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EUROPEAN PATENT APPLICATION

21 Application number: **88115342.3**

51 Int. Cl.4: **B22D 27/11**

22 Date of filing: **19.09.88**

30 Priority: **05.10.87 IT 2214887**

43 Date of publication of application:
07.06.89 Bulletin 89/23

64 Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI LU NL SE

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54 **Process for casting molten metal, in particular aluminium alloys and magnesium alloys, and device for its execution.**

57 Process for casting molten metal, in particular aluminum alloys and magnesium alloys, and device for its execution. The process comprises in succession the steps of: casting molten metal in a molding cavity (13) and in at least one chamber (12) communicating with the cavity and arranged below it, pressure feeding the molding cavity completing its filling and at the same time pressure feeding the chamber in the solidification step, performing a high-pressure compression on the metal during the solidification step from the upper side of the molding cavity, extracting the cast part from the molding cavity.

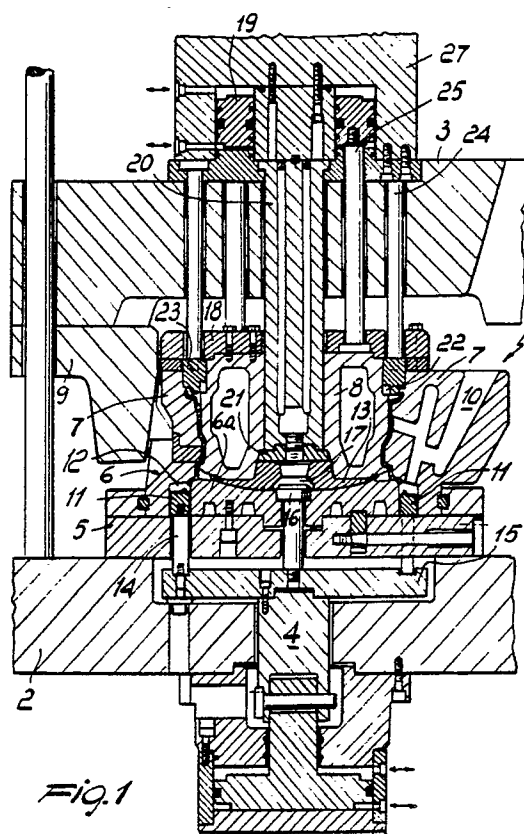


Fig. 1

EP 0 318 655 A2

PROCESS FOR CASTING MOLTEN METAL, IN PARTICULAR ALUMINUM ALLOYS AND MAGNESIUM ALLOYS, AND DEVICE FOR ITS EXECUTION

The present invention relates to a process for casting molten metal, in particular aluminum alloys and magnesium alloys, and to the device for its execution.

Various systems are known for manufacturing molded objects in aluminum and/or in magnesium and related alloys by casting in metallic dies, among which one of the most common is, for example, gravity casting, wherein the metal is cast into the die without feed pressure so that the pressure required for the correct feed of the casting is created by means of risers. Another system is low pressure casting, which allows a feed pressure through the runner not exceeding approximately 0.6 bar; this pressure is exerted on the surface of the liquid contained in the furnace. Another system in widespread use in this field is pressure die-casting, wherein the alloy is injected into the die under high pressure.

Other systems in use are counter-pressure casting, which is in practice a derivation of low pressure casting, and centrifugal casting, wherein the die is rotated during the casting.

There is also the system termed "squeeze casting", which consists of filling part of the die with a certain amount of liquid aluminum and of subsequently introducing the male element of the die in the die itself.

These casting systems, which are variously used according to the type of object to be obtained and to the alloy employed, do not always have optimum characteristics from the production and/or mechanical point of view.

For example, with pressure die-casting the aluminum or magnesium alloy tends to include a certain percentage of air/gas, due to the high injection speed which does not allow all the air contained in the die to evacuate, with the result of creating fragile regions in the finished part since the structure remains under tension due to micro-particles of gas embedded in the molten metal.

