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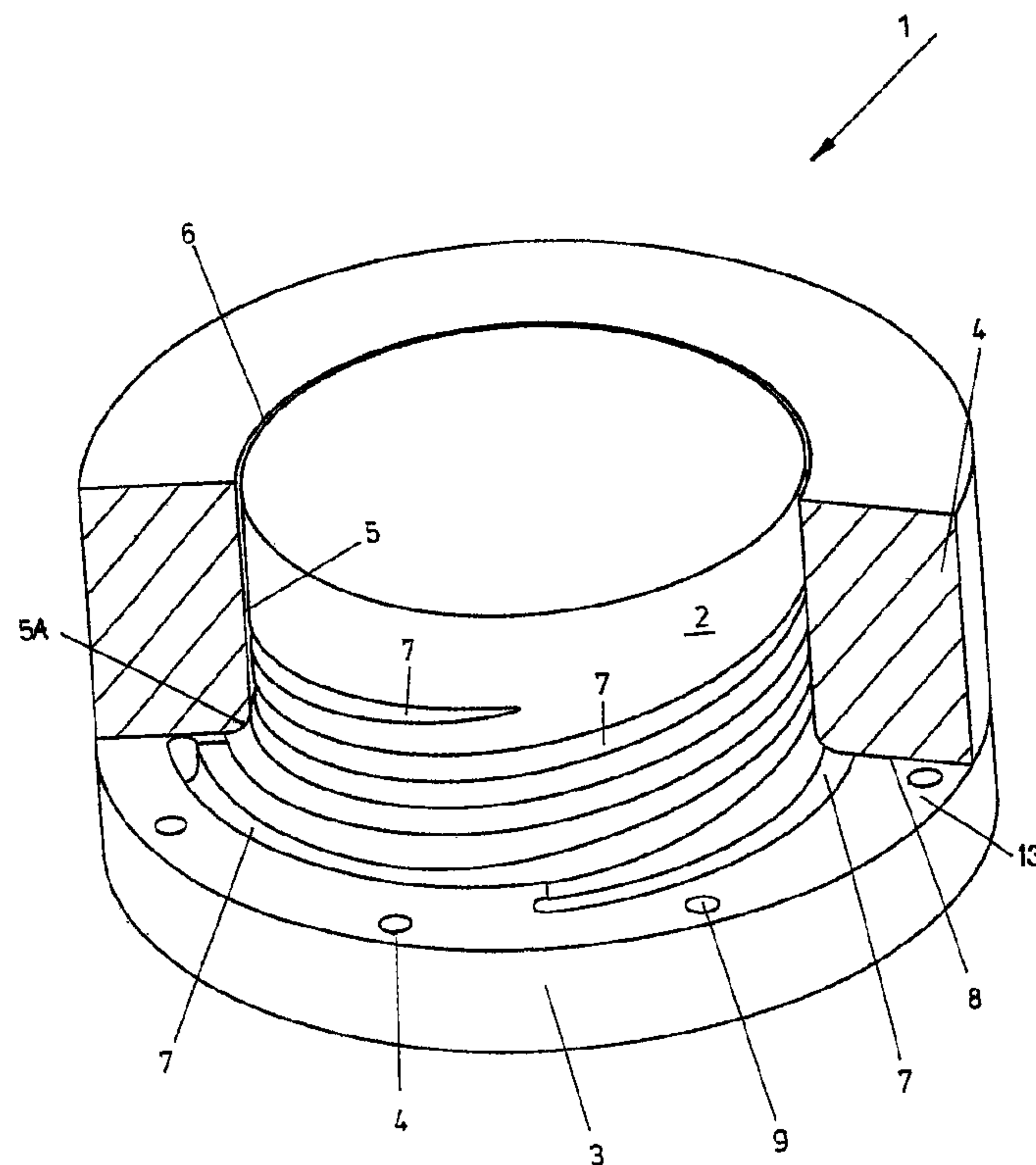
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(54) Title: EXTRUDER DIE HEAD



(57) Abrégé/Abstract:

An extruder die head, preferably a blown film head, comprises an internal cylindrical mandrel and a concentric jacket. Between the mandrel and jacket an annular channel is formed that empties into a die slit. The die head also includes at least one polymer melt feed line in communication with the annular channel remote from the die slit. To prevent a gap appearing between the central mandrel and the jacket as a result of differential thermal expansion, in which polymer melt can become trapped and degrade, thus causing defects in the extrusion, the joint faces between the parts of the die head are located radially relative to the cylinder axis of the die head.



