United States Patent

Fisher

[15] **3,701,377**

[45] **Oct. 31, 1972**

[54] **METHOD AND APPARATUS FOR DIE CASTING BY PRESSURE INJECTION**

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[22] Filed: **Sept. 29, 1970**

[21] Appl. No.: **76,483**

[30] **Foreign Application Priority Data**

Oct. 10, 1969 Great Britain.....50,011/69

[52] **U.S. Cl.** **164/113,** 164/119, 164/137, 164/303, 164/309, 164/339

[51] **Int. Cl.**.....**B22d 27/14,** B22d 33/04

[58] **Field of Search**.....164/113, 119, 137, 303, 306, 164/309, 339, 341

[56] **References Cited**

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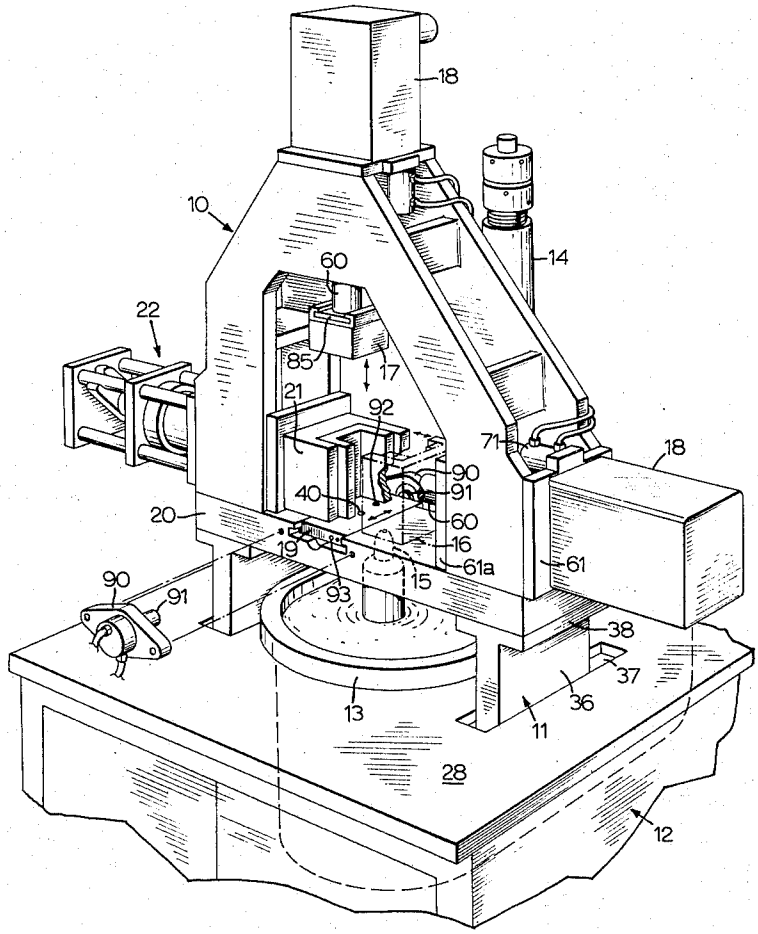
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Primary Examiner—R. Spencer Annear
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[57] **ABSTRACT**

A method and apparatus for pressure die casting in which the frame carrying the gated die is counterbalanced over the injection nozzle for movement between a lowered seated position and a raised unseated position, and floated initially to seat the gate on the nozzle. Certain of the interfitting die parts are moved and releasably locked by applying, by pivotal leverage through the die frame, a force acting in the direction of closing movement of the die, preferably by wedge means acting parallel to that direction. The sprue in the die is sheared by moving the gated die part laterally, and a subsequent lateral movement of the gated die part may introduce pressurized fluid into the die cavity to blow the sprue from the gate.

