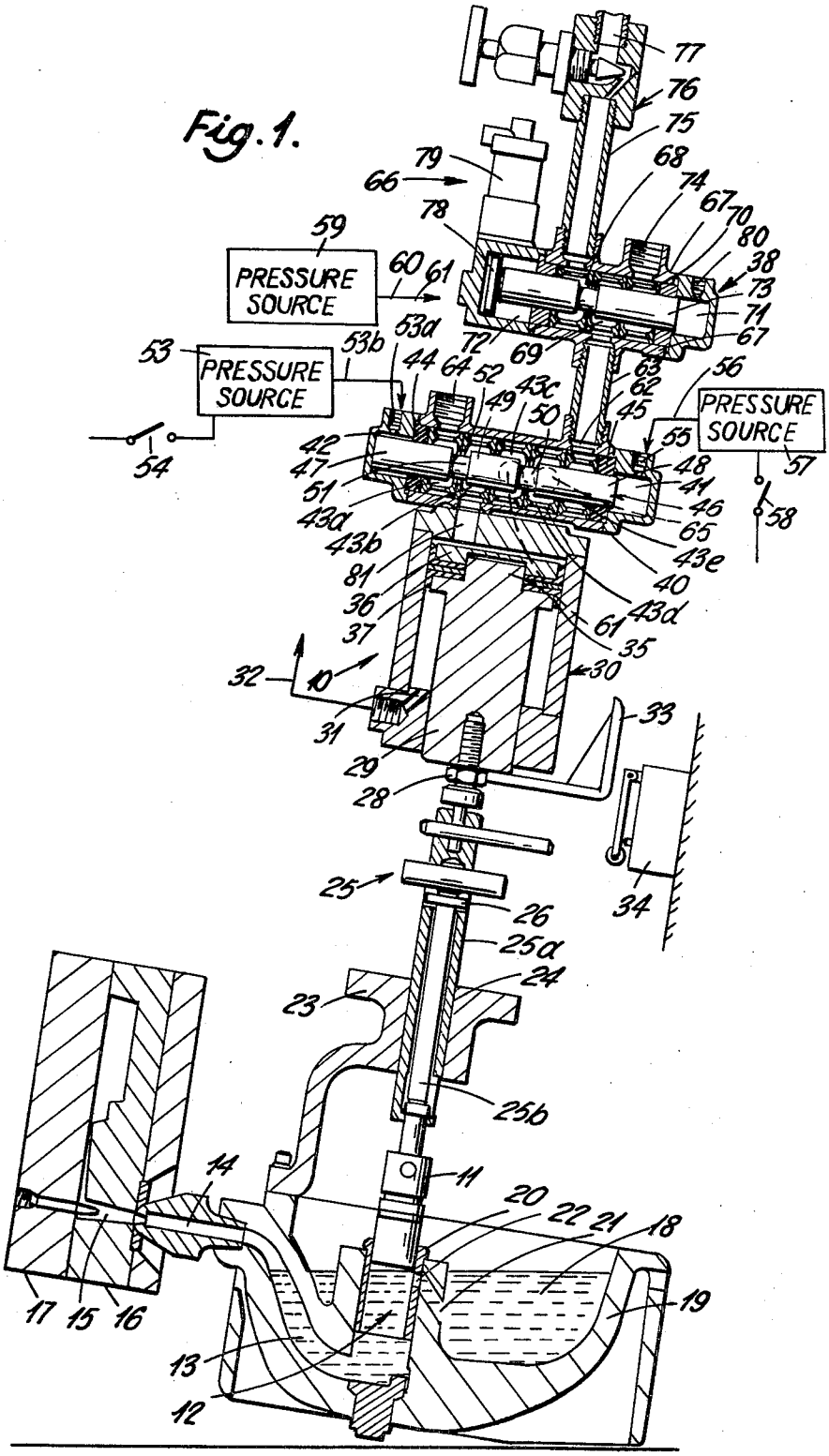
Jan. 27, 1970 E. A. R. MACE 3,491,827

DIE CASTING MACHINE WITH CONTROLLED INJECTION

Filed July 12, 1967 6 Sheets-Sheet 1

