United States Patent

Chatourel et al.

[15] **3,698,471**

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[54] **AUTOMATICALLY OPERATED MULTIPLE CAVITY DIE FOR LOW-PRESSURE CHILL-CASTING**

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[73] Assignee: **Regie Nationale Des Usines Renault,** Billancourt, France

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[21] Appl. No.: **75,920**

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Oct. 15, 1969 France......................6935366

[52] **U.S. Cl.** **164/340,** 164/346, 164/113

[51] **Int. Cl.** **B22d 33/04**

[58] **Field of Search**......164/113, 137, 303, 320, 339, 164/340, 346

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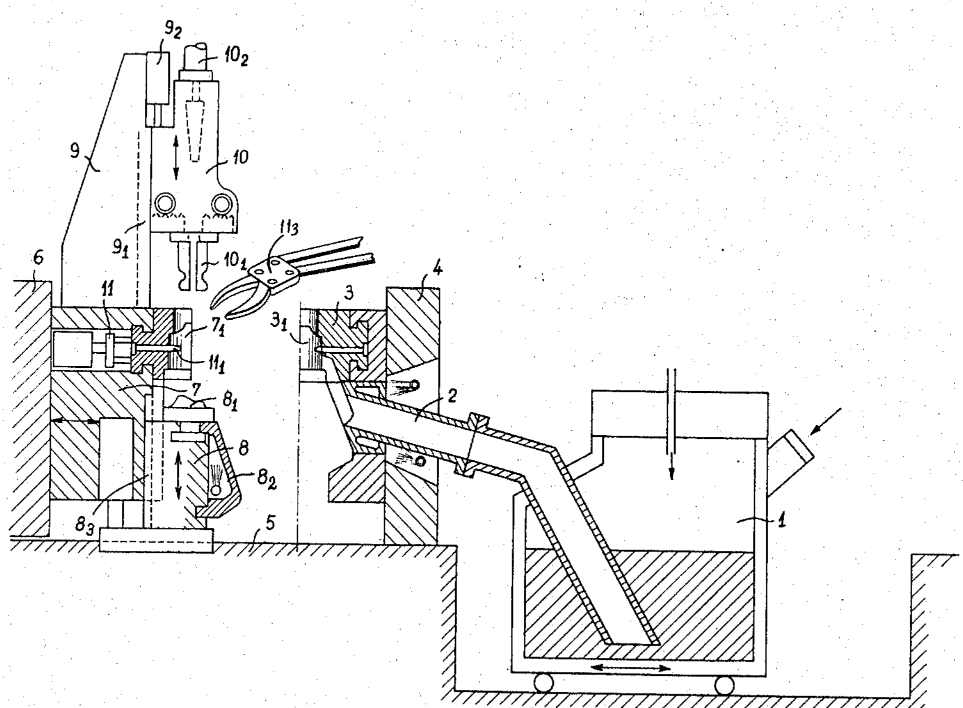
Primary Examiner—R. Spencer Annear
Attorney—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

This device permits the low-pressure chill-casting of parts such as engine pistons in mold cavities formed in pairs of half-dies, said mold cavities being aligned and formed in a fixed half-die receiving the duct supplying the molten metal thereto and in the movable half-die adapted to move by translation away from said fixed half-die by means of retractable members of the type comprising movable core elements, the automatic control units associated with said half-dies being adapted to assemble and disassemble said core elements through a sequence of mechanical movements produced by an actuator, automatic means being associated with the device for ejecting and discharging the castings.

