Oct. 5, 1965 SHIGEICHI DEGUCHI ETAL 3,209,419

METHOD AND APPARATUS FOR DIE CASTING

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Fig. 1

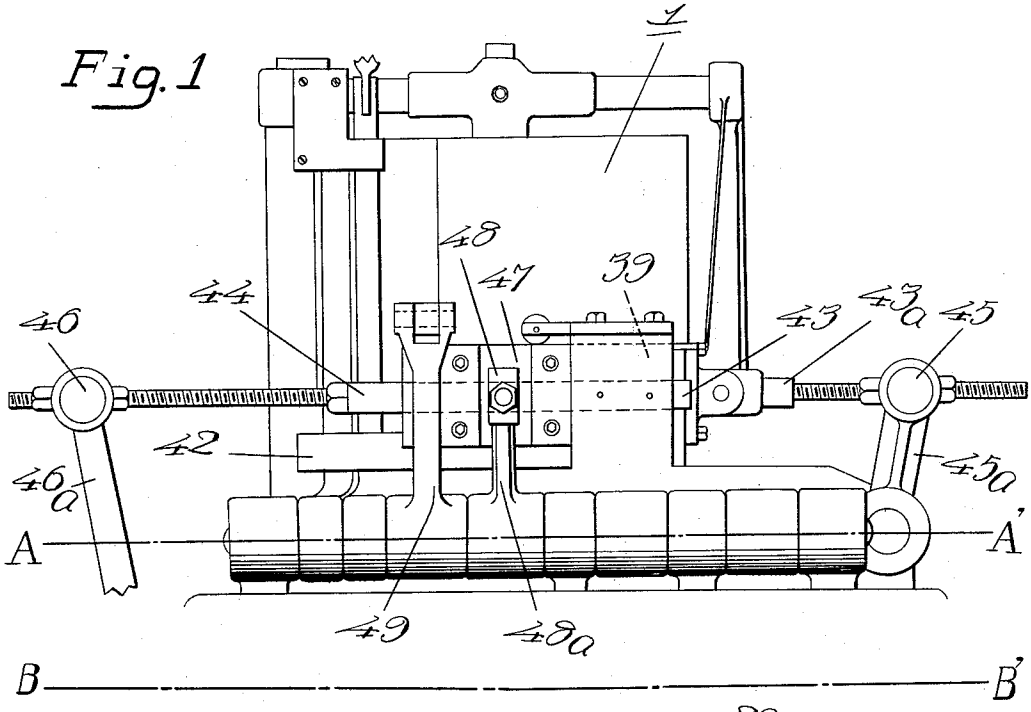
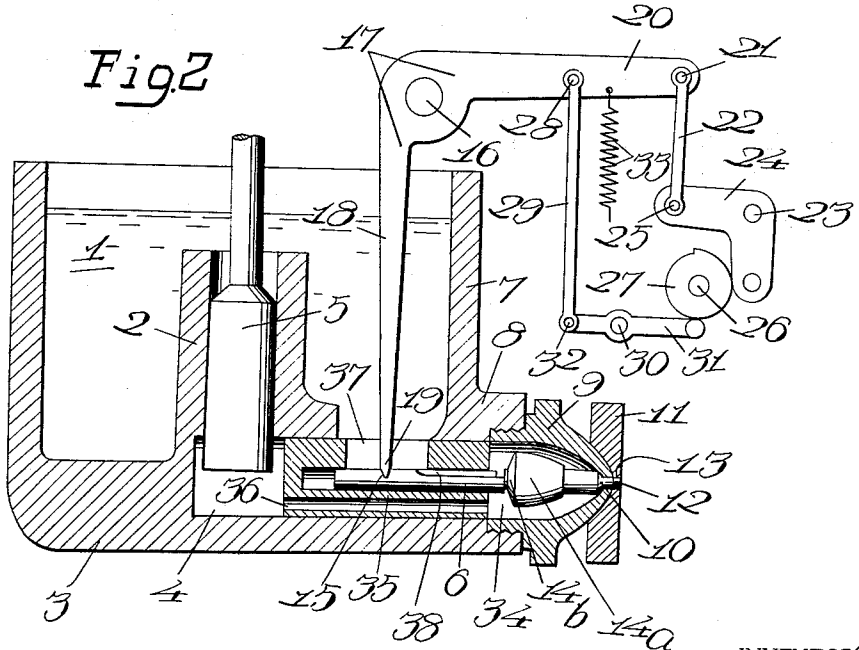


