

Dec. 19, 1944.

N. LESTER ET AL

2,365,282

PRESSURE CASTING MACHINE INJECTION PRESSURE CONTROL

Filed June 15, 1940

2 Sheets-Sheet 1

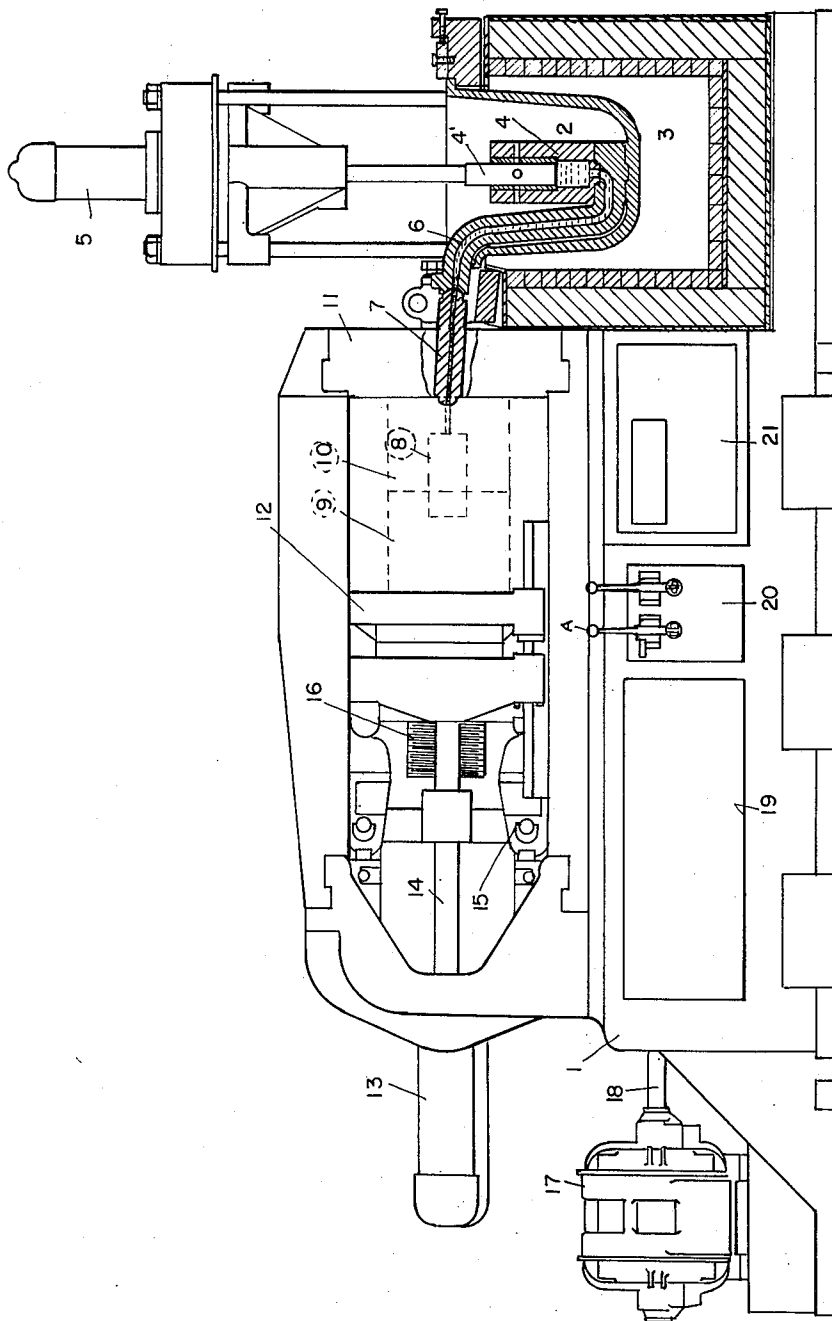


Fig. 1.

INVENTORS

NATHAN LESTER and
WILLIAM H. SCHWARTZ.

BY

Oberlin, Limbach & Day

ATTORNEYS

Dec. 19, 1944.