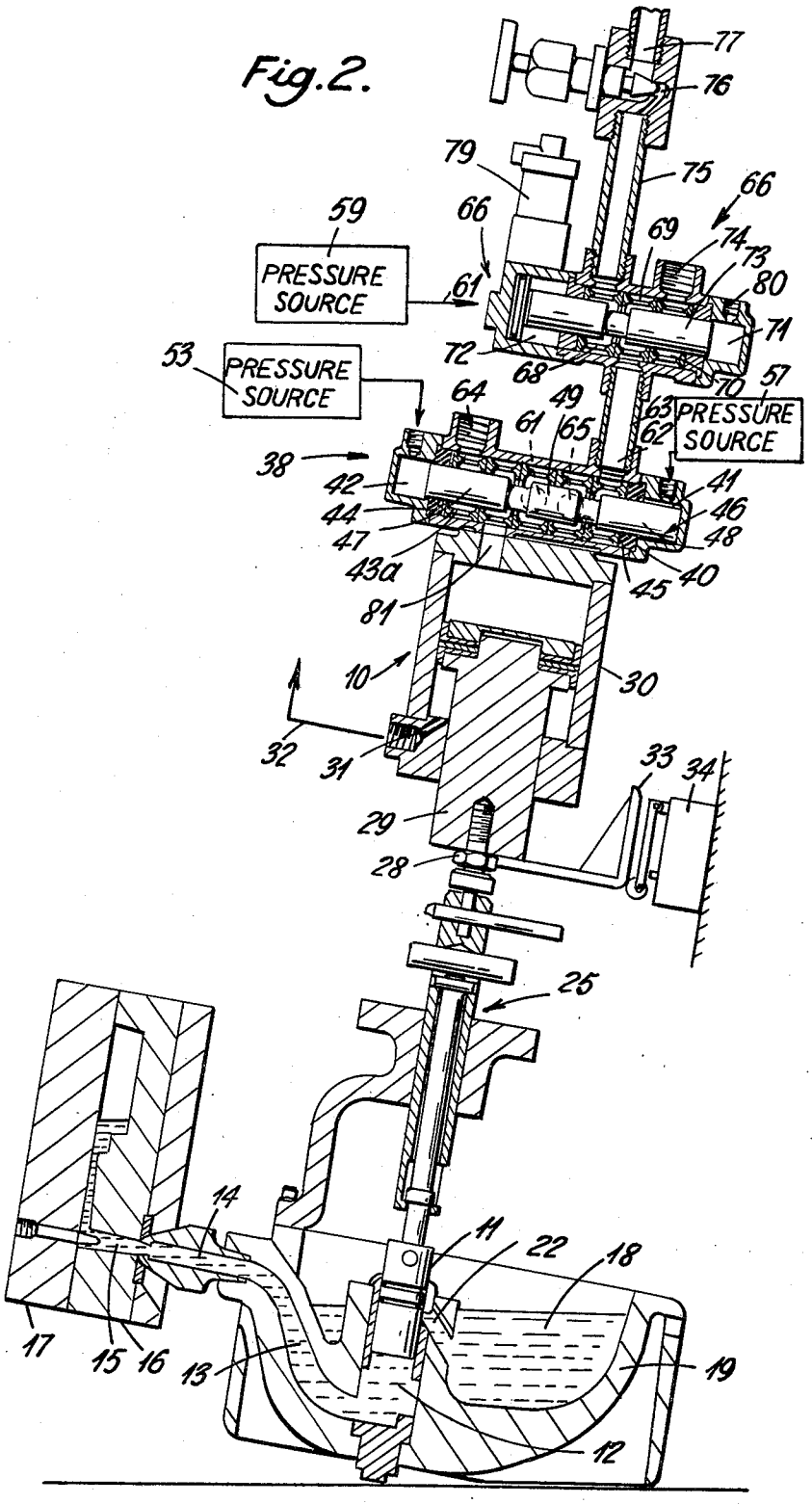
Fig. 1.



DIE CASTING MACHINE WITH CONTROLLED INJECTION

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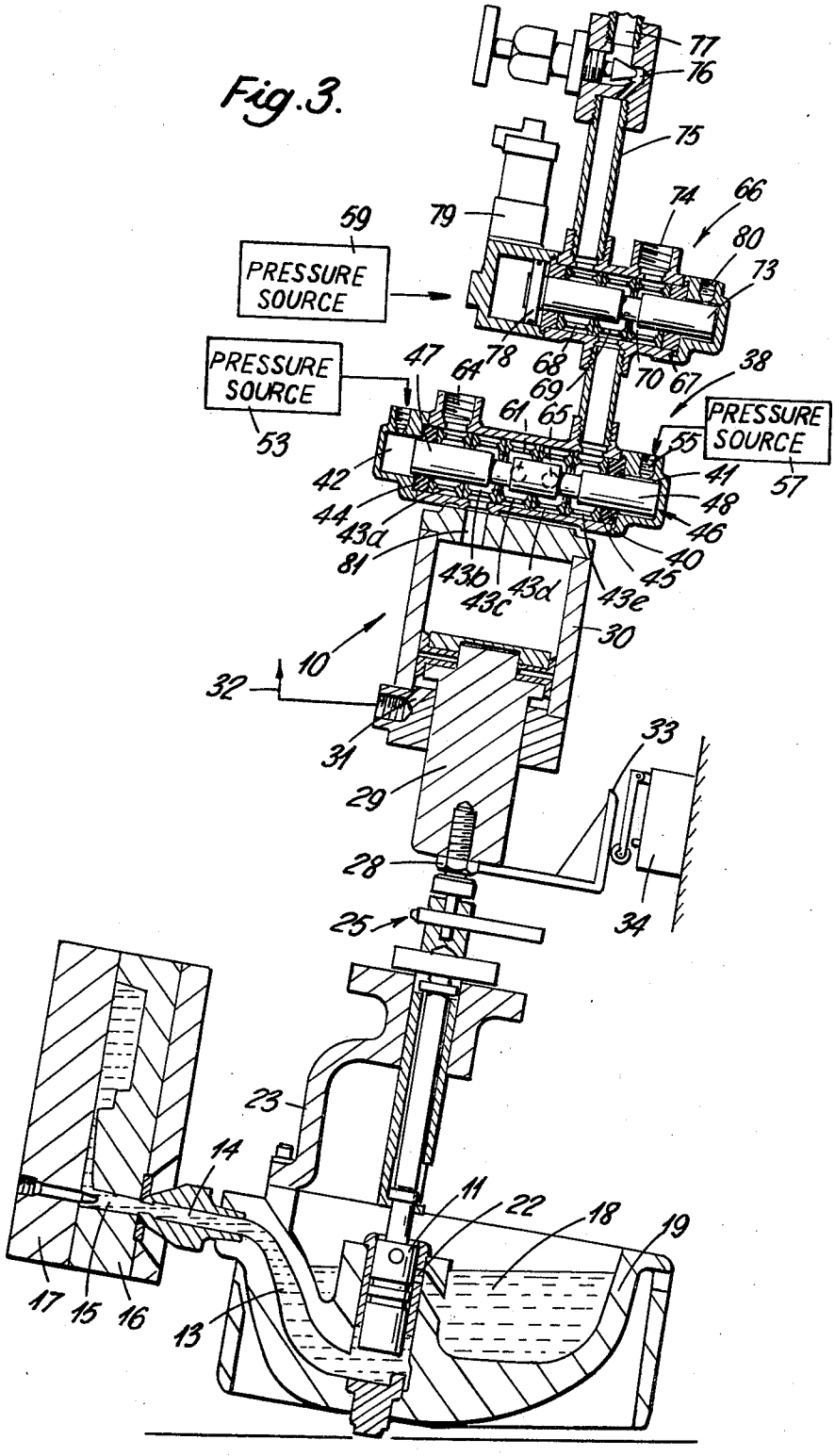
Fig. 2.



