Dec. 18, 1962 R. E. WILCOXON 3,068,539

HIGH PRESSURE PERMANENT MOLDING

Filed Aug. 4, 1960 4 Sheets-Sheet 1

Fig. 1

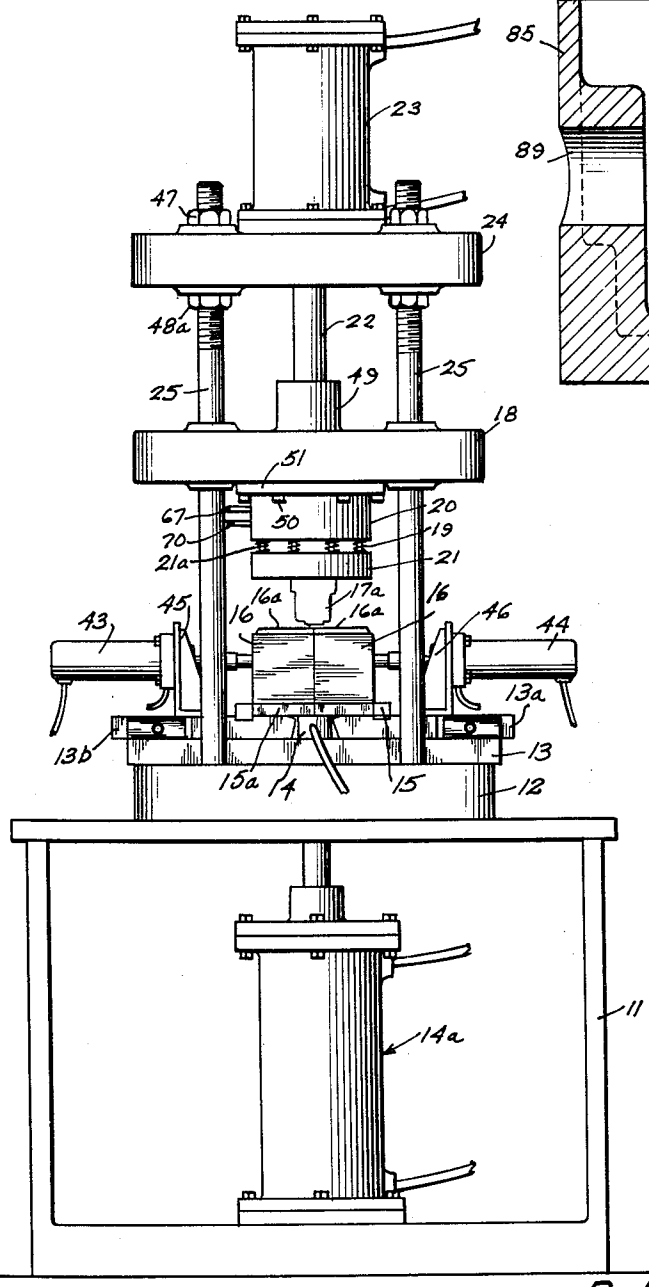


Fig. 8

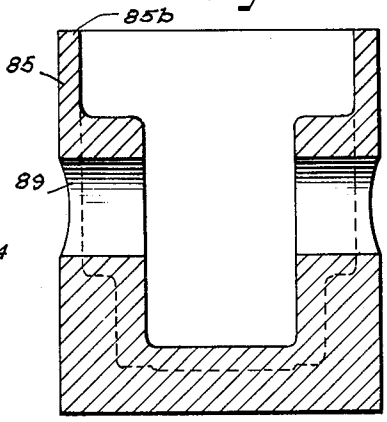


Fig. 7

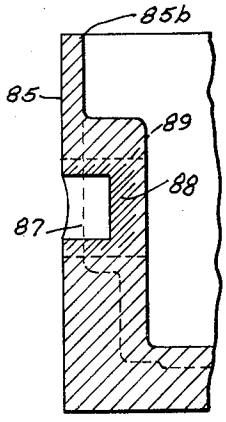
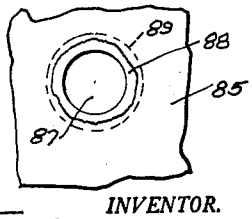


Fig. 6



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HIGH PRESSURE PERMANENT MOLDING