Fig. 2



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Fig. 3

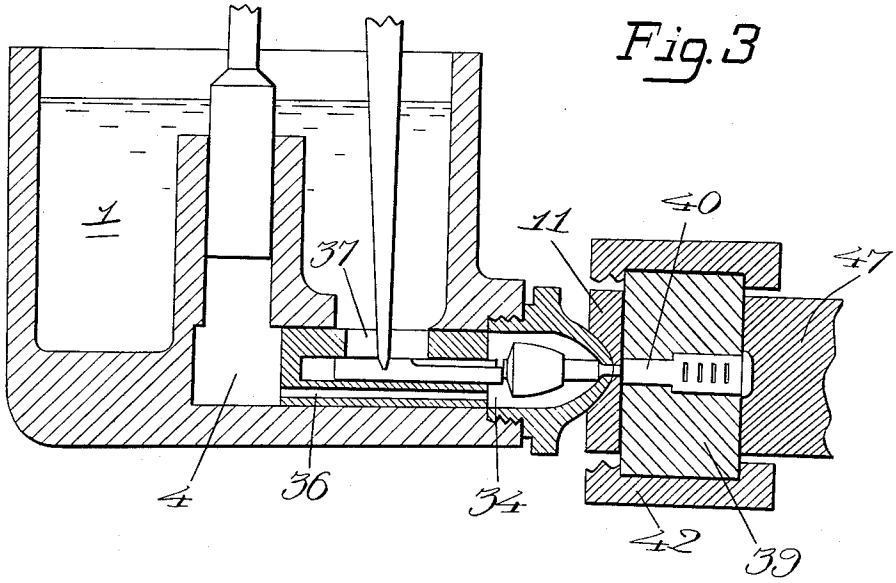
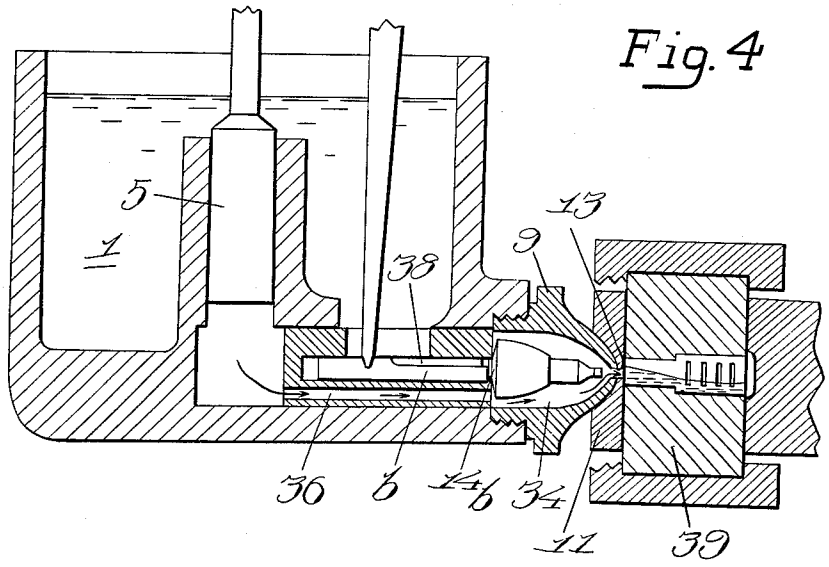


Fig. 4



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METHOD AND APPARATUS FOR DIE CASTING

