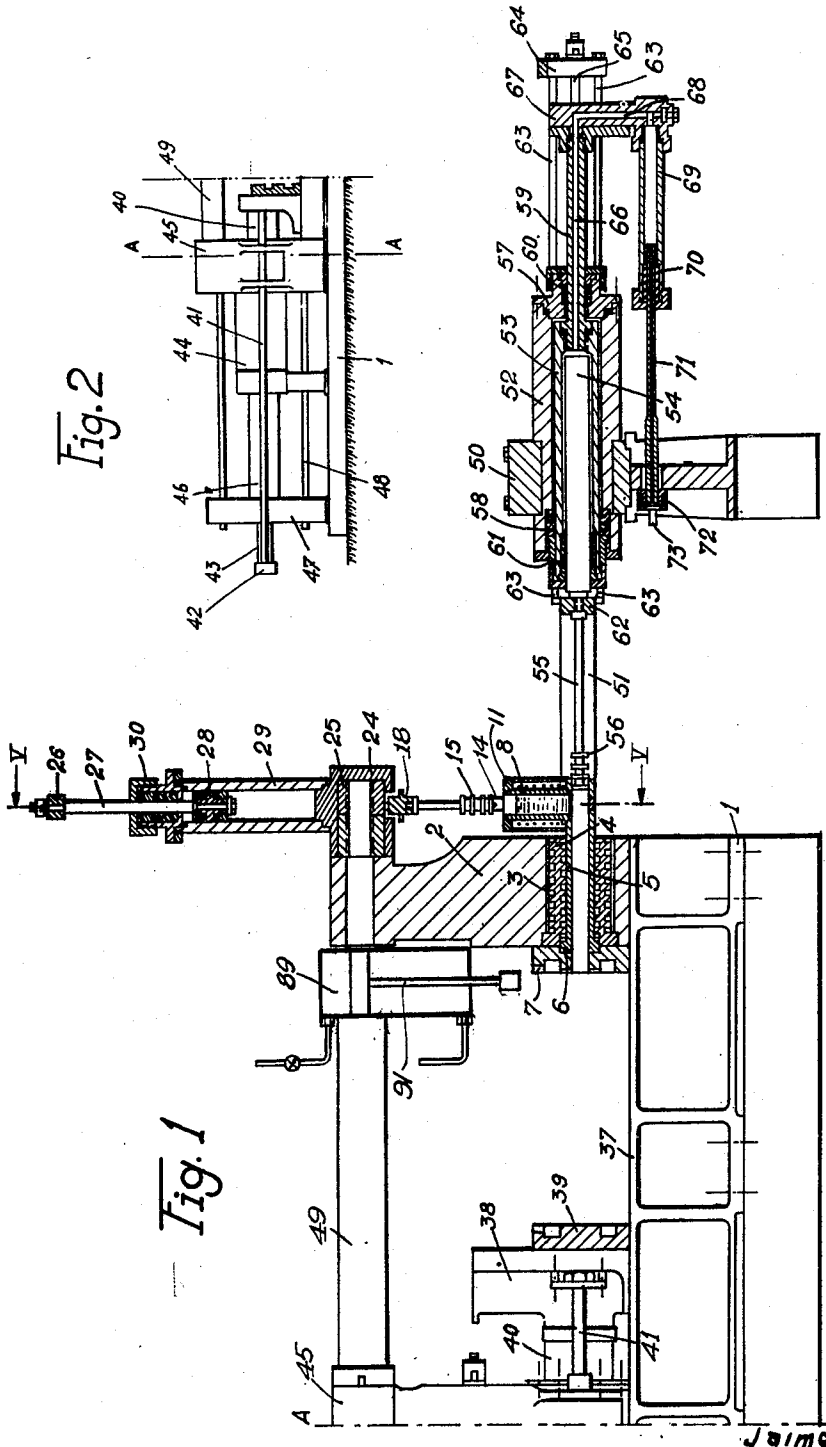


Fig. 2

Fig. 1

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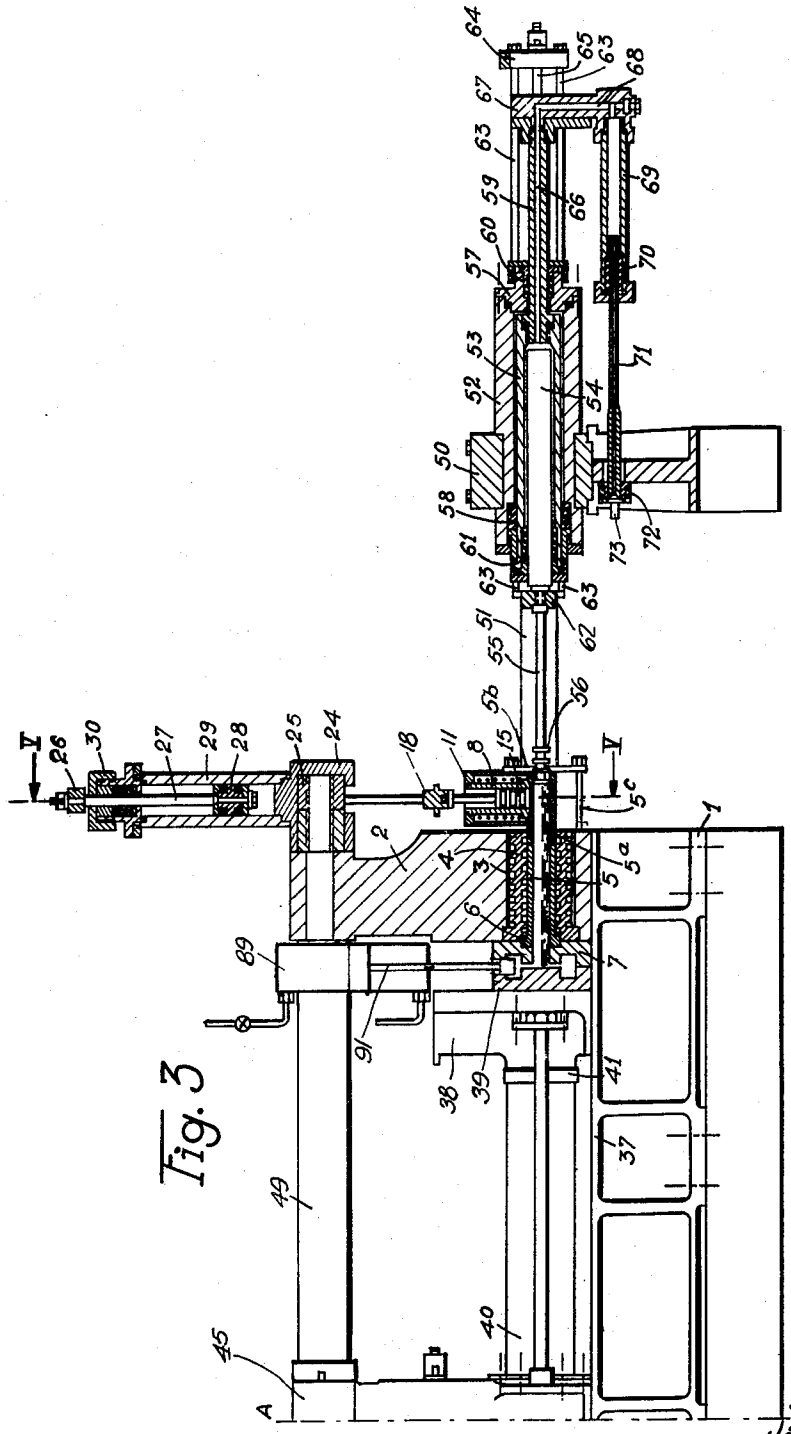