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EXTRUDER DIE HEAD

The invention relates to an extruder die head, preferably a blown film head, comprising an internal cylindrical mandrel and an outer concentric jacket. An annular channel is formed between the mandrel and the jacket, which terminates as an annular die slit. The extruder die head also includes at least one feed line, through which a polymer melt is fed into the annular channel.

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Extruder die heads of this type, including blown film die heads, are well known. In the known die heads, the outer surface of the mandrel commonly includes at least one helical groove, whose depth decreases towards the die slit, so that the polymer melt overflows more and more the webs, which define the groove sides, and assumes a uniform flow in the axial direction toward the die slit. In these known extruder die heads the inner cylindrical mandrel adjacent the beginning of the annular channel is fitted sealingly into a cylindrical bore in the outer concentric jacket. In this construction, the joint faces of the mandrel and the jacket are both cylindrical, and extend along the axis of the die head. When the extruder die head becomes warm, due to the polymer melt flowing through the extruder die head during use, the jacket expands more than the central mandrel. As a result of this differential thermal expansion, an annular slit can be formed between the inner mandrel and the outer jacket. Since the polymer melt is fed into the die head under pressure, it can penetrate and accumulate in the area of this slit. Because of its long residence time in the hot die head, the trapped

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polymer melt can decompose and become brittle; particles of the deposited and encrusted melt can be dragged along in the flow of polymer melt. These particles become obvious in an extruded film tube, or in an inflated film bubble, as defects.

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This invention seeks to provide an extruder die head of the known type in which a slit cannot arise due to differential thermal expansion between the inner central mandrel and the outer concentric jacket in which the polymer melt can
10 accumulate and degrade. In the extruder die head of this invention, the axial joint faces are replaced by cooperating radial joint faces. This can be achieved in at least three ways:

(i) the outer jacket can be attached to an outwardly
15 projecting radial face on the mandrel; or

(ii) the mandrel can be attached to an inwardly projecting radial face on the outer jacket; or

(iii) both the mandrel and the jacket can be mounted onto suitable radial faces on a die block.

20 Since the joint face, according to this invention, is located radially rather than axially, differential thermal expansion cannot result in an annular slit.

Thus in its broadest embodiment, this invention seeks to
25 provide an extruder die head including in combination a cylindrical inner mandrel and a concentric outer jacket, having an annular channel between the mandrel and the jacket which channel includes a transition region and terminates in an annular die slit, and at least one feed line for a polymer
30 melt in communication with the annular channel, wherein each

of the mandrel and the jacket, proximate the transition region and remote from the die slit, comprises a substantially planar joint face constructed and arranged to be sealingly attached to a cooperating joint face in a radial direction relative to
5 the cylinder axes of the mandrel and the jacket.

In the die head of this embodiment, one of the mandrel and the jacket comprises an extension in the said radial direction and the respective joint face is provided on a surface of the
10 extension facing toward the die slit; and the joint face of the other of the mandrel and the jacket comprises the cooperating joint face.

In a first narrower embodiment, this invention seeks to
15 provide an extruder die head wherein

- (i) the extension is provided to the mandrel and comprises an integral outwardly projecting flange-shaped foot, and the joint face of the jacket is sealingly attached to the joint face on the flange-shaped foot;
- 20 (ii) the annular channel between the inner mandrel and the outer jacket extends from the joint face on the flange-shaped foot and includes the transition region; and
- (iii) the polymer feed line for the polymer melt empties into the transition region.

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In a second narrower embodiment, this invention seeks to provide an extruder die head wherein:

- (i) the extension is provided to the jacket and comprises a blind borehole terminating in a radially internally projecting

circular face, constructed and arranged to receive the joint face of the mandrel in a sealing attachment;

(ii) the annular channel between the mandrel and the jacket extends from the circular face and includes the transition
5 region; and

(iii) the polymer feed line for the polymer melt empties into the transition region.

In a third narrower embodiment, this invention seeks to
10 provide an extruder die head further comprising a die body having at least one radially extending substantially planar die body surface, wherein

(i) the annular channel between the mandrel and the jacket extends from the planar die body surface;

15 (ii) the cooperating joint face is located on one of the at least one planar die body surface; and

(iii) each of the planar joint faces provided to the mandrel and the jacket is attached concentrically and sealingly to one of the at least one planar die body surface.