DIE CASTING MACHINE WITH CONTROLLED INJECTION

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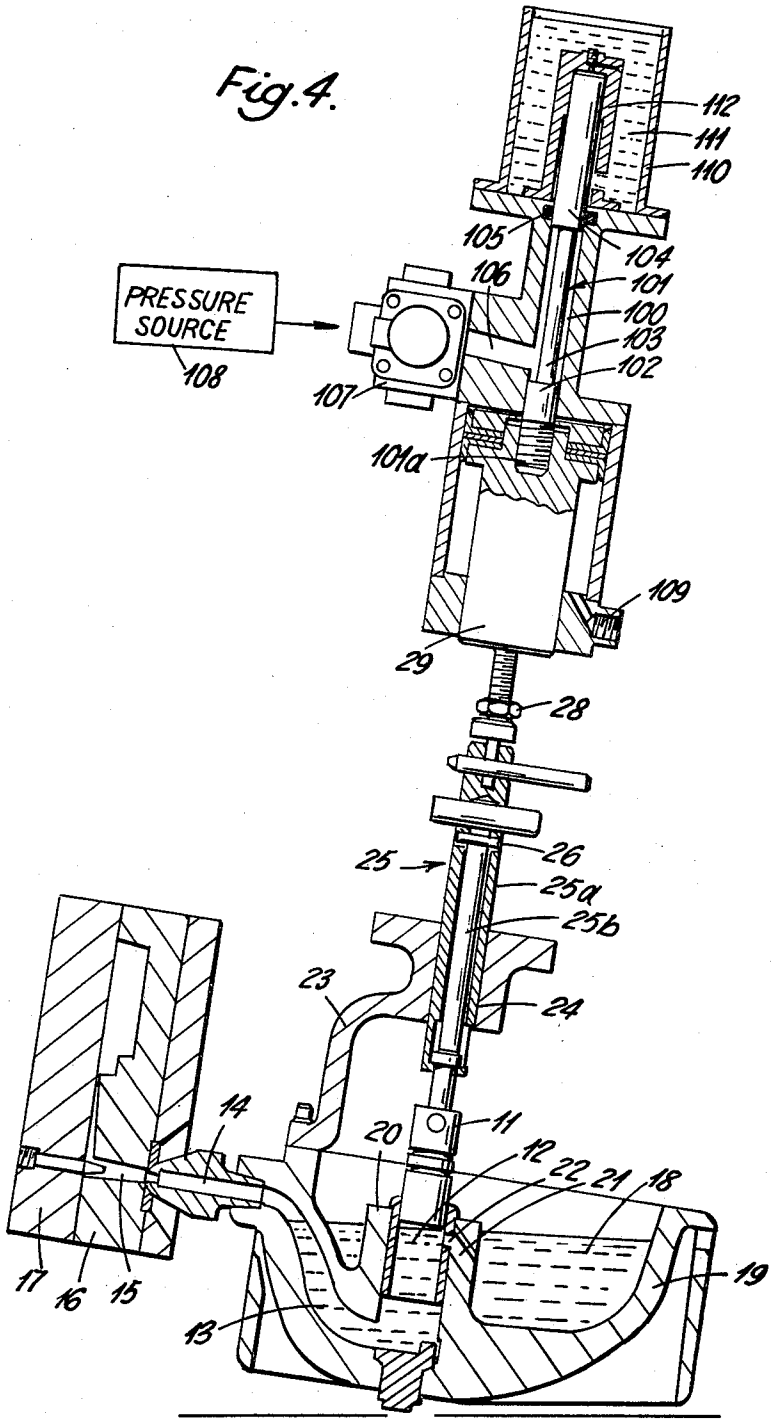
Fig. 3.



DIE CASTING MACHINE WITH CONTROLLED INJECTION

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Fig. 4.



DIE CASTING MACHINE WITH CONTROLLED INJECTION

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Fig. 5.

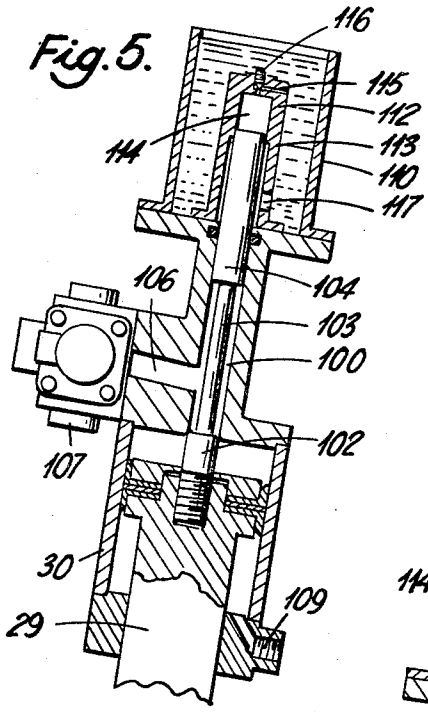


Fig. 6.

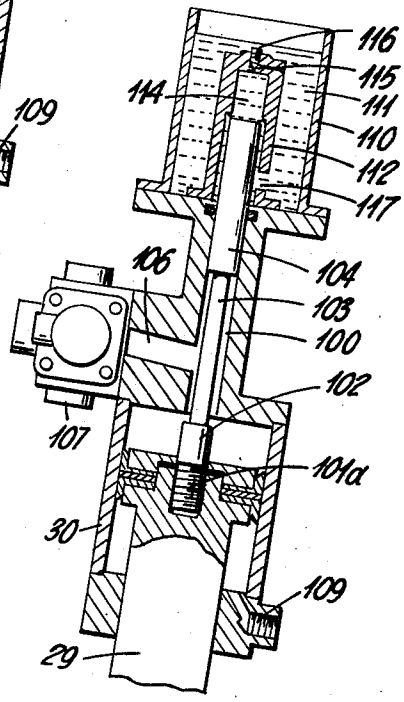
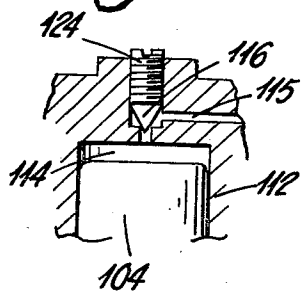


Fig. 7.

