Oct. 3, 1967 H. D. HALL ETAL 3,344,848

DIE CASTING APPARATUS WITH NON-TURBULENT FILL
AND DUAL SHOT PLUNGER ARRANGEMENT

Original Filed June 24, 1963 2 Sheets-Sheet 1

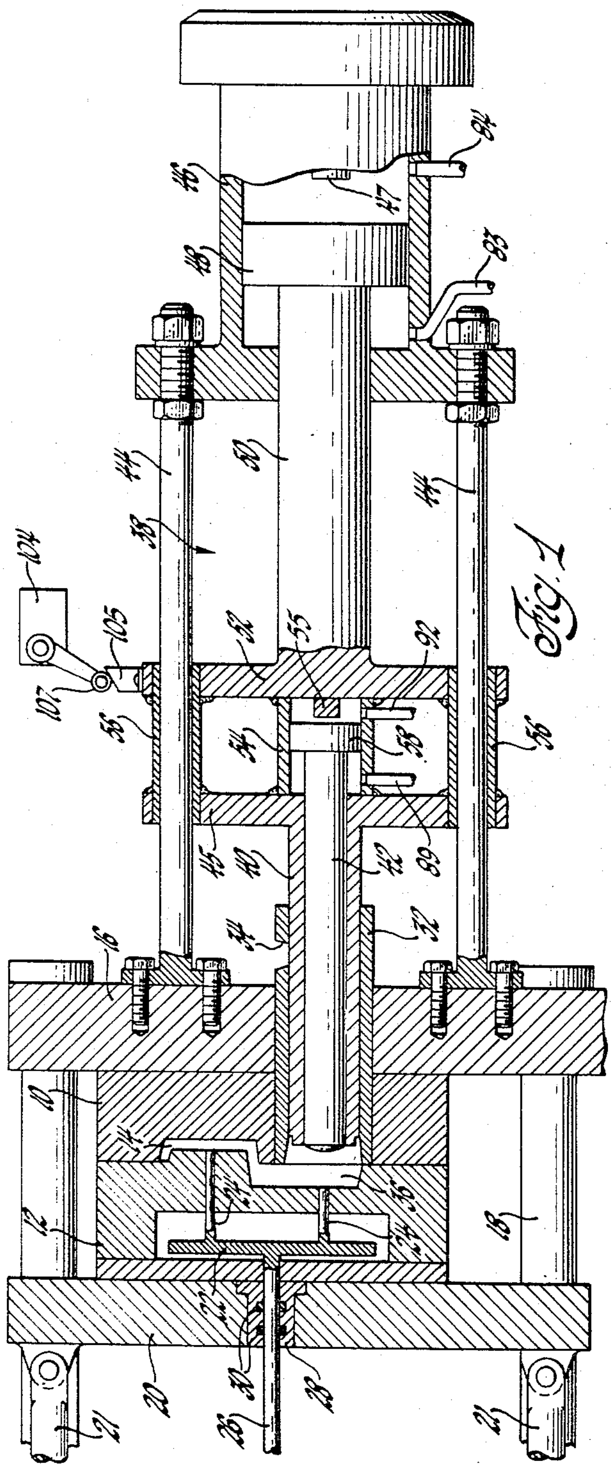

Fig. 1

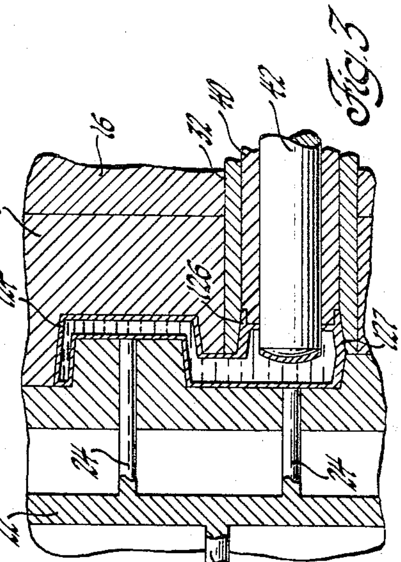

Fig. 3

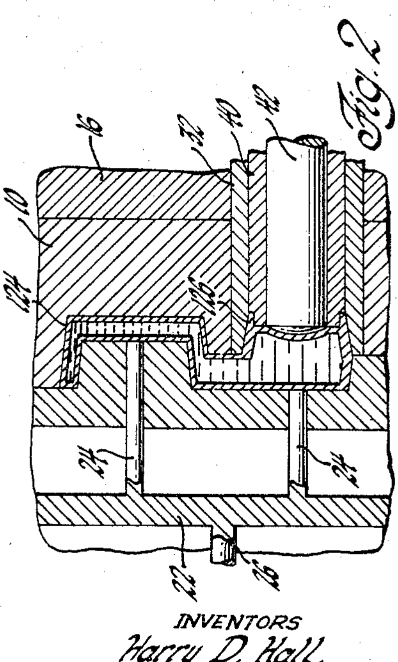

Fig. 2

INVENTORS
Harry D. Hall,
David C. Salatin,
Don R. Sutherland, &
Clayton J. Trible