Fig. 3

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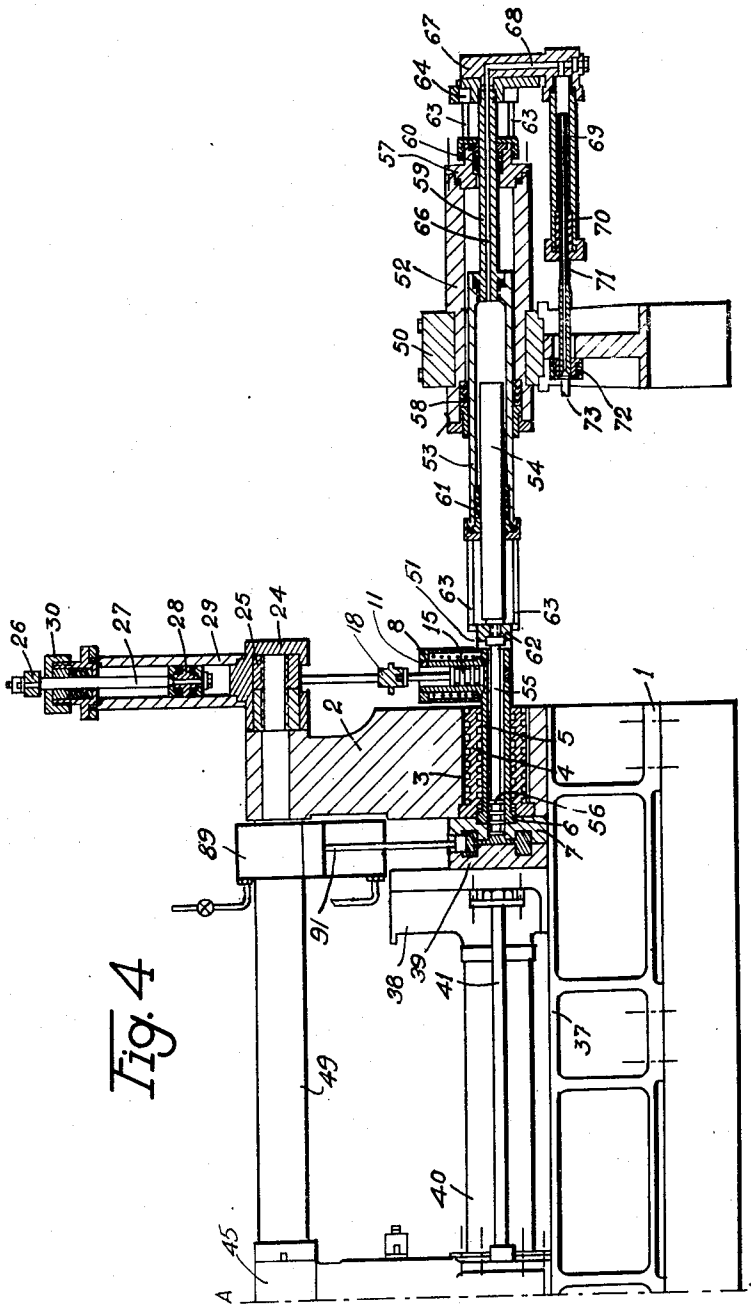


Fig. 4

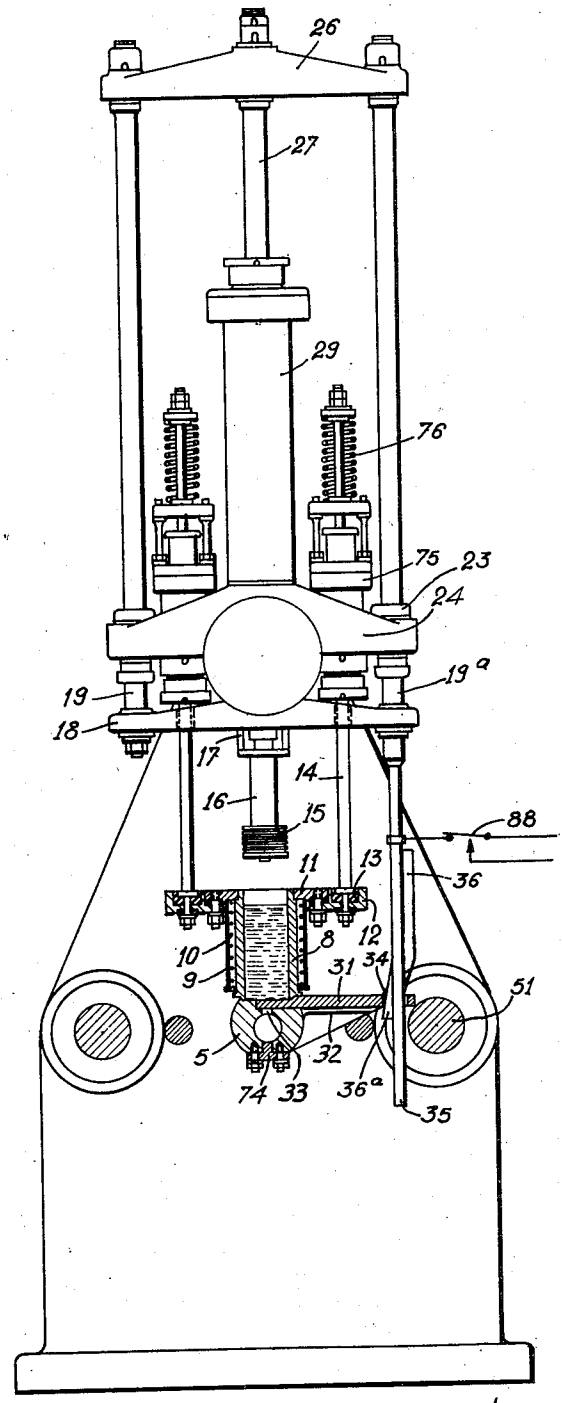
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DIE CASTING MACHINE