9 Claims, 16 Drawing Figures



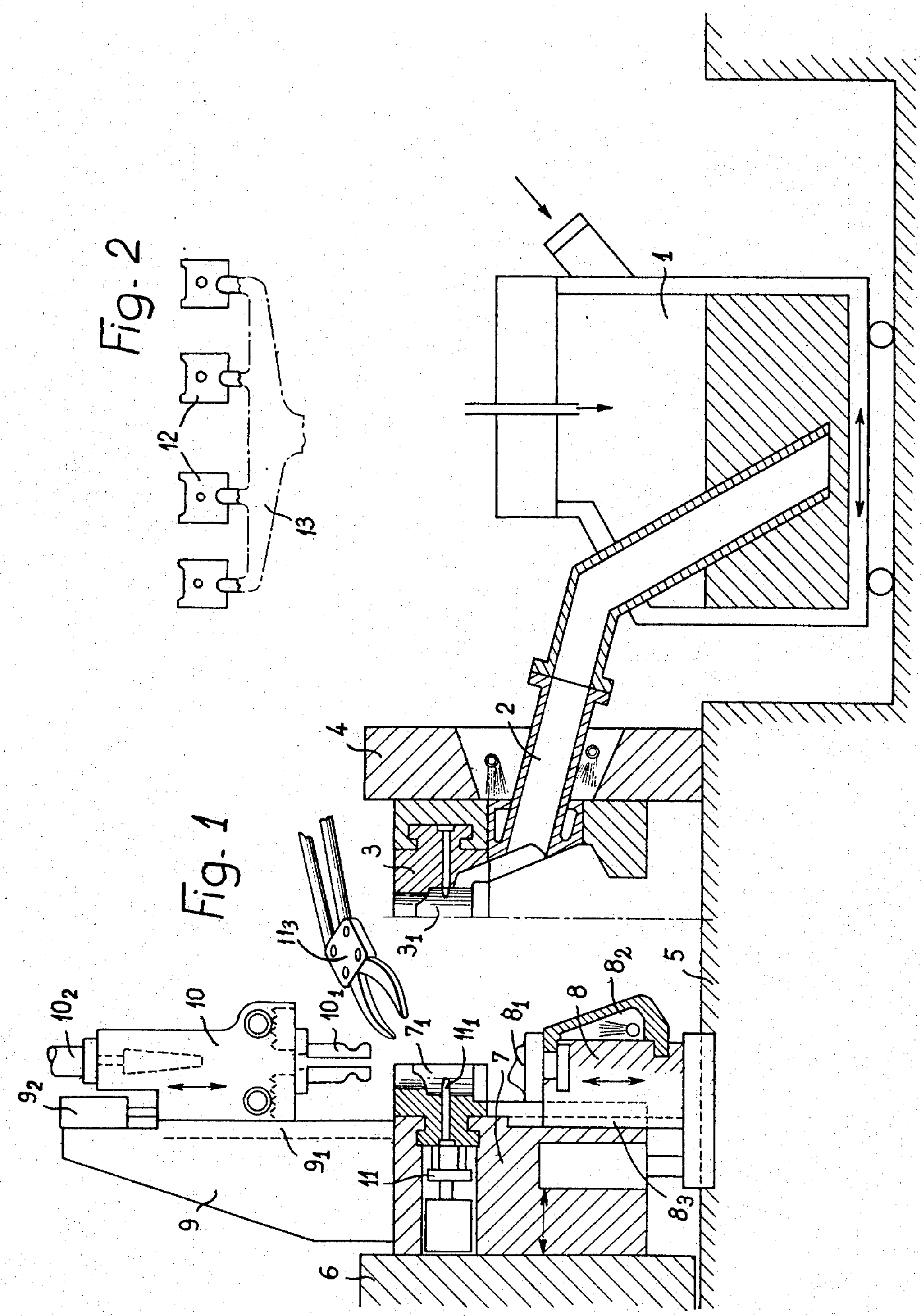


Fig- 2

Fig. 1

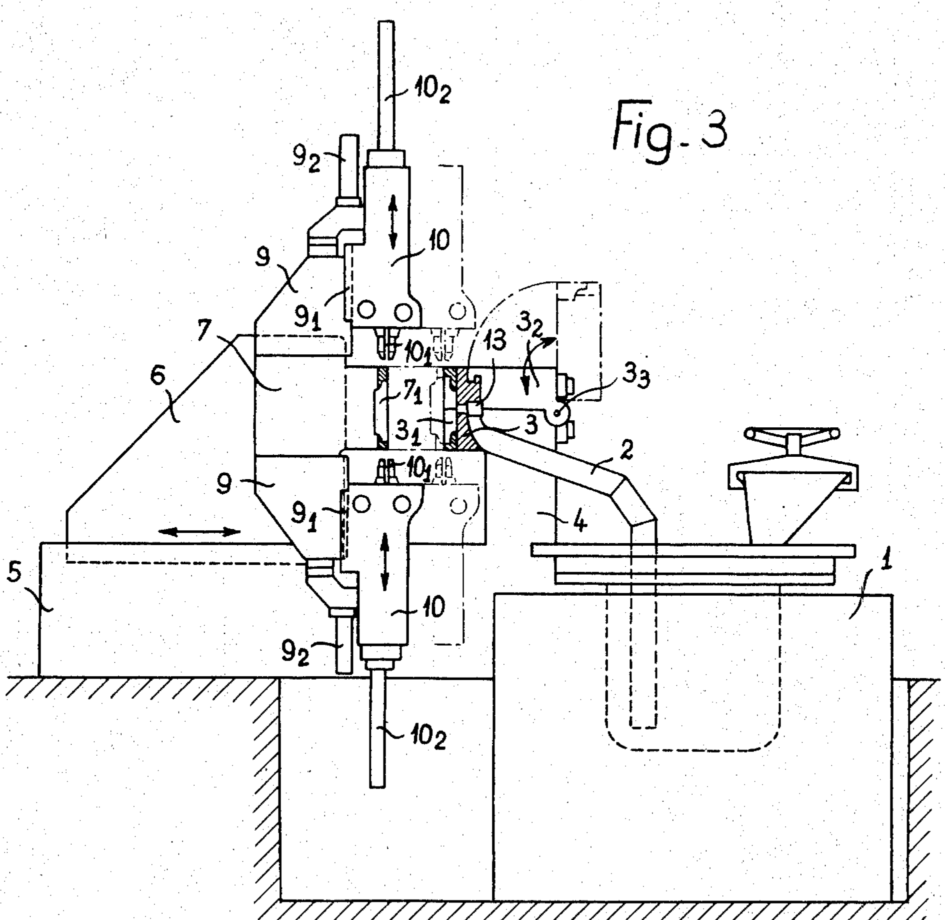

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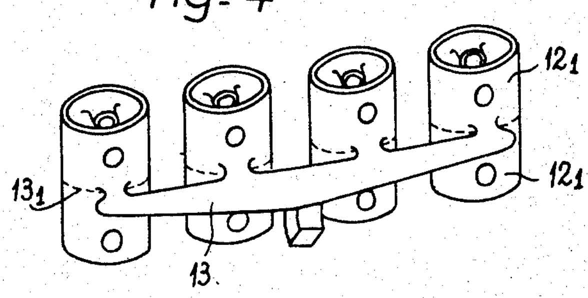
Fig. 3