On the other hand, gravity casting provides a material free from internal tensions, but has a low productivity and provides casting with lower structural compactness, with consequent microporosity of the structure; the low productivity is due to the long cooling time of the aluminum or magnesium alloy inside the die, while the non-compactness of the structure and its microporosity are essentially due to the fact that during the step of solidification of the material the same is fed by risers which normally cannot have considerable dimensions due to the costs of casting and therefore the feed

created by small-size risers does not give a correct casting feed.

The aim of the present invention is to provide a casting process for aluminum alloys and magnesium alloys and a device for its execution, capable of providing a casting with mechanical characteristics superior to those obtained with other systems currently known on the market, together with an increase in the productivity of said system.

Within the scope of this aim, an object of the invention is to provide a system wherein the die can be used for a much greater hourly production than conventional systems, with obvious advantages in terms of costs and production times.

Another object of the invention is to provide a device for the execution of the system which is constructively simpler and therefore more economical than the corresponding known machines, this in relation to the hourly production rate provided, though it provides parts with superior mechanical characteristics.

This aim, as well as these and other objects which will become apparent hereinafter, are achieved by a process for casting molten metal, in particular aluminum alloys and magnesium alloys, characterized in that it comprises in succession the steps of: pouring molten metal in a molding cavity and in at least one chamber communicating with said cavity and arranged below it, feeding said molding cavity under pressure completing its filling and at the same time pressure feeding said chamber in the solidification step, performing a high-pressure compression on the metal during the solidification step from the upper side of said cavity, and extracting the cast part from said cavity.

The process according to the invention can be executed by means of a device comprising a casting die-holder structure defining a molding cavity, characterized in that it comprises one or more lower chambers connected to said cavity and arranged below said die, said chamber comprising first feed and compression means for pressure feeding said metal inside the molding cavity.

Further characteristics and advantages of the invention will become apparent from the description of a preferred but not exclusive embodiment of the process according to the invention and of the device for its execution, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figure 1 is a lateral elevation sectional view of the device for the execution of the process according to the invention, provided with a die for car wheels;

figure 2 is a schematic sectional lateral elevation view of the device during the casting step, in this case performed by tilting the device itself;

figure 3 is a similar view of the device during the step of pressure feeding;

figure 4 is again a similar view of the device during the final compression step;

figure 5 is an enlarged detail view of a pressure feed element;

figure 6 is another enlarged detail view of a compression element;

figure 7 is a plan view of the die applied to the device; and

figure 8 is a schematic lateral elevation view of one of the die actuation cylinders.

With reference to the above described figures, the process according to the invention substantially consists of pouring molten metal, in particular aluminum alloys or magnesium alloys, into a die 6 through a runner 10, preferably tilting the die 6 initially and slowly returning it upright during its filling.

The die 6 is connected to a lower chamber 12 which is also filled with molten metal and in which there slides a pressure feed element which is actuated immediately after the filling step or before the same is completed. The pressure feed element 11 compresses the molten metal inside the molding cavity, filling it completely with a relatively high pressure and at the same time with a sufficiently slow motion of the pressure feed element so that the gas contained in the molten metal can escape through appropriate vents arranged above the molding cavity.

Once the molding cavity has been completely filled under pressure and while the metal is in a pasty state, the part is subject to further pressure by means of an upper pressure element 23, 21. This pressing action is performed with a relatively high speed by the upper pressure element. Once the solidified-part temperature has been reached, the die 6 is opened, first extracting the male element 8 of the die with the same means which actuate the upper pressure element.

Then the half-shells 7 of the die 6 open and then the finished part is expelled, advantageously using the pressure feed element 11 as extractor.