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In one aspect of this embodiment, the extruder die head further includes an inner first concentric ring and an outer second concentric ring, located in the annular channel between the mandrel and the jacket, wherein

25 (i) the mandrel has a conical surface tapering outwardly from adjacent the die body;

(ii) the first concentric ring has an inner conical surface tapering inwardly which provides a first annular channel between the first ring and the mandrel;

(iii) the first concentric ring has a substantially axial outer surface;

(iv) the second concentric ring has a substantially axial inner surface which provides a second annular channel between
5 the first and the second concentric rings;

(v) the second concentric ring has an outer inwardly tapering conical surface;

(vi) the jacket has an inner inwardly tapering conical surface which provides a third annular channel between the outer
10 surface of the second concentric ring and the jacket;

(vii) a polymer melt feed line is provided in communication separately with each of the first, second and third annular channels; and

(viii) the first, second and third annular channels combine
15 into a single fourth annular channel in communication with the die slit.

Preferably, in the first narrower embodiment, the mandrel includes at least one groove formed in part as a spiral groove
20 with an outer closed end and a decreasing radius in the outwardly projecting radial annular surface of the flange-shaped foot and in part as a helical groove on the outer cylindrical surface of the mandrel, which groove extends into the transition region; the depth of the at least one groove
25 decreases towards the die slit; and the polymer feed line comprises a bore hole through the mandrel in communication with the outer closed end of the, or each, spiral groove.

Preferably, in the second narrower embodiment, the mandrel
30 includes at least one helical groove on the outer cylindrical

surface of the mandrel, with a closed end adjacent the circular face, which groove extends into the transition region; the depth of the at least one groove decreases towards the die slit; and the polymer feed line comprises a bore hole
5 through the mandrel in communication with the closed end of the helical groove.

Preferably, the extruder die head is a blown film die head.

10 Preferably, all of the cooperating radial joint faces are flat.

When the extruder die head is a blown film head, the die head will include additional boreholes, through which the required
15 blowing air can be fed and also exhausted again for the purpose of inflating the extruded film tube into a tubular bubble and for the purpose of cooling the inflated film bubble.

20 The invention will now be described with reference to the attached drawings, in which:

Figure 1 is a partly sectioned schematic drawing of an extruder die head according to the first narrower embodiment;

Figure 2 is an axial cross section view of the extruder
25 die head of Figure 1;

Figure 3 is a partly sectioned schematic drawing of an extruder die head according to the second narrower embodiment;

Figure 4 is a bottom view of the mandrel shown in Figure
30 3;

Figure 5 is an axial cross sectional view of the extruder die head shown in Figure 3; and

Figure 6 is an axial cross section of an extruder die head according to the third narrower embodiment, for
5 coextrusion of three types of polymer melt.

Referring first to Figures 1 and 2, the extruder die head 1, according to the first narrower embodiment of this invention, includes an inner cylindrical mandrel 2, which has an integral
10 outwardly projecting flange-shaped foot 3. The mandrel 2 is enclosed by the outer concentric jacket 4. Between the outside wall of the mandrel 2 and the inside wall of the jacket 4 there is an annular channel 5, which terminates as the die slit 6. Starting from adjacent the flange-shaped foot 3, the
15 outside wall of the mandrel 3 includes several rows of grooves 7. The initial part of each groove has a closed end, and is formed as a decreasing radius spiral. Each groove extends through the transition region 5A and continues as a helical groove on the outside of the mandrel 2. The depth of each
20 groove 7 decreases towards the die slit 6, so that the polymer melt, flowing in the grooves 7, overflows the webs between the grooves and is rerouted more and more into the axial direction. In the transition region 5A the angle 3A between the flange-shaped foot 3 and the cylindrical mandrel 2, and
25 the inside corner 4A of the cylindrical jacket 4 are rounded off, so that the annular channel includes the transition region.

The outer concentric jacket 4 has a first radial bottom face
30 8, which rests on the outwardly projecting radial annular

surface 13 of the flange-shaped foot 3. As shown, the cooperating joint faces 13 and 8 are both flat; other profiles can be used if desired. The flange-shaped foot 3 is provided with boreholes 9, through which expansion screws 10 are
5 inserted, which are screwed into the corresponding threaded boreholes of the concentric jacket 4. The expansion screws 10 are chosen so that even when the extruder die head is hot, the cooperating joint surfaces 13 and 8 are forced together, so that the surfaces 13 and 8 are connected together without a
10 gap and mate sealingly with each other, over both the flat areas and the web surfaces between the grooves 7.

