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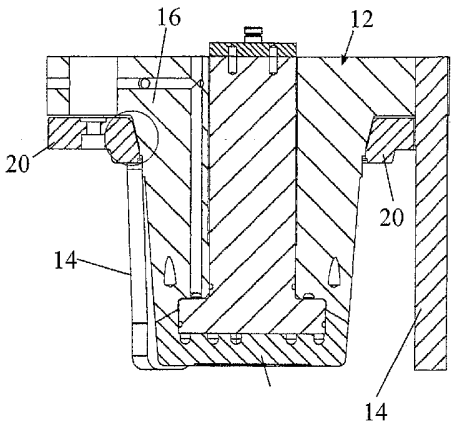
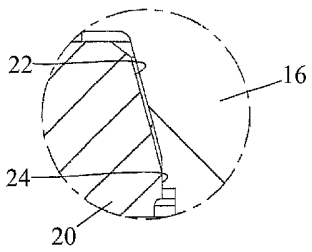
(54) Title: INJECTION COMPRESSION MOULDING





(57) Abstract: A mould for injection compression moulding of an article, comprises a female mould part (10) and a core (16) for mounting in use on the platens of an injection moulding machine for movement towards and away from one another between an open and a closed position. A sealing ring (20) surrounds the core 16 for effecting a seal between the female mould part (10) and the core (16). The core (16), the female mould part (10) and the sealing ring (20) together define a closed mould cavity as the core approaches the closed position. In the invention, the sealing ring (20) has a tapering surface (22) that seals against a tapering surface (26) on the core (16) only after the core has reached the closed position, leaving a venting clearance between the tapering surfaces (24, 26) of the sealing ring (20) and the core (16) as the core (16) approaches the closed position.

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INJECTION COMPRESSION MOULDING

Field of the invention

The present invention relates to injection-compression moulding and is concerned in particular with an improvement of the mould described in PCT Publication WO02/058909.

Background of the invention

In the injection-compression moulding technique to which the present invention relates, an accurately measured quantity a plastics material is injected into a mould cavity before it has been fully closed. As the parts of the mould are brought together, the injected plastics material is compressed and made to fill the cavity by the force applied to close the mould rather than by the pressure applied to inject the plastics material into the mould. As a consequence, it is possible to achieve much higher length to thickness ratios than achievable by conventional injection moulding, even when using lower cost plastics materials having high viscosity. This enables the technique to be used in the manufacture of such items as cups and margarine tubs which have hitherto needed to be manufactured by other methods, such as by vacuum or pressure forming of a heat softened sheet material. A further advantage is the greatly reduced cooling times due to lower processing temperatures and improved packing allowing for faster heat loss through the cavity (conventionally 70% of the heat loss is expected through the core due to shrinkage away from the cavity wall).

WO02/058909, which is believed to represent the closest prior art to the present invention, describes a mould for mounting between the platens of an injection moulding machine for injection compression moulding of a thin walled article. The mould comprises a female mould half mounted on

the stationary platen of a moulding machine and a pressure plate which is mounted on the moving platen and carries a core for closing the mould (there is no reason why these two parts cannot be interchanged if desired). The core passes through, and is sealed relative to, a cylindrical bore in a rim closure ring, arranged between the female mould half and the pressure plate. In use, as the pressure plate is advanced towards the stationary mould half, the rim closure ring is used to seal the mould cavity before the core reaches its end position. Thus, when the plastics material is injected into the mould cavity, it is fully sealed even though the core has yet to be fully advanced into the mould to reduce its volume to its smallest size.

It has been found in practice, however, that it is difficult to form a rim closure ring with a cylindrical bore that effectively seals around the core and yet allows the core to pass freely through it. The clearance required to permit reliable and free movement of the core relative to the rim closure ring does not permit creation of a perfect seal and results in an unacceptable witness line around the rim of the moulded article.