22 Claims, 10 Drawing Figures



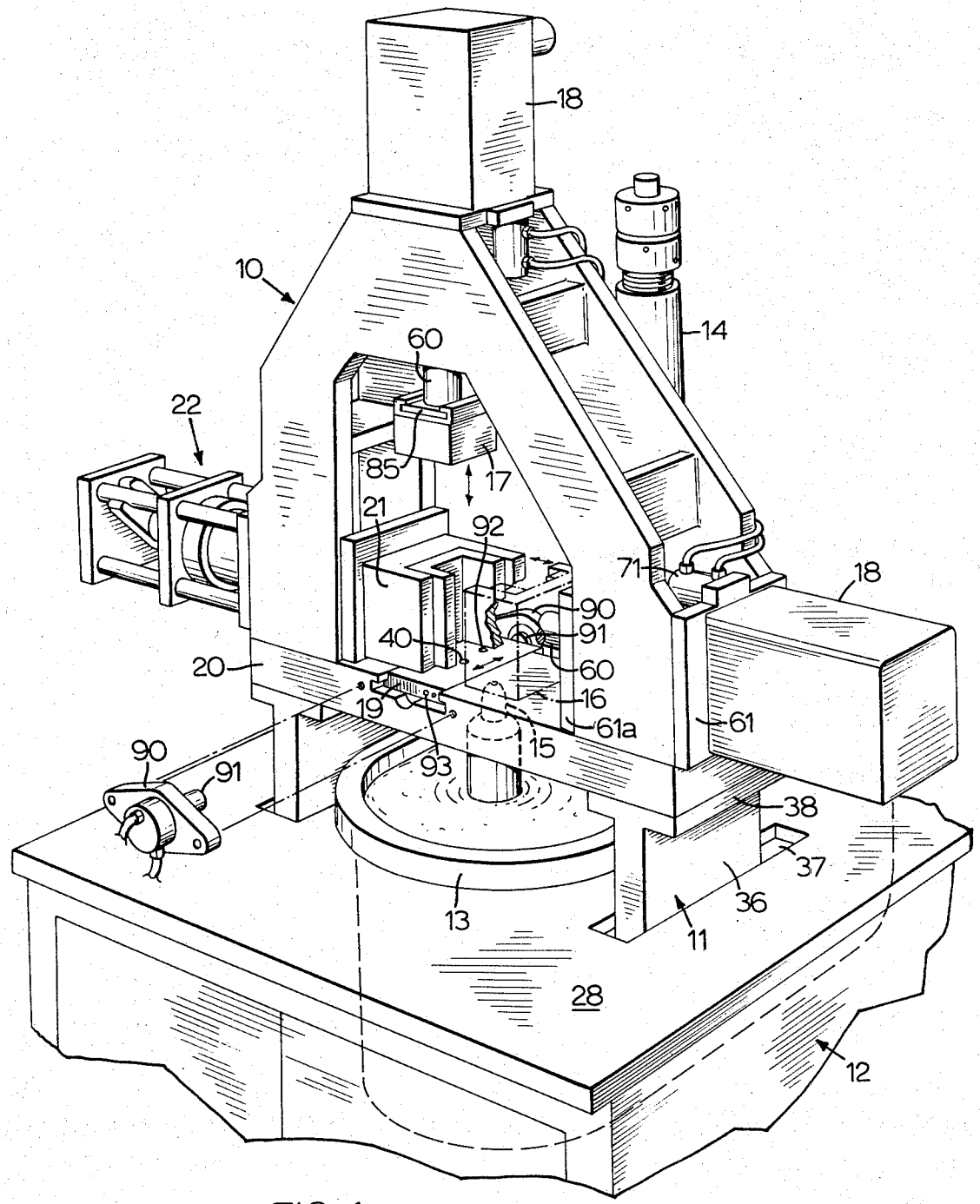


FIG. 1

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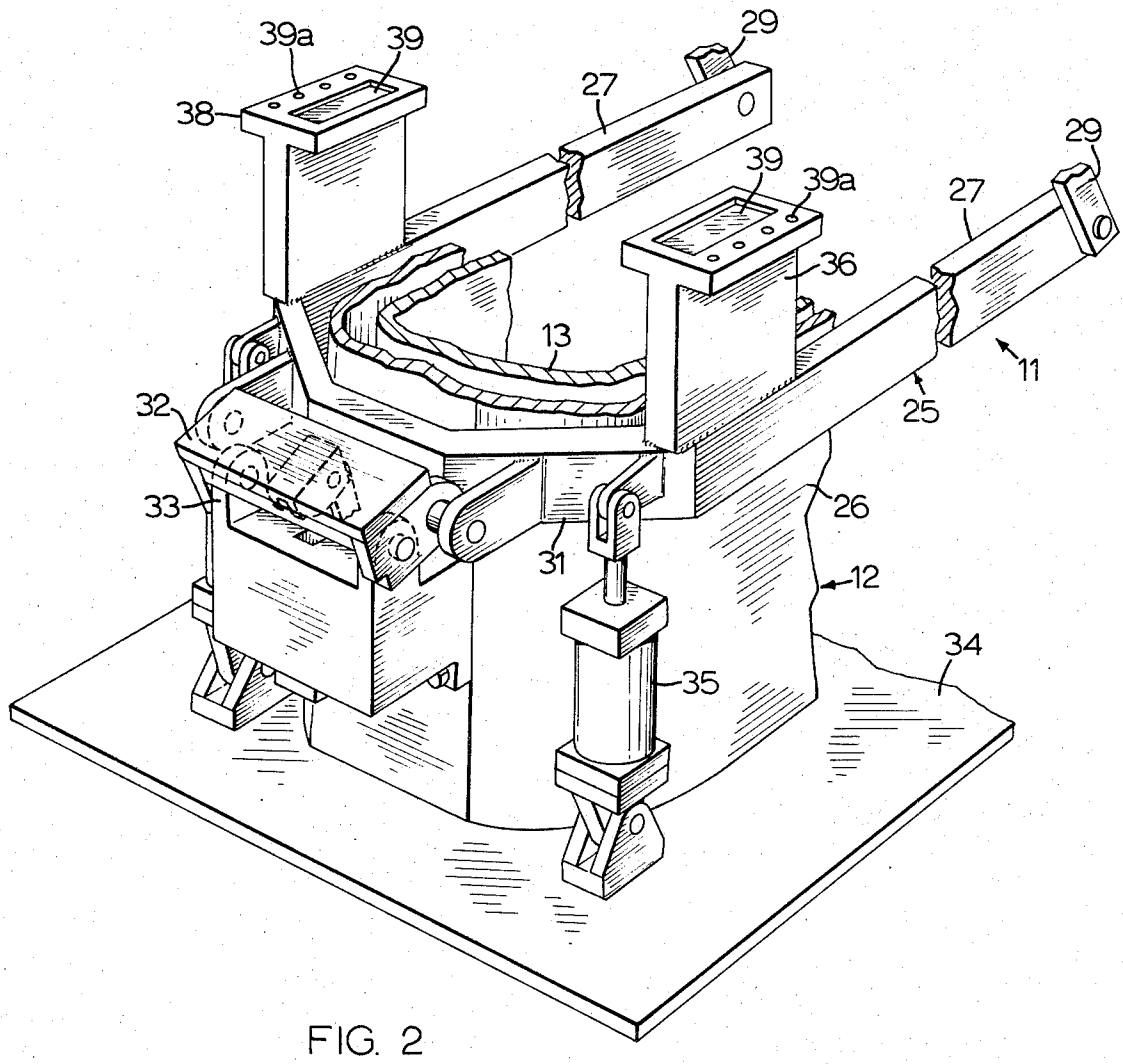


FIG. 2

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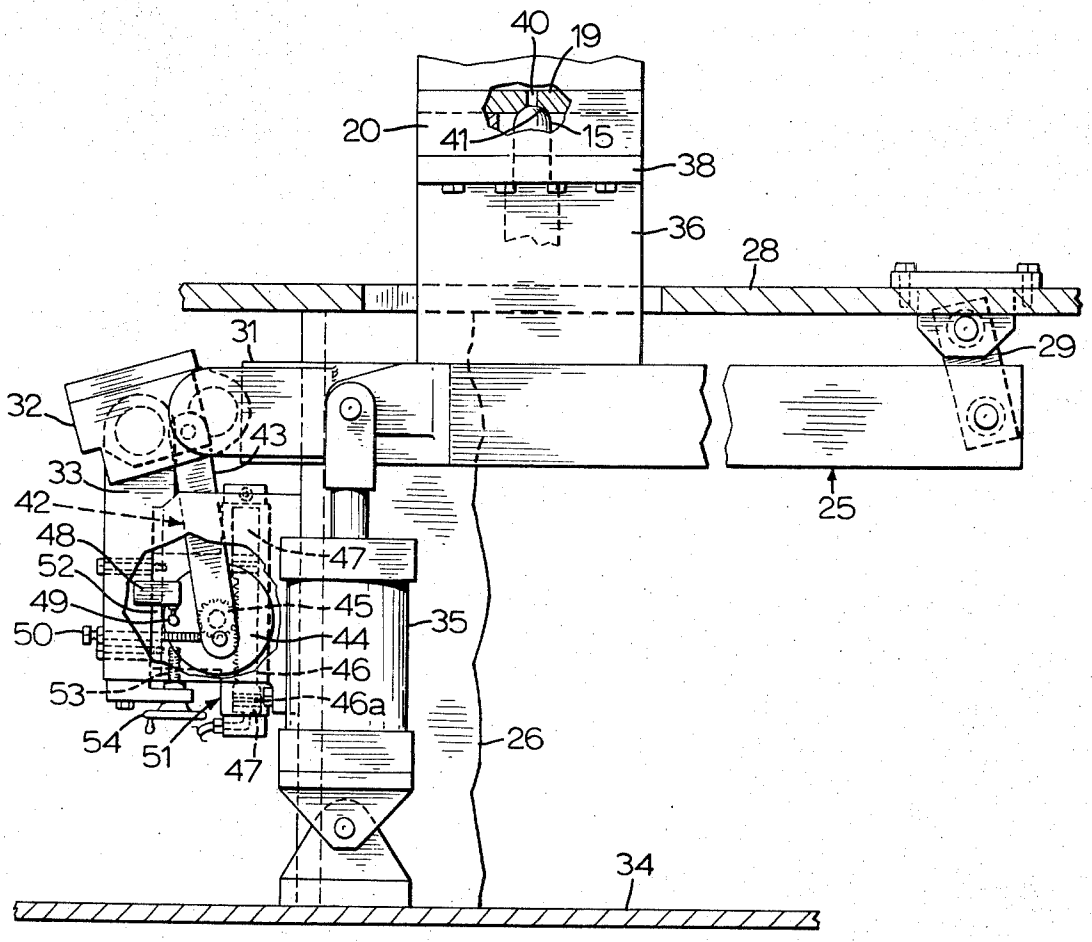