For the execution of the process according to the invention it is possible to use a device, generally indicated by the reference numeral 1, comprising: a lower die-holder structure 2, only partially illustrated, an upper die-holder structure 3, a lower hydraulic cylinder 4, a die base 5 on which the die 6 rests; the die 6 is in turn constituted by the base 6a, by two half-shells 7 and by a male element 8, the two half-shells 7 are actuated by two cylinders 26 and 26a, the upper die-holder structure is ac-

tuated by a cylinder 27 or by other systems such as e.g. gripping toggles, rack screws, etc.

The die illustrated in the figures is used to manufacture wheels for cars, but it may be any other die depending on the part to be obtained.

The male element 8 is associated with the upper die-holder structure 3 with which there are associated the wedge-like elements 9, which prevent the opening of the die during the pressure feed and compression step of the two half-shells 7, this occurring when the cylinder 27 is actuated at high pressure as will be described hereinafter.

In a first step of filling the molding cavity 13 of the die 6, molten metal is poured in a runner 10 provided in the half-shells 7 which are actuated by the cylinders 26 and 26a; advantageously the machine may be rotatable, in a known and not illustrated manner, about a horizontal axis, preferably passing through the inlet of the runner 10, so as to avoid changing the filling point of the die as described hereinafter.

Below the die 6 there is a pressure feed element slideable vertically with respect to the die base 5 and controlled by the lower cylinder 4. The pressure feed element is, in this case, advantageously constituted by a plurality of pistons slideable in an axial direction within related lower chambers provided at the die base 6a and connected to the molding cavity 13. The pressure element may also have other configurations depending on the type of part to be manufactured, e.g. it may be constituted by a series of cylinders arranged in generally perimetral regions of the die and actuated with systems different from the cylinder 4, e.g. rack screws, gripping toggles, etc.

The pressure feed element 11 is connected to the lower cylinder 4 by means of rods 14 which pass through the die base 5 and connect the pressure feed element 11 to a plate 15 fixed to the upper part of the cylinder 4.

Advantageously, the pressure feed element also comprises a lower piston 16 arranged along the central axis of the lower cylinder and also associated with the plate 15. The piston 16 slides within a lower cylindrical chamber 17 arranged below the molding cavity 13.

The upper die-holder structure 3 controlled by the cylinder 27 comprises a movable support 18 which is slideable with respect to said structure and is controlled by a hydraulic device 19 by means of the rods 25; the movable support 18 downwardly supports the male element 8 and delimits its closure stroke by means of a mechanical stop on the two half-shells 7; this is obtained with the cylinder 27 actuated at low pressure. This system allows to obtain: the extraction of the male element 8 from the casting and a compression on the metal with the cylinder 27 at high pressure by

means of the rods 24 and the central piston 20 during the solidification step. The movable support 18 and the male element 8 have a cylindrical seat at the central axis within which the piston 20 is slideably arranged and is rigidly associated with the upper structure 3. The piston 20 has an end 21, shaped according to the part to be obtained, which completes the male element 8 in the central region and is movable with respect to said male element.

Between the male element 8 and the two half-shells 7, at the upper perimetral edge of the molding cavity, one or more upper chambers 22 are provided and are occupied by related pistons 23, slideable along the vertical axis, within the chamber 22 and rigidly associated, by means of the rods 24, with the upper structure 3. The pistons 23 may be replaced with an element having a different configuration according to the shape of the die and be arranged in a different form.

The casting process is performed as follows: initially the device ready for casting has the two lateral half-shells 7 closed, the upper structure 3 actuated by the cylinder 27 lowered at low pressure, the male element 8 which closes the die 6 in the lower position relatively to the cylinder 19 and the lower cylinder 4 also in the lower position as illustrated in figure 1; naturally the molding cavity 13 and the chambers 12, as well as the chambers 22, are empty.

The device may be rotated to be arranged along a more suitable angle to perform the correct filling of the die (figure 2); at this point the molten metal is poured into the molding cavity through the runner 10 in the required amount.

During the filling step, the machine rotates back to a vertical position; this rotation of the device is preferably performed simultaneously with the operation of pouring molten metal and for this purpose, advantageously, the horizontal axis of rotation coincides with the inlet of the runner which determines the stop of the amount of aluminum to be poured into the die.