N. LESTER ET AL

2,365,282

PRESSURE CASTING MACHINE INJECTION PRESSURE CONTROL

Filed June 15, 1940

2 Sheets-Sheet 2

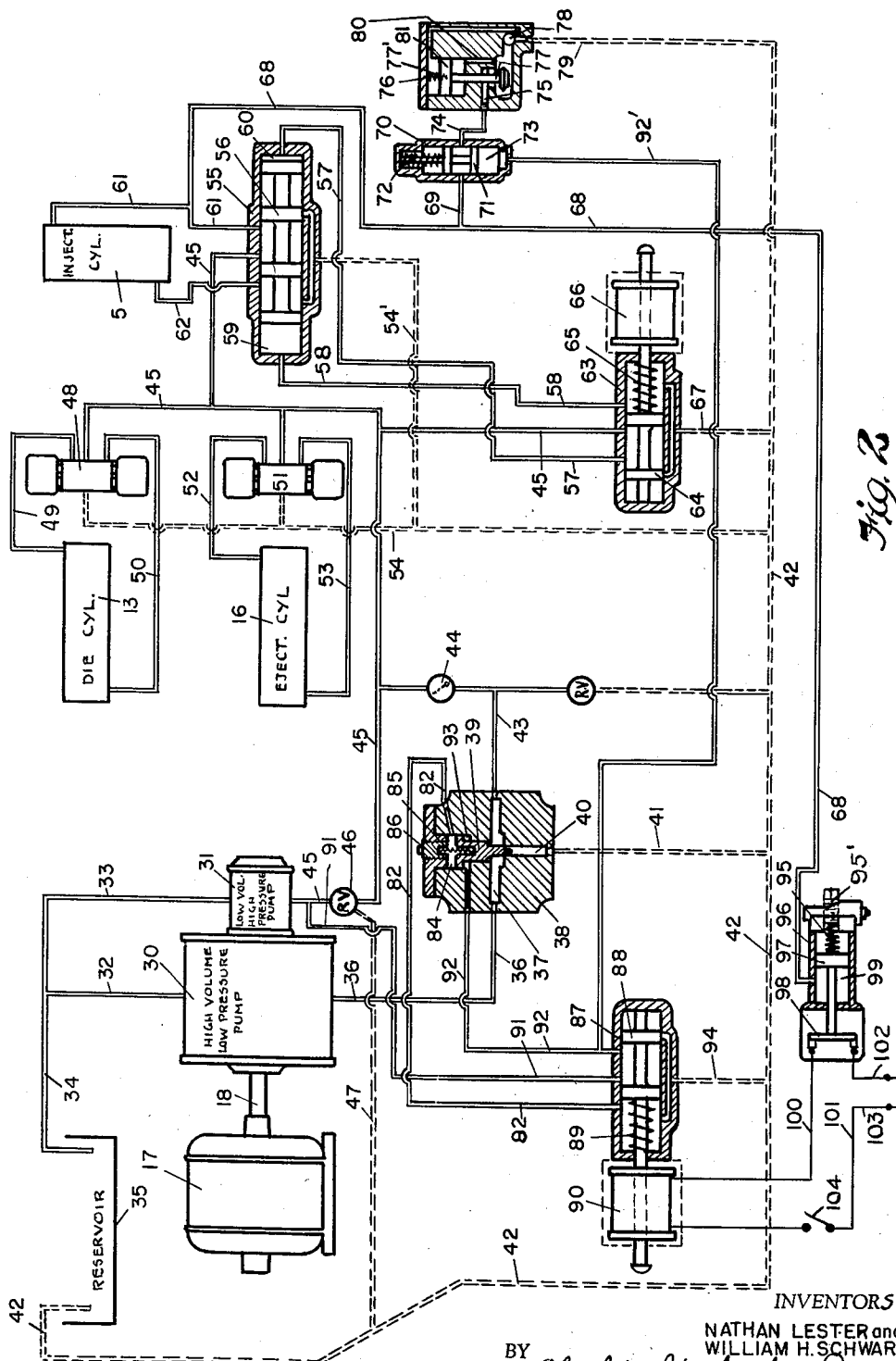


Fig. 2

INVENTORS
NATHAN LESTER and
WILLIAM H. SCHWARTZ.
BY *Oberlin Limbach & Day*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,365,282

PRESSURE CASTING MACHINE INJECTION
PRESSURE CONTROL

Nathan Lester, Shaker Heights, and William H. Schwartz, Cleveland, Ohio, assignors to Lester Engineering Company, Cleveland, Ohio, a corporation of Ohio