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Fig. 5

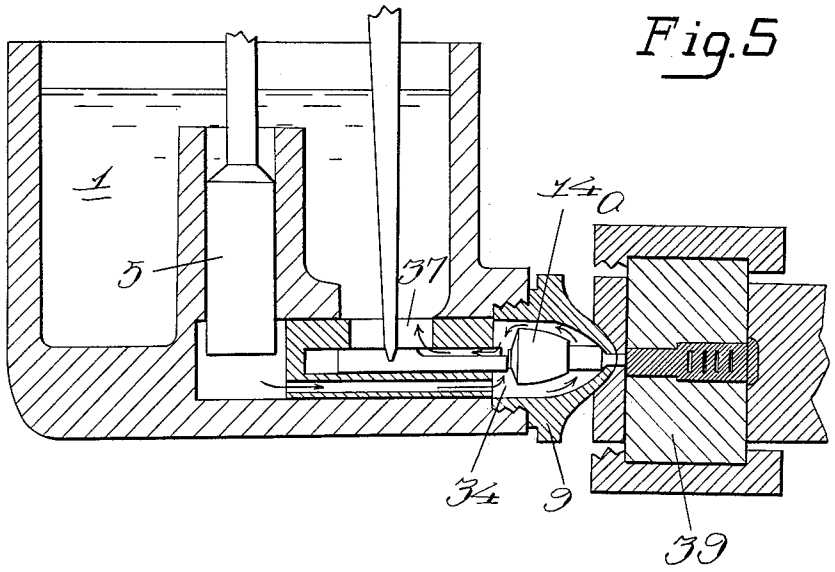
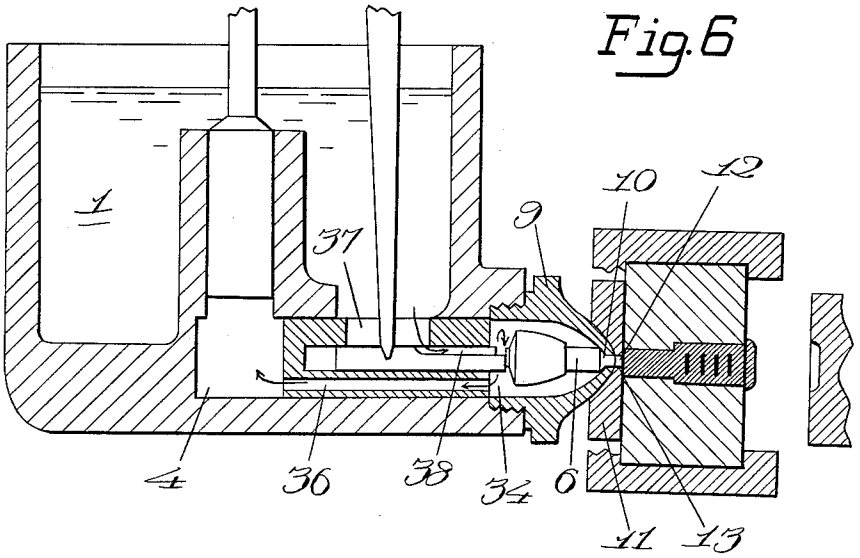


Fig. 6



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METHOD AND APPARATUS FOR DIE CASTING