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Fig. 5




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DIE CASTING MACHINE

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Fig. 6

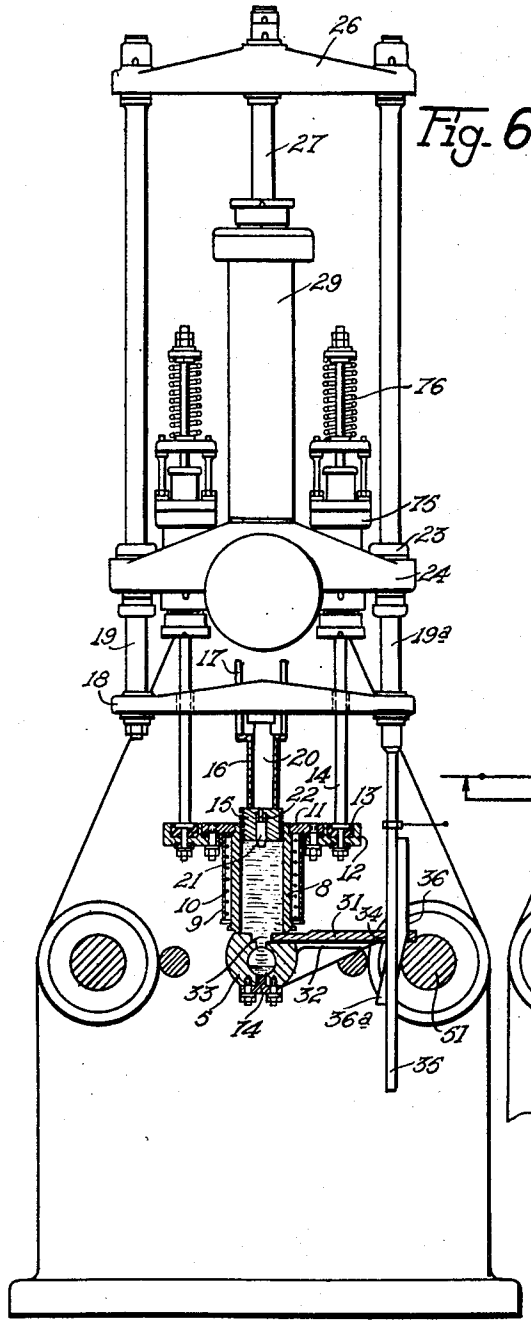
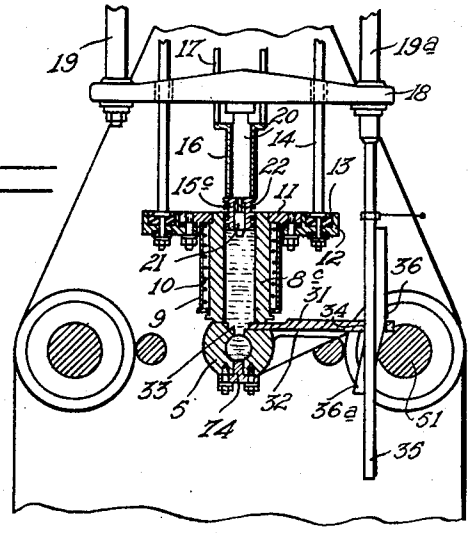



Fig. 9




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DIE CASTING MACHINE

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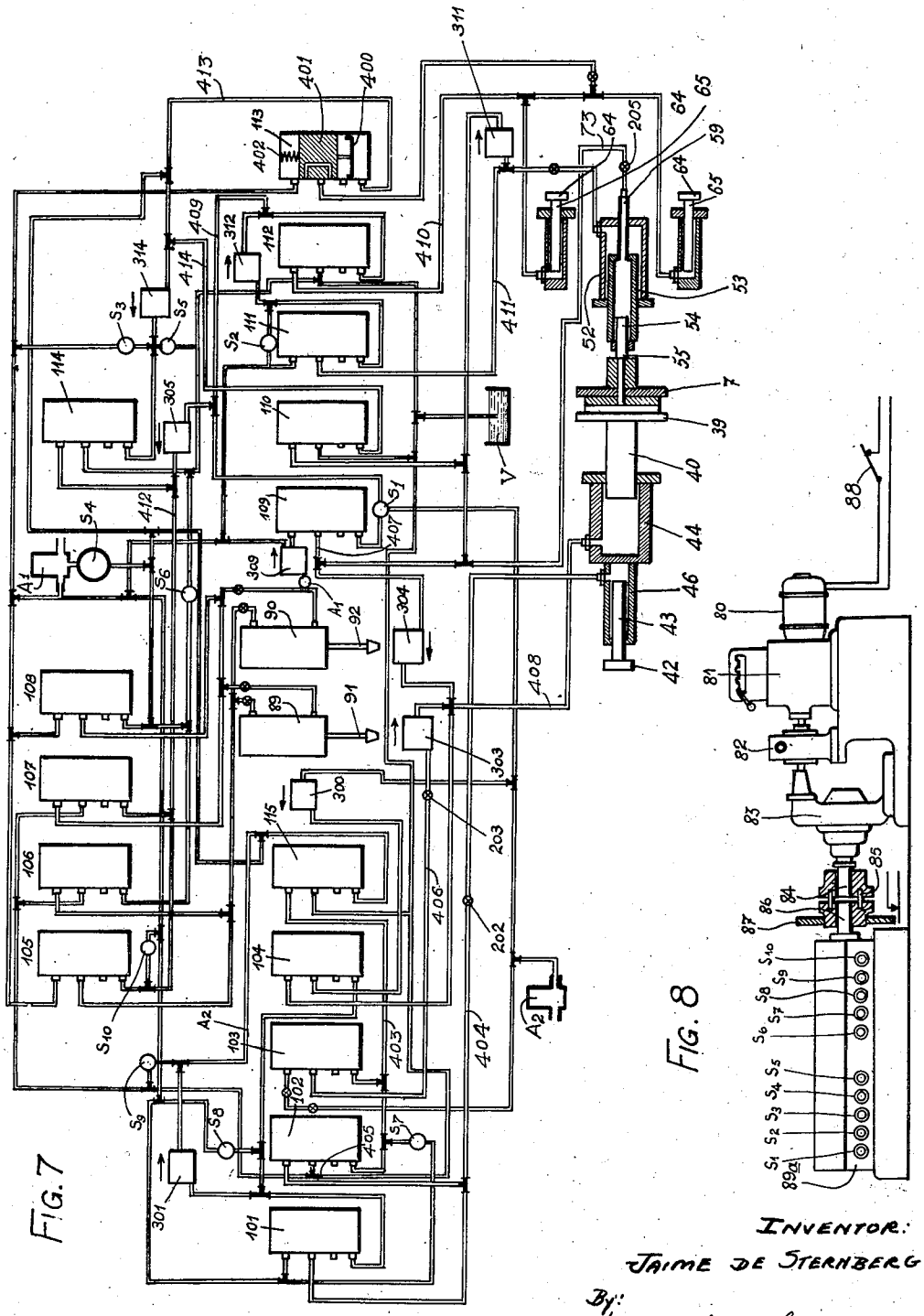