Peter P. Kozak
ATTORNEY

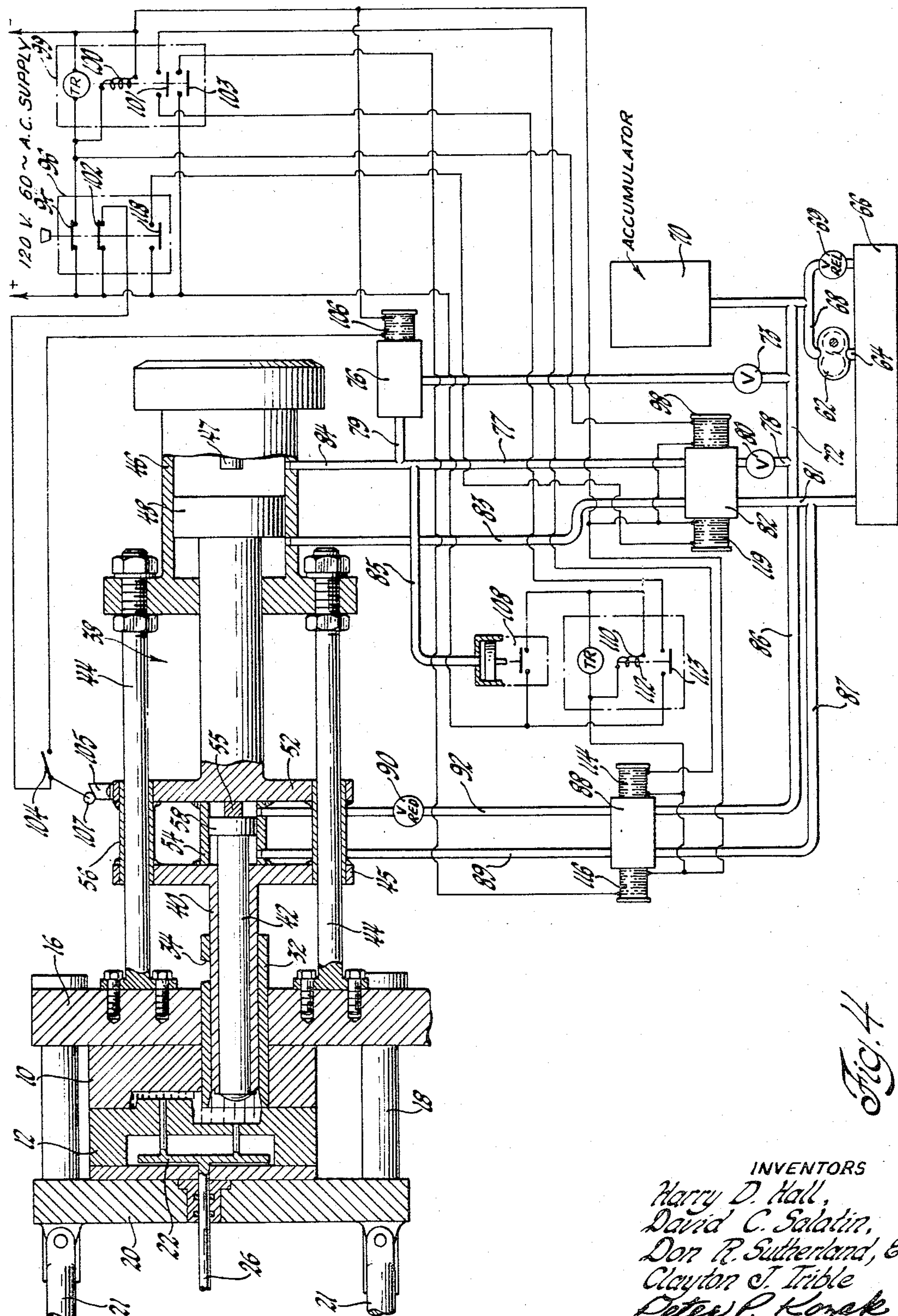

Fig. 4

INVENTORS
Harry D. Hall,
David C. Salatin,
Don R. Sutherland, &
Clayton J. Trible
Peter P. Kozak
ATTORNEY