Fig. 4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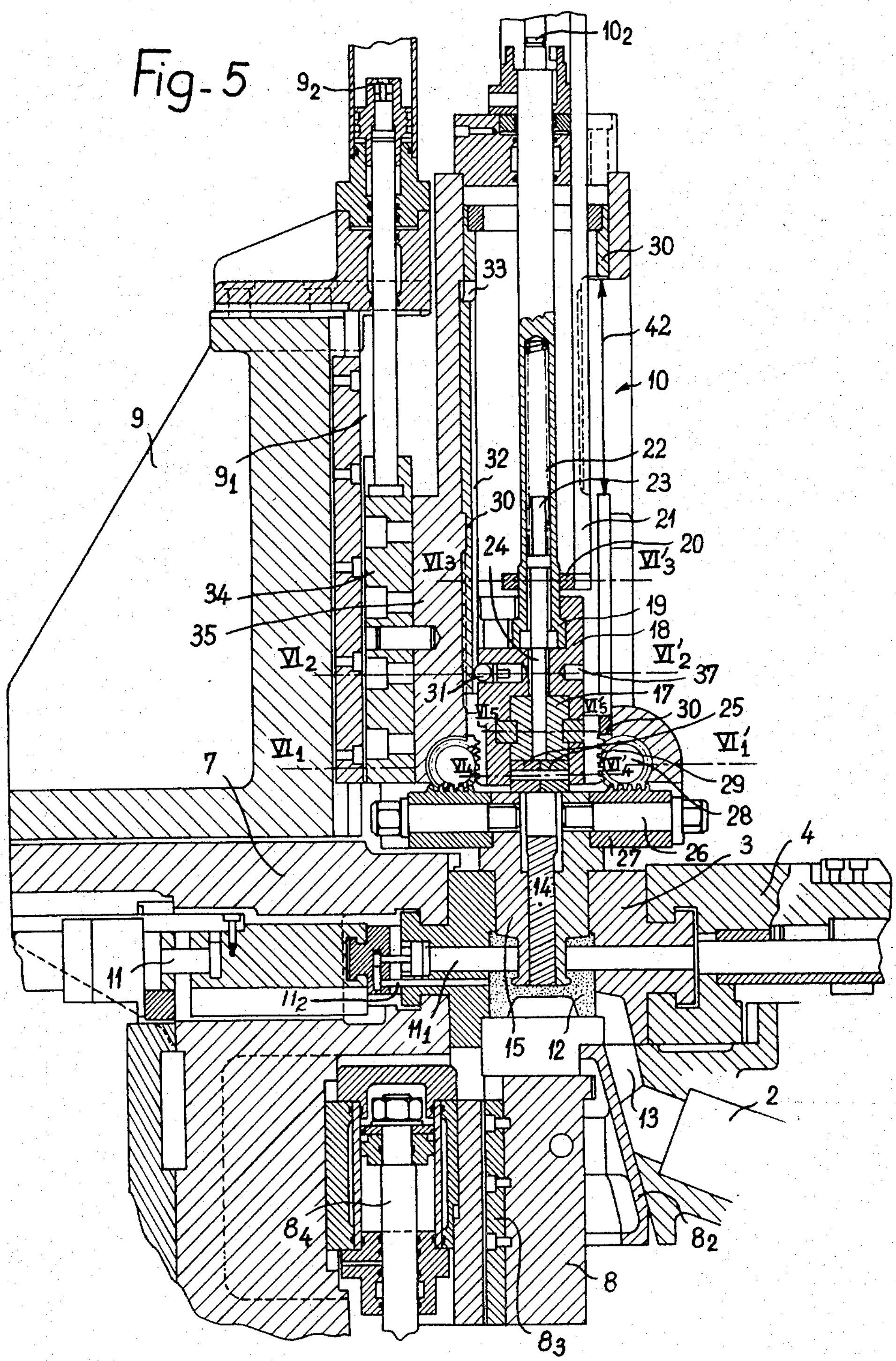
Fig-5
9_2
10_2
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VI'_3
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VI_2
VI'_2
37
31
17
VI_5
VI'_5
30
25
VI_1
VI'_1
VI_4
VI'_4
29
28
7
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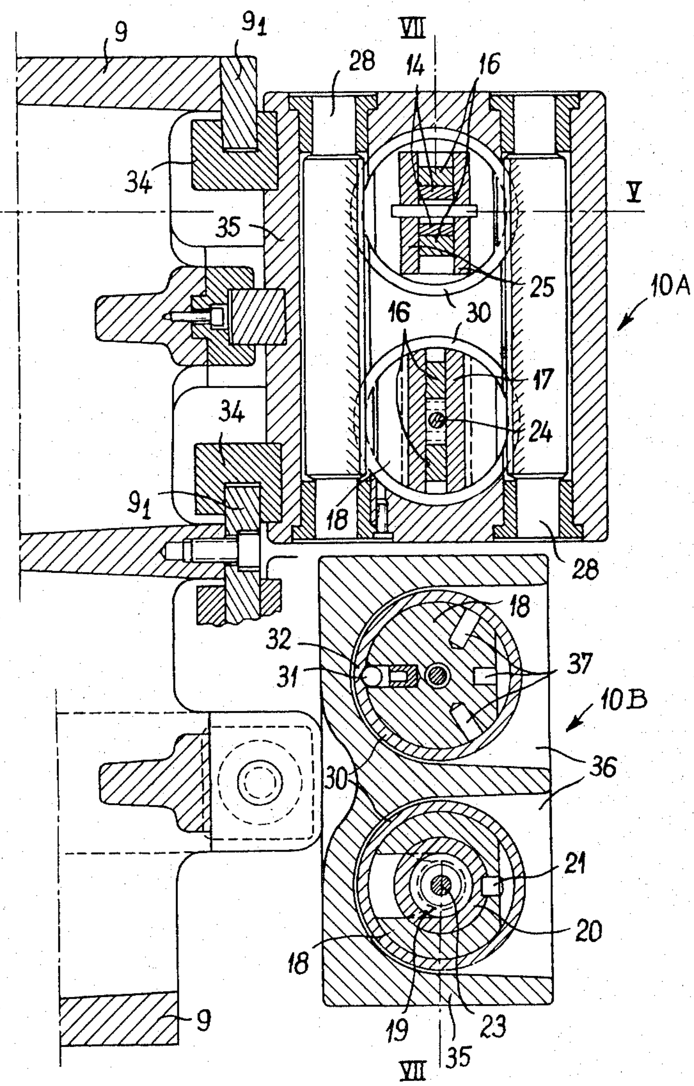
8
8_3

Fig-6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VII

Fig. 7

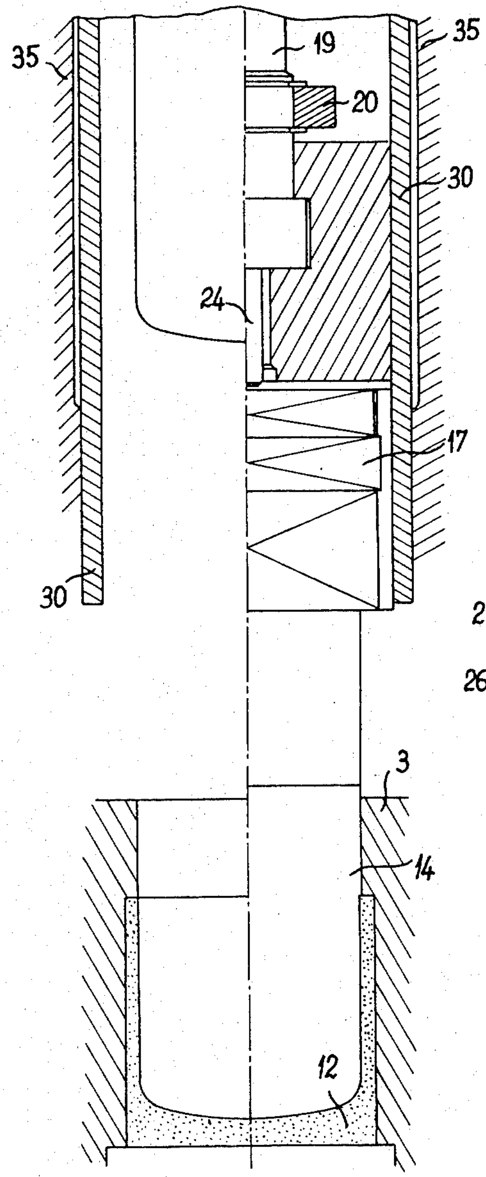
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Fig. 8