Application June 15, 1940, Serial No. 340,834

4 Claims. (Cl. 60—52)

This invention relates to a process, and apparatus adapted to conform with that process, for controlling the application of motivating pressure to the injection cylinder of a pressure casting machine. It has been well-recognized by those skilled in the art of designing, building and operating pressure casting machines, that a difficult problem exists with respect to the satisfactory transfer of the material to be cast from the casting chamber to the mold cavity. Such material, whether it be of a non-metallic nature such as a plastic, or a metallic material such as white metal, and in the case of a pressure casting machine operating upon the injection principle, must first be transformed into a state of proper and desired fluidity before it is injected into the mold. This transformation is usually accomplished by the application of heat to a pressure cylinder or chamber in which the material to be cast is first deposited. The material is then injected from this pressure chamber through a connecting conduit, usually termed the injection nozzle, into the mold cavity, where it subsequently becomes solidified and is thence removed to produce the resultant casting. During such transmission of the material from the pressure cylinder or chamber to the mold cavity, it, of course, undergoes various changes in its physical properties, and this phenomenon, together with the circumstance that the material is filling a confined space, viz., the mold cavity, results in a variation in the resistance to the injection pressure or motivating force applied to the material during the casting stroke. And this resistance to injection pressure, of course, undergoes sudden and rapid increase near the end of the injection stroke as the mold cavity is filled with material.

Thus, it is important that a steady, positive and controlled injection pressure be applied during the major portion of the injection casting stroke, and that an increased pressure be applied and maintained near the end of such stroke and responsive to the sudden increase in resistance or sudden pressure "build-up" in the injection cylinder.

The problem which has been presented, and now solved by our instant invention, therefore, consists in so controlling and regulating the pressure applied to the injection cylinder of a pressure casting machine, as to obtain the proper coordination between the force applied and the variable resistance to that force.

Our invention is productive of the further advantage in that there is a substantial increase

in economy of operation due to the elimination of power loss and decrease in the amount of time required per working stroke of the machine. Furthermore, our invention has produced the unexpected and unusual result in that the castings produced by the machine operating according to the principle of our invention, have a substantially increased density, stronger physical structure, and more sharply and closely defined conformity to casting specification limits, than has heretofore been achieved upon similar pressure casting machines not operating under our injection pressure control process. These advantages and novel results will be explained in further detail as the following description proceeds:

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims. The annexed drawings and the following description sets forth in detail certain means and one mode of carrying out the invention, such disclosed means and mode illustrating, however, but one of various ways in which the principle of the invention may be used.

In said annexed drawings—

Fig. 1 is a side elevational view, partially in section, of a representative pressure casting machine to which the operating process and control apparatus of our invention may be applied; and Fig. 2 is a more or less diagrammatic view, illustrating the pressure control system of our invention.

Now referring more particularly to the drawings, and Fig. 1 thereof, there is shown therein a pressure casting machine of the injection type, which, in this particular instance, is adapted to cast a metallic material, such as white metal. This machine consists of a base 1, a melting pot 2 mounted in the furnace 3, and with a pressure cylinder or chamber 4 in which a piston 4' is adapted to be reciprocated through connection with the hydraulic cylinder 5. A passage or gooseneck 6 leads from the cylinder 4 to the nozzle 7 and thence, to the mold cavity 8 defined by the separable die blocks 9 and 10. The die block 10 is mounted upon the stationary die plate 11 and the die block 9 is carried by the movable die plate 12. A hydraulic die-moving cylinder 13 connects through the medium of the connecting rod 14 and toggle link mechanism 15 to the movable die plate 12, to move the latter toward and away from the fixed die plate 11 and thus, to open and close the separable die blocks 9 and 10. A hydraulic ejection cylinder is mounted within the cylindrical screw jack member in-

licated at 16. An electric drive motor 17 connects through the shaft 18 to the hydraulic pressure pumps, which are not shown in Fig. 1, since they are contained within the base 1 of the machine. A removable panel 19 gives access to the interior of the base 1. Control levers are mounted upon the panel 20, and various indicating and signal instruments are mounted upon the panel 21.

With the essential elements of the pressure casting machine, as above described, now in mind, attention is directed to Fig. 2, which is a diagrammatic representation of the pertinent operating elements and fluid pressure control lines and connections comprising the control system of our invention.