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Fig. 7

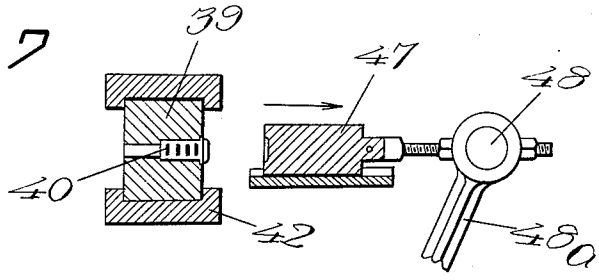


Fig. 8

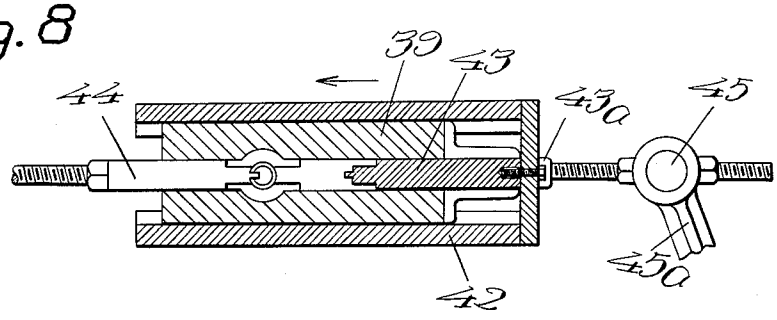


Fig. 9

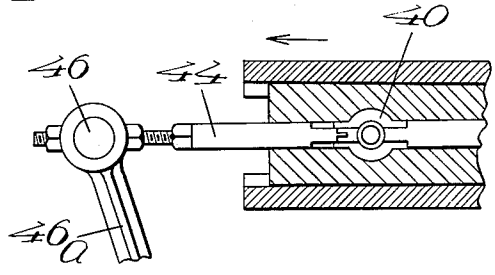
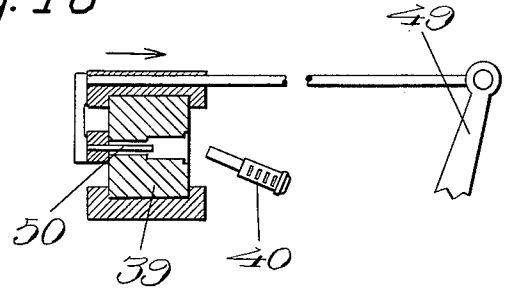


Fig. 10



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METHOD AND APPARATUS FOR DIE CASTING

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6 Claims. (Cl. 22—70)

The present invention relates to die casting.

The present application is a continuation-in-part application of copending application Serial No. 198,663, filed May 29, 1962, for "Casting Equipment," now abandoned.

The object of this invention is to provide a method and apparatus for die casting, automatically and successively, various kinds of articles characterized by the absence of sprues, runners, and gates, and not requiring a special apparatus for cutting off, after casting, excess metal, such as sprues, runners, and gates, of articles die cast by conventional arrangements.

Among the advantages of this invention is that there is no need of remelting of cut-off sprues, runners and gates as such parts are not required by the method of the present invention. Thereby the quality of articles is assured in that the articles can be cast with virgin metal only. Thus, there is no deleterious effect on the article, such as is present in many articles die-cast by conventional methods due to the intermingling of virgin and reused raw materials. As a result, the material cost is lessened and the quality of cast metal is improved.

A further reduction in the cost of casting, by the present method of the invention, is due to the lack of those excess metal portions or projections which usually must be removed from a cast article, as the invention method does not require any sprue, runner, or gate to be cut off after casting. Thus, there is no cost involved for remelting of discarded material, and neither space nor operating expense is necessary to transfer and remelt any discarded material.

In view of the above-mentioned object and other objects that may be describes hereinafter, the arrangement of each part of an apparatus, as an embodiment of the casting method of the invention, is described in the following specification and in the appended claims.

In the accompanying drawings illustrating an embodiment of the apparatus of the present invention in connection with the method thereof:

FIG. 1 is a front elevational view of apparatus embodying the invention;

FIGS. 2 to 6 are semi-diagrammatic partial longitudinal sectional views of the apparatus, showing operational conditions thereof; and

FIGS. 7 to 10 are sectional views of some important parts of the apparatus which are chiefly related to the process of ejecting the casting from the die assembly.

Referring to the drawings, and particularly to FIGS. 1 to 6 thereof, a casting apparatus for practicing the method of the present invention includes a molten metal reservoir or pot **1** which may be heated by suitable means such as an oil burner, a gas burner, or an electric heater, the heat being used both to melt the metal and to maintain the metal molten. A cylindrical body **2** projects upwardly from the bottom wall **3** of the pot **1** and, at its lower end, communicates with a molten metal passage **4** formed on the bottom wall **3** of the pot **1**. The cylindrical body **2** communicates with the molten metal passage **4** near the inner end of the latter, and a nozzle **9** is threaded into a cylindrical projection **8** extending laterally from the side wall **7** of the pot **1** and substantially axially aligned with the molten metal passage **4**. A push rod **6** is disposed within the nozzle **9** in a manner described more in detail hereinafter.

The cylindrical body **2** is always submerged within the molten metal in the pot **1**, and a piston **5** is movably set in the cylindrical body **2**. Suitable mechanism is provided to reciprocate the piston **5** vertically and cyclically, and reciprocation of the piston **5** either draws molten metal from the pot **1** into the molten metal passage **4** or forces molten metal from the molten metal passage **4** through the nozzle **9** in a manner to be described. The push rod **6** is formed with a conically expanded portion **14***a* near its end, this expanded portion having an inner tapered surface **14***b* and an outer conical portion **10** with a cylindrical extension **12**. Conical portion **10** is engageable in a discharge aperture of the nozzle **9** and its cylindrical extension **12** is engageable with an aperture **13** in a mouth plate **11**.