FIG. 3

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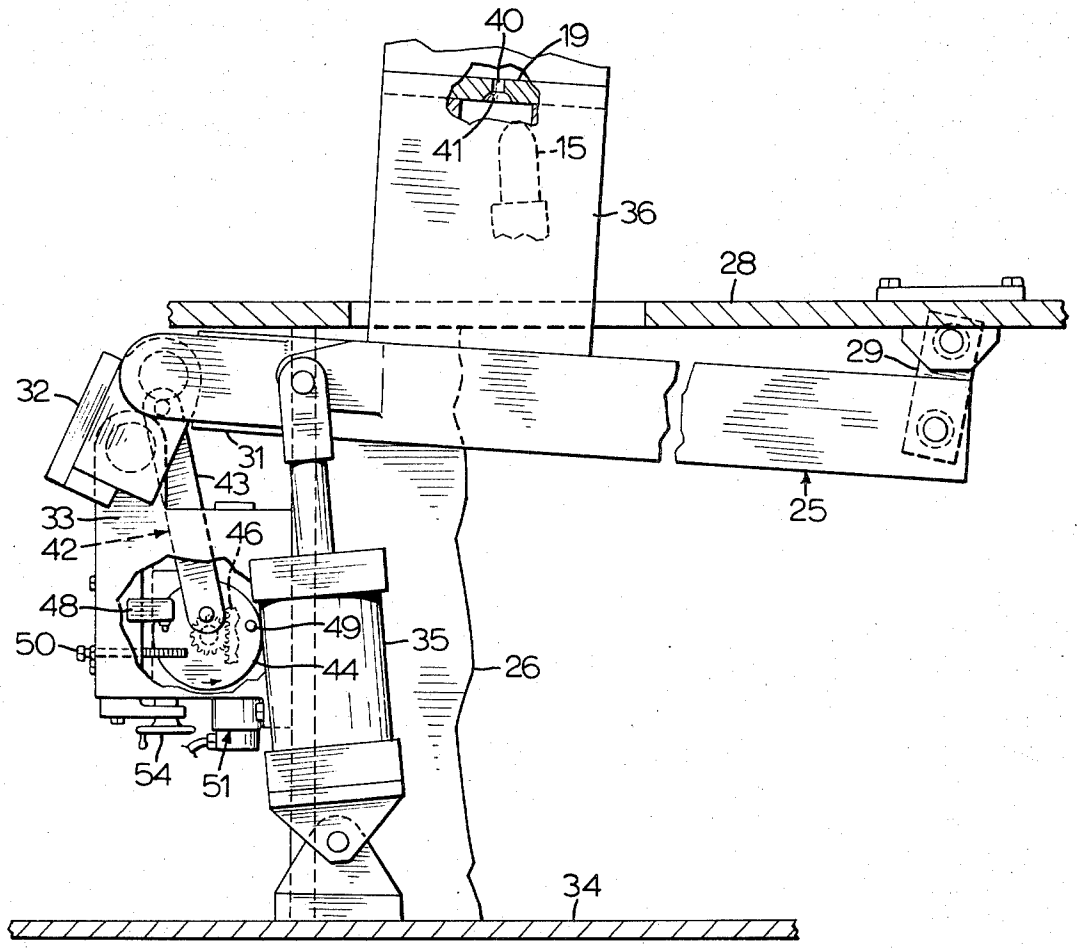


FIG. 4

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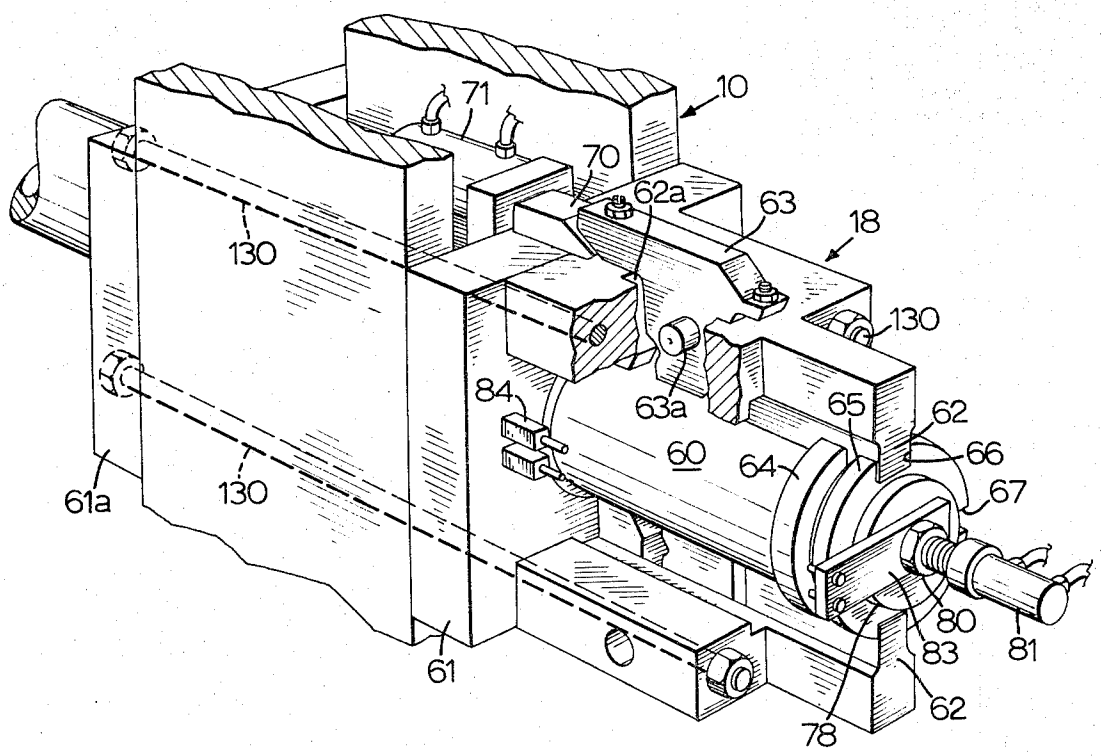