The polymer melt is fed by an extruder(not shown) through the channel 11 and bore 12 to the spiral part of each groove 7,
15 adjacent to its closed end. Each of the grooves 7 has a connection to a bore 12. The polymer melt issues from the grooves 7 in the transition region 5A between the flange-shaped foot 3 and the mandrel 2, enters into the annular channel 5 and then flows with increasing axial flow to, and
20 finally exits through, the annular die slit 6.

The flange-shaped foot 3 is conveniently shaped as a disc, which includes the channel 11 and the bores 12.

25 Figures 3 and 4 show a second narrower embodiment of a die head 20. In this construction, a cylindrical mandrel 21 is inserted into a blind borehole in the outer concentric jacket 22, the mandrel 21 having a radially extending circular flat second bottom face 24, thus forming the annular channel 23

between the inside wall of the borehole and the outer surface of the mandrel 21.

As can be seen in Figures 3 and 4, the mandrel 21 includes a number of grooves 25 which extend through the transition region. A part of each groove 25 is formed as an increasing radius spiral, in the flat bottom face 24 of the mandrel 21, and in part as a helical groove in the outer surface of the mandrel 21. The depth of the grooves 25 decreases toward the die slit 26, so that the melt overflows the webs of the grooves and assumes an axial flow in the annular channel 23.

Referring also to Figure 5, the radial floor of the blind borehole is flat and parallel to the face 24 so that the mandrel bottom face 24 and the floor mate sealingly. The mandrel 21 is fastened to the floor with expansion screws 28, located in boreholes 29 and screwed into threaded boreholes 30. Hence the bottom face 24 of the mandrel 21 lies with its surface in sealing engagement with the flat floor of the blind borehole. The melt-feeding channels 31, 32 are connected to the grooves 25 near to their closed ends, at the outer end of the spiral part of each groove 25.

Figure 6 shows an axial cross section of a third narrow embodiment of the extruder die head, which has several differences from the constructions shown in Figures 1 - 5.

Referring to Figure 6 broadly, inspection of Figures 2 and 5 shows that those die heads are each essentially a two part construction, with the radial joint either outside the

mandrel(Figure 2) or beneath the mandrel(Figure 5); in contrast the die head in Figure 6 shows an alternative three part construction, utilizing an outer concentric jacket 53 with a first radial bottom face, an inner cylindrical mandrel 50 with a second radial bottom face, both of which are mounted onto cooperating radial flat surfaces provided on the die block 41. Thus although this is a three part construction, all of the joint faces are still radial, and therefore are not affected by differential thermal expansion of the three parts.

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In more detail, Figure 6 shows an axial cross section of a third narrow embodiment of the extruder die head, which serves to coextrude up to three different types of polymer melt. The die head 40 comprises five parts. The die head is assembled onto the die body 41, which forms the base of the die head, and to which the other four parts are attached. The die body 41 includes a central circular region with a flat surface 42. Adjoining this central circular region are three flat radial annular surfaces 46, 47 and 48, with rounded off steps 43, 44, 45 in sequence between them. The die block 41 thus includes four concentric radial surfaces: the central circular one 42, and three annular ones 46, 47, 48. A rotationally symmetrical mandrel 50 is sealingly attached to the central flat surface 42. A part of the inner face of the mandrel 50 is conical, and tapers outwardly in segments towards the annular channel 55A. On the annular surfaces 46 and 47 are mounted two rings 51 and 52, which are sealingly attached at their flat radial bottom faces to the surfaces 46 and 47 respectively. Each ring has one tapered face, and one more or less axial face. Outside the ring 52 the concentric outer jacket 53 is