The lower cylinder 4 is actuated and, with a slow adjustable motion, pushes upwards the pistons 11 and the lower piston 16 which push the molten metal, respectively present in the chambers 12 and in the lower chamber 17, into the molding cavity, completing its filling, if required, and simultaneously performing the compression of the liquid aluminum inside the casting, as illustrated in figure 3.

This feed step provides the filling of the molding cavity at a relatively high pressure but at the same time with a movement of the lower cylinder which is slow enough to allow the feed of the casting in the solidification step to compensate any shrinkage; appropriate vents, arranged on the upper part of the die, are furthermore provided for the

escape of gases within the molding cavity.

It should be noted that the feeding step may be performed simultaneously with the casting step, e.g. the upward movement of the lower cylinder 4 can begin simultaneously with the pouring of the molten metal and with the machine's rotation.

The pressure feed may also begin, always by means of the cylinder 4, a few seconds before the machine has completely rotated back to its vertical position.

Once the filling in the molding cavity is complete, and with the metal in a pasty state, the part is subject to a further compression pressure with the piston 27 at high pressure by means of the pistons 23 and the end 21 of the upper piston 20, as illustrated in figure 4.

The compression is performed by actuating the piston 27 of the upper cylinder as described above at high pressure, causing the downward motion of the assembly of the pistons 23 and of the piston 20, while the male element 8 which is slideable relatively to the piston 20 and to the upper support 3 is kept motionless.

Once the solidified-part temperature is reached, the machine is ready to perform the step of extraction of the die parts from the casting and this occurs as follows:

first step: separation of the male element 8 from the casting by actuating the cylinder 19 upwards;

second step: spacing of the upper structure 3 which bears the male element 8, the piston 20 and the movable support 18, by actuating the piston 27 of the upper cylinder;

third step: opening of the two half-shells 7 by means of the two cylinders 26 and 26a.

The extraction of the part from the base of the die is performed by the pistons 11 and 16; in fact the lower cylinder 4 is again actuated to raise the pistons 11 and the piston 16 which push upwards the finished part, which can be gripped in a known manner and expelled from the device.

At this point the casting has been executed and the machine is ready to perform a new casting; the two half-shells 7 close again by means of the cylinders 26 and 26a, the piston of the upper cylinder 27 is lowered, moving the male element 8 between the half-shells 7, and similarly the wedges 9 are at the two half-shells 7, the cylinder 4 is lowered and so is the cylinder 19, as illustrated in figure 1.

It has thus been observed that the process according to the invention allows to obtain parts, in particular in aluminum alloy and magnesium alloy, with superior mechanical characteristics and with high productivity with respect to known systems and is therefore more economical; the method furthermore provides a much more compact casting and almost entirely free from microporosity.

In fact the step of feeding through a lower pressurized chamber, due to the high pressure, allows to obtain: a correct filling of the die, a greater compactness of the casting, as well as a greater resistance of the casting itself and a shorter cooling time, this as a consequence of the pressure exerted on the metal, which reduces the intermolecular distance of the structure of the casting. At the same time blowholes inside the cavity 13 are avoided since the filling of the die occurs slowly, and microporosities and blowholes due to the solidification step are avoided as the casting is fed, in this step, by pressurized liquid aluminum arriving from the chambers created by the pistons 11 and 16.

The reduced cooling time leads to an increase in the number of parts produced per time unit due to the reduced permanence time of the casting in the die.

This leads to another important advantage, which resides in a longer life of the die; in fact it is known that liquid aluminum creates a chemical reaction with the die which is normally made of steel or cast iron so that the longer the permanence time of the molten metal within the die the shorter the life of said die.

Another advantage is due to the fact that the extraction of the part is performed avoiding the installation of further extractors, using the lower pistons 11 and 16 which furthermore exert a distributed action along the entire perimeter of the part, eliminating the danger of deformation thereof due to the action of localized forces.