A V-shaped groove **15** is formed on a portion of the push rod **6**, and one arm **18** of a double arm lever **17**, pivoted on a pin **6** as its center, has its end **19** engaged with the V-shaped groove **15**. The other arm **20** is pivotally connected to one end of a link **22** by means of a pin **21**. The other end of link **22** is pivotally connected to one end of a cam lever **24**, pivotally mounted on a pin **23** as its center, by means of a pin **25**. The other end of the cam lever **24** is in contact with a cam **27** rotating with a pin **26** as its center.

One end of a link **29** is pivotally connected to about the middle of the arm **20** of said double arm lever **17** by means of a pin **28**, and the other end of link **29** is pivotally connected to one end of a lever **31**, pivoted about a pin **30** as its center, by means of a pin **32**. The other end of the aforementioned lever **31** is in contact with the aforementioned cam **27**, and, further, a spring **33**, one end of which is connected to arm **20** of double arm lever **17**, is positioned between said links **29**, **22**.

A bushing **35** is fitted into the molten metal passage **4** and has a central passage slidably receiving the push rod **6**, this central passage being closed at its inner end. The other end of the bushing **35** communicates with the interior **34** of the nozzle **9**. Angularly spaced along the lower part or semi-circular portion of the cross sectional area of the bushing **35**, there are bores **36** each having a circular cross section and each extending completely through the bushing **35** parallel with the axis thereof. The end **19** of the arm **18** which engages the V-shaped groove **15** of the push rod **6** extends through an opening **37** in a wall of the bushing **35**. The push rod **6** is provided with a longitudinally extending groove **38**.

The operation of parts thus described may be summarized as follows. When the piston **5** moves upwardly inside the cylindrical body **2**, as shown in FIG. 6, molten metal is drawn from the pot **1** and to the molten metal passage **4** through the opening **37**, the longitudinally extending groove **38**, the interior **34** of the nozzle **9** and the bores **36** of the bushing **35**. During this operation, the push rod **6** pushed outwards by one end **19** of double ended lever **17**, by virtue of its conical portion **10**, closes the discharge aperture of the nozzle **9** and, by virtue of its cylindrical extension **12**, closes the aperture **13** in the mouth plate **11**. When the molten metal has been drawn to the molten metal passage to the full, as shown in FIG. 3, the piston **5** is motivated to move downwardly, and the push rod **6** is retracted by the arm **18** to open the discharge aperture in the nozzle **9** and the aperture **13** in the mouth plate **11** as shown in FIG. 4. At the same time, the inner conical surface **14***b* of the conically expanded portion **14***a* of the push rod **6** closes the central passage **38** of the bushing **35** at its outer surface. Molten metal is forced by the piston **5** through the bores **36** into the interior **34** of the nozzle **9** and out through the aperture of the nozzle **9** and the aperture **13** in the mouth plate **11**.

The molten metal thus forced out through the aperture **13** in the mouth plate **11** enters into the cavity of die block **39** of die assembly, directly and without any other intervening passages such as sprues, runners, and gates as in conventional casting apparatus, to form a cast article **40**. At this very moment, the piston **5** does not yet reach the lowest position of its stroke and still continues to force the molten metal into the cavity of the die assembly. Then, the push rod **6** is moved toward the discharge aperture by suitably arranged action of the arm **18**, and the conical portion **10** and its extension **12** thrust into the aperture of the nozzle **9** and the aperture **13** in the mouth plate **11** to close the passage thereof completely, as shown in FIG. 5. The casting is quickly cooled by water so as to rapidly extract heat from the casting. In this case, in ordinary practice, it may be feared that an accurate cast article should not be obtainable, since a half solidified body of metal would be formed inside the aperture of the nozzle **9** and inside the aperture **13** in the mouth plate **11**, while cooling is effected as stated, and that this half solidified body of metal should be removed for the subsequent casting. However, by the invention method, as shown in FIG. 5 such a half-solidified body of metal will never be formed, since the conical portion **10** and its cylindrical extension **12** of the push rod **6** remove the molten metal in the apertures, either compressively into the cavity of the die assembly or backwardly into the interior **34** of the nozzle **9**, by having the push rod moved, at the appropriate time of the cyclical operation, toward the nozzle **9** until the cylindrical extension **12** of the conical portion **10** of the push rod **6** reaches the extreme outer edge of the aperture **13** in the mouth plate **11**, forming no half-solidified body of metal there and resulting in no sprue, runner, nor gate casting.