Summary of the invention

With a view to mitigating the foregoing disadvantage, the present invention provides a mould for injection compression moulding of an article, comprising a female mould part and a core movable relative to one another between an open and a closed position, and a sealing ring surrounding the core for effecting a seal between the female mould part and the core, the core the female mould part and the sealing ring together defining a closed mould cavity when the core is in the closed position, characterised in that the sealing ring has a tapering surface that seals against a tapering surface on the core only after the core has reached the closed position, there being a venting

clearance between the tapering surfaces of the sealing ring and the core as the core approaches the closed position.

The material that is to be moulded is conventionally a molten thermoplastic material. It should however be clear to the person skilled in the art that the invention will also find application in moulding molten metals, resins and thermosetting materials. Indeed the material can be any material that is initially sufficiently fluid to be capable of being injected and that will subsequently harden, be it by cooling, heating or chemical curing.

In the present invention, the purpose of the tapering surface of the sealing ring that seals against the core is to maintain a gap between the core and the sealing ring until the mould is fully closed allowing free movement of the sealing ring relative to the core. This is to be contrasted with tapering surfaces provided on sealing rings for alignment purpose, as exemplified by US 6,500,376, where the surfaces meet and leave no gap between them before the mould cavity is fully closed.

The term "sealing ring" is not, of course, to be construed in the present context to be restricted to a circular ring, as its outline will in each case be dictated by the outline of the article to be moulded.

Preferably, the angle of taper measured relative to the direction of movement of the core is small, typically less than 5°, so that only a small gap is present between the core and the sealing ring during the last few millimetres of movement of the core. The width of the small gap that remains as the core approaches the closed position will not allow the injected material to penetrate into it but allows air to escape from the mould cavity.

Because air can escape from the cavity at any time before it is fully closed, it is possible to dispense entirely with the venting gaps that are normally required when injection or injection-compression moulding an article. The ability to dispense with venting gaps has many important advantages. First, because gas has to escape through a vent that is too small to allow the injected material to flow through it, it is heated to a high temperature with the result that the venting gaps require extensive maintenance and can reach a sufficiently high temperature to scorch the plastics material. Second, the back pressure resulting from pumping air through the venting gaps reduces the speed of movement of the injected material and the filling speed of the mould.

The sealing ring is preferably mounted on the core by a connection that allows it a limited degree of movement relative to the core and the sealing ring is urged by at least one of a spring and gas pressure in a direction to increase the size of the gap between tapering surfaces.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which :

Figure 1 is a perspective view of a female mould part looking into the mould cavity,

Figure 2 is a perspective view of a core part to fit into the female mould part of Figure 1,

Figure 3 is a perspective view of the two mould parts of Figures 1 and 2 in the closed position of the mould,

Figure 4 is a section through the core part of Figure 2,

Figure 5 shows part of the section of Figure 4 drawn to an enlarged scale, and

Figure 6 is a section through the mould when in its closed position.

Detailed description of the preferred embodiment

The figures show a single core/cavity set for an injection-compression mould for making an article in the form of a drinking cup having a generally flat base, a frustro-conical side wall and a lip in the form of an inverted "U" surrounding the mouth of the cup. It will be appreciated that the core cavity/set may be one of many in a multi-cavity mould and that the different sets can be arranged side by side and/or stacked back to back. The ensuing description will, however, be refer for simplicity to a single cavity mould.

The mould comprises a female mould part 10 and a core part 12 which fit into one another in the manner shown in Figure 3 to leave between them a mould cavity having the desired shape of the drinking cup to be moulded.

In conventional injection moulding, articles are moulded by first fully closing the mould. Next a plastics material is injected into the mould cavity to fill it completely. After the plastics material has been allowed to cool sufficiently, the mould is opened, the moulded article is ejected and the cycle is repeated. The above technique however places a limitation on the length to thickness ratio of the moulded article. The minimum wall thickness that can be achieved varies with the viscosity of the plastics material and even to produce an article having greater wall thickness than is necessary for the structural integrity of the moulded article requires the use of more expensive low viscosity plastics materials.