Not least advantage resides in the fact that the piston of the upper cylinder 27, besides performing a normal die closure and opening function, also performs the final compression of the metal in the solidification step; in fact this function is at low pressure to obtain the closure of the die and at high pressure for compression.

The device according to the invention furthermore has considerable versatility in use, as the number of elements to be replaced to adapt it to different die shapes is limited.

Another important advantage is finally due to the fact that the device has a relatively low cost, combined with high productivity, by virtue of its constructive simplicity.

Another important advantage of the system resides in that it allows to use a single furnace to feed a plurality of machines.

The process thus conceived, as well as the device for its execution, are susceptible to numerous modifications and variations, all within the scope of the inventive concept; furthermore all the details may be replaced with technically equivalent elements. For example, the upper and lower hydraulic cylinders illustrated in this embodiment may

be replaced with mechanical actuation means, such as e.g. gripping toggles, rack cylinders, screws, etc.

In practice, the materials employed, as well as the dimensions, may be any according to the requirements and to the state of the art.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

Claims

1. Process for casting molten metal, in particular aluminum alloys and magnesium alloys, characterized in that it comprises in succession the steps of: pouring molten metal in a molding cavity (13) defined in a die (6) and in at least one chamber (12) communicating with said cavity and arranged below it, pressure feeding said molding cavity completing its filling and at the same time pressure feeding the chamber in the solidification step, performing a high-pressure compression on the metal during the solidification step from the upper side of said molding cavity, extracting the cast part from said molding cavity.

2. Process according to claim 1, characterized in that said step of pouring molten metal into said molding cavity (13) is performed slowly and by initially tilting said die (6) and subsequently straightening it.

3. Process according to claim 1 or 2, characterized in that said pressure feeding step starts before the end of said step of pouring molten metal into said molding cavity (13) and chamber.

4. Process according to claim 1 or 2, characterized in that said pressure feeding step begins at the end of said step of pouring the molten metal into said molding cavity (13) and chamber (12).

5. Device for casting molten metal, in particular aluminum alloys and magnesium alloys, comprising a casting die-holder structure (2,3) defining a molding cavity (13), characterized in that it comprises at least one lower chamber (12) communicating with said cavity and arranged downwardly to said die (6), said chamber comprising first pressure feed and compression means (11) to exert a pressure on said metal within said molding cavity.

6. Device according to claim 5, characterized in that it comprises second compression means (23) arranged above said molding cavity to exert pressure within said molding cavity.

7. Device according to claim 5, characterized in that said first feed means comprise peripheral piston elements (11) axially slideable in said lower chamber (12) communicating with said molding cavity (13) and a first piston element (16) arranged substantially along the central axis of said die (6) and below the same, first actuation means (4) being provided for said first compression means.

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8. Device according to the preceding claim, characterized in that said peripheral piston elements comprise a plurality of peripheral pistons slideable in related chambers arranged below said die.

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9. Device according to the preceding claims, characterized in that said second compression means comprises a plurality of upper pistons (23) axially slideable in related upper chambers (22) defined above said molding cavity (13) and communicating therewith, and a second piston element (20) arranged substantially along the central axis of said die (6) and above the same, second actuation means being provided for said second compression means.

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10. Device according to the preceding claims, characterized in that said second actuation means (19,25) are connected to a male die element (8) defining the upper region of said die (6), said second actuation means acting on said male element allowing the extraction of the male element from the finished part.

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11. Device according to the preceding claims, characterized in that said first feed and compression means (11) are adapted to expel the finished part when said die (16) is open.

12. Device according to the preceding claims, characterized in that said second and first actuation means are respectively constituted by at least one piston of an upper cylinder (3) and by a lower cylinder (4).

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13. Device according to the preceding claims, characterized in that said male die element (8) is connected to said second actuation means (27) by means of third actuation means (19) adapted to allow a sliding of said male die element (8) relatively to said second compression means (23) in a substantially vertical direction.