FIG. 5

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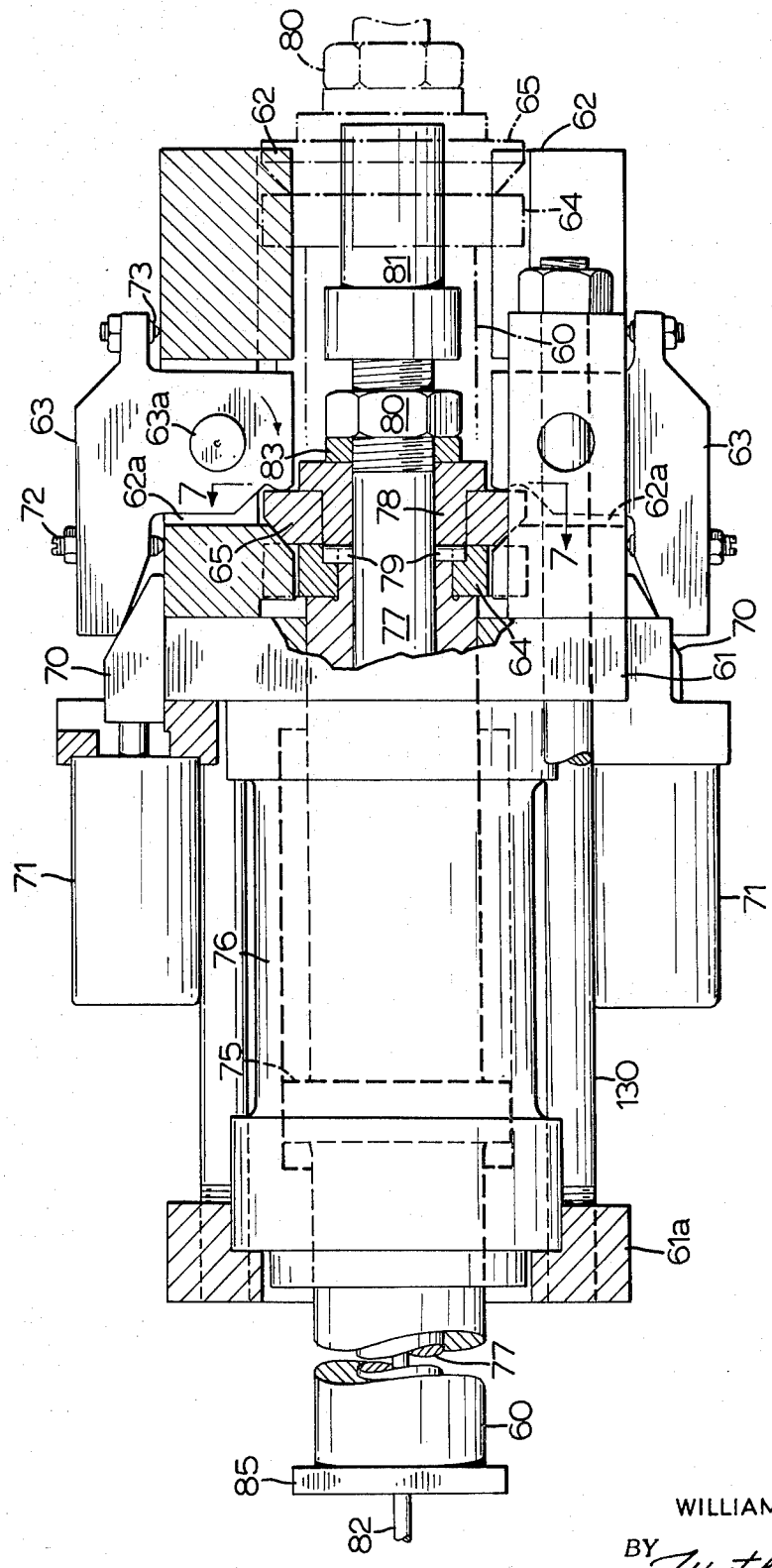


FIG. 6

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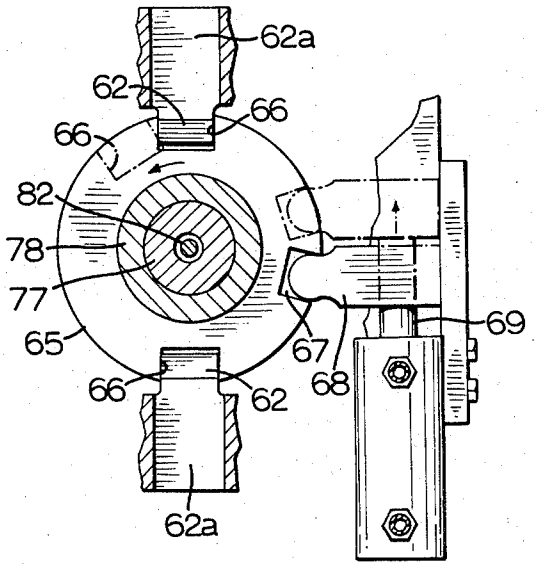