By contrast, in injection-compression moulding, at the end of the injection of the plastics material the core is

not in the fully closed position of the mould cavity. As the core is advanced towards the closed position, the injected plastics material is forced to fill the mould cavity. The plastics material is made to flow by the compression of the mould cavity rather than by the injection pressure and this has many advantages that are documented in the prior art.

Injection-compression moulding does however present certain problems that are not encountered in conventional injection moulding. The first of the problems is concerned with the alignment of the mould parts. Conventionally, conical mating surfaces are provided on the different parts of the mould which centre them relative to one another when the mould is fully closed. However, before the mould is fully closed, the mould parts may not be fully aligned, that is to say they not be concentric or they may not be co-axial. The guiding that is achieved by the tie bars, or other guiding systems used by machine manufacturers of the injection moulding machine, may not guarantee alignment to the required accuracy, especially when it is noted that the main purpose of using injection-compression moulding is to achieve very large flow length to thickness ratios in articles such as cups, margarine tubs or dustbins.

To overcome these problems, in the illustrated embodiment of the invention three flat guide fingers 14 are firmly secured to the core part 12 to surround the central mould core 16 in accurately predetermined positions. Each of the guide fingers 14 has two parallel sided locating sections. One pair of locating sections 14a is provided near the base of each guide finger 14 and the other pair 14b is provided at its free end. The width of the locating sections 14a exceeds the width of the locating sections 14b. The portion of each guide finger in between the locating sections 14a and 14b is shown as tapering gradually, but it may have any shape provided that its width never exceeds the width of the locating sections 14a. Mating parallel locating

sections 18a and 18b are provided as part of U-shaped recesses defined by inserts 18 similarly secures to the female mould part 10.

In use, the mould parts that is not connected to the injection system, usually the core part 12, is mounted in such a manner as to allow it a small degree of lost motion relative to its machine platen. Strong spring pressure is used to retain the mould part in position but, if sufficient force is applied to it, the mould part will move laterally.

The first time the mould is fully closed, the fingers and inserts may not mate perfectly with one another and this will apply a force to the core part to push it into alignment with the female mould part. When the mould is then closed fully, the parts of the mould are brought into perfect alignment with one another in the conventional manner. During subsequent operating cycles, the locating sections 14a and 14b will interact with the surfaces 18a and 18b before the mould is fully closed and will effect in two different and axially separated planes any minor relative displacement of the mould parts that is necessary to assure correct alignment of the mould parts both in terms of concentricity and parallel alignment before the mould is fully closed.

Even though the guide fingers 14 and the inserts 18 ensure the concentricity of the mould parts at both ends of the mould cavity, they do so without the use of locating sections having an axial length matching that of the mould cavity. Instead, no force is applied to align the mould parts until the mould is nearly fully closed. This is important as it avoids excessive wear to the locating sections.

One could consider using conical rods in place of the flat fingers 14 but the latter are preferable because each

finger is only called upon to effect a correction in one plane thereby simplifying the positioning of the locating sections on the mould parts.

In a multiple cavity mould, it is preferred to provide guide fingers around each individual core/cavity set to allow for possible movement of the sets relative to one another. On smaller products, it may be possible to provide guide fingers around two or four cavities if they are tightly grouped together.

Though the illustrated embodiment of the invention uses three guide fingers 14 to align each mould, it is possible to use more, four being preferred.

A further problem that has to be overcome in injection-compression moulding is that of containing the plastics material within the cavity as its volume is being reduced. In the prior art, this has been achieved by using a rim closure ring to close off the cavity in the female mould part and by the core passing through a cylindrical hole in the rim closure ring. This is not a satisfactory solution because it is difficult to form a rim closure ring with a cylindrical bore that effectively seals around the core and yet allows the core to pass freely through it. The clearance required to permit reliable and free movement of the core relative to the rim closure ring does not permit creation of a perfect seal and results in an unacceptable witness line around the rim of the moulded article.