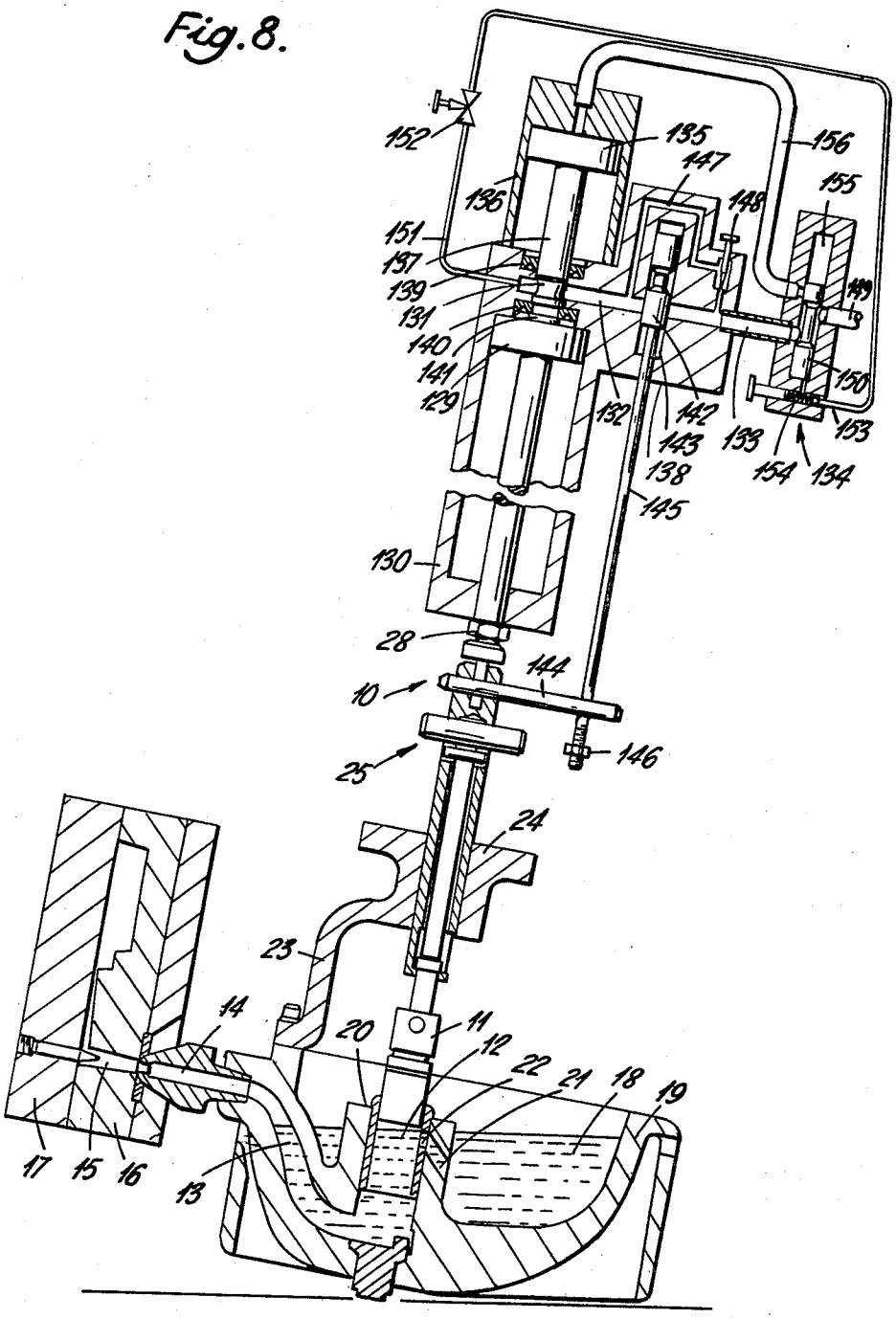


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DIE CASTING MACHINE WITH CONTROLLED INJECTION

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Fig. 8.



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DIE CASTING MACHINE WITH CONTROLLED INJECTION

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Int. Cl. B22d 17/04
U.S. Cl. 164—318 5 Claims

ABSTRACT OF THE DISCLOSURE

A small die casting machine, having a piston and cylinder assembly moving the injection plunger, in which the inlet or outlet fluid flow for the cylinder is restricted during the early stages of injection to allow air to escape from the die cavity and is freer thereafter to accelerate the plunger and give a sharp casting.

This invention relates to die casting machines having dies forming a die cavity and a plunger which is movable (for example: by means of a fluid-operated piston and cylinder assembly) to inject casting material into the die cavity.

One of the problems in die-casting is to ensure that the casting material flows into thin section portions of the die cavity. It is known that air entrapped in the cavity causes difficulty in making castings with thin sections since the air can prevent the metal completely filling the cavity. The problem is particularly acute in small die-casting machines since the time taken for the plunger to inject the material into the die is extremely short in such machines; in many cases, it is insufficient to allow the air to escape from the die via the air vents which are normally provided for this purpose.

It is therefore the object of the present invention to provide an improved die-casting machine and an improved method of die casting, with particular reference to small machines.

The method of die-casting contemplated by the present invention essentialy consists in advancing the plunger to effect injection of casting material relatively slowly at first until the die is partially filled and subsequently advancing the plunger at a relatively faster rate to ensure that the casting material properly fills all the cavity. With this manner of operation, the relatively slow initial movement of the plunger gives sufficient time for most of the air entrapped in thin section portions to be ejected out of the cavity while the final, faster rate of injection ensures that the material is finally injected into the cavity with a force sufficient to ensure that the material fills all the cavity and thereby produce a sharp casting.