FIG. 7

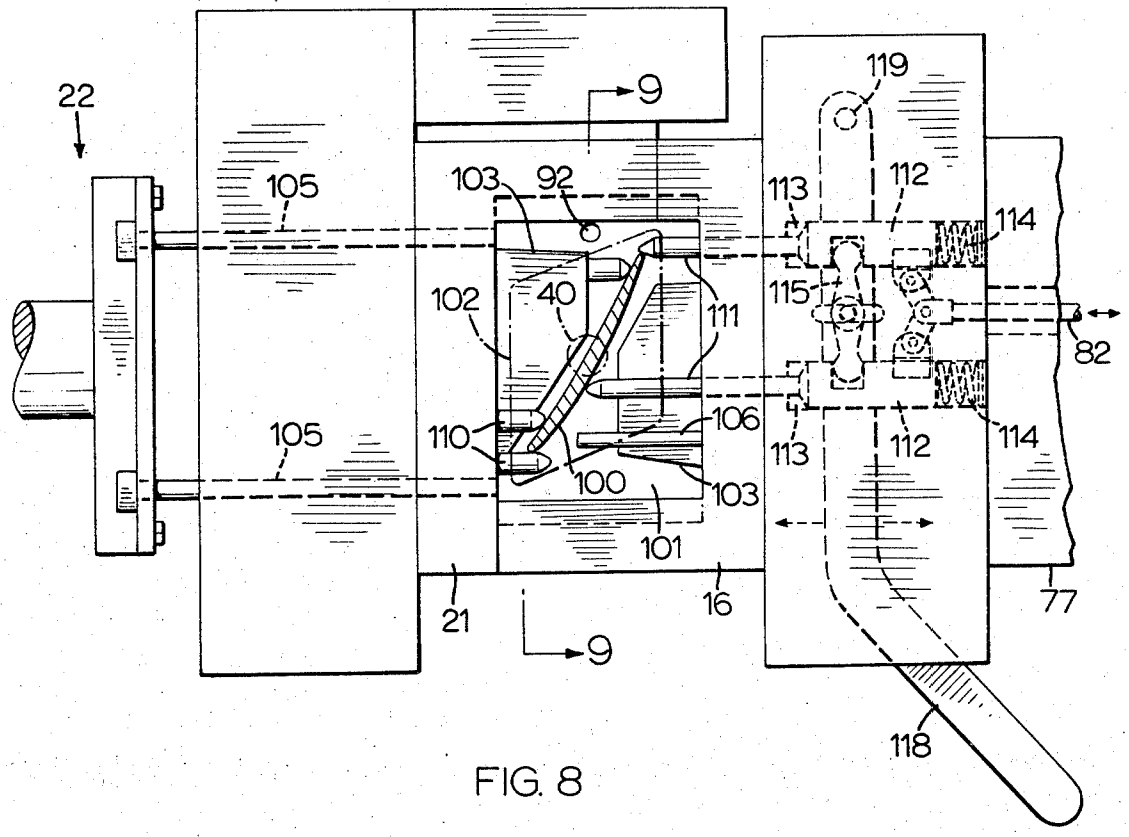


FIG. 8

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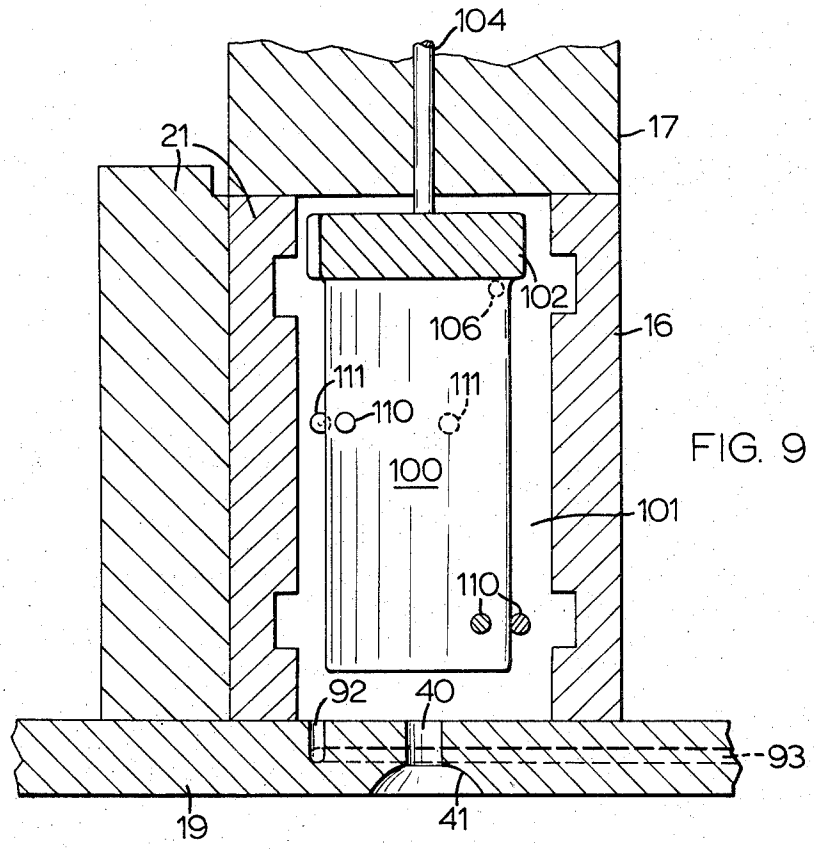


FIG. 9

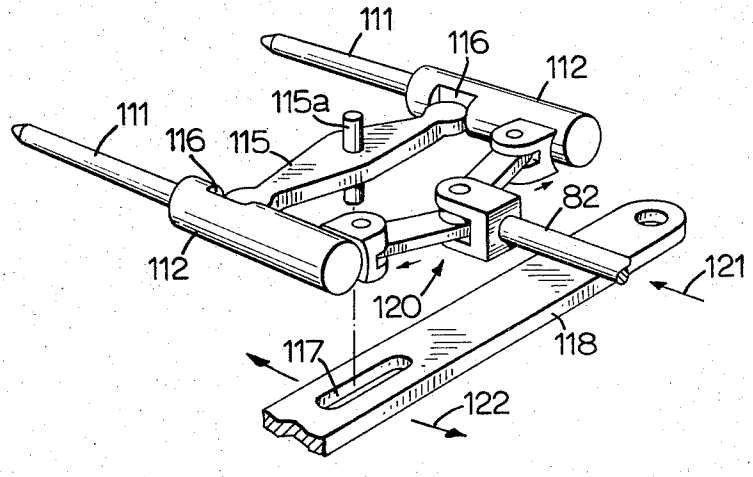


FIG. 10

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METHOD AND APPARATUS FOR DIE CASTING BY PRESSURE INJECTION

This invention relates to die casting.