United States Patent Office

3,344,848

Patented Oct. 3, 1967

1

3,344,848

DIE CASTING APPARATUS WITH NON-TURBULENT FILL AND DUAL SHOT PLUNGER ARRANGEMENT

Harry D. Hall, Birmingham, Mich., David C. Salatin, Anderson, Ind., and Don R. Sutherland, Mount Clemens, and Clayton J. Trible, Berkley, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Original application June 24, 1963, Ser. No. 289,903, now Patent No. 3,270,383, dated Sept. 6, 1966. Divided and this application Apr. 25, 1966, Ser. No. 545,112

4 Claims. (Cl. 164—312)

ABSTRACT OF THE DISCLOSURE

Die casting apparatus including a nonrestricted gate which leads from the shot sleeve to the die cavity, a first shot plunger for non-turbulently moving the molten metal charge from the shot sleeve to the die cavity and subjecting the charge within the cavity to pressure, and a second smaller plunger for breaking through the initially solidified shell which prevents the first plunger from exerting continued pressure and subjecting the interior molten portion of the solidifying charge to additional pressure.

This is a division of the patent application Serial No. 289,903, filed June 24, 1963 and now Patent No. 3,270,-383.

This invention relates to die casting and more particularly to a process for making improved die castings and to apparatus for carrying out the process.

Conventional die casting procedures involve injecting molten metal into a die cavity at a relatively high pressure in order of 10,000 pounds per square inch by means of a piston-like ram. Typically, the molten metal is forced through a restrictive sprue passage to cause the metal to enter the die cavity in particulate form and at a high velocity to facilitate filling of the die cavity. The molten metal therefore enters the die cavity in a highly turbulent state and the high pressure of the injection is relied on to compress the molten metal in the die cavity to obtain reasonably dense castings. Die casting procedures of this type may be of the hot-chamber type, as is typically used in zinc die casting, in which the injection mechanism or gooseneck is submerged in a mass of molten metal or of the cold-chamber type, typically used in aluminum or magnesium casting, in which the injection mechanism is maintained in an atmospheric environment. The principal advantage in the above high pressure type of die casting is in the speed with which the castings are made since only a few seconds are involved in the entire procedure of injecting the molten metal into the die cavity, solidification of the casting, and its removal from the die. The principal disadvantage of this high pressure type die casting is that since as above indicated the metal is injected into the dies under high pressures and generally through a restricted sprue opening the metal enters the die cavity in a highly turbulent condition with the result that the castings tend to be porous and unsuitable for many purposes. Thus, for example, castings made by the above-mentioned high pressure die casting are suitable for automotive body hardware, ornamental parts, and the like. However, due to the inherent porosity of such castings, they are generally unsuitable for making cylinder blocks, cylinder heads, pump housings, and the like.

Another well-known type of die casting generally referred to as low pressure casting involves mounting the dies over an enclosed pot of molten metal, providing a tube or stalk which extends from a point within the

2

molten metal to the sprue of the die, and subjecting the molten metal to a superimposed pressure differential in the order of a few pounds per square inch whereby the molten metal is forced slowly up into the stalk and thence into the die cavity under essentially non-turbulent conditions. The principal advantage in this type of die casting is that a more dense casting is formed. The principal disadvantage resides in the fact that a typical casting cycle requires a considerable amount of time since the molten metal is injected into the die cavity slowly and slow solidification is provided for, to prevent premature solidification of the casting in the cavity.

It is the principal object of this invention to provide an improved die casting process whereby highly improved, dense castings are made at a relatively high speed and whereby the advantages of prior art procedures are realized and the disadvantages are eliminated. Another object of this invention is to provide apparatus for carrying out this process.

These and other objects are carried out by apparatus generally of the cold-chamber type having a novel combination of machine elements including an enlarged gate of sufficient volume to permit non-turbulent passage of the molten metal therethrough into the die cavity, a cold-chamber type shot sleeve, a duplex shot plunger operable within the shot sleeve consisting of a relatively small diameter plunger reciprocally operable within a larger diameter plunger of substantially the same diameter as the shot sleeve, wherein the tip of the smaller plunger is adapted to be positioned substantially at the tip of the larger plunger in a first position thereof and to extend to a longitudinal position substantially beyond the tip of the larger plunger in a second position thereof, and hydraulic and control means for operating the two plungers as a unit when the plungers are in said first position and for operating the smaller plunger independently of the larger one to obtain said second position.