The plunger is conveniently movable by means of a fluid operated piston and cylinder assembly. In general, there are two main ways in which the change in plunger speed may be effected. Where the piston and cylinder assembly is hydraulically actuated, the inlet pressure may be initially restricted by providing only a throttled flow of inlet fluid, the flow being suddenly increased at a suitable time. This method is also suitable for pneumatic operation, with which there is the further possibilty of providing an initial restriction on the exhaust fluid from the cylinder. All these are included within the scope of the invention.

In the following, reference will be made to the accompanying drawings, in which:

FIGURE 1 illustrates a die-casting machine constructed in accordance with the present invention;

FIGURES 2 and 3 illustrate the die-casting machine of FIGURE 1 in different phases of a die-casting cycle;

FIGURE 4 is a simplified illustration of another die-casting machine constructed in accordance with the present invention;

FIGURES 5 and 6 illustrate a detail of the machine of FIGURE 4 and show different phases in a die-casting cycle;

FIGURE 7 illustrates, to a larger scale, a detail of the die-casting machine of FIGURES 4 to 6; and

FIGURE 8 illustrates another die-casting machine constructed in accordance with the present invention.

The three machines shown in FIGURES 1 to 3, 4 to 7 and 8 have, at least as far as conventional features are concerned, many details in common and it will be appreciated throughout the following that the application of like reference numerals to like parts indicates a like construction and function. The conventional features of a die-casting machine will be described in detail only with reference to FIGURE 1.

FIGURE 1 shows one embodiment of a die-casting machine constructed in accordance with the present invention, the machine in FIGURE 1 being at the start of an injection cycle before the injection of casting material is effected. The main parts of the machine comprise a piston and cylinder assembly **10** for effecting movement of a plunger **11** into a well **12** which is or has been filled with molten die-casting material. Downwards movement of the plunger **11** into the well **12** forces the material in the well up a goose-neck passage **13** through a nozzle **14** into a die cavity **15** formed when a fixed die plate **16** and a movable die plate **17** have been closed together. The construction of die cavities has been known for many years in the art and for convenience will not be repeated here. It is usual to provide air vents (not shown) leading away from the die cavity **15** in order that air entrapped when the dies are closed may leave the die cavity when injection of the material from the well **12** is effected. After the die cavity is completely filled, it is conventional practice to withdraw the plunger **11** upwardly, subsequently break the the casting seal by an initial separation of the die plates, finally separate the die plates completely and eject the casting from the die cavity.

In FIGURE 1, molten metal **18** for the casting is retained in a reservoir **19**, the reservoir being replenished at intervals in accordance with the usual practice. The well **12** is retained in a central bush **20** near the centre of the reservoir **19** and a port **21** communicates between the reservoir **19** and the port **22** in the side of the well **12** so that when the plunger **11** is withdrawn to an upper position after injection, casting material may flow from the reservoir **19** to fill the well again. In accordance with usual practice, the machine is tilted so that the height of material in the goose-neck passage after the well has been filled is as low as possible.

Secured to the reservoir **19** is a frame **23** holding a sleeve **24** in which is movable a connecting rod **25** which at its lower end is connected to the plunger **11**. The connecting rod **25** is formed in two main parts, an outer part **25***a* and an inner part **25***b*. The part **25***b* is attached to the plunger **11** and is retained within the hollow lower portion of the part **25**, being retained within the portion **25***a* by a crosspiece **26**, provided at its upper end.

The part **25***a* is attached by means of the screw threaded link **28** to the piston **29** which is movable within a cylinder **30**. The piston itself is reduced at its upper end, a reduced part **35** engaging a circular central recess in a circular plate **36**, the plate **36** and the piston **29** retaining between them a flanged annular sealing ring **37** whose outer flange is a close sliding fit within the cylinder **30**. At the lower end of the cylinder is provided an outlet

port 31 leading to a conduit shown diagrammatically by a line 32. The other end of this conduit leads to an exhaust port whose configuration will be described hereinafter.

Provided on the link 28 is an L-shaped arm 33 which, when the piston 29 has partially completed its downward travel, operates a microswitch 34 whose function will be made apparent hereinafter.

Above the cylinder 30 is an assembly 38 which controls the inlet and outlet fluid from the cylinder. A body 40 of generally cylindrical form has two end chambers 41 and 42 and an inner chamber 43 of larger diameter than the end chambers. At each end of the inner chamber 43 there are two annular bushings 44 and 45 which mount for sliding movement through the body 40 a spool valve 46. The spool valve is shorter than the length of the body portion 40 and has two outer relatively thicker portions 47 and 48 and an inner portion 49 of like thickness, the thicker portions being separated by thinner connecting portions 50 and 51. The chamber 43 is divided into five approximately equal subchambers (43*a* to 43*e*) by the five I-section double sealing rings 52. These have a diameter such that the outermost portions of their flanges are a close fit within the chamber 43; and the webs of the rings 52 have an inner diameter such that the thicker portions of the spool valve 46 are sealingly slidable from side to side in the rings 52.

Communicating with the left-hand end chamber 42 is a pilot port 53*a* supplied with pressure through line 53*b* from a fluid pressure source 53 when the source is actuated by a switch shown diagrammatically at 54. Application of fluid pressure to the pilot port 53*a* causes movement of the spool valve 46 in a rightwards direction. Likewise, there communicates with the right-hand end chamber 41 a pilot port 55 which may be supplied via line 56 with fluid pressure from a source 57 when the source is actuated by a switch 58. The application of fluid pressure from the source 57 to the port 55 effects leftwards movement of the spool valve 46. In the example shown in the drawings, the sources 53 and 57 are pneumatic sources and the switches 54 and 58 are manually operated switches. The middle sub-chamber 43*c* is permanently supplied with pressure from the source indicated diagrammatically at 59 via pipe 60 and the port shown at 61. The left-hand sub-chamber 43*a* communicates with the atmosphere by a port 64. The fourth chamber 43*d* includes a port 65 which leads to the conduit 32. Finally, the right-hand sub-chamber 43*e* communicates with an exhaust port 62 which leads to a conduit 63.