FIG. 7



FIG. 8

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Patented Dec. 9, 1952 2,620,528

# UNITED STATES PATENT OFFICE

2,620,528

## DIE CASTING MACHINE

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Application November 30, 1948, Serial No. 62,686
In France November 18, 1948

6 Claims. (Cl. 22—68)

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Die casting for molten materials which attain the solid state within a die, when such materials have a high melting point, necessitates numerous precautions and may be only performed by using intricate machines the operation of which is very difficult. In the event of die casting metals and, more particularly, steels, the operative stages may not be controlled without complication and with a high rate of production.

An object of the invention is to provide, in a die casting machine having an injection cylinder of predetermined capacity, an auxiliary cylinder acting as a pot for the molten material and associated with an auxiliary plunger movable therein for introducing molten material within the injection cylinder through connecting means ensuring a timed communication between both cylinders with respect to the position of said auxiliary plunger, said auxiliary cylinder being filled with molten material by handling means such as ladles or the like.

Another object of the invention is to provide, in a die casting machine of the character described, means for supplying the injection cylinder with amounts of molten materials inferior, equal or superior to the capacity thereof, said means comprising either a fixed auxiliary cylinder the filling and the discharge of which may be repeated many times sequentially or a set of detachable auxiliary cylinders, the capacity of each of said auxiliary cylinders corresponding accurately to the amount of molten material to be injected, whereby it is avoided to change the injection piston, such a change generating a complete modification in the operative characteristics of the die casting machine.

Another object of the invention is to provide, in a die casting machine of the character described, hydraulic means for moving in timed relation the injection piston and the auxiliary piston and hydraulic means for opening and closing the die, said last means being hydraulically connected to said injection piston, whereby the pressures exerted within the injection cylinder and the die closing cylinder are equal.

Another object of the invention is to provide, in a die casting machine of the character described, means for multiplying simultaneously the injection pressure exerted within the injection and the die closing cylinders when the injection step is ended, thereby to apply an excess pressure to the casting yet in pasty condition. Such means may comprise injection telescopic pistons, the outer piston hydraulically multiplying the original pressure, said multiplied pressure

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being transmitted to the inner piston the cylinder of which is connected with the die closing cylinder, whereby the necessary high pressure is obtained without particular source of energy, giving an important save of energy.

Another object of the invention is to provide, in a die casting machine of the character described, means operated by the auxiliary plunger for connecting a pressure accumulator to the various cylinders in a sequentially timed order, whereby the die casting machine is automatically operated.

The die casting machines according to the invention have a high rate of production with the minimum molten material loss owing to the fact that the injection cylinder may be filled with an amount of molten material corresponding accurately to the capacity of the die.

The ensuing description which is made with reference to the accompanying drawings and is given by way of example and not of limitation, will clearly show in what manner the invention may be carried into practice.

Fig. 1 diagrammatically illustrates in axial cross-section an automatic machine for injecting metal under pressure.

Fig. 2 diagrammatically illustrates that part of the machine which is adapted to come through the mold cover.

Fig. 3 illustrates in a similar manner to Fig. 1 the machine in a second stage of operation.

Fig. 4 shows, similarly to Fig. 3, the machine in another stage of operation.

Fig. 5 illustrates a front view of the machine partly in section on line V—V of Fig. 1.

Fig. 6 illustrates in a like manner to Fig. 5 a section of the machine in a condition thereof corresponding to an intermediate stage.

Fig. 7 shows diagrammatically the circuit and valve means used for the automatic control of a die casting machine according to the invention.

Fig. 8 is an elevational view of the device controlling the automatic control of the machine.

Fig. 9 is a partial view of the device illustrated in Fig. 5, the pot having a different capacity.

The machine comprises a frame 1 on which a front support 2 is secured. The front support comprises a recess 3 into which an isolating fitting 4 is inserted, said isolating being in the nature of heat isolation or lagging. Within the fitting 4 there is introduced an injection cylinder 5 which comprises a reinforcing flange 6 adapted for sealing fixation with a half mould or mould section 7 resting on the frame.

The cylinder 5 has secured thereon a pot 8 in

the form of an auxiliary cylinder, which is secured thereto in a removable but tightly sealed manner. The pot 8 is surrounded with a fixture 9 defining between it and the pot 8 a space in which a lagging or electric reheating elements 10 may be inserted; said elements 10 are supplied from a source of current not shown. The pot 8 is surmounted and maintained by a flange 11 with which it is in shouldered abutting relation, the internal board of the pot 8 remaining clear. The flange 11 has bolted thereto a strap 12 provided with ears, said ears being formed with recesses adapted to be filled with resilient fittings 13 upon which bear push rods 14 the function of which will be explained later.

A piston 15 is adapted to penetrate the pot 8, said piston being rigid with a hollow rod 16 terminating in a dual guide fork 17. The dual fork 17 embraces a cross-member 18, subjected to the pull of lateral tie-rods 19 and 19a rigid therewith. The central portion of the cross-member 18 is rigid with a rod 20 which is adapted for sliding movement in the hollow piston 16 and which is formed with an extension 21 which extends through the piston and terminated in a pointed tip projecting out of that piston head and adapted likewise to be retracted into said piston. The point 21 is connected with the rod 20 through a bar 22 of small diameter. The connection between the members defines upon a piston a shoulder operative to a limit in both directions their displacements which the piston can assume with respect to the rod 20, one of such displacements resulting in the projections of the tip 21 from the piston head, while the other one results in retraction of said tip or point.

The tie-rods 19 and 19a extend through guides 23 secured to a cross-member 24 which in turn is fitted over a cylindrical enlargement 25 integral with the front support of the machine.