Referring to FIGS. 7 through 10, die block **39** is longitudinally slidable in guide **42**, as shown more particularly in FIG. 8. One longitudinal surface of die block **39** bears against mouth plate **11**, and the opposite longitudinal surface thereof is in contact with a core or mold part **47**, as best seen in FIGS. 3 and 5. Core part **47** is displaceable away from die block **39** by operating of a lever **48***a* which has an end connected through a coupling or pivotal connection **48** to a threaded extension of mold part **47**.

Rods **43** and **44** are mounted within die block **39**, and constitute core parts of the mold. Rod **43** is disengageably secured to guide **42**. Movable rod **44** is connected, through a pivotal coupling **46** engaging a threaded extension thereof, to a lever **46***a*. A threaded rod **43***a* is secured to die block **39** and is connected, through the pivotal connection **45** to the upper end of a lever **45***a*. The respective pivotal connections **45**, **46** and **48** are adjustable longitudinally of the threaded extensions engaged thereby.

The operation of all of the various parts of the apparatus is effected by the various levers pivoted about the axis A–A′ of FIG. 1. These levers are operated by cams rotating about their axis B–B′, driven by a motor or other driving means (not shown), and illustrated in FIG. 1.

In the operation of the invention method, after the molten metal has been injected into the cavity of the die assembly through the molten metal passage **4**, the bores **36**, the aperture of the nozzle **9** and the aperture **13** in the mouth plate, by downward movement of the piston **5**, the core part **47** is retracted by a lever **48***a* pivoted by a pivot **48** about the axis A–A′. This releases the die block **39** for longitudinal movement along the guide **42**.

The die block **39** is then moved by the lever **45***a* and the movable rod **43***a* in the direction indicated by the arrow in FIG. 8, and so the core part **43**, which is secured to the guide **42**, is retracted from the casting **40**. As shown in FIG. 9, by movement of the lever **46***a*, the movable rod acting also as core part **44** is moved in the direction of the arrow and thus is also retracted from the casting **40**.

Referring to FIG. 10, an ejector pin **50** is moved into the die block **39** to eject the casting **40**. The ejector pin **50** moves into the die block **39** from the rear and is operated by a lever **49** through the illustrated linkage. After retraction of pin **50**, the parts return to their initial positions for repetition of the cyclical operation.

Heretofore, the casting equipment by conventional methods having sprues, runners or gates has been very complicated in construction and accurate casting has not been possible, and the quantity production of small cast goods is not easily possible as the operation thereof is quite difficult.

By contrast, with the arrangement of the present invention, molten metal from the pot **1** is injected successively and automatically from the nozzle **9**, by the action of the piston **5**, into a metallic die assembly positioned in operative relation with the nozzle **9**. The die assembly is slidably supported on a seat so that, after having molten metal injected into the cavity thereof, the die block **39** is shifted to a predetermined position along the outer surface of the mouth plate **11**, without producing any sprues, runners, or gates. Simultaneously, the core parts of the die assembly are retracted, and the cast article may be ejected by the ejector pin **50**. Thus, very complicated cast articles can be produced automatically in a highly efficient manner and by a cyclical operation.