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14. Device according to claim 8, characterized in that said third actuation means are hydraulic.

15. Device according to one or more of the preceding claims, characterized in that said first pressure feed and compression means comprise a first ring-like element axially slideable in said lower chamber having a substantially annular configuration.

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16. Device according to one or more of the preceding claims, characterized in that said second compression means comprise a second ring-like

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element slideable in said chamber substantially having an annular configuration.

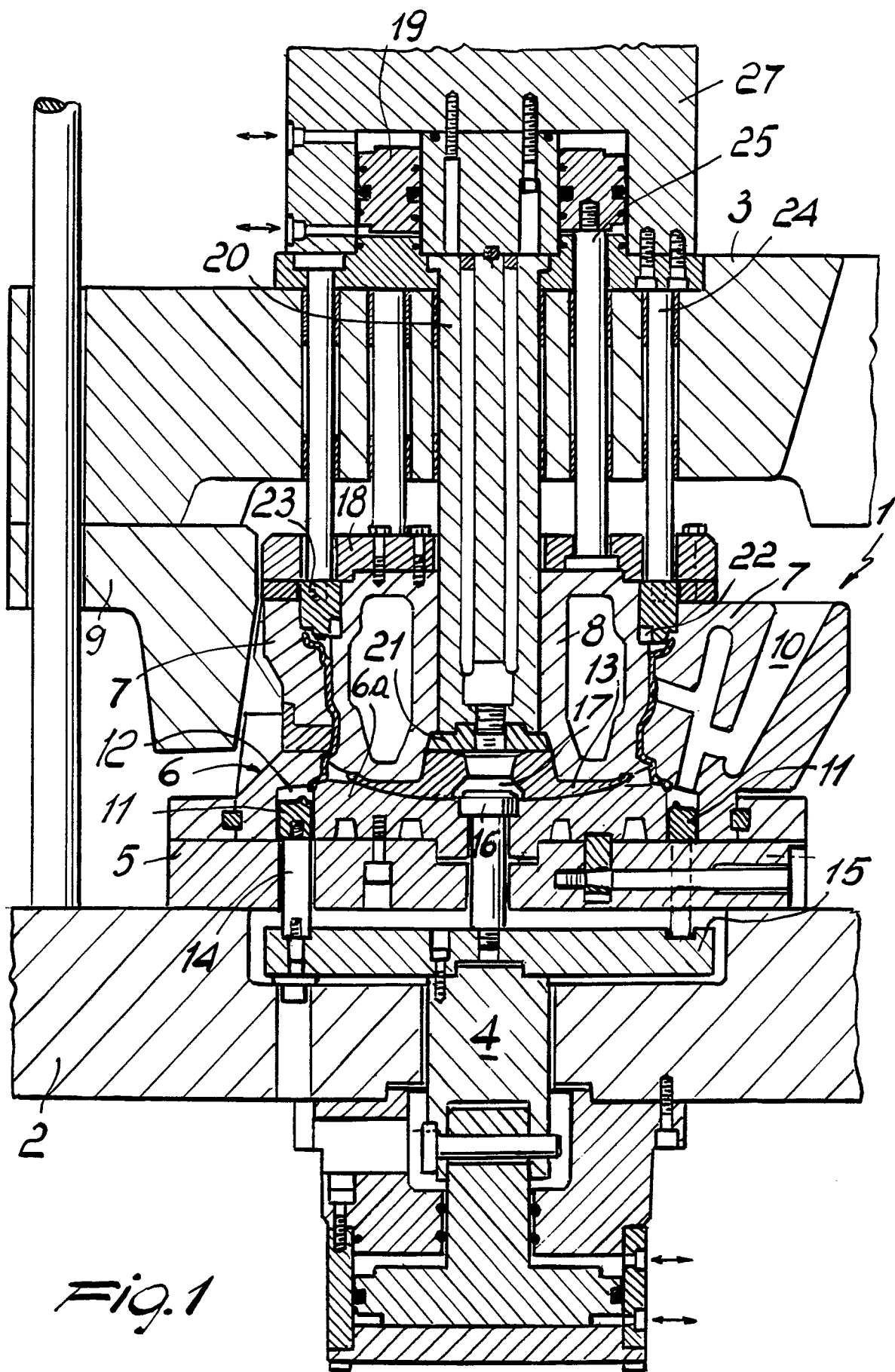


Fig. 1

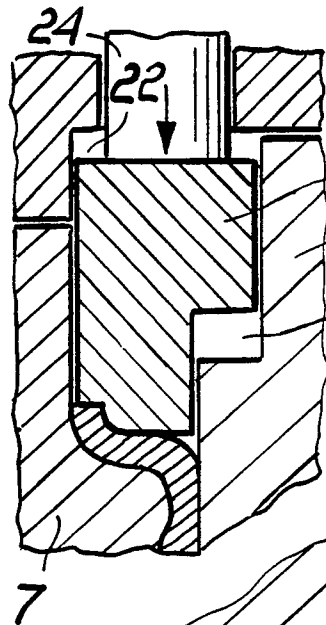


Fig. 6

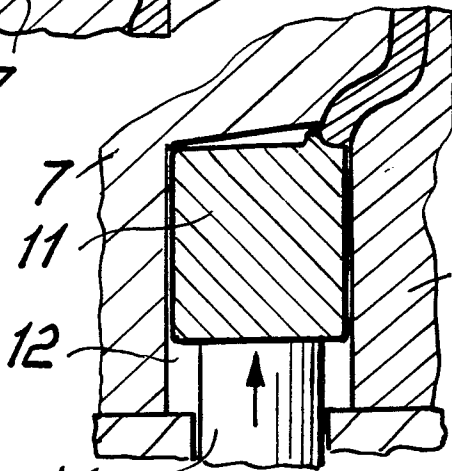
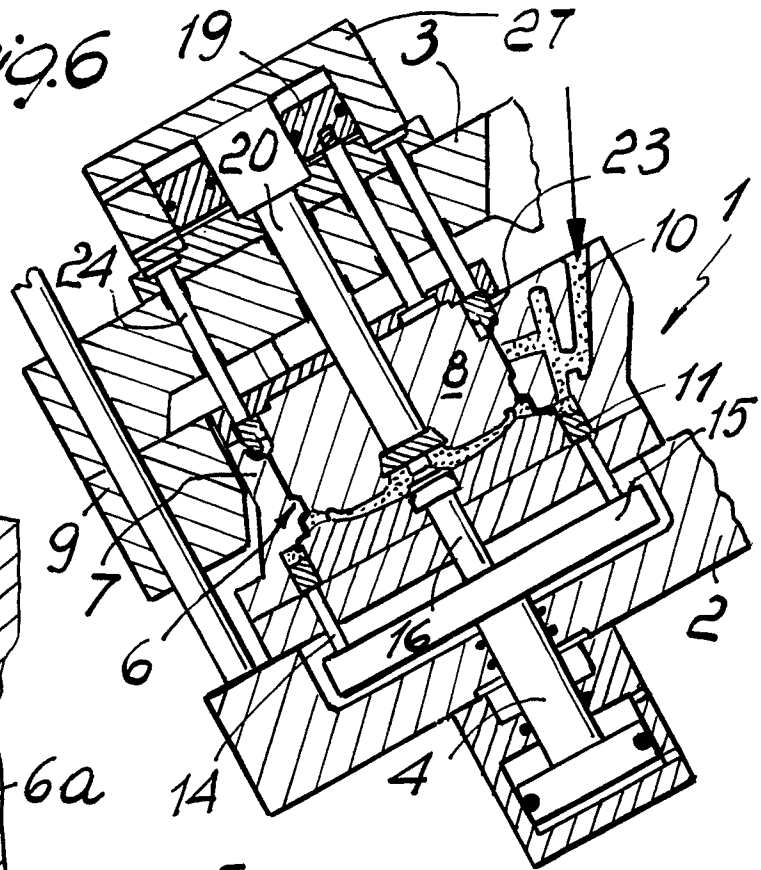