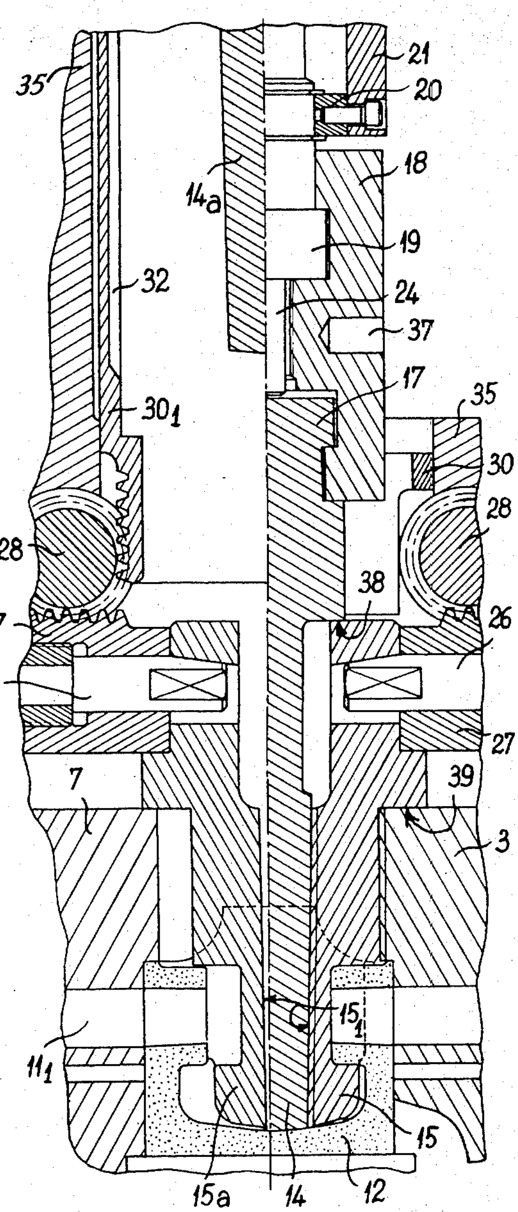
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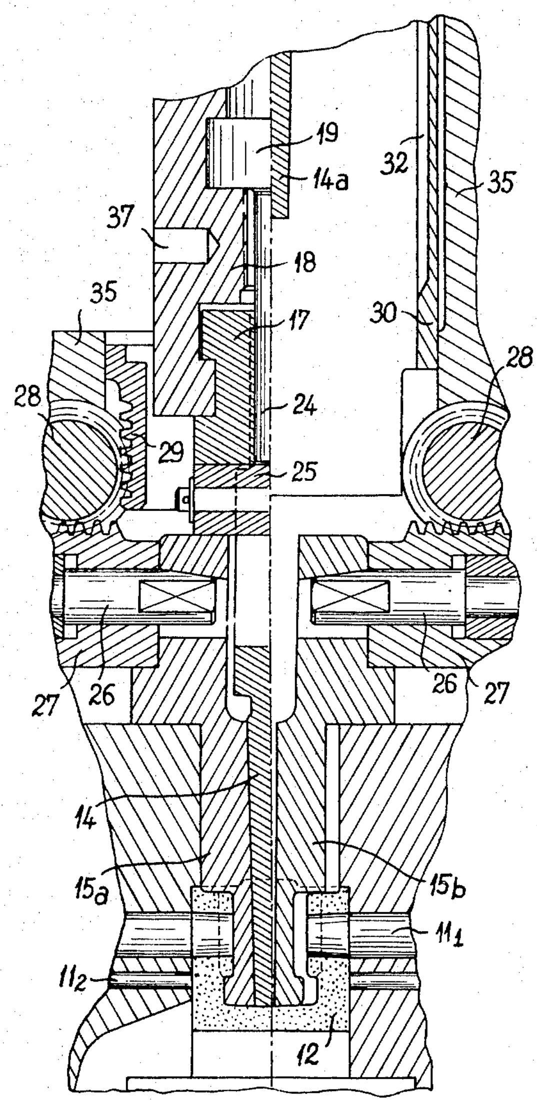
Fig. 9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11_1
11_2
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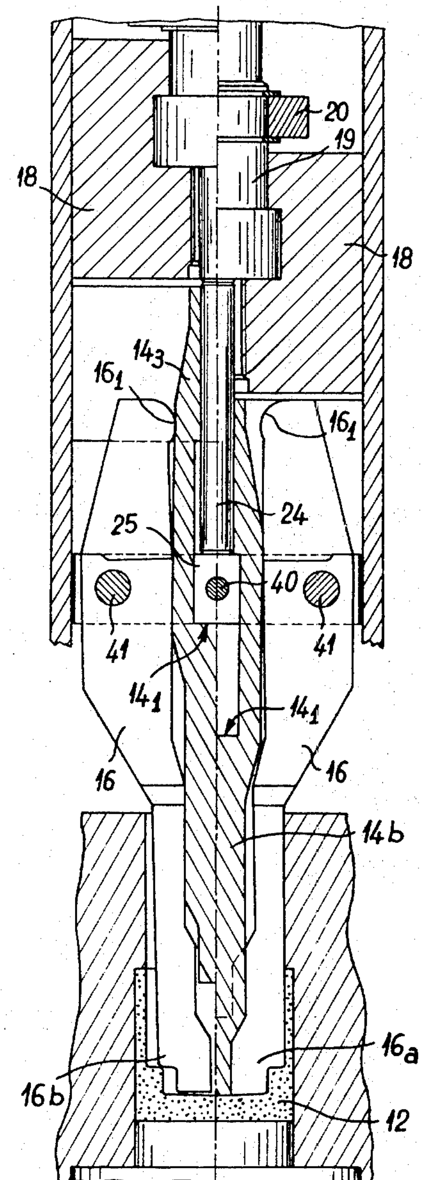
Fig. 10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16b
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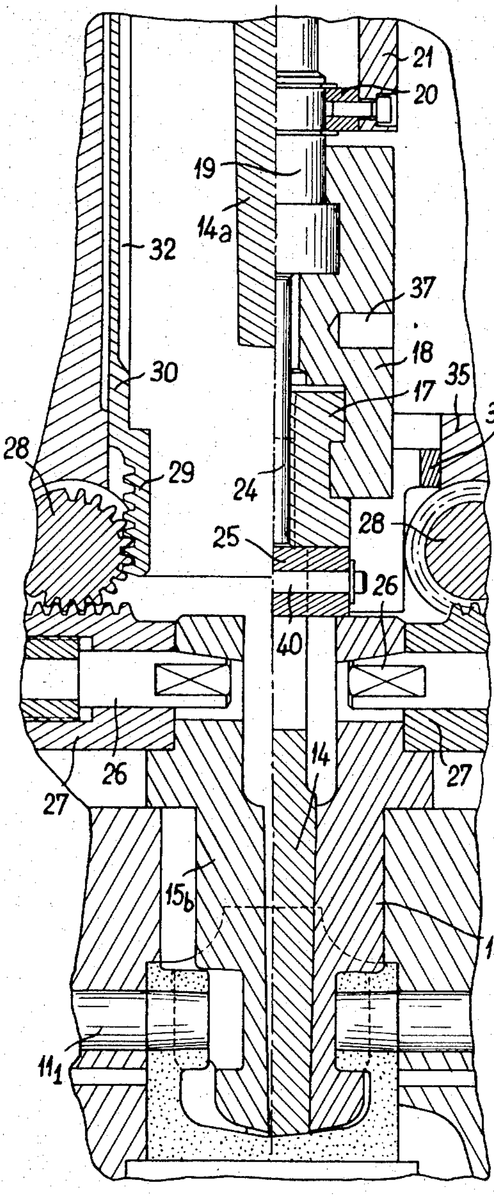
Fig-11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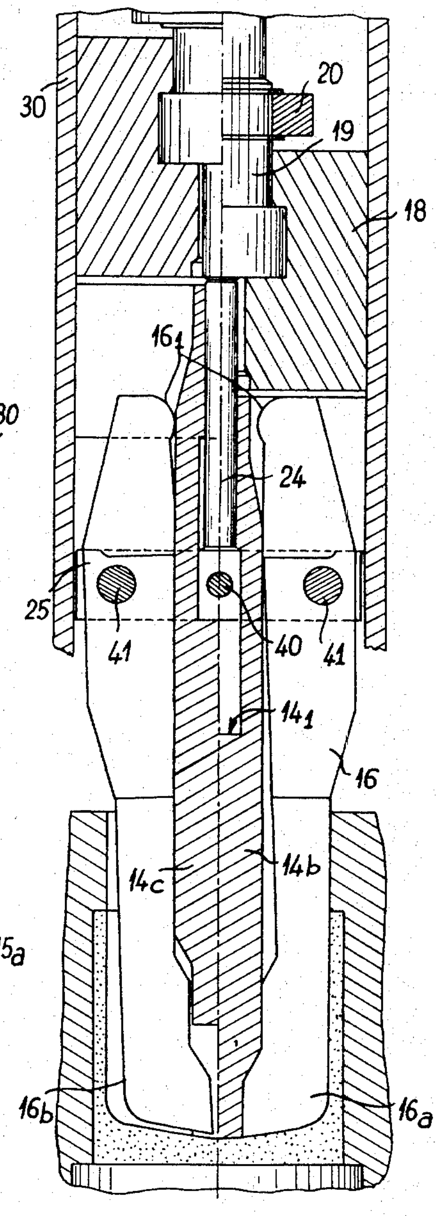
11_1