The electric drive motor 17 (as shown in Fig. 2) is connected through its drive shaft 18 to both the high volume, low pressure pump 30 and the low volume, high pressure pump 31. Thus, at the same speed of rotation, the pump 30 will be most efficiently adapted to deliver, for example, fifty gallons per minute of fluid at 300 pounds pressure; whereas, the pump 31 will be adapted to deliver only seven gallons per minute at 1000 pounds pressure.

The intake lines 32 and 33 of the pumps 30 and 31, respectively, join the common intake line 34 which, in turn, leads from the reservoir 35. The discharge line 36 from the pump 30 leads to the one end of the main, through passage 37 of the by-pass valve 38. The plunger 39 seats in the upper end of the by-pass passage 40 of the valve 38 and normally holds such passage 40 closed to the drain line 41. The drain line 41 connects to the main drain line 42, returning to the reservoir 35.

The line 43 leads from the outlet end of the through passage 37 of the by-pass valve, through the check valve 44, to the main pressure delivery line 45. The line 45 connects to the pump 31, and a relief valve 46 is connected in it in order to serve as a safety valve to limit the maximum pressure obtainable in the line 45. The relief valve 46 is, of course, connected by the drain 47 to the main drain line 42.

The main delivery line 45, directing attention to the righthand portion of Fig. 2, is connected directly to each one of the operating or distributing valves for the die cylinder, the ejection cylinder and the injection cylinder. Thus, the line 45 connects to the solenoid-actuated distributing valve 48 which has one line 49 leading to one end of the die cylinder 13 and another distributing line 50 leading to the other end of the die cylinder 13. The line 45 also connects directly to a similar solenoid-actuating distributing valve 51, connected through the distributing lines 52 and 53 to alternate ends of the ejection cylinder 16. A drain line 54 connects the distributing valves 48 and 51 to the main drain line 42. Likewise the line 45 connects directly to the pressure-actuated distributing valve 55. This distributing valve is of the "dumb-bell" or spool type comprising the spool 56 adapted to slide within the main cylindrical chamber of the valve. Shifting or sliding of the spool 56 is accomplished by means of pressure introduced at opposite ends of the valve 55 through the lines 57 and 58 to the end chambers 59 and 60, respectively, of the valve housing. Distributing lines 61, 62 lead from the distributing valve 55 to opposite ends of the injection cylinder 5. A drain line 54' connects the valve 55 to the drain line 54, then to the main drain line 42.

The main pressure line 45 also connects to the

solenoid-actuated valve 63, from which the lines 57, 58 communicate with the distributing valve 55. The movable valve element or spool 64 in the valve 63 is normally held in a lefthand position, placing the feed line 45 in communication with the line 57, by means of the compression spring 65. The spool 64 is moved in a righthand direction by means of the electric solenoid 66, to place the line 45 in communication with the line 58. A drain line 67 connects the valve 63 to the main drain line 42.

The line 68 connects to the line 61 leading to the head end of the injection cylinder 5. A line 69, in turn, connects the line 68 to the pressure-actuated spool valve 70 in which the spool 71 is normally held in such a position by means of the compression spring 72 as to open the end of the line 69. The spool 71 is moved by means of pressure in the chamber 73 in the end of the valve to close the line 69 to the connecting line 74, to the intake passage 75 of the flow control valve 76. The flow control valve 76 has a poppet type valve 77, normally urged to open position by the compression spring 77'; and also a throttle valve 78 located adjacent the outlet to the drain line 79 connecting to the main drain line 42. The passage 80 leads to the under-side of the piston 81 on the stem of the poppet valve 77, to close the latter against the pressure of the spring 77' when flow through the control valve 76 reaches its maximum predetermined capacity.

The pilot line 92' leads from the chamber 73 of the valve 70 to an outlet line 92 which leads from the solenoid-actuated valve 87 to the under side of the piston of the plunger 39. The compression spring 85, adjustable as to compression by means of the threaded screw 86, normally urges the enlarged head or piston of the plunger 39 against its seat in the outlet passage 40.

The valve 87 is similar to the valve 63, having a spool 88 normally urged in a righthand direction by means of the compression spring 89 and moved in a lefthand direction by means of the solenoid 90. The line 91 connects the main delivery line 45 from a point immediately adjacent the pump 31, to the inlet of the valve 87. A distributing line 92 connects the other outlet of the valve 87 to the upper-side of the piston on the plunger 39 in the chamber 84. The drain line 94 connects the valve 87 to the main drain line 42.