The process includes the steps of admitting a measured charge of molten metal into the shot sleeve, operating the duplex plunger as a unit to move the molten metal non-turbulently into the die cavity in the form of a solid front, maintaining a relatively high compacting pressure on the molten metal by means of the duplex unit until a relatively thin shell of molten metal has solidified adjacent the walls of the die cavity, the gating, and the duplex plunger tip to prevent further application of compacting pressure and thereafter actuating the smaller plunger independently of the larger one whereby its tip breaks through the solidified metal shell adjacent the tip of the smaller plunger to thereby subject the molten core portion of the metal in the die cavity to continued high pressure and continued filling until the metal has solidified.

Preferably, means are provided whereby the actuation of the smaller plunger is in response to the pressure built up against the larger plunger due to the aforementioned solidified metal shell having been formed adjacent the plunger and shot sleeve walls thereby preventing the larger plunger from subjecting the molten metal in the die cavity to further compression and whereby the solidification of the casting is not permitted to progress to a point which would involve solidification of the core portion of the casting or to a point which would make it difficult for the smaller plunger to break through the solidified shell.

Other objects and advantages will be apparent from the following detailed description of the invention, reference being had to the accompanying drawings of which:

FIGURE 1 is a fragmentary cross-sectional view of die casting apparatus embodying this invention showing the dies and injection mechanism in a position just as the die cavity is filled with molten metal.

FIGURE 2 is a fragmentary cross-sectional view of the die cavity and plunger tip portion of the apparatus at an intermediate stage of the process of this invention just prior to the actuation of the smaller plunger.

FIGURE 3 is a fragmentary cross-sectional view similar to that of FIGURE 1 but after the actuation of the smaller plunger.

FIGURE 4 is a view of the apparatus shown in FIGURE 1 together with hydraulic and electrical control apparatus shown in schematic form.

Referring now to the drawings and particularly to FIGURE 1, it will be observed that there is included in the fragmentary illustration of the die casting machine a cover die **10** and an injector die **12** defining a die cavity **14** therebetween. The die member **10** is supported on the face of a stationary platen **16** by suitable bolts (not shown) which in turn is mounted on a base plate (not shown).

The stationary platen **16** also supports one end of each of four longitudinally extending tie bars **18**, the opposite end of each of the tie bars being supported by a suitable upright stationary plate (not shown).

The movable ejector die **12** is supported on the movable platen **20** mounted on the tie rods **18** for longitudinal movement thereon. The movable platen **20** is movable reciprocally along the tie rods **18** between die open and closed positions by means of a toggle device **21** as is well known in the art.

In the space within the movable die **12**, there is provided an ejecting mechanism comprising a head plate **22** and a plurality of ejecting pins **24**. The ejecting pins **24** are each secured at one end of the head plate **22** and are slidably received in suitable bores formed in the ejector die **12**. A plunger **26** has its forward end secured to the head plate **22** of the ejecting mechanism and extends rearwardly through an axially aligned bore in the die **12** and the movable platen **20**. A bushing **28** having sealing rings **30** is provided to prevent leakage through the movable platen about the plunger **26**. When the movable platen **20** is retracted and closely approaches the limits of its rearward movement, the plunger **26** is adapted to engage a stop (not shown) whereby its rearward movement is terminated. The continued movement of the platen to its rearward limit thereafter results in relative movement between the platen **20** and the plunger **26** and between the ejector pins **24** and the movable die **12**, the front ends of the pins being urged outwardly from the face of the die to dislodge the casting formed in the cavity.

Extending snugly through the aligned bores in the platen **16** and the cover die **10** is a shot sleeve **32** having a vertical extending opening **34** therein for admitting a charge of the molten metal into the shot sleeve in any well-known manner. An important aspect of the invention resides in the provision of a wide gating **36** extending from the end of the shot sleeve **32** into the die cavity proper **14**. As will hereinafter more fully be described, the gating **36** is of sufficient volume so that the molten metal may be moved into the die cavity **14** without significant turbulence. As may be seen from the drawing, the gating **36** may be initially of the same dimensions as the shot sleeve to avoid turbulence as the molten metal changes from horizontal to vertical flow into the die cavity.