In the preferred embodiment of the invention (see Figures 4 to 6) a sealing ring 20 surrounds the core 16. The sealing ring is held captive on the core part 12 and is capable of only a small degree of movement relative to the core part in the direction of the axis of movement of the core part 12. Strong springs (or gas pressure) capable of withstanding the pressure within the mould act to hold the

sealing ring 20 against the top surface of the female mould part 10 so that no plastics material can escape laterally from the top of the mould cavity.

The sealing surface between the sealing ring 20 and the core 16 is not cylindrical, as in the prior art, but is formed of two contiguous tapering sections 22 and 24 of which the section 24 has a very small angle of taper, less than 5° and preferably of the order of 1°, and the section 22 has a larger angle of taper. In both sections, sealing contact between the sealing ring 20 and the core 16 does not occur before the mould cavity is fully closed.

In a typical operating cycle, the core 16 is first fully advanced into the cavity in the female mould part 10 to exclude most of the air from the cavity. Next, an accurately measured quantity of plastics material is injected into the mould cavity to form a biscuit at the base of the mould cavity. During this time, the core recoils slightly from the female mould part either by the action of the injection pressure or by movement of the core cavity.

The sealing ring may or may not come into contact with the front of the female mould part before the recoiling movement commences depending on the maximum stroke of the ring and the thickness of the biscuit that is injected into the mould. If the sealing ring does contact the front of the female mould part, then depending on the stroke of the ring relative to the core and the amplitude of the recoiling movement, it may remain in sealing contact with the female mould part during the whole or only the initial part of the recoiling movement.

During the recoiling movement, the core 16 is maintained in alignment with the female mould part by the action of the guide finger 14. The axial movement of the core 16 relative to the sealing ring 20 opens a gap between

the two because of the tapering sealing surfaces 22 and 24. However, because of the steepness of the angle of taper of the section 24, the width of the gap that is created is only wide enough to act as a vent to allow gas to escape from the cavity.

When the core 16 is next advanced into the cavity of the female mould part, the biscuit of plastics material is compressed and is forced to flow up the side walls of the cavity towards the rim of the container. During this time, gas is expelled from the mould cavity first through the gap between the sealing ring and the cavity then through the gap between the sealing ring 20 and the core 16. As the core reaches its end position, the gap between it and the sealing ring 20 is closed fully so as to prevent any egress of the plastics material from the mould.

Because of the accurate axial alignment which is achieved by using the tapered fingers 14 and the U-shaped sections 18, the plastics material flows at an even rate around the entire periphery of the cavity and reaches the end of the cavity at substantially the same time. This reduces the distance that the sealing ring 20 needs to move relative to the core 16.

It will noted that the sealing ring not only closes the mould cavity efficiently to avoid any flashing but it does so without rubbing against the core. Furthermore, the sealing ring provides a vent which decreases in cross sectional area as the core reaches the closed position. Thus, at the commencement of the compression stroke when air needs to be expelled from the cavity, the air can pass freely first between the sealing ring 20 and the cavity 10 then between sealing ring 20 and the core 16. This avoids high temperatures being reached in the vent and reduces air damping of the movement of the core. By the time the gap is finally sealed off, all the air will have been evacuated

from the mould cavity and the seal will prevent any flashing of the plastics material.

The female mould part and the core have been illustrated in greater detail than is necessary for an understanding of the invention but the parts that have not been described in detail are generally conventional and their function will be understood by the person skilled in the art without the need to detailed explanation. In particular parts have been illustrated which are associated with such functions as the injection of the plastics material into the cavity, the cooling of the moulding, the ejection of the mould article from the mould and the mounting of the parts in the mould tool that is mounted to the platens of an injection moulding machine.

It will also be appreciated that the mould as described needs to be mounted in a moulding machine that moves the core and the female mould part relative to one another at the appropriate rate while applying appropriate pressures. It has been found that the pressure/distance profile of a toggle operated moulding machine is ideally suited to the injection compression moulding process but other machines can be programmed to achieve a similar pressure/distance profile. When a machine is not capable of changing smoothly from a low pressure large displacement mode to a high pressure small displacement mode, a further possibility would be to include a module between the mould and the machine platens that is capable of delivering the desired distance/pressure profile.