Die casting includes the encapsulation of jet engine compressor and turbine blades which consists of surrounding each blade with a block of metal, the surfaces of the block having a precise relationship with the airfoil to permit correct orientation for subsequent machining of the root and tip of the blade. A current method of encapsulation employs a low melting point, non-shrinking alloy which is poured into a mould or die having the blade positioned in the die. This is slow and also expensive both with regard to production and with regard to the alloy itself.

The present invention overcomes these disadvantages by providing a method and apparatus for pressure die casting which increases the speed of encapsulation and uses a low cost alloy having a shrinkage factor and higher melting point. This is accomplished by counter-balancing the heavy die frame (on which the die is mounted) required for encapsulation production whereby accurate seating of the gate on the injection nozzle is obtained.

Another problem in pressure die casting is the force required to ensure that the die is properly closed against the high internal pressure of the injected metal. Devices presently in use employ a heavy hydraulic cylinder or a toggle mechanism assembly to close and lock the moving die parts.

In another aspect the present invention overcomes this disadvantage by providing an improved method for closing and releasably locking a die part in a pressure die casting operation, and an apparatus for accomplishing this purpose which is lighter but simple to manufacture, operate and maintain. This is achieved by applying, through pivotable leverage, a force in a direction parallel but opposite to the reactive force on the die when closed, such force acting through the die frame.

Die casting apparatus normally employs a core punch or similar device to cut and remove the sprue or plug from the gate after casting. The present invention in another aspect provides a simple method and means for sprue severance and removal by using a laterally movable die plate to shear the sprue, the slidable plate being used to expose an aperture in the die cavity and inject lubricating mist and/or air, under pressure, into the cavity which acts to eject the sprue remaining in the gate from the previous casting if the sprue has not already fallen out.

It will be appreciated that the various aspects of the invention are applicable to die casting operations other than encapsulation.

Example embodiments of the invention are shown in the accompanying drawings, in which:

FIG. 1 is a view in perspective of a die casting apparatus;

FIG. 2 is a perspective view, partly broken away, of the movable supporting mechanism for the apparatus of FIG. 1;

FIG. 3 is a view in elevation of the supporting mechanism of FIG. 2 in its "closed" position over the injection nozzle of the apparatus;

FIG. 4 is a view similar to FIG. 3 showing the supporting mechanism in its "open" position away from the injection nozzle;

FIG. 5 is a view in perspective of a die closing mechanism used in the apparatus of FIG. 1;

FIG. 6 is a cross-sectional view in elevation of the die closing apparatus of FIG. 5;

FIG. 7 is a view taken along the line 7—7 of FIG. 6;

FIG. 8 is a plan view of a die open at the top and with a turbine blade located in the die cavity for encapsulation;

FIG. 9 is a cross-section taken generally along the line 9—9 of FIG. 8, with the die fully closed, and

FIG. 10 is a perspective view of the locating pins and actuating mechanism shown in FIG. 8.

The apparatus of FIG. 1 consists of a die frame 10 mounted on a movable supporting mechanism 11 which is in turn mounted on a fixed base 12. A pot 13 for molten metal is mounted in base 12 together with an injection pump 14, and fixed injection nozzle 15 projects upwardly from pot 13 below frame 10, in a manner known in the art, for instance as shown in applicant's U.S. Pat. No. 3,256,572 issued June 21, 1966.

Frame 10 carries a pair of die parts 16 and 17 each fixed on a die closing mechanism 18 mounted on the frame at right angles one to the other, a transversely movable lower die plate 19 mounted on a cross-arm of the frame, and a fixed die part 21 mounted on the frame in conjunction with an ejection mechanism 22.

As seen in FIG. 2 of the drawings, supporting mechanism 11 comprises a U-shaped yoke or bar 25 located about a pillar 26 of base 2 and having each arm 27 pivotally mounted on the underside of a top plate 28 of the base (see FIGS. 3 and 4) by means of a connecting arm 29 pinned freely at each end to the arm and top plate respectively. Cross-arm 31 of bar 25 is pivotally mounted through a channel link 32 on trunnions 33 fixed to pillar 26 of base 12. Cross-arm 31 of bar 25 is also pivotally connected, on each side of trunnions 33, to a lower plate 34 of base 12 by a fluid cylinder and piston assembly 35. Finally, arms 27 of bar 25 each carry a T-shaped pillar 36 which project through slots 37 in top plate 28 of base 12 and to which cross-arm 20 of die frame 12 is attached. The face of upper end plate 38 of pillar 36 is recessed to provide a cavity 39, connected with fluid pressure means (preferably air) to float cross-arm 20 of frame 10. End plate 38 also carries apertures 39*a* to receive bolts for anchoring frame 10 after it has been oriented on supporting mechanism 11.

FIGS. 3 and 4 of the drawings shows lower die plate 19 having a gate 40 and a nozzle seat 41, and also show with a drive assembly 42 for moving die plate 19 onto and away from nozzle 15. Drive assembly 42 consists of a drive arm 43 pivoted at one end to channel link 32 and at the other end eccentrically to a drive wheel 44 which is keyed to a pinion 45 engaging a rack 46 carrying a piston 46*a* actuable by a hydraulic cylinder 47 to move in either direction. A limit switch 48 is actuable by a pin 49 fixed on drive wheel 44. A threaded stop pin 50 bears against drive arm 43 in its lower portion as shown in fIG. 3, when nozzle 15 is in seat 41 of die plate 19. Drive wheel 44, pinion 45, rack 46 and cylinders 47 are all mounted on a frame 51 which is slidable in a keyway 52 and adjustable vertically in the keyway by a threaded shaft 53 actuable by a handwheel 54.

In FIGS. 5, 6 and 7 of the drawings die closing apparatus 18 is shown which consists of a cylindrical shaft

60 mounted in blocks 61 and 61*a* on die frame 10 for longitudinal movement. Block 61 carries a pair of opposed guide keys 62 which extend along shaft 60, and a pair of latch members 63 are rotatably mounted each on a pin 63*a*, in recesses 62*a* of guide keys 62. Mounted adjacent one end of shaft 60 are an inner ring 64 and an outer ring 65, the outer ring abutting the inner ring. Both rings 64 and 65 have a pair of notches 66 to accommodate keys 62 while outer ring 65 has an an additional notch 67 engageable by a finger 68 extending laterally from a piston-actuated shaft 69 (see FIG. 7). A pair of wedges 70 mounted on the pistons of a pair of hydraulic cylinders 71 are adapted to move between block 61 and latches 63. Each wedge 70 carries an adjustable stop nut 72 and a spring loaded ball 73 which is also adjustable on the wedge and serves to give clearance for outer ring 65.