sealingly attached to the outermost flat surface 48, which also has an internal surface matching that of the mandrel. As shown schematically in Figure 6, the die block 41, the mandrel 50, the two rings 51 and 52, and the concentric jacket 53 are all held together by suitably located expansion bolts as at 57, 58, 59 and 60. Additionally, the tapered faces of the central core 50, the two rings 51 and 52, and the outer concentric jacket 53, and the axial faces of the two rings 51 and 52 are also constructed to provide three annular channels 50A, 51A and 52A through which the three polymer melts flow. To facilitate polymer melt flow, several sets of grooves are cut into the central core 50, the ring 51, and the ring 52. In each case, these grooves commence as increasing radius spirals facing the flat surfaces 42, 46, and 47, and extend beyond the transition regions onto the outer conical, or cylindrical, surfaces of the central core 50, the ring 51, and the ring 52 as helical grooves. These grooves decrease in depth towards the die slit 55. Each groove is connected to a polymer melt feed line, as shown at 62, 63 and 64. This construction thus provides the three substantially concentric annular channels 50A, 51A and 52A respectively between the central core 50 and the ring 51, between the rings 51 and 52 and between the ring 52 and the outer jacket 53. These annular channels empty into one another at the common intersection 56 and then a single annular channel 55A continues to the die slit 55.

Since the mandrel 50, the rings 51 and 52, and the outer jacket 53 have radial flat faces which are attached to complementary flat radial surfaces in the die body 41, no

gaps or slits are present into which the polymer melt can penetrate and accumulate. Further, since all of the faces, although not co-planar, are all radially aligned, no slits or gaps can arise due to differential thermal expansion of the
5 parts making up the die head. The only paths through which the polymer melts can flow are defined by the cooperating grooves and annular channels.

What is claimed is:

1. An extruder die head including in combination a cylindrical inner mandrel and a concentric outer jacket, having an annular channel between the mandrel and the jacket which channel includes a transition region and terminates in an annular die slit, and at least one feed line for a polymer melt in communication with the annular channel, wherein each of the mandrel and the jacket, proximate the transition region and remote from the die slit, comprises a substantially planar joint face constructed and arranged to be sealingly attached to a cooperating joint face in a radial direction relative to the cylinder axes of the mandrel and the jacket.

2. An extruder die head as claimed in Claim 1, wherein

(i) one of the mandrel and the jacket comprises an extension in the said radial direction and the respective joint face is provided on a surface of the extension facing toward the die slit; and

(ii) the joint face of the other of the mandrel and the jacket comprises the cooperating joint face.

3. An extruder die head according to Claim 2 wherein:

(i) the extension is provided to the mandrel and comprises an integral outwardly projecting flange-shaped foot, and the joint face of the jacket is sealingly attached to the joint face on the flange-shaped foot;

(ii) the annular channel between the inner mandrel and the outer jacket extends from the joint face on the flange-shaped foot and includes the transition region; and

(iii) the polymer feed line for the polymer melt empties into the transition region.

4. An extruder die head according to Claim 3 wherein the mandrel includes at least one groove formed in part as a spiral groove with an outer closed end and a decreasing radius in the joint face of the flange-shaped foot and in part as a helical groove on the outer cylindrical surface of the mandrel, which groove extends into the transition region; wherein the depth of each groove decreases towards the die slit; and wherein the polymer feed line comprises a bore hole through the mandrel in communication with the outer closed end of each spiral groove.

5. An extruder die head according to Claim 2 wherein

(i) the extension is provided to the jacket and comprises a blind borehole terminating in a radially internally projecting circular face, constructed and arranged to receive the joint face of the mandrel in a sealing attachment;

(ii) the annular channel between the mandrel and the jacket extends from the circular face and includes the transition region; and

(iii) the polymer feed line for the polymer melt empties into the transition region.

6. An extruder die head according to Claim 5 wherein the mandrel includes at least one helical groove on the outer cylindrical surface of the mandrel, with a closed end adjacent the circular face, which groove extends into the transition region; wherein the depth of each groove decreases towards the die slit; and wherein the polymer feed line comprises a bore hole through the blind borehole in communication with the closed end of the helical groove.

7. An extruder die head according to Claim 1 further comprising a die body having at least one radially extending substantially planar die body surface, wherein

- (i) the annular channel between the mandrel and the jacket extends from the planar die body surface;
- (ii) the cooperating joint face is located on one of the at least one planar die body surface; and
- (iii) each of the planar joint faces provided to the mandrel and the jacket is attached concentrically and sealingly to one of the at least one planar die body surface.