Another important aspect of the invention resides in a duplex plunger indicated generally as **38** which consists of a relatively larger outer plunger **40** snugly and reciprocally received in the shot sleeve **32** and a relatively small plunger **42** reciprocally received within a longitudinal bore of the larger plunger **40** centrally thereof. The larger plunger **40** is slidably supported on a plurality of tie rods **44**, each bolted at one end thereof to the stationary platen **16**, by means of the flange **45** integrally attached to the plunger **40**. To the opposite ends of the tie rods **44** there is bolted a hydraulic cylinder **46** including a piston stop **47** attached to the end thereof and having a piston **48** reciprocally positioned therein. The piston **48** is attached

to a connecting rod **50** which is slidably mounted on the tie rods **44** by means of the integral flange **52**. The flange **52** is connected to the flange **45** of the plunger **40** by means of the cylinder **54** welded thereto whereby the piston **48** is connected to the plunger **40** by means of the connecting rod **50**, the flanges **45** and **52**, and the cylinder **54**. The flanges **45** and **52** have aligned bores therein which receive the bushings **56** and are welded thereto. These in turn slidably receive the tie rods **44**. The cylinder **54** also forms a hydraulic cylinder including the piston stop **55** attached to the rod **50**, which contains a piston **58** attached to the smaller plunger piston **42**.

It will thus be observed that reciprocal motion of the piston **48** is operable to move the smaller or inner plunger **42** and the larger or outer plunger **40** as a unit. On the other hand, the reciprocal motion of the piston **58** is operative to reciprocate the inner plunger **42** independently of the motion of the outer plunger **40**. As will be hereinafter described, hydraulic and control means are provided for moving the outer plunger **40** and the inner plunger **42** in a predetermined sequence in accordance to the requirements of the process of this invention.

Referring to FIGURE 4, an example of suitable hydraulic mechanism for practicing the process of this invention includes a gear pump **62** having an input line **64** connected to an oil sump **66** and an output line **68** connected to a relief valve **69** discharging to the sump; to an accumulator **70**; to a first line **72** connected to the portion of the cylinder **46** outwardly of the piston **48** through a flow control valve **73**, a two-way solenoid operated valve **76**, the hydraulic line **79** and the hydraulic line **84**; and to a second line **78** connected to the portion of the cylinder **46** outwardly of the piston **48** through the flow control valve **80**, the solenoid operated four-way valve **82** and the lines **77** and **84**. The line **78** is also connected to that portion of the cylinder **46** inwardly of the piston **48** through the flow control valve **80**, the four-way solenoid operated valve **82** and the line **83**. The outlet **68** of the gear pump **62** is also connected to a third line **86** which connects with the portion of the cylinder **54** outwardly of the piston **58** through the four-way solenoid operated valve **88** and the reducing valve **90**. The line **86** is also connected to the portion of the cylinder **54** inwardly of the piston **58** through the four-way valve **88** and the line **89**. The portion of the cylinder **46** inward of the piston **48** is also connected to the oil sump **66** through the line **83**, the four-way valve **82**, and the line **81**. The portion of the cylinder **46** outward of the piston **48** is also connected to the oil sump through line **84**, the four-way valve **82** and the line **81**. Similarly, the portion of the cylinder **54** inward of the piston **58** is connected to the oil sump **66** by means of the line **89**, the four-way valve **88**, and the line **87**; and the portion of the cylinder **54** outwardly of the piston **58** is connected to the sump **66** through the line **92**, the four-way valve **88** and the line **87**. The character and operation of the electrical components for operating the hydraulic apparatus will be apparent from FIGURE 4 and the detailed description of the operation of the mechanism to be made hereinafter.