As seen in FIG. 6, shaft 60 carries a piston ring 75 which moves in a hydraulic cylinder 76 mounted between blocks 61 and 62. Within shaft 60 is a concentric intermediate prestressed shaft 77 which carries at its outer end a flanged collar 78 carrying outer ring 65 concentrically rotatable on the collar. An opposed pair of studs 79 key inner ring 64 to shaft 60 and are held in position by a threaded nut 80 bearing against collar 78. A hydraulic cylinder 81 is threaded onto nut 80 and actuates a rod 82 concentrically mounted within shaft 77. A plate 83 held by nut 80 interacts with a limit switch 84 on block 61. Fixed on the end of shaft 77 adjacent block 62 is a die holding plate 85. It will be noted from FIGS. 5 and 6 that tie bolts 130 secure blocks 61 and 61*a* to frame 10. The axis of each pair of bolts 130 preferably intersect, or lie near, the axis of adjacent pin 63*a* on which latch 63 freely pivots.

All die parts 16, 17, 19 and 21 are water cooled. As seen in FIG. 1, lower die plate 19 is movable by a pair of hydraulic cylinders 90 having their pistons 91 engaging the die plate. In addition to gate 40, die plate 19 has an aperture 92 which is located beneath one wall of die part 21 when the die plate is in a position of rest and is connected with a flexible conduit through a passageway 93 for pressure injection of a lubricating mist.

FIGS. 8 to 10 of the drawings shows the structure of the die assembly. FIG. 8 shows die parts 16 and 21 closed together with a blade 100 located in die cavity 101, root 102 of the blade being at the top (dotted in FIG. 8 for clarity). Core pieces 103 (not shown in FIG. 9 for clarity) project from die parts 16 and 21 into the cavity to reduce the volume of the cavity. A locating pin 104 (FIG. 9 only) and ejection pins 105 (FIG. 8 only) also project into die cavity 101, and also as root support pin 106.

Fixed locating pins 110 project into die cavity 101 from die part 21 while resilient locating pins 111 project into the die cavity from die part 16. Pins 110 and 111 are arranged for holding blades of different cross-sections. As seen in FIGS. 8 and 10, pins 111 are mounted on barrels 112 slidable in cavities 113 in die part 16 and urged forward by compression springs 114. A bar 115 engaging notches 116 in barrels 112 is linked by a pin 115*a* slidable in a slot 117 in a lever bar 118 which is pivoted on a pin 119. Rod 82 (see FIG. 6) terminates in a linkage arrangement 120 which, when rod 82 is moved in the direction of arrow 121 by cylinder 81 clamps barrels 112 against the walls of cavities 113 and locks pins 111 in position against blade 100. When rod 82 is released and lever 118 is moved laterally in the direction of arrow 122, pins 111 are pulled, against the action of springs 114 away from blade 100. Alternately, compressive spring pressure may be exerted on lever 118 instead of on cylinders 112, allowing the pressure on pins 111 to be equalized.

Before initiating the cyclical operation of the apparatus of FIGS. 1 to 4, horizontal die plate 19 is first located on nozzle 15 by moving floating cross-arm 20 on upper plates 38 of pillars 36 while supporting mechanism 11 is in its lowered position as seen in FIG. 3 of the drawings. Cross-arm 20 is then bolted to upper plates 38 and supporting mechanism 11 is moved to its raised position as seen in FIG. 4 of the drawings.

In the cyclical operation of the apparatus of FIGS. 1 to 4, horizontal die part 16 is closed against fixed die part 21, whereupon a turbine blade 100 to be encapsulated is inserted into the die cavity, in the manner described with respect to FIGS. 8 to 10, and vertical die part 17 is closed against die parts 16 and 21. The operation of the die closing apparatus will be described subsequently with respect to FIGS. 5 to 7 of the drawings. After die parts 16 and 17 have been moved to close the die, die plate 19 is then slid forward by cylinders 90 to expose aperture 92 and inject lubricating mist into the die cavity, which also serves to eject the sprue or slug, of the previous casting, for gate 40 if it has not already fallen into pot 13. Die plate 19 is then returned by cylinders 90 to its original position.

In the next operational step, die plate 19 is lowered to seat nozzle 15 in gate 40. This is done by actuating piston 46*a* integral with rack 46 and movable in cylinders 47, to rotate pinion 45 and drive wheel 44 in a clockwise direction which causes arm 43 to rotate channel link 32 and move bar 25 forwardly as seen in FIG. 3. The rotation of drive wheel 44 is stopped by pin 50 just after the center line of arm 43 passes the center of rotation of the drive wheel to lock die plate 19 against nozzle 15. Alternately the rotation of drive wheel 44 may be stopped by having the end of rack 46 strike the end of either cylinder 47. Cylinders 35 provide sufficient hydraulic pressure to give die frame 10 a "negative" weight so that drive assembly 42 must pull bar 25 downwardly. The amount of pressure of die plate 19 on nozzle 15 can be adjusted by handwheel 54 which slides frame 51 in keyway 52, after which locking bolts 51*a* can be tightened.

Limit switch 48 initiates he next operational step, in which molten metal is injected by pump 14 from pot 13 through nozzle 15 and gate 40 into the die cavity, in known manner. When the molten metal has been allowed to stand in the die cavity long enough to solidify, frame 10 is moved by drive assembly 42 to lift die plate 19 away from nozzle 15 and to one side of the nozzle. After a further time to allow the casting to cool, the lock releases on the pins and die parts 16 and 17 are released and retract, the casting being held in position by the sprue or plug. Die plate 19 is then moved horizontally by pistons 91 to sever the plug in gate 40 from the casting. The position of frame 10 enables the plug to fall from die plate 19 into pot 13 clear of nozzle 15. If the plug does not drop from gate 40 it will be ejected in the next operational cycle when lubricating

mist is injected under pressure into the closed die through aperture **92** as previously described. Ejection device **22** is then actuated to push the casting from fixed die part **21** in known manner.

In the operation of the die closing apparatus **18** of FIGS. **5**, **6** and **7**, piston **75** is actuated within cylinder **76** to move shaft **77** forward (to the left in fIGS. **5** and **6**), rings **64** and **65** moving along keys **62** until outer ring **65** is located in annular recesses **62***a* of the keys while inner ring **64** remains keyed, as seen in FIGS. **6** and **7**. This actuates limit switch **84** which in turn actuates shaft **69** to cause finger **68** to rotate outer ring **65** whereby notches **66** are moved out of alignment with keys **62**. Hydraulic cylinders **71** are then actuated to move wedges **70** against latches **63**, causing the latches to bear against outer ring **65** with a compressive force which locks die part **16** (or **17**) tightly against the complementary parts of the die.