8. An extruder die head according to Claim 7 further including an inner first concentric ring and an outer second concentric ring, located in the annular channel between the mandrel and the jacket, wherein

- (i) the mandrel has a conical surface tapering outwardly from adjacent the die body;
- (ii) the first concentric ring has an inner conical surface tapering inwardly which provides a first annular channel between the first ring and the mandrel;
- (iii) the first concentric ring has a substantially axial outer surface;
- (iv) the second concentric ring has a substantially axial inner surface which provides a second annular channel between the first and the second concentric rings;
- (v) the second concentric ring has an outer inwardly tapering conical surface;
- (vi) the jacket has an inner inwardly tapering conical surface which provides a third annular channel between the outer surface of the second concentric ring and the jacket;

(vii) a polymer melt feed line is provided in communication separately with each of the first, second and third annular channels; and

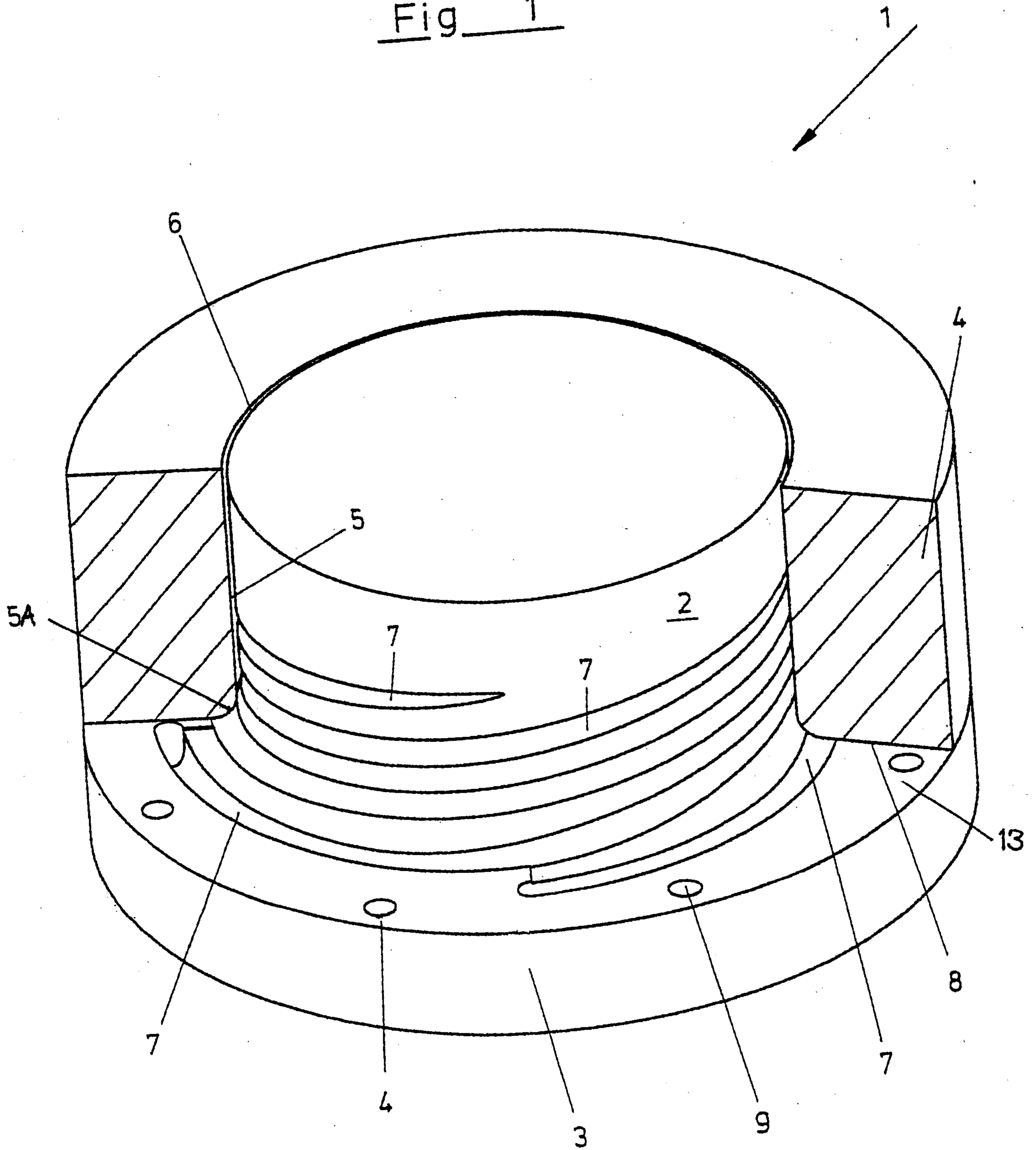
(viii) the first, second and third annular channels combine into a single fourth annular channel in communication with the die slit.