The tie-rods 19 and 19a at the opposite ends thereof are secured to a bridge member 26 whose central portion is rigid with the rod 27 of a piston 28 slidable in a press cylinder 29. Said press cylinder is at its lower portion rigidly connected with the cross-member 24. The rod 27 is slidable in a tightly sealed fitting 30 so that the piston is a double acting one and is adapted to receive the pressure from an operating fluid on either one of its faces to cause upward or downward movement of the piston 15. Between the pot 8 and the cylinder 5 a space is defined in which a flat locking member or valve 31 is adapted to slide in a direction perpendicular to the axis of the pot 8, the slidable valve 31 being slidable on a bearing surface 32 and being adapted to seal an aperture 33 formed through the side wall of the cylinder 5. The slidable valve 31 is formed with a port 34 into which an extension 35 of the tie member 19a projects, said extension being provided with bosses 36 and 36a, adapted to act as control cams for the slidable valve 31. The cam 36 bears against the side of the recess 34 farthest removed from the axis of the pot 8, while the cam 36a bears against the opposite side of recess 34.

The cooperation between both said cams results, as the piston 15 moves downward, in opening the aperture 33 and, when the piston 15 moves up again in closing said aperture, by means of said slidable valve 31.

The machine frame beyond the front support 2 comprises a slideway 37 on which a slide block 38 is slidable, said slide block carrying the mould section 39 complementary to the mould section 7. The slide block 38 is set into motion by a large diameter press piston 40 operating in single action effect to move the mould section 39 towards the mould section 7, on the one hand, and on the other hand, said slide block is adapted to be actuated through operating rods or links 41 connected with a cross-member 42 having attached to it a smaller diameter press piston 43 and the action of which is to move the mould section 39 away from the mould section 7. The piston 40 operates in a cylinder 44 rigid with an intermediate support 45 of the machine extending parallel with the front support 2. The end wall of the cylinder 44 at the same time constitutes the end wall of the cylinder 46 in which the piston 43 operates, the said cylinder 46 being rigid with a rear support 47 connected through tie-rods 48 with the intermediate support 45. The intermediate support 45 rigid with the frame 1 is connected with the front support 2 through the slideway 37 and a tie-rod 49 arranged as an extension of the cylindrical reinforcement 25 which is threaded over the head of the tie-rod 49 in order to clamp the latter against the front support 2.

The front support 2 is connected with a support 50 through cylindrical lateral tie-rods 51 (Fig. 5). The support 50 is traversed by a cylinder 52 containing a recessed piston 53 and the interior of said last mentioned piston in turn serves as a cylinder for a piston 54. The piston 54 is connected with a rod 55 having secured to the end thereof an injection piston 56 slidable in the internal bore of the cylinder 5. The cylinder 52 is provided with an end wall 57 sealingly secured to it. At the end opposite from the end wall 57 there is a packing seal 58 through which the piston 53 slidably extends. The piston 53 has secured to it a hollow counter rod 59 slidable through a packing seal 60 in the end wall 57. The piston 54 likewise slidably extends through a packing seal 61 carried by the piston 53. The piston rod 55 carries a cross member 62 connected to two pairs of lateral tie rods 63 attached to a cross member 64. The pairs of tie-rods 63 extend through the support 50 in appropriate guiding means. The cross-member 54 is connected with two lateral piston rods 65 not shown in Fig. 1, the related pistons being arranged within the shanks of the recessed rod 51. The piston rods 65 operate in compression on the cross-member 54 which in turn exerts a pull on the cross-member 62 to restore the pistons 53 and 54 to their rearward positions by abutment against the piston 54; the latter, when fully retracted within the piston 53, results in the retraction of said piston 53 into the cylinder 52.

The hollow counter rod 59 is sealingly connected to the piston 53, the internal duct 66 in said counter rod being opened to the interior recess of the piston 53 and consequently to the cylinder of the piston 54. The hollow counter rod 59 is sealingly connected with a movable head 67 in which there is formed a duct 68 opening into a cylinder 69 extending parallelly to the hollow counter rod 59 but offset with respect to the axis of the latter. The cylinder 69 comprises a packing seal 70 which tightly surrounds a pipe 71, thus making possible for the cylinder 69 to move with respect to the pipe 71, which, in turn, is secured to the support 50. The pipe 71 is carefully calibrated with respect to the surface traversed by the packing 70 and is connected through a union 72 with a communicating conduit 73.

With the purpose of avoiding the possibility of metal solidifying in the port 33, a plug member 74

is penetratingly secured within the wall of the cylinder 5 so as to make it possible to effect the requisite plugging or pricking operation. In order that attachment of the pot 8 through the tie-rod 14 be adapted tightly to unite said pot with the cylinder 5, the tie-rods 14 are connected with small pistons reciprocating into cylinders 75 adapted to be placed under pressure and subjected to the resilient return urge of springs 76.

The above described device operates as follows:

All the cylinders communicate with sources of hydraulic fluid under various pressures through a set of pipes and pressure controlled valves; said pipes, gates and valves are diagrammatically illustrated in Figs. 7 and 8 and will be described later.

In a first step, the slidable valve 31 being closed, the piston 15 being in its uppermost portion completely uncovering the feeding aperture for the pot 8, and the piston 56 being retracted inwardly with respect to the aperture 33, a suitable amount of molten metal is introduced so as to ensure that the mould cavities will be completely filled. This condition of the machine elements is clearly shown in Fig. 1. Hydraulic pressure is first admitted to the cylinders 75. The bottom wall of the pot 8 is strongly applied against the cylinder 5.

Hydraulic pressure is then admitted into the cylinder 29 above the piston 28. The hollow piston 15 moves down and reaches (see Fig. 6) the upper level of the body of molten metal contained in the pot and maintained at a suitable temperature by the reheating means 10. Upon continued descent of the hollow piston 15, the latter is brought to bear against the shoulder of the rod 20. The fork 17 engages the cross member 18 and at the same time the cam 36 causes the slidable valve 31 to recede. The molten metal is then expelled through the port 33 in cylinder 5.

Prior to the above operation, hydraulic operating pressure has been admitted into the cylinder 44 and by means of the slideway 38 the mould section 39 has been put into engagement with the mould section 7.

The molten metal spreads out in the cylinder 5 (Fig. 3) and may even partly fill the mould, without being able to escape because of the presence of the piston 56 acting as a sealing plug.