The process of this invention stated generally in terms of FIGURES 1, 2, and 3 involves first returning the duplex plunger **38** to a cycle commencement position in which the plunger **40** is withdrawn sufficiently from the shot sleeve to expose the inlet **34**. When operated as a unit the tips of each of the plungers are substantially aligned to form a composite tip of more or less conventional shape. A measure charge of the molten metal is poured into the shot sleeve which is sufficient to fill the die cavity **14** as well as the enlarged gating portion **36** when the plunger **38** reaches the end of its stroke. Hydraulic fluid is then caused to enter the hydraulic cylinder **46** on the side thereof outward of the piston **48** whereby the duplex plunger **38** including the outer plunger **40** and the inner plunger **42** moves as a unit forward toward the die cavity to non-turbulently move the molten metal into the die cavity **14**. The volume of the gating **36** and the speed of the duplex plunger is such as to provide a lineal velocity through the gate not in excess of about 50 feet per second, i.e., a non-turbulent flow, whereby a solid front of the metal moves into and fills the cavity. Just before the die cavity **14** is filled with molten metal, additional hydraulic pressure is applied outwardly of the piston **48** whereby a squeeze in the neighborhood of 5,000–10,000 pounds per square inch is applied to the metal in the die cavity **14**. The molten metal begins immediately to solidify in the die cavity and the gating adjacent the metal walls of the die. After the lapse of a short period of time in the vicinity of a fraction of a second, a relatively thin layer of the molten metal **124** is formed adjacent the metal walls of the die within the die cavity **14** as well as the gating **36** and over the tip of the duplex plunger as shown in FIGURE 2. The formation of this metal shell prevents the further application of pressure by the duplex plunger tip on the molten metal since this metal shell creates an annular barrier **126** about the periphery of the duplex plunger tip. This condition is evidenced by a marked increase in the hydraulic pressure developed in the cylinder **46** outwardly of the piston **48**. Electrical and hydraulic control mechanism is provided to cause this increase in pressure to then admit hydraulic pressure into the cylinder **54** outwardly of the smaller piston **58** whereby the smaller inner plunger **42** is caused to move forward and break through the shell **124** as shown in FIGURE 3 and whereby the core or internal molten portions of the casting is subjected to continued pressure on the order of 10,000 pounds per square inch to further feed molten metal into the die cavity to compensate for shrinkage until the molten metal has solidified, and thereby produce a high quality dense casting. After the metal has solidified, the hydraulic pressure outwardly of the smaller piston **58** is relieved and hydraulic pressure is applied to the cylinder **54** inwardly of the piston **58** whereby the smaller plunger **42** is withdrawn from the casting. The dies are then opened and the continued pressure of the duplex plunger upon the solidified gating biscuit forces the latter from the cover die **10**. Thereafter the pressure in the cylinder **46** outwardly of the piston **48** is relieved and hydraulic pressure is applied inwardly of the piston **48** whereby the entire duplex plunger is withdrawn from the shot sleeve so as to expose the inlet **34** preparatory to another casting cycle. Withdrawal of the smaller plunger **42** prior to the withdrawal of the larger plunger **40** is essential to efficiently eject the casting.

It will be apparent that the process described has a number of important advantages. As described above, the molten metal is moved into the die cavity slowly and non-turbulently in the form of a substantially solid front so that atmospheric air in the die cavity is expelled through the die vents ahead of the rising front of molten metal thus minimizing casting porosity due to air entrapment. The slow progressive filling of the die cavity operates to seal the die vents and the die parting line crevices at low pressure and thus "flashing" (liquid metal escaping from the die cavity through the parting line and vents) is minimized. Thus, the process is particularly advantageous in producing castings with dies which are somewhat deteriorated at the parting lines. Further, the solid shell **124** is formed substantially at lower pressures and the shell functions to contain the molten metal within the shell when the high pressure is applied by the final squeeze of the larger plunger and the smaller plunger thus reducing the necessary die clamping force by as much as 50%. Moreover, the high pressures applied by the smaller plunger causes the shell **124** to lie up snugly against the casting cavity to obtain improved casting dimensions. A very important aspect of the process is that the inner portions of the casting are subject to continued pressure until complete solidification has been substantially completed whereby shrinkage and porosity of the casting is minimized.

The process described may be advantageously practiced using the hydraulic and electrical apparatus shown in FIGURE 4. At the commencement of a casting cycle, the dies **10** and **12** have been closed by actuation of the toggle mechanism **21** operated by the usual hydraulic means and the duplex plunger **38** has been moved outwardly so that the plunger exposes the shot sleeve opening **34**. The shot sleeve is then charged with molten metal. At this time, the operator moves the switch **96** to the plunger forward position shown in FIGURE 4. In this position of the switch the contact **118** is open whereby the large plunger return solenoid **119** of the four-way double solenoid valve **82** is de-energized whereby the portion of the cylinder **46** inwardly of the piston **48** is open to the oil sump **66** through the hydraulic lines **83** and **81**. The contact **102** thereof is closed to prepare the circuit of the solenoid **106** of the two-way valve **76**. The contact **94** thereof is closed and is operative to energize the forward motion solenoid **98** of the four-way valve **82** to open the portion of the cylinder **46** outwardly of the piston **48** to hydraulic pressure from the gear pump **62** through the hydraulic line **78**, the flow control valve **80**, and the lines **77** and **84**. The closure of the contact **94** also energizes the timer **99** to close the normally open contacts **101** and **103** by means of the coil **100** and as will be seen is necessary at a subsequent stage of the cycle to return the smaller plunger **42** from its forward position.