Fig-12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16b
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Fig- 13

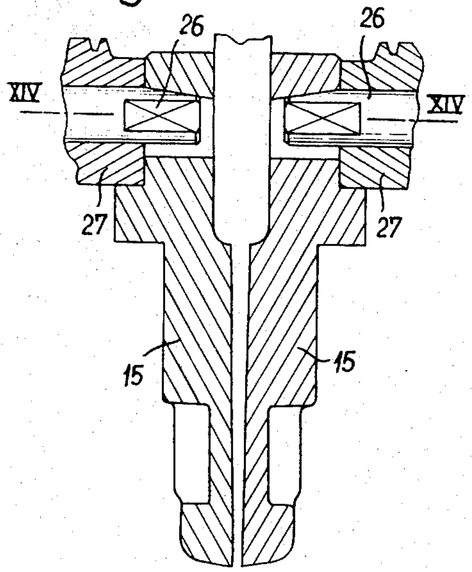


Fig- 14

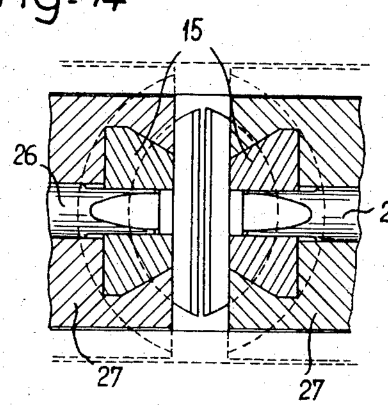


Fig- 15

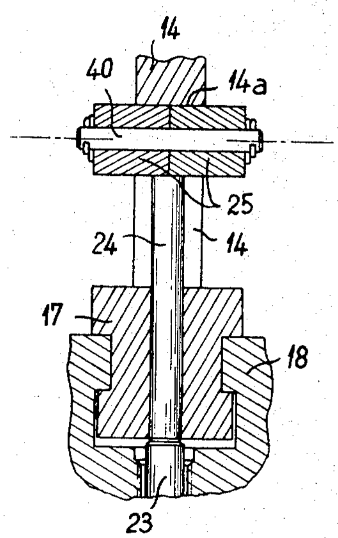
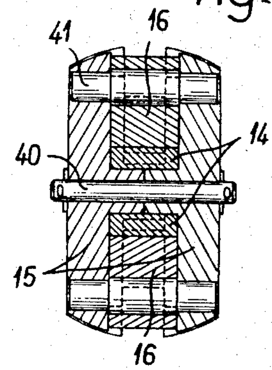


Fig- 16



AUTOMATICALLY OPERATED MULTIPLE CAVITY DIE FOR LOW-PRESSURE CHILL-CASTING

The present invention relates to chill-casting devices and has specific reference to a device for the production of castings, notably engine pistons, by low-pressure casting in multiple-cavity chill-casting molds.

The casting of relatively thick parts such as pistons is not advantageous if the conventional high-pressure die casting methods are used, since they are considerably more expensive than the gravity die casting or chill-casting methods hitherto used for producing these castings. However, these last-named methods are objectionable when it is contemplated to produce great numbers of such castings, due to the high cost of labor and/or the insufficient efficiency, since the castings must be made manually and separately.

On the other hand, the easy automation and high efficiency of die casting processes are impaired by the high cost of the initial equipment and the depreciation charges inherent to the machines, not to mention the relatively rapid wear of expensive tools which is increased by the bulky character of the castings such as pistons and also by the fragility of the core-type molding elements utilized for obtaining the internal shape of these pistons.

It is the essential object of the present invention to provide a low-pressure, multiple-cavity chill-casting device, notably for the mass production of engine pistons, which is free of the inconveniences set forth hereinabove.