Filed Aug. 4, 1960 4 Sheets-Sheet 2

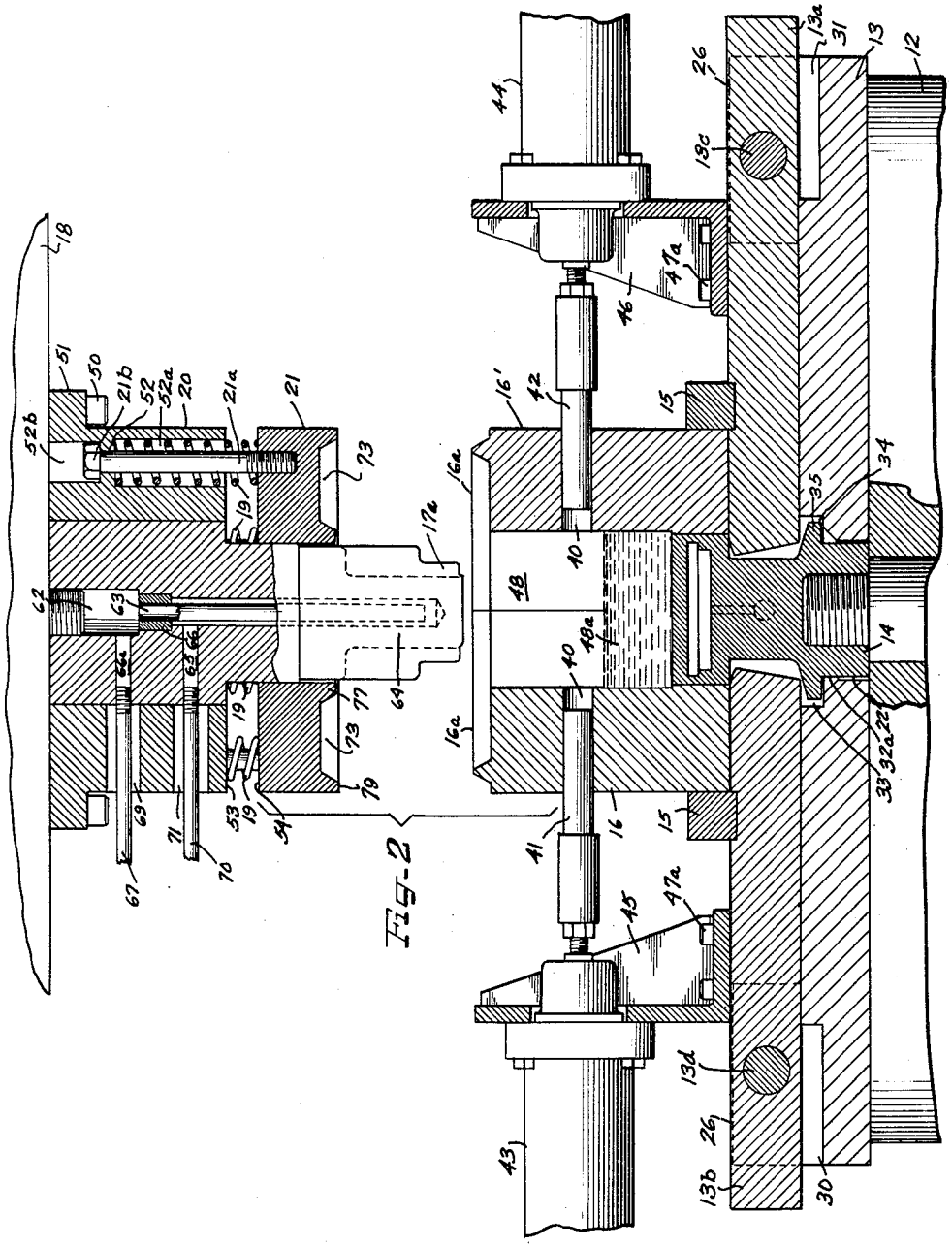


Fig-2

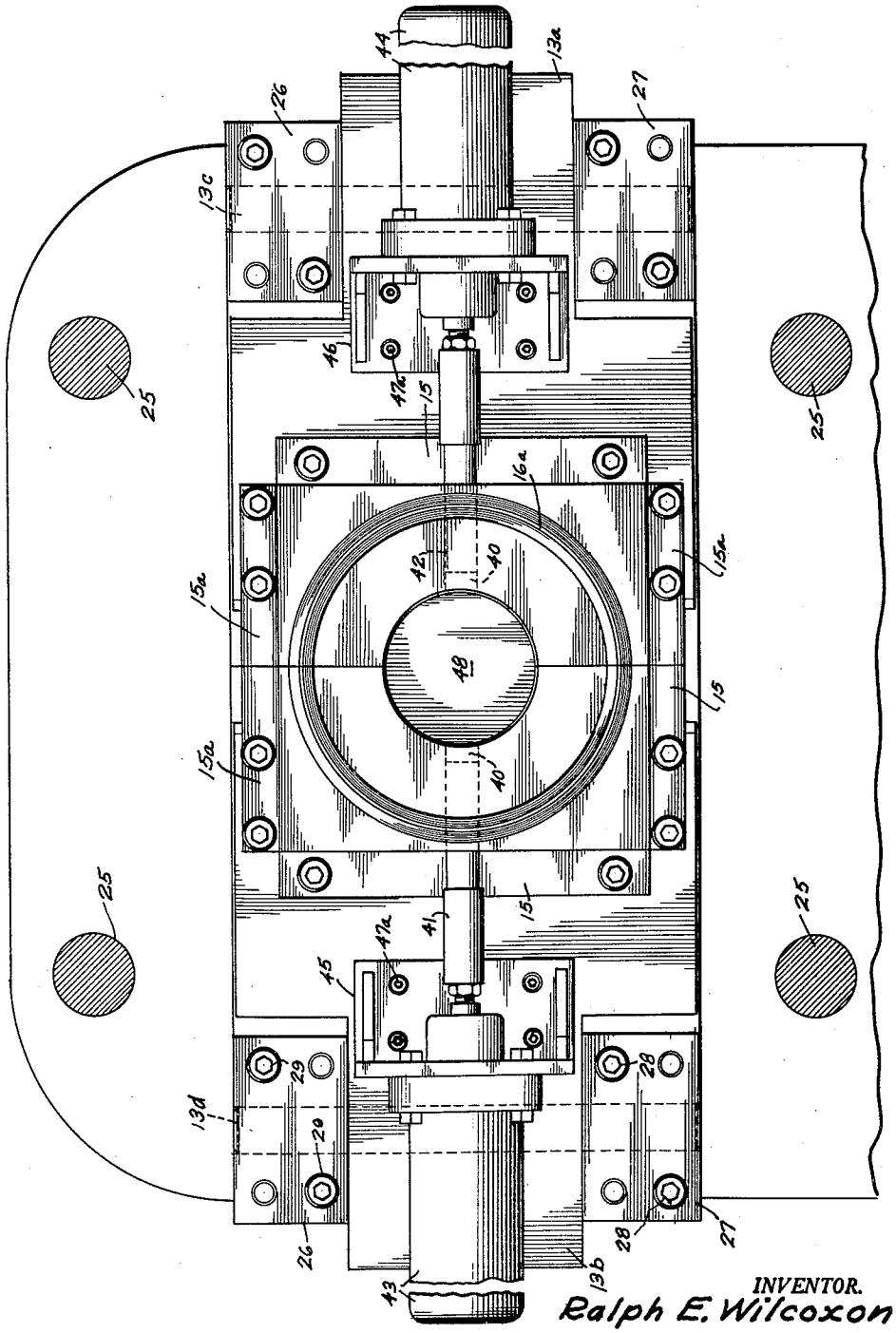
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HIGH PRESSURE PERMANENT MOLDING