The conduit 63 leads to an assembly 66 which controls the flow of exhause gas from the cylinder 30. In this embodiment, the flow of exhaust gas is to be restricted until the die cavity is partly filled and relatively freer thereafter. Although this could be effected by using an adjustable orifice it is more convenient to provide two separate exhaust passages with a valve movable to select the relatively freer passage when the die cavity is partly filled. The assembly 66 embodies this form of control. It comprises a body 67 which is similar in construction to body 40, being divided into sub-chambers 68, 69 and 70 and end chambers 71 and 72 in a similar manner. In the body 67 is slidable a spool 73 whose thicker portions are a sealing fit within the sealing rings. The conduit 63 leads to the middle sub-chamber 69. The right-hand sub-chamber 70 leads to atmosphere via a relatively wide exhause port 74, whereas the left-hand sub-chamber 68 leads via conduit 75 to an adjustable needle valve 76 and an exhaust port 77.

The spool 73 carries at its left-hand end a ferromagnetic portion 78 constituting an armature for a solenoid shown diagrammatically at 79. The solenoid is actuated by the microswitch 34 to move the armature 78 and spool rightwards, the spool 73 being movable by means of fluid pressure applied to port 80 to return to the extreme leftwards position shown in FIGURE 1.

Other forms of actuation are possible, provided that they incorporate a member movable by or in accordance with the plunger, co-operating with an actuator in a fixed position to operate the valve spool 73 when the plunger 11 has partly filled the die cavity. There may be, for example, a pneumatic or hydraulic valve operable to apply fluid pressure to move the valve spool rightwards.

The manner of operation of the die casting machine shown in FIGURE 1 is as follows.

With the machine at rest at the beginning of a cycle, the piston 29 is at the top of the cylinder 30 with the exhaust port 64 open and with the air supply, which is permanently attached to port 61, being transferred via the inner annulus of the valve spool 46 to the port 65 and then through conduit 32 to the port 31 to hold the piston 29 at the upper end of the cylinder 30. At this time, casting material from the reservoir 19 will have filled the well 12. The casting cycle commences with the operation of switch 54 to cause the pressure source 53 to apply pneumatic pressure to the pilot port 53*a* to transfer the valve spool 46 in a rightwards direction to the position shown in FIGURE 2.

When the machine is in the position shown in FIGure 2, air is transferred from the port 61 via the annulus in valve spool 46 through the port 81 in the top of the cylinder 30. This applies pressure to the front face of the piston 29 and the piston now starts to descend to force the material in the well 12 up the goose neck passage 13.

The exhaust from the cylinder is transferred via the port 31 and the conduit 32 and through parts 65, 43*d*, 43*e*, 62, 63, 69 and 70 to the conduit 75. During the initial part of the injection cycle, the valve spool 73 is in its extreme left-hand position so that the exhaust from the cylinder 30 is transferred only through the restricted outlet passage via the needle valve 76 and port 77. Accordingly, during this part of the injection cycle the movement of the piston 29 is relatively slow, the actual rate of movement being determined by the position of the adjustable needle in valve 76.

The slow movement of the piston continues until it is moved approximately half way down the cylinder. At this time the arm 33 operates microswitch 34 (which stays operative for the remainder of the injection stroke) to provide a signal to operate the solenoid 79. Of course, suitable current amplifying arrangements may be incorporated in order that the solenoid may be energized with sufficient current but such amplifying arrangements have not been shown since they will readily be appreciated by those skilled in the art.

When the microswitch 34 and accordingly the solenoid 79 is operated, the valve spool 73 is transferred to its extreme right-hand position. This position, now shown in FIGURE 3, changes the path of the exhaust from the cylinder 30 to the relatively free exhaust port 74 (since now chamber 69 can communicate with chamber 70). Since the inlet pressure to the cylinder is the same the piston moves at a greatly increased rate for the remainder of its downward travel.

During the initial relatively slow movement of the piston and the plunger there will have been sufficient time for air in small parts of the die cavity to escape through the conventional air vents. However, during the latter, relatively faster movement of the piston and plunger the casting material is injected into the cavity with a greater force and thus it properly fills all the thin section portions of the die cavity.

When the casting is complete and it is desired to withdraw the piston and plunger the valve spool 46 is moved to its left-hand position, (FIGURE 1), the switch 58 being operated to apply inlet pressure to the port 55 for this purpose. Then the air from the air supply 59 is transferred to the lower face of the piston (via port 31) which is thereby drawn up to its uppermost position of FIGURE

1. At the same time, the exhaust from the outer face of the piston is via the port **81** and the exhaust port **64**.

As the piston rises arm **33** disengages from switch **34** to release the spool **73** to its original position.

Reference will now be made to FIGURES 4 to 7 which illustrate a die casting machine incorporating an alternative embodiment of the invention. The die casting machine of these figures is identical, as far as the parts below screw threaded link **28** are concerned, with the machine of FIGURES 1 to 3. However, the machine in FIGURES 4 to 7 employs a different inlet pressure control.

The machines shown in FIGURES 4 to 7 and 8 differ from that of FIGURES 1 to 3, in that, in place of restricting the exhaust from the cylinder **30**, a valve member is disposed in an inlet duct to provide a throttled flow of fluid to the cylinder until the die cavity is partly filled. FIGURES 4 to 7 show an arrangement primarily intended for pneumatic operation and FIGURE 8 shows an arrangement primarily intended for hydraulic operation. Suitable modification, if necessary, would render them suitable for hydraulic and pneumatic operation respectively.