The pilot line 98 terminates in the chamber 99 of the pressure-actuated electric switch 96, which is normally held in closed position by the compression spring 95. Thus, as the piston 97 carries the switch bar 98 in a righthand direction and against the pressure of the compression spring 95 (adjustable as to pressure by the screw 95'), electric contact is broken through the wires 100 and 101 leading to the solenoid 90 to deenergize the latter. The circuit of the wires 100 and 101 derives power from the wires 102 and 103 leading to a suitable electric power source. The switch 104, connected in this circuit is operated by being connected to the manual control lever A on the panel 20.

The operation of the control system just described in connection with Fig. 2, and particularly with respect to the application of pressure to the injection cylinder 5, is as follows:

When the pressure casting machine is "on production," the electric motor 17 and pumps 30 and 31 are in constant operation. To start the machine on its casting stroke, the die plates 9 and 10 are, of course, closed by operation of the valve 48 and die cylinder 13. The valve 63, during this

operation, is in the position as shown in Fig. 2, whereby pressure is led through the main delivery line 45 to the line 57 to move the spool 56 of the valve 55 in a lefthand direction into the position opposite to that shown in Fig. 2, so that pressure from both of the pumps 30 and 31 is delivered to the line 62 to the rod end of the injection cylinder, whereupon the casting plunger 4' is held at the upper end, or initiating point of its casting stroke. Up to this point, it will be seen that pressure from the high volume, low pressure pump 30, passes from the line 36 through the by-pass valve 38 to the line 43 and joins with the fluid delivered from the pump 31 in the line 45. During this time, viz., preparatory to the working stroke of the injection cylinder 5, or before the machine is ready to deliver its "injection shot," all of the various hydraulic cylinders 5, 13 and 16 are moved with comparative ease and rapidity. Hence, the pump 30 is best suited to deliver the major portion of the hydraulic pressure required. As these hydraulic cylinders 5, 13 and 16 reach the end of their preparatory stroke positions, it is no longer feasible or efficient to maintain a "holding" pressure in them by means of the pump 30, but on the contrary, this pump should be disconnected from the main pressure line 45 and such holding pressure maintained by the low volume, high pressure pump 31 which is most suitably and efficiently designed to do so. This maintenance of connection of both of the pumps 30 and 31 to joint delivery to the main pressure supply line 45 is achieved as follows:

Pressure from the line 91 enters the valve 87 and since the latter is in the position as shown in Fig. 2, such pressure is delivered to the line 92, to the under-side of the by-pass valve plunger 39, tending to raise the latter and to allow pressure from the line 36 to pass out through the by-pass outlet 40. Thus, for example, if the by-pass valve compression spring 85 is set at a point corresponding to a pressure of 300 pounds per square inch, as soon as this pressure is attained in lines 91 and 92, the valve plunger 39 will be raised against the spring pressure and the pump 30 thus disconnected at the point where it has achieved its maximum operating pressure efficiency, leaving the pump 31 to supply any needed additional pressure such as, for example, in holding the die cylinder 13 and the ejection cylinder 16 in closed position, or in holding the piston in the injection cylinder 5 at the upper end of its stroke. At this point in the operation of the casting machine and the control system, the injection cylinder 5 is ready to start upon its "injection shot" or working stroke, which is initiated by manipulation of the lever A on the control panel 20, which is electrically connected to the solenoid 66 and also connected to the switch 104. The solenoid 66 on being energized, moves the spool 64 in a righthand direction to connect the main line 45 to the line 58 to move the spool 56 in a righthand direction and in the position as shown in Fig. 2, whereby pressure from both of the pumps 30 and 31 is delivered to the line 61 to the head end of the injection cylinder to start the plunger 4' on its injection stroke. At the same time, the switch 104 being closed, and the switch 98 closed by the pressure of the spring 95, the circuit in the wires 100 and 101 is closed to energize the solenoid 90, to move the spool 88 in a lefthand direction. This places the line 91 in communication with the line 82, whereby pressure is directed to the upper side of the by-pass valve plunger 39 to hold it in a downward direction, preventing the outlet

passage 40 from opening, even though the delivery pressure of the high volume, low pressure pump 30 might exceed its optimum capacity of 300 pounds per square inch.