Filed Aug. 4, 1960 4 Sheets-Sheet 3

Fig-3



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HIGH PRESSURE PERMANENT MOLDING

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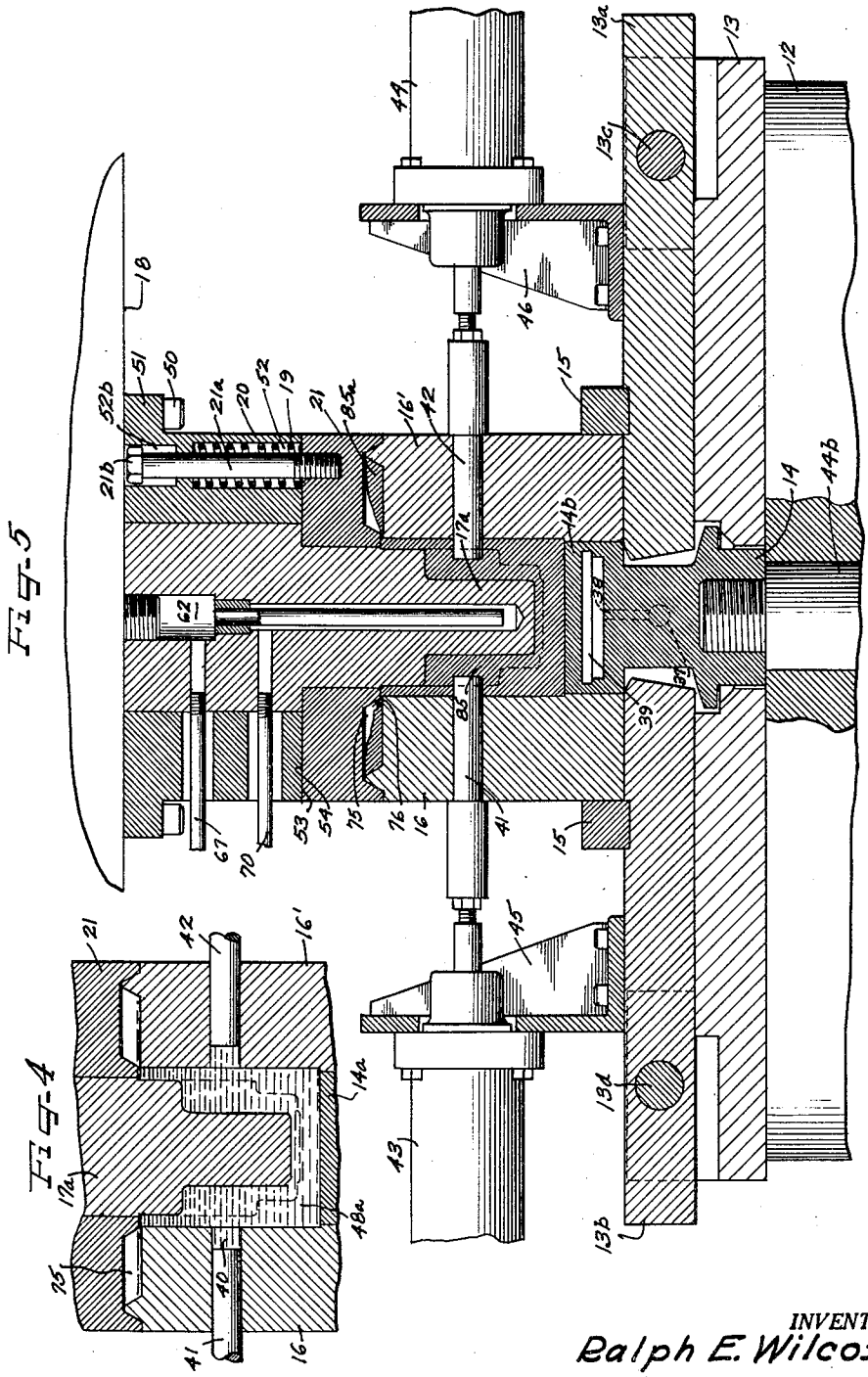


Fig-5

Fig-4

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HIGH PRESSURE PERMANENT MOLDING

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Filed Aug. 4, 1960, Ser. No. 46,605
12 Claims. (Cl. 22—93)

This invention relates to the manufacturing of pistons and more particularly to improved methods and means for high pressure molding of internal combustion engine pistons from molten metal involving filling of a die cavity therewith, followed by the insertion of a plunger in the metal to form a core, and controlling of the flow of metal under pressure, thereby producing a piston requiring no inside finish.