All of the previously mentioned parts remaining in their last described conditions, hydraulic operating pressure is then admitted through the pipe 73, cylinder 69, union 68 and port 66, causing the piston 54 to move forward. The piston 54 moves the piston 56 forward, filling the mould cavity 7, 39. The tube 59 slides through the packing 60 and the packing 70 slides over the tube 71. Upon hydraulic pressure being admitted in turn into cylinder 52, the mould being completely filled, a hydraulic pressure much higher than the operating pressure is built up within the cylinder 53, by closing the latter and admitting pressure into the cylinder 52. Thus, the metal is subjected to a die casting operation in the mould assembly 7, 39. In order to maintain both mould sections in a tight sealing engagement a valve to be described hereinafter makes it possible to provide communication from the pipe 73 to the cylinder 44. For a short time the metal contained in the mould recesses is compressed by the piston 56 under the effect of the above mentioned high pressure in the cylinder 53 which acts on the piston 54 and at the same time said compression pressure is applied to the piston 40 which tightly presses the mould section 39 against the mould section 7. A desired pressure multiplication is obtained as a result of the differential surface areas between pistons 53 and 54.

Then, after the metal has cooled to a sufficient extent, this being obtained quite rapidly, the compression pressure in cylinder 52 is relieved.

During the above described mould filling and metal compressing operation in the mould, the hollow piston 15 was caused to move upwards by admitting operation pressure into the cylinder 29 below the piston 28. The ends of the fork 17 upon engaging the cross-member 24 have caused the point 21 to be retracted into the hollow piston 15 and it is then an easy matter to remove any portions of solidified metal which may cling to the head of hollow piston 15. It is also possible through the spring 76 to cause the pot assembly 8 to move up as a whole whenever it may be required to clean the bottom thereof, the port 33 and the area surrounding the slidable valve 31. Upon applying renewed pressure to the cylinder 75, the pot assembly 8 is again applied against the cylinder 5 and then, it is possible, after having closed the slidable valve 31 to fill said pot again, completely or in part, during such intermediate stage.

Under the action of the hydraulic pistons actuating the push rods 65 and the cross member 64 which in turn actuates the tie rods 63, and by venting the pipe 73, the pistons 54 and 53 as well as the piston 56 may be caused to recede. In the same way, by venting the cylinder 44 and applying pressure to the cylinder 46, the mould assembly 7, 39 is opened and it is then possible to extract the die castings. The previously described cycle of operations may then be renewed.

The apparatus described is adapted for use in filling most of various capacities without replacement of the cylinder 5, because of the position of the intermediate pot 8. Thus, the pot 8 and the cylinder 5 may be used as additional supplies for the injection of amounts of metal greater than the cylinder 5 may contain or greater than the capacity of the pot 8 alone. For this purpose, it is possible to both fill the pot 8 and, without altering the positional setting of the piston 56, open the slidable valve 31 and cause the hollow piston 15 to expel the molten metal in cylinder 5. This operation may be repeated several times, the mould being gradually filled up to the point where the mould only has to receive an amount of metal equivalent to the capacity of cylinder 5. At that time the piston 56 is actuated in the manner previously described.

Moreover, upon alteration of the capacity of the mould and without altering the compression device comprising cylinder 5 and its piston 56, thus changing all the characteristics of the machine, it is possible to fit a pot 8c of different capacity and only change the hollow piston 15c (Fig. 9). In order that the pot 8 be readily removable, it is possible, for instance, to have said pot fitted to a front cylinder member 5a (as shown in Fig. 3), said front cylinder having a bore of the same diameter as the cylinder 5 and being secured through a flange 5b and tie-rods 5c provided with nuts thereon, to the front support 2. The cross-member 24 is so mounted as to permit adjustment thereof with respect to the front support in response to varying diameters of the pots such as 8 (Figs. 5 and 6) or 8c (Fig. 9). A changing of mould can be effected without changing all the injection mechanism.

The operation of the machine having just been described there will now be disclosed an exem-

plary embodiment of an automatic control system for said machine, particular reference being made to Figs. 7 and 8. In this embodiment, it will be understood that the movements of the piston 28 are controlled by the operation of manually actuated controlled valves, suitable hydraulic or electrical relays (not shown in the drawings) being interposed in the circuits.

The automatic controlled equipment comprises an electric motor 80 which actuates a speed change gear 81, in the output of which an electric brake 82 is arranged. The output shaft from the brake 82 projects into a reducer gear 83 whose output shaft 84 is coupled through a coupling means 85 with a cam shaft 86 adapted to actuate a plurality of valves S1, S2, etc. . . . S10. The shaft 86 further includes a cam 87 which controls the opening of an electric contact in the control circuit. Said control circuit includes a supply source for the motor 80 and further includes a trip contact means or switch 88 actuated by the rod 35 since the beginning of its stroke.

When the moulding operations are about to be commenced, downward movement of the piston 15 is caused and the electric control circuit is closed by action of the rod 35 on the trip contact means 88. The motor 80 is started and the brake 82 released. The cam shaft 86 is set into rotation, successively controlling the various valves S. The cam 87 after having completed a revolution is effective to cut off the circuit. The brake is clamped on and the motor stopped. The switch 88 is opened. The automatic controlled mechanism therefrom performs a complete cycle of operations under manual control.

The valve box 89*a* is connected through a suitable piping with a series of relay valves diagrammatically indicated in Fig. 7. Each of said relay valves is controlled by a piston, such as piston 400, and is formed as a slide valve, such as slide valve 401, the construction of said relays being of well known character and requiring no further description. Upon the relay valve controlling piston being subjected to pressure, the slide valve member thereof rises against the opposing action of a returned spring, such as spring 402, and communication is established between the two upper pipes connected with the valve casing. Said relay valves are all identical.

In order to simplify the drawings a pressure accumulator A1 has been conventionally indicated as well as a pressure accumulator A2 and each of the controlled valves is indicated by a circle provided with a suitable reference designation. The accumulator A1 supplies a pressure of about 1700 lbs. p. s. i. while the accumulator A2 supplies an operating pressure of about 430 lbs. p. s. i. by means of a common noncompressible operating pressure fluid, said fluid being pumped from a drain tank by pumps, these well known devices needing no further description and representation.

To facilitate the disclosure, the apparatus will be described progressively in connection with its successive stages of operation.

*Closing of the mould*

The switch 88 closing, the motor 80 is started and the valve S7 provides communication from the accumulator A1 to a pipe 403 which terminates below the operating pistons of the relays 102, 103. The relays 102 through the slide valve member thereof provides communication from a pipe 404 opening into the cylinder 46 to a pipe 405 which leads to the drain tank V. The piston 43 is free to recede at a rate as adjusted by a valve 202. At the same time, the slide valve of relay 103 has provided communication from the accumulator A2 to a pipe 406 which leads to the cylinder 44 through an adjusting valve 203 and an automatic check valve 303 which only permits the flow of fluid in the direction indicated by the arrow. The cylinder 44 becomes filled with fluid at a pressure of 430 lbs. p. s. i. and the mould cover 39 moves towards the mould 17.