With the invention arrangement, as the die block **39** is in flush slidable relation with the mouth plate **11**, and thus easily displaceable relative to the nozzle **9**, the construction of the equipment is greatly simplified and movement of the die block from the charging position to the ejection position can be effected smoothly by means of the several levers. In this connection the rods, such as **43** and **44**, are part of the core assembly. Thus, the invention apparatus has the advantage of providing cast goods without damage to the die assembly.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. Die casting apparatus comprising, in combination, a molten metal reservoir; a nozzle communicating with said reservoir and having a discharge aperture; a mouth plate having one surface in heat conductive contact with said nozzle discharge aperture and having an opening therethrough in alignment with said aperture; a metal mold in heat conductive juxtaposed contact with the other surface of said plate and formed with a mold cavity having an injection opening alignable with said plate opening; a reciprocable ejection pin movable through said injection opening and cavity to eject a casting from said metal mold; a guide mounting said metal mold for movement along and in such juxtaposed contact with said other plate surface between an injection position, in which said injection opening is aligned with said plate aperture, and an ejection position in which said injection opening is aligned with said ejection pin; means operable when said metal mold is in the injection position to move molten metal from said reservoir into said nozzle and to eject the molten metal from said nozzle through said discharge aperture and said plate aperture into said mold cavity; a push rod reciprocable axially in said nozzle and in said discharge aperture and said plate opening, said push rod having an operative position in which an outer conical portion thereof enters and blocks said discharge aperture and a cylindrical extension thereof extends through said plate opening to a position wherein its outer surface is substantially flush with the plane of juxtaposition of said plate and said mold, and a retracted position in which said outer conical portion and cylindrical extension of said push rod are withdrawn from said discharge aper-

ture and said plate opening; means operable to move said push rod to its retracted position during injection of molten metal into the mold cavity; means operable, responsive to completion of the injection of molten metal into said mold cavity, to move said push rod to its operative position to exclude molten metal completely from said discharge aperture and said plate opening; means operable, when said metal in said mold cavity is cooled and partly solidified, to move said mold along and in the juxtaposed contact with said other plate surface to the ejection position; and means operable, when said mold is in the ejection position to reciprocate said ejection pin through said injection opening and cavity to eject the solidified casting from said metal mold.

2. Die casting apparatus, as claimed in claim 1, including core elements associated with said mold cavity and movable relatively therewith; and means operable, after injection of said molten metal into said mold cavity and before movement of said metal mold to said ejection position, to retract said core elements from said mold cavity.

3. Die casting apparatus, as claimed in claim 1, in which said reservoir is formed with a molten metal passage having an outer end communicating with said nozzle; a bushing mounted within said passage; said bushing reciprocably mounting said push rod; and means extending through an aperture in the wall of said bushing and engageable with said push rod to operate the same cyclically.

4. Die casting apparatus, as claimed in claim 1, in which said means for moving metal from said reservoir into said nozzle and for ejecting metal from said nozzle comprises a cylinder communicating with the molten metal in said reservoir, a piston in said cylinder, and means for reciprocating said piston.

5. Die casting apparatus, as claimed in claim 4, in which said reservoir is provided with a first molten metal passage having an outer end communicating with said nozzle; a second molten metal passage connecting said nozzle to said cylinder; said piston, when moved in a retracting direction in said cylinder, drawing metal from said receptacle through said molten metal passages and said nozzle into said cylinder and, when moved in the opposite direction, forcing molten metal from said cylinder through said second passage and into said nozzle for

injection into the mold cavity; said push rod, in its retracted position, blocking said outer end of said first molten metal passage.

6. A method of die casting without the formation of sprue, runners, or gates, said method comprising the steps of: providing a die with a cavity having neither sprue, runner nor gate portions, with the cavity corresponding solely to the finished external shape of the casting, the cavity including an injection opening through a wall of the die; positioning the die with such wall juxtaposed flush to the surface of a mouth plate having an aperture therethrough, with the die being slidable longitudinally relative to the mouth plate; moving the die, in flush relation with the mouth plate, to a position in which the injection opening is aligned with the aperture in the mouth plate; injecting molten metal through the aperture in the mouth plate into the die cavity under pressure to completely fill the die cavity and force air from the cavity; as the die cavity fills with molten metal, moving a plunger into the aperture of the mouth plate to a position in which the end of the plunger is flush with the surface of the mouth plate engaged by the die wall, to intercept the flow of metal into the cavity and force excess metal backwardly around the plunger; moving the die, with the metal in the cavity partly solidified due to heat extraction by water, to a position in which the injection opening is displaced from the aperture in the mouth plate, while maintaining such die wall flush with the surface of the mouth plate, to detach and remove the partially solidified metal from the plunger at the end surface of the latter flush with the surface of the mouth plate; and thereafter ejecting the solidified casting from the cavity by inserting an ejection member through the injection opening to force the solidified casting out of the die cavity.

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