In accordance with this invention, lightweight metals, such as aluminum and aluminum alloys, may be heated to above their melting points and poured into a split die mold. A sealing collar is then wedge fitted on a complementarily tapered rim of the split die mold. The collar and mold rim define therebetween a chamber for receiving the molten metal overflow from the die cavity which communicates with the die cavity through a narrow, restricted passage for restricting metal flow and to hold the pressure in the die cavity.

The plunger type core has a snug sliding fit in the collar and, as the core is urged into the molten metal pool, the excess metal flows into the overflow chamber.

The molten metal is poured into the die cavity in a quantity in excess of that required for molding of the piston. The stationary base of the die assembly includes an ejector housing which forms the base of the die cavity. When the molten metal has cooled sufficiently, the movable core assembly is retracted, and a pneumatically or hydraulically operated piston assembly moves the ejector housing which pivots the split dies and pushes out the newly formed piston casting.

A feature of this invention resides in the provision of a spring-biased collar carried by the movable core platen which positively pre-seats on the rim of the split die means securing the die means before the molding pressures are applied to the collar and die assembly by the core. A further feature of the present invention resides in passaging of the split dies in communication with the die cavity in a location where the wrist pin bores are to be formed in the casting being molded and the positioning of movable members in the die passages which, in a first retracted position, define sump or reservoirs for molten metal and which may be movable to an extended position into the die cavity thereby forcing the metal from the reservoirs into the die cavity to compensate for volume loss due to cooling caused shrinkage. It has been my experience that metal injected from a reservoir to compensate for cooling caused shrinkage in the die cavity produces a weaker grain structure in the area where the metal is injected, apparently because of the difference in cooling rates and times of the metal initially solidifying in the die cavity and the metal subsequently injected. Additionally the grain crystalline growths of the metals are different which appears to cause a weaker interstitial bond between the aforementioned initial and injected metals. This phenomenon is visible to the naked eye as is hereinafter more fully explained.

By injecting the metal in the area from which the wrist pin bores are to be drilled or otherwise removed, I effectively eliminate substantially all of the weakly bonded injected metal from the formed piston. The above arrangement eliminates the heretofore required gates, riser formation, related molding components and, in addition, reduces the metal setting time within a fraction of that heretofore required in the prior art.

It is, therefore, a general object of the present invention to provide improved pistons.

Another object of the present invention is to provide a method of molding pistons under high pressure conditions.

A still further object of the present invention is to provide a method of making molded aluminum pistons.

A still further object of the present invention is to provide a method of manufacturing internal combustion engine type pistons by filling the die cavity of molding apparatus with molten metal followed by the insertion of a core into the metal in the cavity to form the interior of the piston and thereafter controlling the flow of metal under pressure.

It is yet another object of the present invention to provide high pressure molding apparatus for the manufacture of components of irregular contour.

A still further object of the present invention is to provide apparatus requiring a minimum number of parts for high pressure molding of molten metal.

Yet another object of the present invention is to provide pistons molded under high pressure conditions requiring a minimum of finishing and of fine grain and high structural strength.

A still further object of the present invention is to provide apparatus for high pressure molding of pistons which is simple and compact in construction and efficient and high speed in operation.

These and other features, objects and advantages of the present invention will become more apparent upon a careful consideration of the following detailed description, when considered in conjunction with the accompanying drawing illustrating a preferred embodiment of the present invention, wherein like reference characters and numerals refer to like or corresponding parts throughout the several views.

On the drawings:

FIGURE 1 is a front elevational view of molding apparatus according to this invention.

FIGURE 2 is a fragmentary view in cross-section of the apparatus of FIGURE 1.

FIGURE 3 is a view taken along lines III—III of FIGURE 1.

FIGURE 4 is a fragmentary view in cross-section illustrating the excess metal plungers in the retracted position.

FIGURE 5 is a fragmentary view in partial cross-section illustrating the excess metal plungers in extended position.

FIGURE 6 is a fragmentary plan view of a formed piston illustrating the injection area of the weakened bond between the initial and compensating metal.

FIGURE 7 is a fragmentary view in cross-section of the plunger injected metal, and

FIGURE 8 is a view in cross-section of a piston formed in accordance with the present invention.

As shown on the drawing:

Briefly stated, apparatus for piston manufacture illustrated in FIGURE 1 may include a base support member **11** carrying a die assembly base **12**, having secured thereto an ejector assembly base **13** which has pivotally mounted thereto a pair of ejector actuator arms **13***a* and **13***b* which are adapted to be moved by contact with an ejector housing **14** operatively responsive to a pneumatic or hydraulic piston assembly **14***a*. Removably held by a plurality of restraining members **15** is a generally rectangularly shaped split die comprising die members **16** and die member **16'**, each of which is secured to the ejector arms **13***a* and **13***b* respectively, by flanges **15***a* and each of which is provided with a raised annular flange or rim **16***a*.

A movable platen 18 seats a plurality of springs 19 in a sleeve 20. Springs 19 urge a movable collar 21 from contact with the sleeve 20 and surround a movable collar support means 21*a*. Collar 21 has a peripheral flange complementary to the rims 16*a* of the split dies for holding the dies securely together and for cooperating with the die members to define an overflow chamber for receiving molten metal from the die cavity. Movably carried by the platen 18 is a die core assembly 17*a* dimensioned to the desired internal configuration of the piston to be formed.