Thus, during the initiation and major portion of the injection or working stroke of the cylinder 5, both pumps 30 and 31 are working together as a team to give a positive, constant motivating force on the injection stroke. If any minor resistance is incurred during this stroke, the pump 30 will not be disconnected, but rather will its work be augmented by the higher pressure capacity of the pump 31, so that there is no hesitance in the injection or "shot" stroke of the plunger 4'. Thus, for example, if the pressure requirement in the injection cylinder 5 during its working stroke should vary from 200 to 500 pounds per square inch as an incident to the resistance of movement to the material being cast, the pump 30 will not be intermittently connected and disconnected to the main delivery line 45 which would otherwise produce a variation in the rate of travel of the casting plunger 4', but will remain connected so that both pumps so deliver their pressure as to move the plunger 4' surely and uniformly throughout the major portion of its stroke.

During this injection stroke, pressure built up in the line 61 is transmitted through the line 68 to the valve 96, which is set at such a predetermined point that the piston 97 will be moved to open the switch 98, thus de-energizing the solenoid 90, moving the spool 88 in a righthand direction and placing the line 91 in communication with the line 92, to raise the plunger 39 and allow fluid to flow out through the outlet 40 of the by-pass valve 38. It has previously been indicated by way of example, that a suitable delivery pressure for the pump 30 might be 300 pounds per square inch and for the pump 31, 1000 pounds per square inch, as the most efficient operating pressures for these two respective pumps. Thus, the valve 96, in such an exemplary situation, should be set at 1000 pounds per square inch, whereupon, the pump 30 would be shunted or by-passed to discharge when its high volume capacity is no longer needed.

The check valve 44, of course, prevents the increased pressure in the line 45 from passing back through the line 43 to the by-pass valve 38. By effecting this automatic disconnection of the pump 30, the power loss incident to operating it under pressure and volume conditions derogatory to efficiency, is substantially reduced.

The flow control feature of our system as embodied principally in the function of the valves 70 and 76, is also interdependent with the last-described automatic disconnection feature of the high volume, low pressure pump. This flow control feature of our system operates as follows:

As the piston in the cylinder 5 begins its stroke upon introduction of pressure through the line 61, pressure on spool 73 of valve 70 from pressure line 92' is released due to solenoid of valve 87 energizing and shifting its spool, opening pressure in line 91 to line 82 and line 92 to drain 94. The valve 70 then opens to the line 69, to the line 74, to the flow control valve 76. This latter valve so functions as to limit the maximum rate of flow from the main delivery line 45 to the line 61, and it does so, not by throttling or metering the fluid flow in the line 61, but by bleeding off or withdrawing the excess above a predetermined maximum. The reason for so controlling the rate of flow in the line 61 is substantially this:

It is quite often found that certain materials to be cast should be evacuated from the casting

cylinder at an optimum rate. This rate, of course, can be controlled by the rate of introduction of fluid through the line 61. The obvious way to so control the rate of fluid flow through the line 61 would be by a throttle valve, but such a throttle valve would operate, in effect, as a resistance in the pressure supply line, particularly when the demand for increased pressure in the injection cylinder 5 arises, thus rendering such an expedient of flow undesirable. Hence, according to our flow control feature, as the high volume, low pressure pump 30 is automatically disconnected when the pressure "build-up" in the injection cylinder 5 rapidly increases, the control of the maximum rate of flow in the line 61 is no longer necessary so the flow control valve 76 is rendered inoperative.

This is accomplished by the connection of the line 92' to the pressure line 91, through the shifting of the valve 87. At the same time, spool 71 is forced against spring 72 which closes off the end of the line 69. This prevents the pump 31 delivering its small volume through the flow control valve 76, thus eliminating a drop of pressure throughout the system.

It will thus be seen that through the operation of our flow control system, that the plunger 4' is caused to move at a uniform, controlled and efficient rate during the major portion of its injection stroke, with an automatic response of the pressure system to the sudden increased resistance to the travel of such plunger near the end of its stroke.