*Moving of the cores when the mould is provided with*

The valve S10 is then open and provides communication from the accumulator A1 through the operating piston for relays 107 and 105 whose slide valve members operate. The accumulator A1 through the slide valve of relay 106 supplies pressure fluid to the top of the double acting cylinders 89, 90 while at the same time the bottom of cylinders 89, 90 is drained off through the slide valve member of relay 107 to the drain tank V. It is possible in this manner to cause the insertion of core-carrier members 91, 92 into the mould 7, 39.

*Filling up of the mould*

The valve S1 is then open, establishing communication from the accumulator A2 to the piston of relay 109. The slide valve member of relay 109 provides communication from accumulator A1 to a pipe 407 connected to the cylinder 53. The connecting pipe 407 for relay 109 communicates also with a one way check valve 304 through which the fluid may flow and which communicates through the pipe 408 with the cylinder 44 which thus remains under pressure.

Opening the valve S1 therefore results in advancing the piston 54 under the 1700 lbs. p. s. i. operating pressure, the molten metal contained within the injection cylinder 5 is squirted into the mould under said pressure of 1,700 lbs. p. s. i. during the completion of the full stroke of piston 54. The mould is filled with molten metal and piston 54 remains stationary at the end of its full stroke. At the same time, the valve S1 through pipe 409 causes the accumulator A2 to communicate with the operating piston of a relay 112 the slide valve member of which provides communication with the drain tank V for a pipe 410 which opens into the cylinders of the return pistons 65. The latter are therefore free to recede when the piston 54 is free to advance.

*Application of excess pressure*

At that time the valve S2 opens and establishes communication from the accumulator A1 to a pipe leading to the control piston for relay 111. The slide valve member of this relay is opened and the accumulator A1 then supplies a pipe 411 which leads to the cylinder 52. This cylinder is put under pressure. The said pipe 411 communicates through the check valve 311 through which the fluid can flow with the valve member of relay 109 open consequently to the communication established between accumulator A1 and the piston of relay 109 through check valve 312 and the check valve 304 through which the fluid can flow. However, the outlet from relay 109 is closed by the check valve 309. The check valve 304 therefore makes it possible to distribute the fluid through the pipe 408 to the cylinder 44. Any increase in pressure at the level of the check valve 304 will thus at that time be transmitted to the cylinder 44. The pressure of 1,700 lbs. p. s. i.

admitted into the cylinder 52 generates in the cylinder 53 which remains filled of liquid a pressure applied to piston 54 and which is multiplied in the ratio of the sectional areas of piston 54 to that of piston 53 and such multiplied pressure is transmitted through a connection to the check valve 304 which in turn transmits the multiplied pressure to the cylinder 44 for equalizing the pressures applied to the die. The multiplied pressure is maintained by the relay 110 closed and the check valve 311 closed in this direction. During a time which is considerably less than the time necessary to complete the full stroke of injection piston 54 the metal is die cast under pressure in the mould both sections of which are strongly applied against each other, thereby to apply an excess pressure to the metal filling the mould and which is yet in pasty condition. Piston 54 remains stationary at the end of its full stroke.

*Moving back of injection pistons*

At that time the valve S3 opens and establishes communication from accumulator A1 to a pipe connection leading to that operating piston for relay 114. The slide valve member of the latter opens and causes communication with the drain tank V through the pipe 412 of the operating pistons for relays 107 and 105 whose slide valve members close. The relay 105 closed cuts off the intake of fluid into the upper chambers of the pistons 89 and 90. The relay 107 closed cuts off communication from the lower chambers of the pistons 89, 90 to the drain tank. The fluid flowing from accumulator A1 through valve S3 open is arrested by automatic valve 314 through which the fluid cannot pass in this direction.

At this point the valve S4 opens and provides communication from accumulator A1 to a pipe 413 leading to the operating piston for relay 113. The slide valve member of said relay 113 opens and establishes communication from the accumulator A1 to a pipe leading to the cylinders of both pistons 65. The said cylinders are thus placed under pressure and attempt to cause the piston 54 to move back, adjustment of the rate of this backward movement being possible through valve 205. From the valve S4 a pipe connection 414 leads to the piston of the relay 118. The slide valve member of the latter rises and vents the outlet connection of valve 311 and the outlet connection of the valve 304 to the drain tank V, the last mentioned valve 304 being impervious to the fluid in the direction considered, while the valve 311 allows the fluid to flow therethrough for draining the cylinder 52. At the same time the relay 110 vents to the drain tank the supply connection for cylinder 53 from which the multiplied pressure is then released. Simultaneously the valve S4 establishes communication from the accumulator A1 to the piston of the relay 115 whose slide valve member vents the pistons of relays 102 and 103 to the drain tank; the slide valve members of the last mentioned relays close. Communication from the cylinder 46 to the drain tank is cut off and communication from cylinder 44 to the 430 lbs. p. s. i. operating pressure is also cut off.

*Moving up of the cores*

Furthermore the valve S4 provides communications from accumulator A1 to the pistons of the relays 106 and 108. The relay 106 vents the upper chambers of cylinders 89, 90 to the drain tank while the relay 108 causes communication from accumulator A1 to the lower chambers of the cylinders 89, 90.

The core-carriers 91, 92 move up.

*Ventings*

At this time, the valve S5 vents to the drain tank V the pipe connection leading to the piston of the relay 114; the slide valve member of said relay 114 moves down and cuts off the venting communication for the pipe 412 leading to the pistons of relays 105 and 107, and at the same time cuts off venting communication for the pipes leading to the pistons of relays 109 and 112, as well as the venting communication for the piston of relay 111 through the check valve 312. At the same time, through the check valve 314 open to the fluid in this direction, the valve S5 vents the piston of relay 113, which cuts off the pressure admitted into the cylinders of pistons 65; the pistons 65 have at this time finished their return stroke restoring to their rearward position the pistons 53 and 54, whose connecting pipes were vented through the relay 110. The check valve 305 has vented the piston of relay 109 and the slide valve member of the last mentioned relay, closed at the time, has cut off communication with accumulator A1, check slide valve 309 and outlet pipe of the valve member of said relay 109. When the valve S5 is opened upon the slide valve member of relay 110 dropping back, said opening cuts off the venting communication provided by the latter relay.

At this point the valve S6 opens and vents the pistons or relays 108 and 106 whose slide valve members drop back. The relay 106 stops the venting of the upper chambers of the pistons 89 and 90 and the slide valve member of relay 108 cuts off communication between the lower chambers of pistons 89, 90 with accumulator A1, causing the cores 91, 92 to remain up.