CLAIMS

1. A mould for injection compression moulding of an article, comprising a female mould part (10) and a core (16) movable relative to one another between an open and a closed position, and a sealing ring (20) surrounding the core (16) for effecting a seal between the female mould part (10) and the core (16), the core (16) the female mould part (10) and the sealing ring (20) together defining a closed mould cavity when the core (16) is in the closed position, characterised in that the sealing ring (20) has a tapering surface (24) that seals against a tapering surface on the core (16) only after the core has reached the closed position, there being a venting clearance between the tapering surface (24) of the sealing ring (20) and the core (16) as the core (16) approaches the closed position.

2. A mould as claimed in claim 1, wherein the angle of taper measured relative to the direction of movement of the core is less than 5°.

3. A mould as claimed in claim 2, wherein the angle of taper measured relative to the direction of movement of the core is substantially 1°.

4. A mould as claimed in any preceding claim, wherein the only venting gap provided to vent gas from the mould cavity is the gap between the tapering surface (24) of the sealing ring (20) and the core (16).

5. A mould as claimed in any preceding claim, wherein the sealing ring (20) is mounted on the core (16) so as to be capable of a limited degree of movement relative to the core (16), the sealing ring (20) being urged by at least one of a spring and gas pressure in a direction to increase the size of the gap between tapering surface (24) and the core (16).

6. A mould as claimed in any preceding claim, wherein at least one of the core and the female mould part is adjustably mountable on a platen of an injection moulding machine to permit the code and the female mould part to be axially aligned with one another, wherein a plurality of guide fingers is provided on one of the mould parts and distributed about the core axis to be received in recesses of complementary shape in the other mould part as the mould parts approach the fully closed position, each finger having two parallel sided locating sections that are spaced from one another along the length of the finger, the locating section nearer the free end of the finger being narrower than the other and the length of each locating section being at least equal to the final part of the stroke of the platens during which compression of the injected plastics material takes place.

7. A mould as claimed in claim 6, wherein the part of each finger lying between the two parallel sided locating sections is continuously tapering.

8. A mould as claimed in claim 6 or 7, wherein each of the fingers is flat and is secured to the core and the recesses are formed in flat inserts releasably secured to the female mould part.