Actuation of the solenoid **98** causes hydraulic pressure to be admitted into the cylinder **46** through the lines **77** and **84** whereby the duplex plunger moves relatively slowly into the shot sleeve as a unit moving the molten metal ahead of it non-turbulently and with a solid front. The flow of hydraulic fluid is controlled by the flow control valve **80** to insure a solid fill flow velocity of about 50 lineal feet per second or less. As the duplex plunger nears the end of its stroke, it closes the limit switch **104** by the action of the cam **105** attached to the flange **52** acting on the switch arm **107**. The actuation of the limit switch **104** energizes the solenoid **106** of the two-way valve **76** whereby the valve opens and additional hydraulic fluid with the aid of the accumulator **70** is moved into the cylinder **76** outwardly of the piston **48** through the lines **72**, **79**, and **84**. This increases the speed of the duplex plunger at the very end of its stroke and subjects the metal in the cavity to an increased filling velocity. Since the gating is now submerged, the solid front fill is not disturbed by this increased velocity and the resulting higher pressure.

When the pressure in the cylinder **46** outwardly of the piston **84** builds up to a pre-set relatively higher pressure due to the die cavity having been filled and the molten metal therein having been compressed, the pressure switch **108**, which is exposed to the pressure in the outward portion of the cylinder **46** through the line **85**, is closed whereby the timer **110**, including the coil **112** and the contact **113**, is energized to close the contact **113**. When the timer **110** times out, which involves a time delay in the neighborhood of a fraction of a second, sufficient to allow the solidification of the layer **124** and **126**, the timer energizes the solenoid **114** of the four-way valve **88** through the timer **99** which as described above had been closed when the timer **99** was energized. As a consequence, the portion of the cylinder **54** outward of the piston **58** is subjected to hydraulic pressure through the pressure reducing valve **90**, the line **92**, the valve **88** and the line **86** and the smaller plunger **42** is caused to move forward and break through the solidified shell **124** as shown in FIGURE 3 to subject the molten material to continued pressure and to cause the shell to lie up snugly against the cavity walls and to compensate for metal shrinkage.

A short time before the dies **10** and **12** are to be opened, the timer **99** times out thereby deenergizing the solenoid **114** and energizing the solenoid **116** of the four-way valve **88**. This causes the hydraulic pressure outwardly of the piston **58** to be relieved through the lines **92** and **87** and for hydraulic pressure to be applied inwardly of the piston **58** through the lines **86** and **89**. As a result, the plunger **42** is caused to be withdrawn from the solidified casting biscuit and returned to its original position as shown in FIGURE 4. Thereafter, other mechanism is actuated (not shown) to open the dies and effect ejection of the casting by the action of the ejector pins **24** associated with the bar **22** and plunger **26** in a well-known manner. While the dies are being opened, however, continued pressure applied by the duplex plunger forces the casting biscuit **127** (FIGURE 3) from the cover die. After the dies are fully open, the operator moves the switch **96** to a return position. As a consequence, the contact **94** is opened deenergizing the solenoid **98** and the timer **99**. As a result, the hydraulic pressure outwardly of the large hydraulic piston **48** is relieved. The contact **102** is opened deenergizing the solenoid **106** and the contact **118** is closed energizing the return solenoid **119** whereby hydraulic pressure is applied inwardly of the piston **48** through the lines **78** and **83** to return the duplex piston to its original position. The return of the piston **48** to its original position causes the limit switch **104** to open whereby the cycle is completed.

It will be understood that the control mechanism described above to illustrate the invention is a simplified version of control apparatus which may be used. However, it will be obvious to those skilled in the art that it is desirable to integrate the operation of the apparatus described with the control of the operation of the entire die casting apparatus and to install additional control and safety features.

Although the invention has been described in terms of a specific embodiment, it will be understood that various modifications may be made within the scope of the invention.

We claim:

1. In a die casting apparatus the combination comprising a stationary cover die and a movable ejector die movable between die open and die closed positions cooperatively defining a cavity therebetween, a shot sleeve having one end extending into the cover die, said dies including a substantially nonrestricted passage extending upwardly from said end of said shot sleeve to said cavity, said shot sleeve having a molten metal charging opening externally of said cover die, a first shot plunger having a tip reciprocable within said sleeve between a retracted position in which said opening is exposed for receiving a charge of molten metal and an advanced position near the said one end of said sleeve, said first plunger including a second smaller plunger reciprocable within a longitudinal bore in said first plunger substantially centrally thereof between a retracted position in which the tip forms the central portion of the first plunger tip and an advanced position substantially beyond said first plunger tip, means for advancing said first plunger from its retracted position to its advanced position while the second plunger is maintained in its retracted position.