The platen 18 is movably carried by a shaft 22 which is actuated by a pneumatic or hydraulic piston assembly 23 of conventional construction. A stationary platen 24 may support the piston assembly 23 and may serve as a support for a plurality of guide members 25 for the movable platen 18 and the core assembly 17*a*.

Referring particularly to FIGURE 2, wherein the core assembly 17*a* is shown in the retracted position, each of the ejector follower arms 13*a* and 13*b* is provided with a pivot 13*c* and 13*d*, respectively, each of which is journaled in a pair of raised bearing members 26 and 27 secured to the ejector assembly base 13, as by bolts 28 and 29 respectively. The ejector assembly base 13 is recessed as at 30 and 31 to permit a wider pivot arc for members 13*a* and 13*b* (FIGURE 2 and 3) during operation.

Centrally located within the base 13 is a bore, indicated by the numeral 32, which is provided with a tapered shoulder 32*a* and a counterbore 33 for receiving the ejector 14 and for providing a shoulder 34 for the peripheral annular flange 35 of the ejector 14.

Similarly, each of the T shaped pivotable arms 13*a* and 13*b* is inwardly tapered from the top surface thereof, as shown in FIGURE 2 to prevent binding thereof with the ejector 14 during the ejection operation.

As more clearly appears in FIGURE 3 the split die members 16 and 16' are rectangular in shape and when assembled define a die core receiving cavity. The split die members 16 and 16' are held in position by a plurality of bracket members 15 carried by the actuator arms 13*a* and 13*b* and the die flanges 15*a* secured thereto.

The core guides 25 may, if desired, pass through the base member 12 and be secured in the base member 11.

As appears in FIGURES 2 and 5, the ejector assembly may be provided with means for cooling the split die members thereby reducing the time required to solidify the molten metal. For this purpose, the ejector 14 may be provided with an inlet conduit 37 for introducing the cooling medium into an internal passage 38 which communicates with an annular passage 39 in the upper portion of the ejector which provides the base for the split die means. The annular passage 39 in the ejector head 14*b* communicates with a similar internal outlet passage and port (not shown) for discharge of the coolant medium from the ejector.

The two die members 16 and 16' define therebetween the molten metal die well or cavity 48, and which, for purposes of the example hereof, is cylindrical in configuration.

As aforementioned, the upper core portion as appears in FIGURE 1 includes a stationary platen 24 which may carry the core piston assembly 23 and may serve as support means for the guides 25 of the core carrying movable platen 18. Guides 25 may be secured at the lower end in the support member 12 and to the stationary platen 24 at the upper ends in threaded engagement therewith as by nuts 47 and 48*a*.

As appears in FIGURE 1, the movable platen 18 has secured thereto or formed integral therewith an upper boss 49 which is adapted to secure the piston rod 22 of the core piston assembly 23 to the platen 18. Secured as by bolts 50 to the under side of the movable platen 18 is the peripherally flanged sleeve 20.

Inwardly of the flange 51, the sleeve or ring 20 is bored to receive the plurality of movable threaded members 21*a* adapted to retain and support the collar 21. Adjacent the collar 21, the ring 20 is provided with a plurality of annularly spaced bores 52 to receive the springs 19 which urge the collar from contact with the ring 20. Each of the springs 19 seats against the shoulder provided by the complementary counterbore 52*a* in the ring 20 and is bottomed against the collar 21. Each of the pin receiving bores are also counterbored, as indicated by the numeral 52*b*, adjacent the movable platen 18 to permit movement of pins 21*a* and contact between the opposed faces 53 and 54 of the ring and collar during the molding operation, as clearly appears in FIGURE 5. The heads 21*b* of the pins 21*a* prevent unlimited movement of the pins.

The core head 17*a* is prevented from rotating by a key 59, as appears in FIGURE 7, and is removably secured to the ring 20 as by bolts (not shown) inserted through slots 60 formed in the ring 20.

Centrally located in the core head 17*a* is a stepped passage defining a cooling medium inlet 62 communicating with a passage of smaller diameter 63 which is opened at the botom end to permit circulation of a cooling medium in the fluid passage 64 which comunicates with the fluid outlet passage 65. The passage conduit 63 is supported by a plug 66 which prevents the fluid flow from circulation passage 64 into inlet passage 62. Inlet passage 62 communicates with an inlet 66*a* which may be adapted to receive the fluid inlet conduit 67 which passes through a bore 69 provided in the ring 20. Similarly, outlet 65 is adapted to receive conduit 70 which passes through a similar bore 71 in the ring 20. Thus a circulation system is provided for the core assembly 17*a* which cooperates with the circulation system provided in the ejector 14 to reduce the time required to set the molten metal being formed in the die cavity 48.

The collar 21 carried by the bolts 21*a* is provided with an annular channel 73 inwardly of the periphery thereof and has complementarily tapered surfaces for engagement with the rims 16*a* of the split die members 16 and 16', thereby locking the die members. Thus, the rim 16*a* and the groove 73 of the collar 21 cooperate, as appears in FIGURES 4 and 5, to define a chamber 75 which receives the overflow of molten metal from the die cavity 48 through an annular passage 76 of restricted height defined by the internal flange 77 of the collar 21 and the opposed top surface 78 of the split die members. The peripheral flange 79 of the collar 21 and the rim 16*a* of the dies 16 and 16' cooperate to prevent extrusion of molten metal across the parting line to the exterior of the apparatus.

The core, of course, is shaped to define the inside diameter of the particular component to be molded in the apparatus above described, and, for purposes of illustration, is shown shaped to define the interior of an internal combustion engine piston.