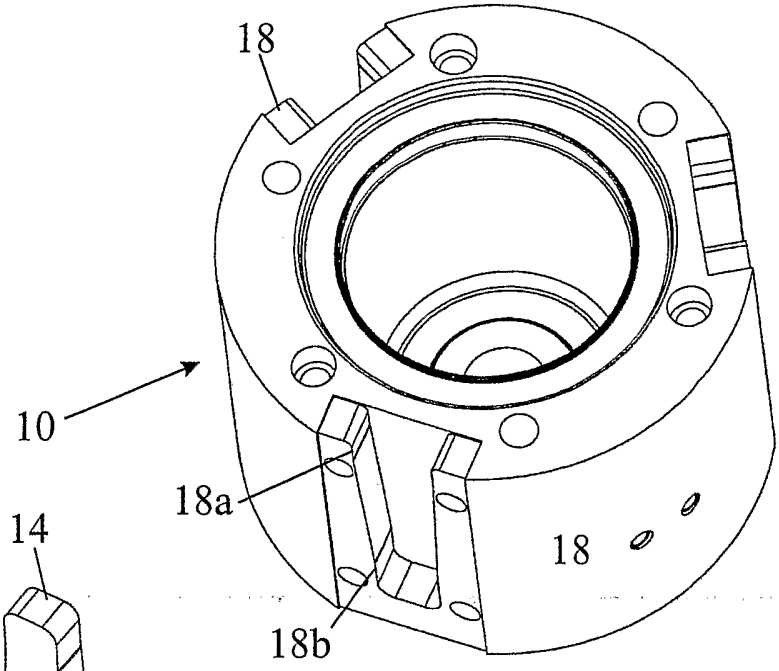

Fig. 1

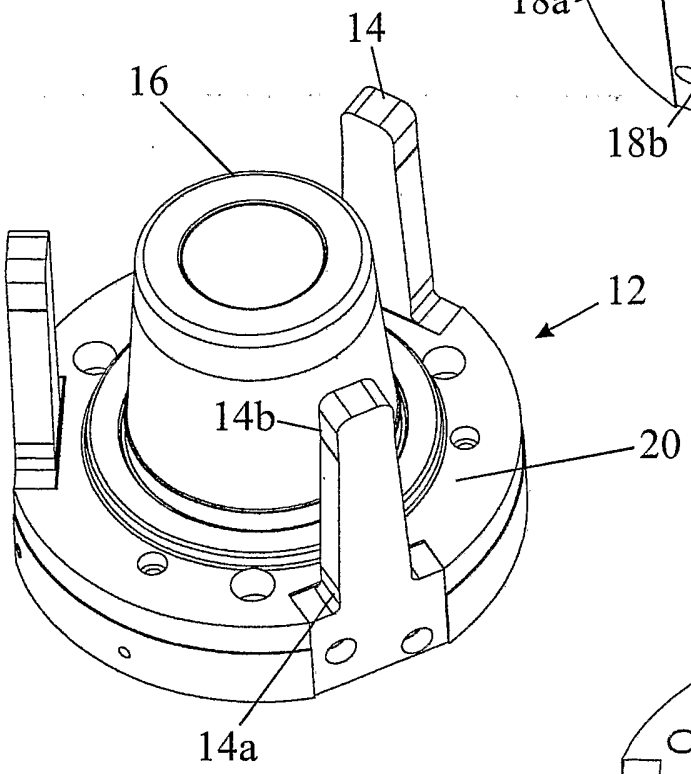

Fig. 2

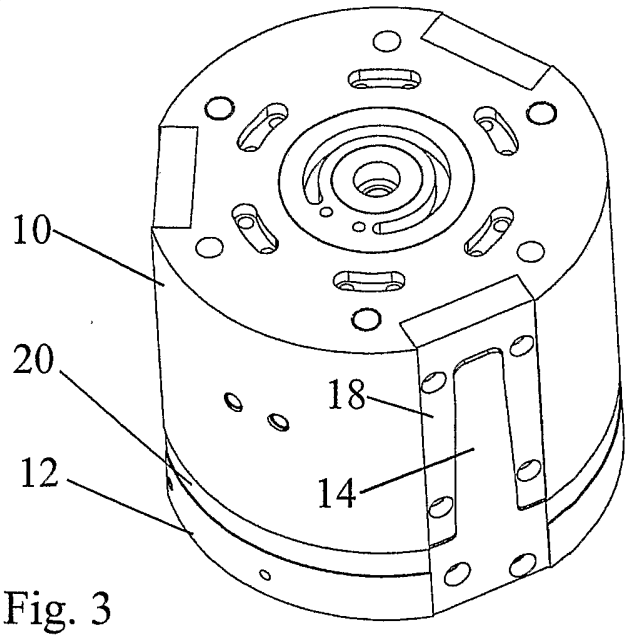

Fig. 3