The device according to this invention is characterized essentially in that the molds comprise each two half-dies, i.e., a fixed half-die and a movable half-die, that the mold cavities are aligned in even number and formed on the one hand in a fixed half-die receiving the feed duct and on the other hand in a movable half-die adapted to move by translation away from the fixed die and in the plane joint of these two half-dies, by means of retractable mold elements whether of single or compound type adapted to be assembled by means of core members known per se, wherein the core members are fitted in position or removed therefrom by standardized automatic control units each adapted to control two mold cavities and of which the core member fitting or release operations are produced through a sequence of mechanical movements known per se under the control of a single actuator, automatic means also known per se being associated with the device for ejecting and discharging the cluster of castings.

It is another object of the present invention to combine these mechanical mold stripping units with the structure of automatic low-pressure casting machines intended for casting miscellaneous parts.

Thus, for example, in the frequent case of engine pistons not requiring any relief or projection cast integrally therewith on their top faces, these pistons are cast with their top faces coupled and opposed along two parallel rows of pistons disposed symmetrically on either side of a median plane. Then mechanical stripping units will be mounted in opposition to control the die elements provided for shaping the inner cavities of the pistons.

This device is adapted to be combined with a low-pressure chill-casting device described and illustrated in the U.S. Pat. Ser. No. 47,978 of June 22, 1970.

With the present device the high production rates hitherto inherent only to die-casting methods can be obtained, due to the use of multiple mold cavities and also to the automatic control of the casting and molding operations. On the other hand the low pressure to which the injected molten metal is subjected reduces considerably the wear and tear of the tools and equipments, notably the core members and spindles constituting the piston cavity molding elements. These relatively thin elements surrounded by a relatively thick body of metal are stressed both thermally and mechanically, and therefore constitute the wearing part of the die. Considering the high cost of these members having a complicated relief design and fitted with precision, the increment in their useful life by resorting to low-pressure chill-casting methods affords substantial savings in comparison with die-casting methods.

The linear arrangement of the mold cavities permits assembling the mechanical stripping units on common, sturdy and rigid supports, on which the driving and control means can be mounted without difficulty to constitute a sturdy and precision assembly adapted to withstand continuous operation conditions. Moreover, assembling the detachable mold elements on identical mass-produced control units affords a simpler and more economical construction of the mechanism while increasing its strength.

Furthermore, limiting these units to the control and actuation of two core structures corresponding to the interior of two castings eliminates any risk of wedging due to the thermal expansion of parts during the operation, thus ensuring a satisfactory operation of the mechanism under all temperature conditions.

Finally, this device ensures substantial savings in the usually lost riser, constituting a serious inconvenience in die-casting processes, in comparison with conventional gravity casting, since the only risers are the casting slot connected to the common molten-metal supply duct. This advantageous feature is further improved in the case of flat-topped pistons cast by pairs in mutual opposition, since the number of castings is doubled for an equivalent weight of sprue or riser metal implemented. In either case, and especially in the last one, the casting slot opens into the thickest zone of the casting, thus ensuring a gradual setting of the metal and improving the quality of the final casting.

In the case of equipment opening along a vertical joint with a retractable lower portion, the fall of the cluster of castings towards the discharge means will complete the completely automatic cycle of operation of the device, thus ensuring an extremely regular production. Under these conditions the operator's duty consists simply in supervising and adjusting or regulating the operating conditions.

A preferred form of embodiment of this device will now be described more in detail with reference to the attached drawings illustrating diagrammatically by way of example a piston casting unit, but it will readily occur to those conversant with the art that the invention should not be construed as being strictly limited to this application. In the drawings:

FIG. 1 illustrates an elevational and part-sectional general view of the device of this invention;

FIG. 2 shows a cluster of 4 pistons cast by using the device of FIG. 1;

FIG. 3 illustrates the device of this invention in the specific case of flat-topped pistons cast in two linear rows of pistons disposed by pairs in a single cluster;

FIG. 4 illustrates in perspective a cluster of eight pistons cast by using the device of FIG. 3;

FIG. 5 illustrates in vertical section taken along the line V—V of FIG. 6 a mechanical control unit for assembling and disassembling a five-element core unit adapted to shape the inner cavity of the piston, together with other die elements and the molten metal supply means of the device shown in FIG. 1;

FIG. 6 illustrates in section one portion of an assembly comprising two control units, i.e., one along the general section VI_1–VI'_1 and the fragmentary sections of a control socket along the lines VI_4–VI'_4 and VI_5–VI'_5, respectively, and the other in fragmentary sections along the lines VI_2–VI'_2 and VI_3–VI'_3 of FIG. 5;

FIG. 7 illustrates in fragmentary section details of a three-element core assembling head of a mechanical control unit, the section being taken along the line VII–VII' of FIG. 6;

FIG. 8 shows in sectional view details of a three-element core assembling head, the section being taken along the line V–V' of FIG. 6;

FIGS. 9 and 10 show in section constructional and operating details of a five-element core assembling head, the section being taken along the lines V–V' and VII–VII' of FIG. 6;

FIGS. 11 and 12 show the same details as FIGS. 8 and 9, respectively, but in the case of larger castings;

FIG. 13 is a sectional view taken along the line V–V' of FIG. 6 showing details of the assembling of the lateral core elements;

FIG. 14 is section taken along the line XIV–XIV' of FIG. 13;

FIG. 15 shows in section details of the assembling of the pivot means of the pivotal mounting of core elements, the section being taken along the line V–V' of FIG. 6, and

FIG. 16 is a section taken along the line XVI–XVI' of FIG. 15.

Referring first to FIG. 1, a low-pressure casting furnace 1 and its injection device 2 according to the above-mentioned patent application are associated with a fixed chill-casting half-die 3 having a plurality of mold cavities 3_1, this half-die 3 being rigid with a support 4 and a frame structure or floor 5.

Secured to a tray 6 movable on said frame structure 5 is a movable half-die 7 having a plurality of mold cavities 7_1 symmetric to mold cavities 3_1. Mounted to the base of half-die 7 is the mold bottom element 8 receiving the multiple mold cavities 8_1 adapted to shape the piston crowns or heads, and also heated insert elements 8_2 constituting the low-pressure casting duct. This bottom element 8 is movable along vertical slideways 8_3 provided on said half-die 7.

A bracket 9 mounted to the upper portion of half-die 7 carries on slideways 9_1 the mechanical control units 10 ensuring the automatic assembling and disassembling of core elements 10_1 adapted in their assembled condition to constitute the mold "core" for shaping the inner cavity of the piston during the casting process.