Each of the split die members 16 and 16' has a passage 40 communicating with the interior of the die cavity adapted to receive retractable and extendable plunger members 41 and 42, respectively, generally shaped preferably to the dimension of the wrist pins. The plunger members 41 and 42 are reciprocably responsive to conventional piston assemblies 43 and 44, respectively, which are mounted on a pair of brackets 45 and 46 secured to the pivotable ejector actuator arms 13*a* and 13*b* as by bolts 47*a*.

In operation, molten metal 48*a* may be poured into the die cavity and the plunger arms 41 and 42 retracted to the position shown, thereby defining the sump or reservoir chambers 40 communicating with the die cavity.

The platen 18 is moved downwardly carrying with it the core 17*a* for insertion thereof in the molten metal in the die cavity 48. The spring-biased collar 21 seats on the rim 16*a* of the split die members and holds them securely together while cooperating therewith to define the overflow chamber communicating with the die cavity through the narrow annular passage 76 before article-

forming pressure is applied by the core 17*a* in the die cavity.

A coolant is introduced through conduit 37 of the ejector assembly 14, and a coolant is also introduced into the core 17*a* through conduit 67 for circulation and discharge through conduit 70.

In the second stage of operation, with the collar 21 urged downwardly by the springs 19 in engagement with the rim 16*a* before the plunger core 17*a* is fully positioned in the die cavity, the upper platen 18 continues in its downward movement against the forces exerted by the springs 19 until contact is made between the opposed faces 53 of the ring 20 and 54 of the collar 21, as appears in FIGURE 4. The pins 21*a* will have been moved to their uppermost position in the recesses 52*a* (FIGURE 4) when contact between the collar and ring 20 is made. Similarly, with the core 17*a* moving into the pool of molten metal 48*a*, the displaced metal will flow into the reservoirs 40 and through the narrow restricted passage 76 into the overflow chamber 75. As aforesaid, the ejector head 14*a* serves as a base or bottom for the die cavity.

The coolant circulation systems in both the core and ejector reduce the metal setting temperature within a range from about 350° F. to about 450° F., if water is the cooling medium.

After the metal has partially set, the plungers 41 and 42 are moved inwardly by activation of the piston assemblies 43 and 44 forcing the molten metal from the reservoirs 40 into the die cavity to compensate for the shrinkage of the molten metal which takes place as the metal solidifies. Movement of the plungers 41 and 42 in compensating for metal loss in the die cavity due to shrinkage does not cause displacement of the metal through the narrow, restricted passage 76 leading to the overflow chamber since the plungers are not moved until the metal in the restricted passage 76 has frozen or solidified before the plungers 41 and 42 are extended.

As an example of the material to be molded, a high silicon content aluminum alloy (MS 143) preferably formed of the following general composition was heated to a pouring temperature of approximately 1220° F.:

	Percent
Silicon	11
Manganese	0.5
Copper	2
Aluminum	Balance

Impurities, such as the following may also be included in the alloy:

	Percent
Iron	1
Zinc	0.5

A preferred specific alloy forming the pistons in accordance with the practice of this invention include the elements of the general composition set forth above as well as the impurities.

Heretofore, it was necessary to permit a chill time from 2 to 10 minutes in order to permit setting of the molten metal before the formed piston was removed from the die cavity. By my method, the time required for setting is reduced to from about 10 to about 30 seconds, depending upon the alloy involved and other physical and metallurgical properties desired, since a colder die is used and since pressure forces are employed to control flow.

For the example above given, the core 17*a* was constructed of high temperature die steel material sold by the Crucible Steel Company under the trade name "NU-DIE-V" which is a hot-work, chromium-vanadium steel. The die members 16 and 16' of the above example were constructed of a low alloy sold by the Wheelock-Lovejoy Company under the trade name "HY-TEN-B-3X" which is a ferrous alloy of nickel and chromium.

In the third stage of the operation, the plungers 41 and 42 may be extended into the die cavity to form the wrist pin bores, as appears in FIGURE 5.

Next, after an appropriate setting time, preferably within the range of from about 10 seconds to about 30 seconds, has elapsed, the piston assembly 23 is actuated to retract the core 17*a* from the die cavity. As the core is being initially withdrawn from the die cavity, the springs 19 maintain the collar 21 firmly seated on the die rim 16*a* thereby maintaining the split dies in the locked position until the bolts or pins 21*a* contact the bottom of the recesses 52*a* and carry the collar upwardly from contact with the rim 16*a* of die members 16 and 16'. Thus, the die members are securely locked together before pressure is applied in the die cavity and remain locked by the collar until pressure is removed from the die cavity.

The plunger piston assembly 43 and 44 are then actuated to retract the plungers 41 and 42 from the die mold cavity into the passages in the split die members. Circulation of the coolants in the ejector assembly and the core 17*a* is terminated and thereafter the ejector piston assembly 14*a* actuated to move the piston head 44*b* upwardly in contact with the ejector 14. The ejector head 14*b* will continue its upward movement whereby the ejector 14 is unseated and the ejector flange 35 engages the ejector actuator arms 13*a* and 13*b* and pivots the arms upwardly. The split die members 16 and 16' are therefore opened and the molded formed piston 85 is now ready for removal from the apparatus.

The molded piston 85 is easily removed from the ejector 14.