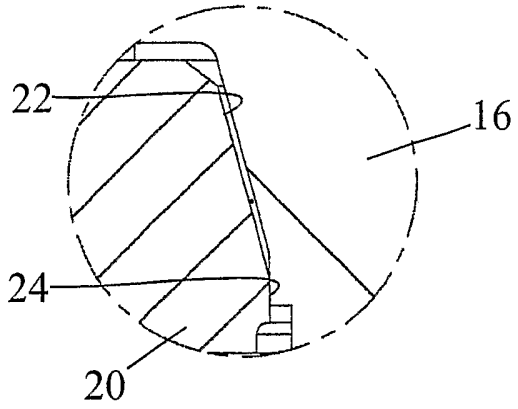

Fig. 5

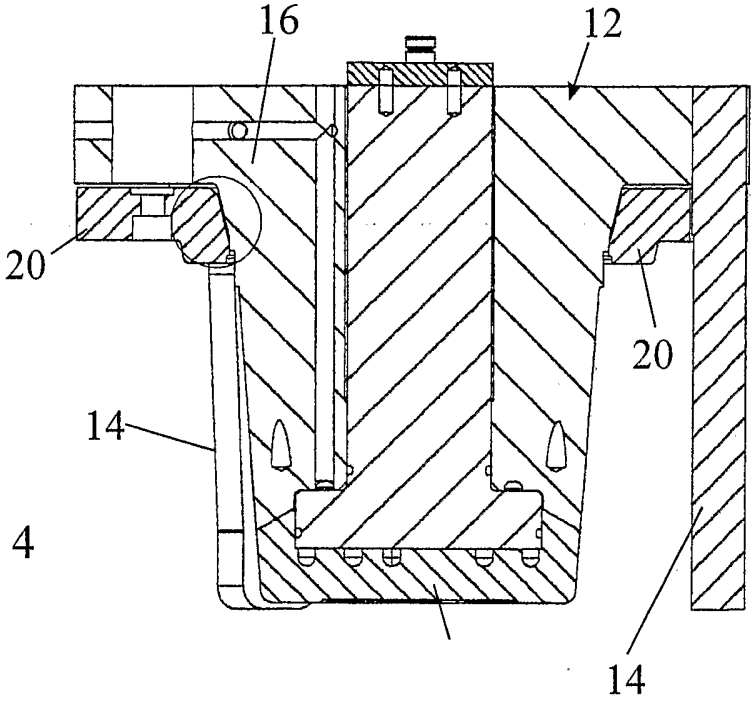

Fig. 4

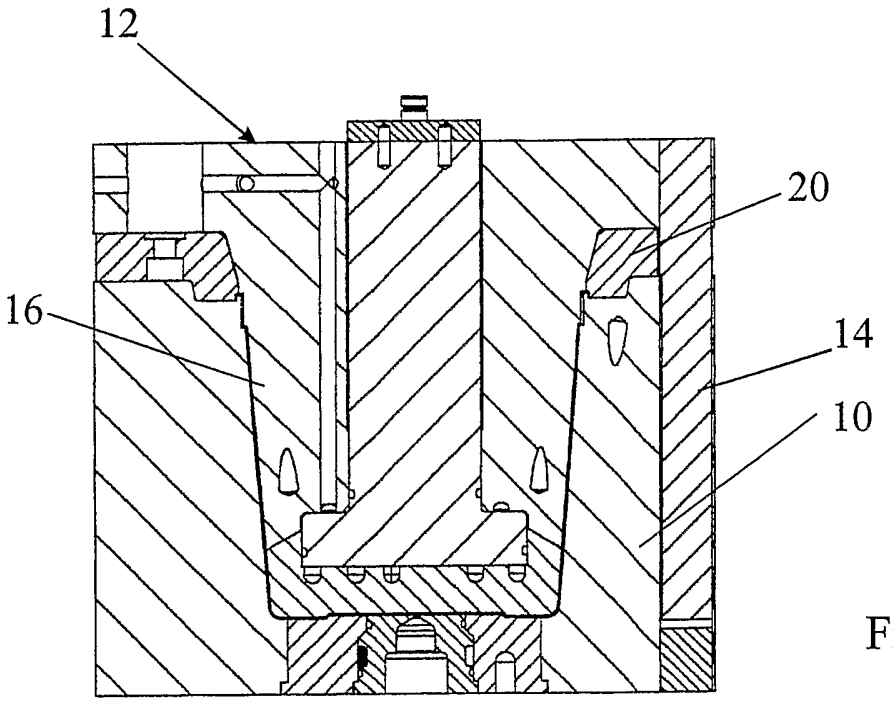

Fig. 6