In FIGURE 4, there is shown leading from the outward end of the cylinder **30** the conduit **100** in which the valve spool **101** is located. The spool valve is secured to the upper end of piston **29** by means of the screw threading **101***a* and comprises a first relatively thick portion **102** that is only slightly thinner intermediate portion **103** connecting the portion **102** with a similar portion **104** whose function will be described in more detail hereinafter. The upper end of the conduit **100** is sealed by a conventional sealing ring **105** engaging the periphery of the upper portion **104**.

Leading off the conduit **100** is the port **106** which is fed with pneumatic fluid pressure from the valve **107**. The valve is operative by suitable conventional means (not shown) to supply pressure either to the port **106** or to the port **109** so as to lower and raise piston **29** respectively. The valve is supplied with pressure from a source indicated diagrammatically at **108**. For convenience in the description of FIGURE 4 it will be assumed that the fluid pressure source is pneumatic but hydraulic operation may equally well be selected.

The downward (injection stroke) phase of operation of the die casting machine of FIGURE 4 is as follows. The valve **107** admits fluid into the port **106** and into the cavity formed in the conduit **100** between the portions **102** and **104** of the spool valve **101**. Air cannot pass upwards owing to the seal provided by the sealing ring **105** but can only slowly enter the main cylinder **30** through the small clearance between the portion **102** and the inner face of the conduit **100**. Thus the piston initially travels downward at a slow rate, alowing air trapped between the metal level and the die cavity **15** to escape through the aforementioned vents in the die cavity. The slow downward movement of the piston continues until the portion **102** of the spool valve **100** start to leave the passage **100** (FIGURE 5).

At this point, fluid will enter the cylinder **30** at a greatly increased rate, since portion **103** is narrower than portion **102**, and since the reverse side of the piston will have had time to exhaust through the exhaust port **109** down to atmospheric pressure, the piston will travel downwardly at a high speed not only due to this equalisation of pressure but also due to the increase in fluid pressure provided by the increase of effective area of the inlet port which now essentially comprises the lower end of the conduit **100** with the intermediate reduced portion **103** of the valve spool within it.

When casting is completed, the piston has to be returned to its initial position. A great problem often encountered in die casting is the dripping of the molten metal in the nozzle onto the face of the cover half of the die. Torches may be applied to the nozzle to keep this metal molten so that when the metal in the cavity is solidified, that which is in the nozzle will remain fluid to allow flow of metal during the next shot. If this molten metal is not withdrawn from the nozzle, it will drip, when the dies separate, onto the faces of the dies. This would prevent the dies from closing completely during a a subsequent casting operation. The machine of FIGURES 4 to 7 incorporate features directed to solving this problem.

It will be apparent that when the plunger **11** is withdrawn from the well **12**, a vacuum is created in the goose neck passage **13** so that when the port **22** from the reservoir **19** is uncovered molten metal from the reservoir rushes up the goose neck passage and out through the nozzle to drip onto the fixed die plate as well as the metal already in the nozzle.

It will also be apparent that the plunger has to be withdrawn to draw away the casting material in the nozzle before the dies are open. Withdrawal of the plunger is normally effected by applying pressure from the valve to the exhaust port **109** and it will be appreciated that if the port from the reservoir is uncovered before the dies are separated (to destroy the partial vacuum in the goose neck) the goose neck will be substantially filled with casting material and the aforementioned dripping will occur. The machine shown in FIGURES 4 to 7 ensures that there will be sufficient time to open the die cavity before the port **22** from the reservoir is uncovered. This is essentially achieved by providing an initial fast rate of withdrawal of the plunger **11** (to ensure proper withdrawal from the nozzle of the molten metal) and then slowing down, *but not stopping*, the plunger up to when the die plates have been opened.

FIGURE 6 shows in detail the upper part of the piston and cylinder assembly of the machine of FIGURE 4. The upper end of the conduit **100** is flanged to provide a generally circular table on which is mounted a hollow cylinder **110** containing oil **111**. Over the passage **100** is formed the well **112** into which the valve spool end portion **104** extends. The well **112** is formed with a lower part of somewhat greater cross-section than the portion **104** but has a shoulder **113** defining an upper part **114** of the well in which the portion **104** is a slidingly sealing fit. At the top of the well, and as more particularly shown in FIGURE 7, there is an exhaust passage **115** with a needle valve **116** adjustable in position by means of the screw threading **124** engaging a co-operating threading in the body of the well.

During the slow down of movement of the piston a partial vacuum will be left in the upper portion of the well. This partial vacuum is relieved when the valve spool portion **104** leaves the shoulder **113**, the oil in the reservoir entering the well by means of the port **117** to fill the well completely.

Referring particularly to FIGURE 6, when pressure is applied to the exhaust port, the piston will start to return in an upward direction at high speed. This will ensure that the injection plunger, which is normally a Nitralloy sleeve immersed in molten zinc (casting material) will not seize. The valve spool **101** will likewise travel rapidly upwards through the conduit **100** until it starts to enter the upper portion of the well **112**. It has already been explained that during the injection phase of the casting cycle the well has been filled with oil from the reservoir (cylinder **110**) through the port **117** provided. The initial upward rapid movement of the plunger withdraws all the casting material from the nozzle. When the portion **104** reaches the shoulder **113** in the well **112** the movement of the valve spool **101** and accordingly the piston **29** and plunger **11** will slow very substantially since oil from the upper part **114** of the well **112** can only escape very slowly through the passage **115** which is controlled by the needle valve **116**. The needle valve **116** is adjusted so that the port **22** is not uncovered until the dies have started to open. The opening of the die cavity

destroys the vacuum which is normally present and accordingly by the time the plunger **11** uncovers the port **22** from the reservoir **19** the vacuum in the goose neck passage **13** has been destroyed by the opening of the die cavity and the metal in the goose neck will not rise and refill the nozzle **14**.