The flash 85*a* of the molded piston is quite thin near the inner periphery thereof and may be easily removed. The end surfaces 85*b* of the sleeve portion of the piston is substantially uniformly flat requiring a minimum of finishing in this area. No finishing is required on the inside of the piston, and the close tolerance permitted by the molding method described above facilitates external finishing of the piston. Thus sound pistons are obtained in less time, thereby increasing production rates, and, because of the reduced chill time required, a finer grain piston is obtained having greater structural strength than was heretofore considered obtainable without additional treatment of the piston. In addition, grain refiners, such as titanium, boron, etc., are not required as alloy additives. Moreover, in the molding operation, closer tolerances may be obtained than were heretofore possible with the permanent die type apparatus which must be coated to prevent attack on the dies in the high temperature, slow cooling methods.

If desired, conventional toggle arrangements may be employed to maintain the core in the die cavity. For this purpose, the toggle cleats may be pivotally secured to the upper stationary platen 24 and to the movable platen 18.

As appears in FIGURE 6, the effects of different cooling and solidifying rates is readily apparent visually. The bores 87 in the formed piston from which the plunger was extracted is surrounded by a discolored area, the limits of which, for purposes of illustration, are indicated by the numeral 88 and the size of which depends upon such factors as plunger pressure and the amount of metal being forced into the die cavities to compensate for cooling caused shrinkage. The dotted line 89 indicates the outer limits of the area from which the wrist pin bore will be drilled, the size of which depends upon such factors as the ultimate use of the piston.

FIGURE 8 illustrates in cross-section the piston after the final finishing and wrist pin bore milling operation. Thus, it will be appreciated that, by positioning the plungers to force the shrinkage compensating metal into the die cavity in a location where the wrist pin bores are to be drilled, I provide an improved piston having the same structural strength and grain refinement throughout.

For the aluminum piston of the above example, the flash is merely broken off, the piston then subjected to

a heat treatment for a period of from about 8 hours at about 400° F. and then air quenched. After this treatment, the piston was ready for the machining and milling operations.

It will, therefore, be appreciated that with the high pressure molding apparatus and methods of the present invention, I provide means for the elimination of gates and riser formations, reduce the time required to set the molded piston, and obtain a piston of higher quality than was heretofore obtained without the necessity of additional alloy elements or fabricating steps and treatments.

Although minor modifications might be suggested by those skilled in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon, all such embodiments as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. Apparatus for high pressure permanent molding of articles from molten metal comprising: die means defining a core-receiving die cavity; a movable die core-carrying platen; means normally biasing a separate collar movably carried by said platen from contact therewith, said biased collar being adapted to contact said die means and remain in contact therewith when said core is being inserted or retracted from said cavity for applying molding presssure on molten metal in said cavity; said contacting collar and said die means cooperating to define therebetween a molten metal overflow chamber communicating with said die cavity through a narrow, restricted passage; said platen being movable to a second position in pressure contact with said collar to insert the core in the die cavity for applying article-forming molding pressure on molten metal therein whereby excess metal flows from said cavity into said overflow chamber; at least one compensating passage communicating with said die cavity and formed in a side of said die means, means for forcing molten metal into said die cavity through said passage formed in said die means to compensate for metal volume loss due to cooling caused shrinkage; and ejector means for unseating a formed article in said cavity.

2. Apparatus for high pressure permanent molding of articles from molten metal comprising: split die means defining a core-receiving die cavity; a movable die core carrying platen; means normally biasing a separate collar movably carried by said platen from contact therewith, said biased collar being adapted to lock said die means and remain in locking contact therewith when said core is being inserted or retracted from said cavity, said collar and said die means when in contact cooperating to define therebetween a molten metal overflow chamber communicating with said die cavity through a narrow restricted passage, said platen being movable to a second position in pressure contact with said collar to insert the core in the die cavity for applying article-forming molding pressure on molten metal therein whereby excess metal flows from said cavity into said overflow chamber; at least one compensating passage communicating with said die cavity and formed in a side of said die means, means for forcing molten metal through said passage in said die means into said die cavity to thereby compensate for metal volume loss due to cooling caused shrinkage; and ejector means for parting said split die means and for unseating a formed article in said cavity.

3. Apparatus for high pressure permanent molding of articles from molten metal comprising: a stationary base member; split die means on said base member defining a core-receiving die cavity therebetween; a movable die core-carrying platen disposed to position a die core in said cavity; a separate collar movably carried by said platen normally biased from contact with said platen, said biased collar being adapted to contact with split die means when said platen is in a first position before said core is fully inserted or retracted from said die cavity for applying molding pressure therein, said collar and said split die means cooperating to define a metal overflow chamber communicating with said die cavity through a narrow, restricted passage therebetween; said platen being adapted to move to a second position against the force of the collar biasing means to thereby contact said collar and position said core in said die cavity for applying article-forming molding pressure on molten metal therein whereby excess metal flows into said overflow chamber through said restricted passage; at least one compensating passage communicating with said die cavity and formed in a side of said die means, piston actuated plunger means for forcing molten metal from said passage in said die means into said die cavity to thereby compensate for metal volume loss due to shrinkage; an ejector assembly for separating said split die means and for unseating a formed article in said die cavity, and said ejector assembly forming the base of said die cavity.