*Opening of the mould*

Then the valve S9 opens, providing communication from accumulator A1 to the piston of relay 101. The slide valve member of this relay causes communication from accumulator A1 to the cylinder 46 whose piston tends to recede. Through the same valve S9, the accumulator A1 is connected with the piston of relay 104 whose slide valve member opens and connects the accumulator A2 through check valve 300, open in this direction, and cylinder 44 which can be exhausted under the action of piston 43. The mould assembly 7, 39 opens up, and the castings may be removed therefrom.

At the same time the valve S9 causes communication from the accumulator A1 to the piston of relay 115 through the check valve 301 open in this direction, and the slide valve member of the relay 115 is raised to vent the pistons of relays 102 and 113 whose slide valve members are lowered.

*Coming back at rest*

At this point the valve S9 opens and vents the outlets of the check valve 301 and the piston of relay 115. The relay 104 the piston of which is vented by said check valve 301 cuts off communication from cylinder 44 to accumulator A2 while relay 115 cuts off communication from the pistons of relays 102 and 103 to the drain tank V. The entire apparatus is then restored to its idle condition and, at this point, the cam 87 cuts off the supply for the motor 89. It will be noted that the pressure of about 7,100 lbs. p. s. i.,

which corresponds to the above mentioned multiplied pressure, only acts for a short period of time upon the side walls of the mould assembly and more particularly on the sealing services of the joint in the latter. Said pressure is only effective during the time in which the same pressure is exerted on the molten metal being die cast.

The above described operation will be repeated anew each time that the pistons 15 have been caused, under a manual control operation, to begin to go down before expelling the molten metal into the cylinder 5.

All the so controlled operations are swiftly fulfilled.

It will of course be understood that modifications may be made in the constructional details disclosed without exceeding the scope of the invention as defined in the ensuing claims.

What I claim is:

1. In a pressure casting machine having an injection piston reciprocable within an injection cylinder for injecting material into the mold cavity of a twin-part die, one part of said die being secured on the injection cylinder and a die closing piston connected to the other part of the die and movable in a die closing cylinder; the combination of two telescoped coaxial differential pistons the smaller of which is reciprocably mounted within the bigger one and is connected with said injection piston, a constant hydraulic pressure supply source, means for applying constant hydraulic pressure from the source to said smaller piston to effect a full stroke of said injection piston through the injection cylinder for injecting the material in molten condition into the mold cavity of the die under a constant predetermined pressure, means for applying said constant hydraulic pressure to the bigger piston of said telescoped differential pistons when said full stroke of the injection piston is completed during a period of time which is considerably shorter than that necessary to complete the fiilling of the mold cavity with molten material, means for isolating the interior of said bigger piston from said source of constant hydraulic pressure so that the bigger piston remains full of liquid when said hydraulic pressure is applied against said bigger piston thereby obtaining an hydraulically multiplied pressure in said interior of the bigger piston to apply an excess force to said injection piston while the latter is stationary and during said shorter period of time, thereby to exert an excess pressure on the injected metal while it is still in pasty condition, and means operative during said shorter period of time to communicate said interior of the bigger piston with said die closing cylinder for applying said hydraulically multiplied pressure to the part of the die which is not connected with said injection cylinder.

2. In a pressure casting machine having an injection piston reciprocable within a fixed injection cylinder for injecting material into the mold cavity of a die, a fixed die section secured on the injection cylinder and communicating therewith, and a second movable die section; the combination of a single acting piston carrying said second die section, an operating cylinder within which said single acting piston moves, a double acting operating piston connected with the injection piston, a double acting hollow piston having a cavity within which said double acting operating piston is reciprocably mounted, a multiplying cylinder within which said hollow piston is reciprocably mounted, a hydraulic pressure supply source, first valve means for connecting said source with said operating cylinder to effect closing of the die by the application of the movable die section against the fixed die section and for maintaining the same closed during an injection step, second valve means operative when the die sections are closed to connect said source with the cavity of said hollow piston at the beginning of the injection step for applying the hydraulic pressure against said double acting operating piston to thereby inject the material in molten condition into the mold cavity of the die under a constant predetermined injection pressure, said second valve means being operative to maintain the connection between said source and said cavity until said injection piston has completed its full stroke and then isolating said cavity from said source, third valve means for connecting said source with said multiplying cylinder, fourth valve means for connecting said cavity with said operating cylinder, and a device operative to render said third and fourth valve means simultaneously effective during a period of time which is considerably less than that necessary to complete the filling of the mold cavity with molten material so that the cavity of said hollow piston isolated from said source remains full of liquid for applying the thus obtained multiplied hydraulic pressure during said shorter time against said injection piston which remains stationary and against said single acting piston carrying the movable die section so that an excess pressure is exerted on the injected metal while it is still in a pasty condition.

3. In a pressure casting machine of the type having an injection piston reciprocable within a fixed injection cylinder for injecting molten material into the mold cavity of a die; the combination of an auxiliary cylinder acting as a pot for the molten material to be injected, said auxiliary cylinder being perpendicular to the injection cylinder and having a discharge nozzle connecting the same with said injection cylinder, a plunger movable in said pot for discharging the molten metal contained therein into said injection cylinder, means for maintaining constant the temperature of the molten material in said pot, means for closing the connection between said discharge nozzle and said injection cylinder, and means for actuating said closing means in relation to the position of said plunger in order to charge said injection cylinder with molten material in an amount corresponding to the capacity of the mold cavity, means for actuating said plunger, and means for actuating the injection piston only when the amount of material necessary to complete the filling of said mold cavity is no greater than the total capacity of the injection cylinder.

4. In a pressure casting machine, the combination according to claim 3, wherein said pot has a capacity smaller than that of the mold cavity of the die and including means for operating said closing means and the plunger actuating means as many times plus one as the capacity of the mold cavity contains an integral number of times the capacity of the pot for successively discharging from said pot into said injection cylinder amounts of molten metal the sum of which corresponds substantially to the capacity of the mold cavity.

5. In a pressure casting machine, the combina-

tion according to claim 3, wherein said closing means comprises a slidable valve located between said pot and the injection cylinder and having a slide formed therein, and wherein the means for actuating said valve comprises two cams fixedly connected with said plunger and successively engaging in reverse directions said slide formed in the valve for closing and opening the latter.

6. In a pressure casting machine, the combination according to claim 3, wherein said pot is one of a plurality of pots having different capacities, each of said pots being mounted on a corresponding detachable front cylinder member constructed and arranged to be carried by the injection cylinder and wherein the pot of the selected unit formed by a pot and the corresponding front cylinder member and mounted on said injection cylinder has a capacity which is no greater than the capacity of the mold cavity of the die to be used.

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