Mechanisms 11 for inserting and removing lateral core elements 11_1, and controlling the casting stripping members, known per se, are also arranged within the half-die 7.

In operation, after injecting the molten metal through the duct 2 and maintaining the metal pressure throughout the setting period, the control unit 10 is actuated for disassembling the core elements 10_1 by means of a cylinder and piston actuator 10_2 and then releasing these elements by raising the unit 10 along the slideways 9_1 by means of another cylinder and piston actuator 9_2. The mode of operation of this unit 10 will be described more in detail presently in the specification.

The backward movement of movable tray 6 along the frame structure 5 is attended by the opening of the mold due to the movement of the movable mold element 7 away from the fixed mold element 3, the cluster of castings remaining attached to the movable element 7.

The bottom element 8 of the mold is then released along the slideways 8_3 and the cluster of castings is gripped by a discharge clamp 11_3 and released from the mold cavities 7_1 by retracting the core members 11_1 and pushing the ejectors 11_2 by means of the aforesaid mechanism 11.

A device of the type illustrated in FIG. 1, equipped with a pair of units 10 disposed side by side, is designed for producing a cluster of four castings 12 interconnected through a duct 13 as shown in FIG. 2. As a consequence of the pre-heating of the casting duct 8_2 the quantity of injected metal depends only on the capacity of the furnace 1; in any case, the number of castings mentioned in this example concerning but a specific form of embodiment should not be construed as limiting the invention. In fact, by using a different arrangement of the means implemented by the present invention it is also possible to retract members 8 and 10 simultaneously and to insert the mechanisms 11 into the half-die 3 on which the cluster of castings 12 remains attached at the end of the casting process. Then, actuating the ejectors will cause the castings to fall into a discharge pit substituted for the clamp discharge means mentioned in the preceding form of embodiment.

In the low-pression chill-casting device illustrated diagrammatically in FIG. 3 and designed for casting pistons arranged in clusters, the pistons are disposed by pairs assembled by their tops along two rows, and the casting furnace is similarly of the low-pressure type 1 connected through a feed duct 2 to a fixed half-die 3 having mold cavities 3_1 formed therein; this fixed half-die 3 is mounted to a fixed support 4 rigid with a frame structure 5. Another half-die 3_2 rotatably movable about a shaft 3_3 completes the mold structure 3. A movable tray 6 slidably mounted on the frame structure 5 receives the other half-die 7 having a plurality of mold cavities 7_1 and equipped symmetrically with supports 9 provided with slideways 9_1. Control Control units 10 are also provided for assembling and disassembling the core elements 10_1 for shaping the inner cavities of the pistons, these units 10 being also movable along slideways 9_1.

In operation, after the molten metal has been injected through the casting duct 2 and set in the mold cavities, the control units 10 are adapted simultaneously to disassemble and retract the core elements 10_1 and then control the backward movement of tray 6 along the frame structure 5 for releasing the die section 7. Then the removal of the core elements from half-die

3 will permit the upward movement of the mold element 3_2 carrying the cluster of castings 12 by rotating through about 90° about the shaft 3_3, the gripping of said cluster by means of a handling clamp (not shown), the release thereof in relation to mold element 3_2 by means of ejectors, and finally its discharge. As an alternative solution, the mold element 3_2 may be raised separately after the removal of the core members adapted to form the piston spindle bores, the cluster of castings remaining in the mold cavities 3_1 of the fixed half-die 3 from which it is subsequently removed by ejectors so as to fall into the discharge pit.

FIG. 4 shows a cluster of eight castings 12_1 thus obtained and interconnected by a casting sprue 13, these castings being assembled by pairs and in opposition. The pistons of each pair are subsequently separated by cutting along the dash-lines 13_1. With a sprue 13 substantially equivalent to that of the example shown in FIG. 2, this solution permits the casting of twice as many pistons. The limitations of the number of castings by injection are the same as those mentioned in connection with the preceding example.

FIG. 5 illustrates a control unit 10 for assembling and disassembling five-core elements for constituting the inner cavity of two pistons disposed side by side, as well as the mold elements of the example shown in FIG. 1; in the arrangement of FIG. 5 there are a central core member 14 and two lateral core members 15 constituting in conjunction with two other lateral core members 16 (not visible in this Figure) the configuration of the inner cavity of piston 12.

The central core member 14 is rigid with a mounting head 17 permitting assembly thereof with a connecting member 18 rigid with the piston rod 19 of an actuator 10_2 controlling the mechanism. Associated with this piston rod 19 are a ring 20 and a rod 21 actuating the control means of the aforesaid actuator 9_2 at the end of the stroke of actuator 10_2.

The end of rod 19 is hollow and adapted to house a coil compression spring 22 actuating in turn a push member 23 and a rod 24 bearing against an assembly comprising two pivot members 25 so as to urge said rod against core members 15. These core members are rigid with the trunnion 26 and rack members 27 in meshing engagement with pinions 28 driven from the rack end 29 of the socket 30.

A spring-loaded ball 31 housed in a radial bore 37 in member 18 is adapted to slide along a groove 32 of socket 30. A hole 33 at the end of this groove permits, by snapping the ball 31 into it, detent-positioning the socket 30 and member 18 in the upper position of said member 18.

The actuator 9_2 is adapted to operate a slide 34 rigid with the frame structure 35 of control head 10 to raise the latter.

FIG. 6 illustrates an assembly comprising two units 10A and 10B mounted side by side on a common frame structure 9. Lateral openings 36 formed in the body 35 illustrated in unit 10B permit the access to control holes 37 and the rotation of member 18 in the socket 30 by moving the ball 31 out from its groove 32.

The unit 10A shows the relative positions of the different component elements of the mechanism at the levels of the various sections.

The different movements of the control mechanism, in the case of a three-element core unit, are illustrated in FIGS. 7 and 8. As in the preceding case the assembly comprises a central core element 14 reproducing in conjunction with a pair of lateral core elements 15 the inner shape of the cavity of piston 12. The mounting head 17 of core element 14 fits into a connecting member 18 similar to the five-element core mounting described in the foregoing, all the other component elements of the mechanism being also similar to those of the preceding example.

In operation, after the injection and setting of the casting 12, the central core member 14 is retracted by means of its operative connection 17 with the intermediate member 18 coupling said core member 14 to the piston rod 19. When the core member 14 is in position 14_a as shown in FIG. 8, the detent-positioning ball 31 (FIG. 5) having moved along the groove 32 engages the hole 33 in member 30, thus moving the latter to the upper position 30_1, the mechanism comprising pinions 28, racks 27 and shafts 26 causing the core members 15 to be released in position 15_a from the cavity of casting 12. At the end of the upward movement the rod 19 of actuator 10_2 controls through a rod 21 an electric limit switch (not shown) monitoring a solenoid-operated hydraulic valve (not shown) controlling the movement of actuator 9_2 (FIG. 5) for raising the complete unit 10 and eventually releasing the core members 15 from the cavities of castings 12.