4. Apparatus for high pressure permanent molding of articles from molten metal comprising: a stationary base member; split die means carried by said base member defining a core-receiving die cavity therebetween; a movable die core-carrying platen disposed to position a die core in said cavity; a separate collar movably carried by said platen normally biased from contact with said platen, said biased collar being adapted to contact and lock said split die means defining said die cavity when said platen is moved to a first position before said core is fully inserted in or retracted from said die cavity for applying article-molding pressure on molten metal therein, said collar and said split die means cooperating to define a metal overflow chamber communicating with said die cavity through a narrow, restricted passage therebetween, said platen being adapted to move to a second position against the collar biasing means to thereby contact said collar and position said core in said die cavity for applying article-forming molding pressure on molten metal therein whereby excess metal flows into said overflow chamber through said restricted passage; a pair of compensating passages formed in the side of said die means and communicating with said die cavity, each of said passages being adapted to receive a piston actuated plunger for forcing molten metal from the passage into said die cavity to thereby compensate for metal volume loss due to shrinkage; and a die cavity base-defining ejector assembly for unseating a formed article in the die cavity.

5. Apparatus for a high pressure permanent molding of articles from molten metal comprising: split die means defining a core-receiving die cavity; a reciprocal platen carrying a die core; spring means normally biasing a separate collar movably carried by said platen from contact therewith, said collar being adapted to lock said die means and remain in locking contact therewith when said core is being inserted or retracted from said cavity for applying molding pressure on molten metal in said cavity, said contacting collar and said die means cooperating to define therebetween a molten metal overflow chamber communicating with said die cavity through a narrow, restricted passage, said platen being movable to a second position in pressure contact with said collar to position the core in the die cavity for applying article-forming molding pressure on molten metal therein whereby excess metal is displaced from said die cavity into said overflow chamber; a pair of compensating passages formed in the sides of said split die means and in communication with said die cavity for receiving metal displaced when said core is inserted in the die cavity, and means for forcing displaced metal from said passages into said die cavity to compensate for cooling caused shrinkage; ejector means for opening said split die means and for unseating a formed article in said cavity including a housing defining die cavity base and a pair of pivotable members supporting said housing operatively responsive to movement of said housing to separate said split die means; and means for moving said ejector

assembly to pivot said ejector assembly arms and to separate said split die means when said core is retracted from said cavity; means for cooling said cavity.

6. Apparatus for high pressure permanent molding of piston assemblies from molten metal comprising: die means defining a core-receiving die cavity; reciprocable die core carrying means; a separate collar movably carried by said core carrying means normally biased from contact therewith, said biased collar being adapted to contact said die means and remain in contact therewith when said core is being inserted or retracted from said cavity and to cooperate with said die means to define therebetween a molten metal overflow chamber communicating with said die cavity through a narrow, restricted passage; said core carrying means being reciprocably movable to a second position in pressure contact with said collar to insert the core in the die cavity for applying piston-forming pressure to molten metal therein whereby excess metal flows from said cavity into said overflow chamber; at least one compensating passage communicating with said die cavity and formed in a side of said die means at the wrist pin axis of said piston assembly, and means for forcing molten metal, displaced from said die cavity by said core into said compensation from said compensating passage into said cavity to compensate for metal volume loss due to cooling-caused shrinkage; and ejector means for unseating a formed piston in said cavity.

7. Apparatus for high pressure permanent molding of articles from molten metal comprising: split die means defining a die cavity and having a pair of compensating passages formed in the sides thereof for receiving metal displaced from said die cavity by a core inserted in the die cavity for applying article-forming pressure to molten metal therein, and means including a movable member in each passage adapted to force said displaced molten metal from said passage into said die cavity to compensate for metal volume loss due to cooling-caused shrinkage in the die cavity.

8. Apparatus for high pressure permanent molding of articles from molten metal comprising: a die cavity defined by a pair of split die members, said die cavity being adapted to receive a core, a compensating passage formed in the side of each of said split die members for receiving metal displaced from said die cavity by said core when inserted into said cavity for applying article-forming pressure on molten metal therein, and means including a movable member in each of said passages for forcing said displaced molten metal from the passage into the die cavity to compensate for metal volume loss due to cooling-caused shrinkage.

9. Apparatus adapted for high pressure permanent molding of articles comprising: die means defining a pressurizable die cavity for receiving a core adapted to apply article-forming pressure on molten metal in said die cavity, at least one passage formed in a side wall of the die means and directly communicating with the die cavity for receiving molten metal from said die cavity displaced by said core, and a movable member disposed in said passage for forcing said displaced molten metal into the die cavity to compensate for metal volume lost due to cooling-caused shrinkage in the die cavity.

10. Apparatus adapted for high pressure permanent molding comprising: split die means defining a pressurizable die cavity, at lesat one passage formed in a side wall of the die means and in direct communication with the die cavity for receiving molten metal displaced by a core inserted in the cavity for applying article-forming pressure on molten metal therein, and a movable member disposed in the passage for forcing said displaced molten metal from the passage into the die cavity to compensate for metal volume loss due to cooling-caused shrinkage.

11. Apparatus for high pressure permanent molding of articles comprising: split die means defining a pressurizable die cavity, a plurality of passages formed in a side of each split die means and in direct communication with the die cavity for receiving molten metal displaced by a core inserted in the pressurizable die cavity for applying article-forming pressure to molten metal in the die cavity, and a movable member disposed in each passage for forcing displaced molten metal from the passage into the die cavity to compensate for metal volume loss due to cooling-caused shrinkage.

12. Apparatus for high pressure molding comprising: split die means defining a pressurizable die cavity, a pair of diametrically opposed passages formed in a side of the die means and in direct communication with the die cavity for receiving molten metal displaced from the die cavity by a core inserted therein for applying article-forming pressure to molten metal in the cavity, and a movable member disposed in each passage for forcing said displaced molten metal into the die cavity to thereby compensate for metal volume loss due to cooling-caused shrinkage.

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