It will be apparent that a valve member similar to that shown in FIGURES 4 to 7 could be provided in the machines shown in FIGURES 1 to 3 or 8 as a separate extension on the connecting rod between the piston and the plunger. Such an arrangement has not been shown for convenience.

In FIGURE 8 is shown a die casting machine incorporating yet another embodiment of the invention.

The machine shown in FIGURE 8 is intended for hydraulic operation only. The details of the machine as far as the plunger **11**, reservoir **19** and die cavity are concerned are the same as those described with reference to FIGURES 1 and 4. In FIGURE 8, the piston **129** is slidable in the cylinder **130**. At the inlet end of the cylinder is a port **131** leading to a transverse passage **132** communicating via a duct **133** with an inlet control valve **134**. Aligned with the piston **129** is a further piston **135** movable in a cylinder **136** formed on the body **138**. A rod **137** extends from the piston **135** through a port (not referenced) towards an extension **141** on piston **129**. The ports between the cylinders **130** and **136** are sealed from the transverse passage **132** by the sealing rings **139** and **140**, which are close fits around the rod **137** and extension **141**.

Arranged transverse the passage **132** is a valve spool **142** movable in a passage **143**. The valve spool is attached by means of a lost motion linkage to the piston **129**. A bar **144** extends outwardly from port **25**, the bar receiving the rod **145**, which has an adjustable stop **146** and is connected to valve spool **142**. By-passing the valve spool **142** is a bleed passage **147** containing a needle valve **148**.

At the start of an injection cycle, oil under pressure is transferred to the inlet port **149** in the valve **134**. At this time, valve spool **150** in the valve **134** is located so that the duct **133** is open to the oil. The oil is transferred to the passage **132** which is blocked by the valve spool **142**. The inlet oil thus traverses the passage **147** via the needle valve **148** to the left-hand end of the passage **132**, and through port **131** to move the piston **129** slowly downwards. The die cavity **15** will be filled at a relatively slow rate. The needle valve **148** is adjustable so that the slow forward movement of the piston may be at an adjustable rate.

The piston **129** will continue to move downwards slowly until the bar **144** strikes the adjustable stop **146**, which will be carried along with the bar **144** and will therefore move the rod **145** to open the passage **132**. It will be readily apparent that spool valve **142** and its passage must be designed and arranged to ensure that passage **132** remains open for the rest of the injection stroke. Oil at inlet pressure will thereby be transferred through port **132** into the cylinder **130** to move the piston **129** downwards at high speed. The piston will travel forward at this high speed for the remaining part of the injection stroke, thus, as in the previously described embodiments, ensuring a "sharp" casting.

Since the pressure in a hydraulic system with a free moving piston is below the inlet pressure, the pressure in the left-hand end of the passage **132** will be below the pressure applied to the inlet port **149**. It follows that since the pipe **151** is restricted by needle valve **152** there will be a slight pressure drop between passage **132** and duct **133**. When the dies are almost completely filled and the piston tends to stop there will then be a sharp rise in the oil pressure in the passage **132** and the pressure at port **153** will increase. The spring loaded needle valve **154** only opens when the pressure in the pipe **151** is approximately 90% of the normal line inlet pressure at **149** so that when the pressure in passage **132** rises sharply oil is transferred via port **153** to push valve spool **150** to close passage **133** to the inlet pressure and open duct **156** to the inlet pressure. The main oil supply is now transferred to the rear of piston **135** which will travel forwards rapidly, its rod **137** sealing the passage **132**. The rod **137** strikes the extension **141** of piston **129** and since the cross-sectional area of the piston rod **137** is considerably less than the area of the piston **135** the pressure exerted on the piston **129** will be increased. Preferably the ratio of the areas of the rear piston **135** and rod **137** is approximately 3 to 1 so that, using a typical line pressure at 1500 lbs. p.s.i. the pressure of the rod **137** on the piston **129** will be stepped up to 4500 lbs. p.s.i. This will provide a sharp increase of injection pressure to ensure a sharp casting.

I claim:

1. A die casting machine having dies forming a die cavity, a nozzle for the injection of material in the cavity a plunger movable to force material through said nozzle, a piston connected to the plunger and movable to cause injection of material when fluid pressure flows from a pressure source through an inlet duct to a cylinder in which the piston moves, a valve member in said inlet duct, said valve member having means to provide a throttled flow of fluid through said inlet duct during an initial period of injection and being actuated by the movement of the piston and plunger to provide a relatively freer fluid flow through said inlet duct when the plunger has partly filled the die cavity, said valve member having means to initially block the inlet duct and means including a restricted orifice, for providing a fluid by-pass, the valve member being connected through a lost-motion linkage to the plunger and piston.

2. A die casting machine as claimed in claim **1** wherein the restricted orifice comprises an adjustable valve.

3. A die casting machine as claimed in claim **2** wherein the fluid source is hydraulic.

4. A die casting machine having dies forming a die cavity, a nozzle for the injection of material into the cavity, a plunger movable to force material through said nozzle, a piston connected to the plunger and movable to cause injection of material when fluid pressure flows from a pressure source through an inlet duct to a cylinder in which the piston moves, a valve member in said inlet duct, said valve member having means to provide a throttled flow of fluid through said inlet duct during an initial period of injection and being actuated by the movement of the piston and plunger to provide a relatively freer fluid flow through said inlet duct when the plunger has partly filled the die cavity, a further piston and means, responsive to the increase of pressure in the cylinder to cut off fluid flow to the inlet duct and redirect the fluid flow from the source to move the further piston to strike the first piston thereby to provide a sudden increase in injection pressure.

5. A die casting machine as claimed in claim **4** wherein the pressure source is hydraulic, and a passage is provided to lead from the inlet duct, to a spring loaded valve, said last named valve being opened by the increase in the hydraulic fluid in the duct, and being thereby directed to move a further valve to cut off fluid to said inlet duct and to effect the redirection of the fluid flow.

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ROBERT D. BALDWIN, Primary Examiner

U.S. Cl. X.R.

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