Fig. 5

Fig. 2

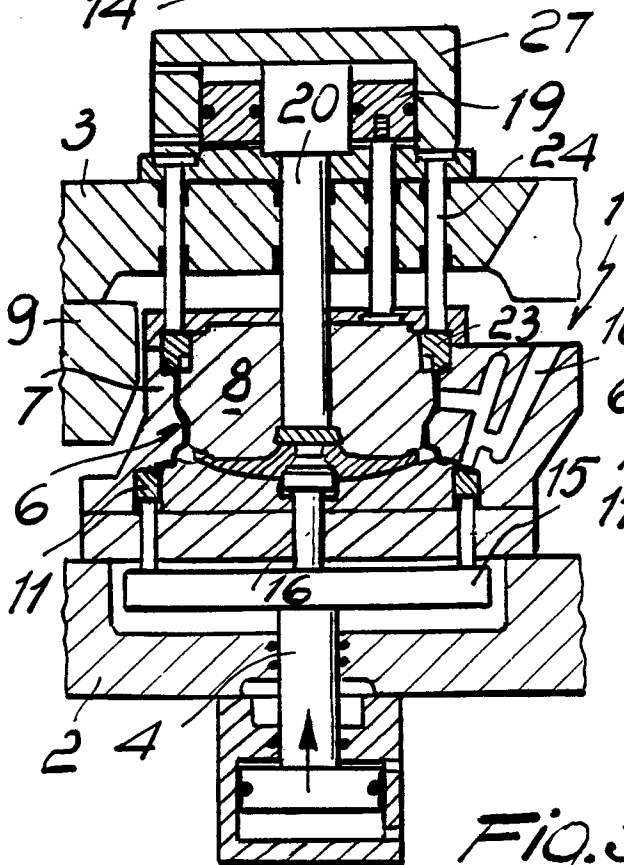


Fig. 3

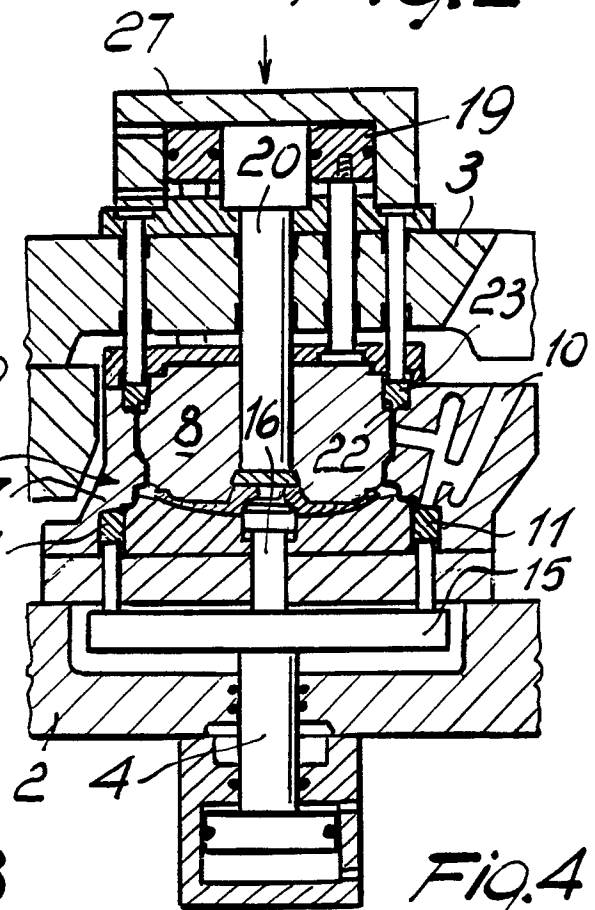


Fig. 4