All the sequences of movements of said actuators are obtained by using limit switches monitoring solenoid-operated hydraulic valves according to a technique well known per se.

A play of at least 2 mm is provided between the two core members 15 in position 15_a to avoid any contact between their assembling faces 15_1.

Of course, the reverse sequence of operations will reassemble the core members 14 and 15 in cavity 12 before performing another injection step. The stacking of core members on the bearing faces 38 and 39 of half-die 3 will avoid any possibility of jamming and wear by friction on the contact faces 15_1.

FIGS. 9 and 10 are sections taken along two orthogonal planes, showing the mechanism obtaining in the case of a five-element core assembly of the type shown in FIG. 5, i.e., a central core member 14 having lateral extensions 16 and covered on either side by another pair of lateral core members 15. The half-sections clearly show the relative movements of the component elements of this mechanism.

In contrast to FIGS. 9 and 10 showing a typical example of an adaptation to relatively small castings (pistons), FIGS. 11 and 12 show the same sections and the same movements in the case of larger castings, in order to illustrate the adaptability or flexibility of the mechanism.

FIG. 13 shows in detail the assembling of the lateral core elements 15 with the shafts 26 and racks 27. FIG. 14 shows the locking action resulting from the engagement of dovetailed ends of core members 15 in racks 27 and the wedging thereon by the bevelled ends of shafts 26.

FIG. 15 illustrates the detail of the assembling of pivot means 25 of core members 16 with the central core member 14. The members 25 assembled by a common shaft **40** are urged against the bottom 14_a of the central opening of core member **14** by the pressure exerted on rod **24** through the assembling head **17** by push member **23**. FIG. **16** shows the assembly of the lateral core members **16**, pivotally mounted on shafts **41**, with the pair of pivot members **25** engaging the shafts **41** and assembled by means of a central pin **40**.

In operation, in the case of a five-element core assembly as shown in FIGS. **9** to **12** inclusive, after the injection and setting of the molten metal to form the castings **12** the central core member **14** is retracted by the action of piston rod **19** of actuator 10_2 exerted on the connecting member **18** and on the mounting head **17**. When the core member **14** has moved from position 14_b to position 14_c, it engages and pushes the rounded studs 16_1 of core members **16** to pivot these members about the shafts **41**, thus freeing the ends of these core members and moving same from position 16_a to position 16_b.

The face 14_1 of the central rectangular opening of core member **14** then engages the members **25** and carries along the core members **16** during its release movement. Then, the snap engagement of ball **31** (FIG. **5**) into hole **33** of socket **30**, after its movement along the groove **32**, will move the member **30** and release the lateral core members **15** according to the same process as in the case of a three-element core already explained hereinabove. As core member **14** moves to position 14_a (see half-section of FIGS. **9** to **12**) the core members **15** move from position 15_a to position 15_b, thus permitting the final release of the assembly under the control of actuator 9_2.

The rotation of member **18** by means of the control holes **37**, as a consequence of the disengagement of ball **31** from its groove **32** will permit of positioning the member **18** in alignment with the opening **36** (FIG. **6**) and also with the lateral opening **42** (FIG. **5**) of socket **30**. Under these conditions, the member can be released laterally along the T-sectioned fitting grooves formed in the piston rod of actuator **19** and of assembling head **17**, so that the central core member **14** can be retracted. The core members **15** are disassembled beforehand through the backward movements of shafts or pivot pins **26**, and the core members **16** are disassembled by the lateral removal, through openings **42** and **36**, of shaft **40** and members **25**. With this combination it is possible to replace the core member assemblies very rapidly, for instance in case of failure or damage, or when changing the type of tool, so that the control units **10** constitute standard mounting heads adaptable to a great number of combinations and applications.

We claim:

1. An automatically operated multiple cavity die device for low pressure casting, comprising:
   - a chill-casting mold comprising two half-dies, one of said half-dies being fixed and the other of said half-dies being movable, both half-dies having an even numbered plurality of mold cavities therein aligned in a joint plane of said half-dies;
   - a casting feed duct communicating with the mold cavities in the fixed half-die;
   - injection means for injecting material into said mold cavity through said feed duct;
   - means for moving the movable half-die toward and away from the fixed half-die;
   - retractable core members oriented for entry into said mold cavities substantially along said joint plane of said half-dies;
   - automatic core assembly means for performing assembling and disassembling movements of said core members in a pair of two mold cavities, said core assembly means including only one piston actuator for actuating said assembly.

2. A device according to claim **1**, additionally comprising ejection means on the movable half-die, and an automatic handling clamp for discharging clusters of castings from said movable half-die.

3. A device according to claim **1**, additionally comprising ejection means on the fixed half-die, for discharging castings into a discharge pit after stripping and retracting the other half-die and the core members.

4. A device according to claim **1**, wherein the half-dies define engine piston castings disposed symmetrically by pairs in opposition with joined heads, two symmetrical rows of automatic core assembly means being provided for actuating the core elements adapted to shape the inner cavities of said pistons, the fixed half-die comprising a pivoting portion for clearing the casting duct.

5. A device according to claim **1**, wherein the actuator associated with the automatic core assembly means has the end of a piston rod connected to an intermediate connecting member rigid with a central core member of the device.

6. A device according to claim **5**, wherein the automatic assembly means comprises a socket also movable in translation along the axis of said actuator, said connecting member being slidably mounted in said socket and held against rotation by a spring-loaded ball sliding in an inner groove formed in said socket and provided at its end with a hole for locking said socket against translation in relation to said intermediate connecting member.

7. A device according to claim **6**, wherein the socket has an end portion formed with rack teeth in meshing engagement with pinions driving other rack means assembled by dovetail fitting and lock pins to lateral core elements of the device.

8. A device according to claim **1**, wherein a five-element core structure is provided for shaping the inner cavities of castings, comprising two core elements constituting extensions of a central core element, said extensions mounted on pivot members, a rod urged against said pivot members by a push member and a spring enclosed in a hollow end portion of the piston rod of said actuator, and cam faces provided on said central core element for rocking said extensions by engaging rounded studs pivotally mounted on pins.

9. A device according to claim **6**, wherein said socket and a frame structure of said automatic assembly means are formed with lateral openings for disassembling said connecting member.

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