2. In a die casting apparatus the combination comprising a stationary cover die and a movable ejector die movable between die open and die closed positions cooperatively defining a cavity therebetween, a shot sleeve having one end extending into the cover die, said dies including a substantially nonrestricted passage extending upwardly from said end of said shot sleeve to said cavity, said shot sleeve having a molten metal charging opening externally of said cover die, a first shot plunger having a tip reciprocable within said sleeve between a retracted position in which said opening is exposed for receiving a charge of molten metal and an advanced position near the said one end of said sleeve, said first plunger including a second

smaller plunger reciprocable within a longitudinal bore in said first plunger substantially centrally thereof between a retracted position in which the tip forms the central portion of the first plunger tip and an advanced position substantially beyond said first plunger tip, means for advancing said first plunger from its retracted position to its advanced position while the second plunger is maintained in its retracted position, means for increasing the velocity of said first plunger as it closely approaches its advanced position, means for advancing and retracting said second plunger while said first plunger is in said advanced position, and means for maintaining said forward pressure on said first plunger while said dies are being opened.

3. In a die casting apparatus the combination comprising a stationary cover die and a movable ejector die movable between die open and die closed positions cooperatively defining a cavity therebetween, a shot sleeve having one end extending into said cover die, said dies including a substantially nonrestricted passage extending from said end of the shot sleeve to said cavity, said shot sleeve having a molten metal charging opening externally of said cover die, a first shot plunger having a tip reciprocable within said sleeve movable between a retracted position in which said opening is open for receiving a charge of molten metal and an advanced position near said end of said sleeve, said first plunger including a second smaller plunger reciprocable within a longitudinal bore in said first plunger substantially centrally thereof between a retracted position in which its tip forms the central portion of said first plunger tip and an advanced position substantially beyond said first plunger tip, a first hydraulic means for operating said first plunger and a second hydraulic means for operating said second plunger, control means for operating said first and second hydraulic means, for advancing said first plunger at a relatively slow velocity adapted to move a charge of molten metal in the form of substantially a solid front into said cavity while said second plunger is maintained in its retracted position, for increasing the velocity of said first plunger as it closely approaches its advanced position adapted to subject the molten metal in the cavity at a relatively high pressure, for advancing said second plunger to its advanced position and into the molten metal while said first plunger is in said advanced position in response to a predetermined pressure build-up in said first hydraulic means resulting from the solidification of a layer of molten metal at the periphery of said first plunger, for retracting said second plunger a predetermined time after the die cavity has been filled and after the metal has solidified and for maintaintaining pressure on said first plunger while said dies are being opened.

4. In a die casting apparatus the combination comprising a stationary cover die and a movable ejector die movable between die open and die closed positions cooperatively defining a cavity therebetween, a shot sleeve having one end thereof extending into said cover die, said die including a substantially nonrestricted passage extending from said one end of the shot sleeve to said cavity, said sleeve having a molten metal charging opening externally of said cover die, a first plunger having a tip reciprocable within said sleeve movable between a retracted position in which said opening is open and receiving a charge of molten metal and an advanced position near said end of the sleeve, hydraulic means for operating said first plunger, said first plunger including a second smaller plunger reciprocable within a longitudinal bore in said first plunger substantially central thereof between a retracted position in which its tip forms the portion of said first plunger tip and an advanced position substantially beyond said first plunger tip, and control means for operating the said first and second plungers, for advancing said first plunger at a relatively slow velocity adapted to move a charge of molten metal in the form of substantially solid front into said cavity while said second plunger is maintained in its retracted position and for applying pressure to the molten metal in said cavity, for advancing said second plunger to its advanced position and into the molten metal while said first plunger is in said advanced position in response to a predetermined pressure developed in said hydraulic means resulting from the solidification of a layer of molten metal at the periphery of said plunger.

References Cited

UNITED STATES PATENTS

2,265,333	12/1941	Wry	22—68
2,356,338	8/1944	Misfedt	22—68 X
3,038,220	6/1962	Saives	22—68

J. SPENCER OVERHOLSER, *Primary Examiner.*

R. S. ANNEAR, *Assistant Examiner.*