It should be noted that die closing mechanism **18** may be adapted to rotate its associated die part for sprue severance. This is done by widening notch **66** of inner ring **64** and fixing outer ring **65** to he inner ring so that both rings are rotatable as a single unit. The die part is mounted on one end of an inner slide (equivalent to shaft **77**) and the two rings **64** and **65** are mounted on the other end, whereby the thrust is transmitted through the inner slide; the outer slide (equivalent to piston **75**) acting merely to move the assembly back and forth by hydraulic means.

I claim:

1. A method of pressure die casting employing an injection apparatus having a nozzle and a die frame carrying a gated die seatable on the nozzle, comprising the steps of:

supporting the die frame above the nozzle on movable means and counterbalancing the supporting means between a lowered position and a raised position;

floating the die frame on the movable supporting means by fluid pressure to precisely align and seat the gate of the die on the nozzle when the supporting means is in the lowered position, and anchoring the die frame on the supporting means when the gate is seated on the nozzle; and

lowering and raising the movable supporting means to seat and unseat the die on the nozzle in a cyclical casting operation.

2. A method as claimed in claim **1** in which the supporting means is counterbalanced by fluid pressure urging the supporting means about a pivot into the raised position.

3. A method as claimed in claim **1** in which the supporting means is moved both axially and laterally with respect to the nozzle.

4. A method as claimed in claim **1** in which the supporting means is releasably locked in the lowered position.

5. Apparatus for pressure die casting using an injection nozzle and means for the controlled feeding of molten metal through the nozzle, comprising:

a die frame having die parts mountable thereon including a die gate;

means supporting the die frame, said supporting means being counterbalanced and movable between a lowered position and a raised position;

means to float the die frame on the supporting means whereby the die gate is precisely aligned and seated on the injection nozzle when the supporting means is in the lowered position, and means to anchor the die frame on the supporting means when the gate is seated on the nozzle; and

means to lower and to raise the counterbalanced supporting means whereby the die gate is cyclically seated and unseated on the injection nozzle.

6. Apparatus as claimed in claim **5** in which the supporting means includes a yoke pivotally mounted adjacent one end on a fixed base and supported adjacent the other end by fluid piston means adapted to urge the yoke towards the raised position.

7. Apparatus as claimed in claim **5** in which the lowering and raising means is adapted to move the die gate both axially and laterally with respect to the nozzle.

8. Apparatus as claimed in claim **5** in which the supporting means is adapted to be releasably locked in the lowered position.

9. Apparatus as claimed in claim **6** in which the raising and lowering means comprises link means pivotably interconnecting the base and the free end of the yoke, and means to pivot the link means about the base.

10. Apparatus as claimed in claim **9** in which the pivoting means comprises a rack and pinion assembly, a drive wheel keyed to the pinion, and a drive arm pivotably connecting the drive wheel and the link means, and fluid pressure means adapted to actuate the pinion reciprocally.

11. Apparatus as claimed in claim **10** in which the pinion is adapted to move the drive arm past dead center to abut stop means whereby the supporting means is releasably locked in the lowered position.

12. In a pressure die casting operation employing a plurality of die parts mounted on a die frame and interfitting to form a die cavity, a method of releasably closing and locking at least one of said die parts comprising the steps of:

moving said one die part, in a direction opposite to the reactive force on the die when closed and charged, to close the die;

applying, by pivotal leverage through the die frame when the die is closed, a force acting on said one die part in the direction of closure of the die, said force acting through the die frame and sufficient to withstand the reactive force on the die part when the die is charged.

13. A method as claimed in claim **12** in which a said force is effected by wedge action applied through the die frame in a direction parallel to said reactive force.

14. In pressure die casting apparatus, a device for moving and locking a die part to close a die mounted on a die frame, comprising:

means mounting the die part on the die frame;

means to move the die part mount, in a direction opposite to the reactive force on the die part when closed and charged, to close the die;

at least one latch member pivotably mounted on the die frame and engagable with the die part mount when the die is closed; and

means mounted on the die frame and actuable, when the die is closed, to engage he latch member whereby the latch member bears against the die part mount in the direction of closure thereof.

15. A device as claimed in claim 14 in which the means to engage the latch member comprises wedge means actuated by hydraulic means fixed on the die frame.

16. A device as claimed in claim 15 in which the wedge means is adapted to move against the latch member in a direction parallel and opposite to said direction of closure.

17. A method of pressure die casting employing a plurality of die parts interfitting to form a die cavity, one of said die parts carrying a die gate adapted to seat on an injection nozzle, comprising the steps of:

seating the die gate on the nozzle and injecting molten casting material through the nozzle into the die cavity;

allowing the molten material to solidify and moving the die to unseat the die gate from the injection nozzle;

moving laterally that die part carrying the die gate to shear the sprue, formed by solidification of the molten material in the die gate, from the casting in the die cavity;

separating the die parts to remove the casting from the die cavity, reclosing the die parts to re-form the die cavity, and

moving laterally that die part carrying the die gate to expose an aperture therein and introduce fluid under pressure into the die cavity whereby the sheared sprue if retained in the die gate is ejected therefrom.

18. A method as claimed in claim 17 in which the pressurized fluid is a lubricating mist.

19. A die for use in pressure casting, comprising:

a plurality of die parts interfitting to form a die cavity;

one of said die parts having a flat inner surface and being adapted to slide laterally along said surface, and said one die part carrying a gate therein for injection of molten casting material into the die cavity, an aperture in said one die part opening into said cavity, said aperture being adapted to register with a duct connecting said die with a source of pressurized fluid whereby, when said one die part is slid laterally a predetermined distance along said surface and when said die cavity is empty, said fluid is released under pressure into said cavity whereby a sheared sprue if retained in the gate is ejected therefrom.

20. A die as claimed in claim 19 in which the pressurized fluid is a lubricating mist.

21. Apparatus as claimed in claim 5 in which the means to float the die frame comprises at least one cavity located in the supporting means, the die frame including a surface portion covering the cavity, and fluid pressure means connecting with the cavity whereby the die frame is movable laterally on the supporting means.

22. A device as claimed in claim 14 including a guide key fixed to the die frame in the direction of closure of the die part mount and having the latch member coextensive therewith, first slotted means fixed on the die part mount and engagable with the guide key to prevent lateral rotation of the mount, second slotted means rotatable on the die part mount, the second slotted means being engagable with the guide key except when the mount is closed and laterally rotatable when the mount is closed to provide a bearing surface for the latch member against the mount.

* * * * *