The above-described control system and method of operation thereof has resulted in a new method of injection casting, which also forms a part of our present invention. Heretofore, in injection casting, it has been found necessary to so maintain the temperature in the passage leading from the casting cylinder to the mold cavity as to prevent a freezing out or loss of fluidity of the material passing therethrough. Thus, for example, means have been provided to heat the nozzle 7. On the contrary, and by means of our present invention, we purposefully permit the temperature in the nozzle 7 to drop below melting or permit the temperature in the nozzle 7 to drop below melting or fluidity point of the material to be cast so that a small "gate slug" is formed in its end communicating with the gate to the die cavity 8. The formation of this "gate slug" prevents the material to be cast from prematurely passing into the mold cavity 8 and not until the nozzle 7 and gooseneck 6 have been completely filled with material and air otherwise entrapped therein has been evacuated. Such entrapment of air, of course, has heretofore been carried over with the material to be cast into the mold cavity 8, resulting in a porosity in the resultant casting.

The sure and positive application of hydraulic pressure to move our casting plunger 4' during this injection stroke renders it possible to permit this "gate slug" to form in the end of the nozzle 7 without involving heretofore objectionable conditions, such as a sudden pressure drop in the injection cylinder nozzle after the resistance necessary to dislodge the "gate slug" has been overcome. Such a sudden pressure drop would possibly prove fatal to the entire casting operation in that it would permit the melting point of the material under pressure to lower and hence, to freeze out or solidify throughout the entire length of the nozzle 7, to thereby result in a clogging of the passage from the casting

cylinder to the mold cavity, which could not be overcome regardless of the pressure applied to the material and without the application of external heat to such passage to again liquefy or render fluid the material therein.

We have unexpectedly discovered that castings made according to our last-described novel casting method and with a machine to which our above-described flow control system has been applied, possess much greater density, improved grain structure, and closer conformity to casting specifications than have otherwise been obtainable. Thus, for example, in the case of the making of white metal castings, those produced from a machine controlled according to our present invention, have averaged about 7% greater density than could be produced heretofore on the same machine, not operated with our control system.

Other modes of applying the principle of our invention may be employed instead of the one explained, change being made as regards the means and the steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

We, therefore, particularly point out and distinctly claim as our invention:

1. Injection pressure control mechanism for a pressure casting machine comprising an injection cylinder, a plurality of fluid pressure supply pumps, each having different volume and pressure delivery capacities, conduit means, jointly connecting all of said pumps to said cylinder, pressure responsive means connected to said conduit means and actuated by a pressure variation therein for disconnecting one of said pumps from said conduit means, flow control valve means connected to said conduit means for regulating the rate of fluid flow therein, and means for rendering said flow control valve means inoperative during disconnection of said one of said pumps.

2. Injection pressure control mechanism for a pressure casting machine comprising an injection cylinder, a plurality of fluid pressure supply pumps, each having different volume and pressure delivery capacities, conduit means, jointly connecting all of said pumps to said cylinder, valve means connecting those of said pumps having relatively higher volume capacity to free discharge, flow control valve means connected to said conduit means for regulating the rate of fluid flow therein and pressure responsive control means connected to said conduit means, to said first valve means and to said flow control valve means, said pressure responsive control means being adapted to open simultaneously said first valve means to free discharge and to render said flow control valve means inoperative on increase of pressure beyond a predetermined limit in said conduit means.

3. Injection pressure control mechanism for a pressure casting machine comprising an injection cylinder, a high volume, low pressure capacity pump, a low volume, high pressure capacity pump, a conduit connecting both of said pumps to said cylinder, a flow control valve adapted to regulate fluid flow in said conduit by bleeding off a portion of the fluid passing therethrough, a bypass valve adapted to connected said first-named pump to free discharge, and control means actuated by a predetermined pressure in said conduit for opening said by-pass valve and rendering said flow control valve inoperative.

4. Injection pressure control mechanism for a pressure casting machine comprising an injection

tion cylinder, a high volume, low pressure capacity pump, a low volume, high pressure capacity pump, a conduit connecting both of said pumps to said cylinder, a by-pass valve adapted to connect said first-named pump to free discharge, said by-pass valve being pressure-actuated, a second conduit leading from said second-named pump, a flow control valve adapted to regulate the rate of fluid flow in said first conduit by bleeding off a portion of the fluid passing there-
through, said flow control valve being pressure-

10 actuated, an electrically actuated 4-way valve adapted to connect said second conduit alternatively to said by-pass valve and to said flow control valve, a pressure-actuated electric switch electrically connected to said 4-way valve, and a pilot conduit connecting said first conduit to said electric switch for actuating the same when a predetermined pressure is reached in said first conduit.

• NATHAN LESTER.
WILLIAM H. SCHWARTZ.