9. An extruder die head according to Claim 8 wherein at least one face of the mandrel, of the first concentric ring and of the second concentric ring each include at least one groove with a closed end whose depth decreases toward the die slit, and wherein a polymer melt feed line communicates with each groove adjacent its closed end.

10. An extruder die head according to any one of Claims 1 to 9 which is a blown film die head.

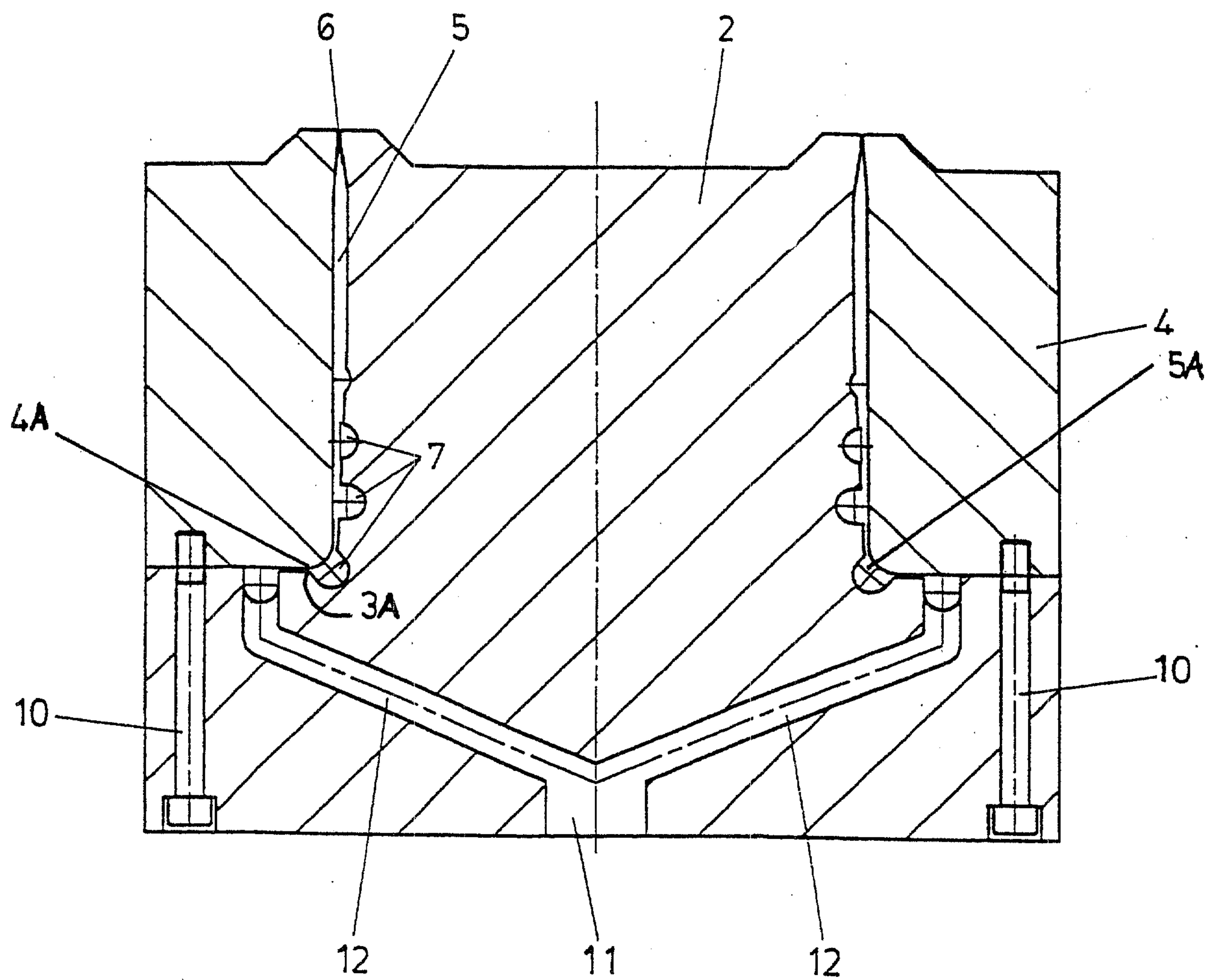
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Fig 1

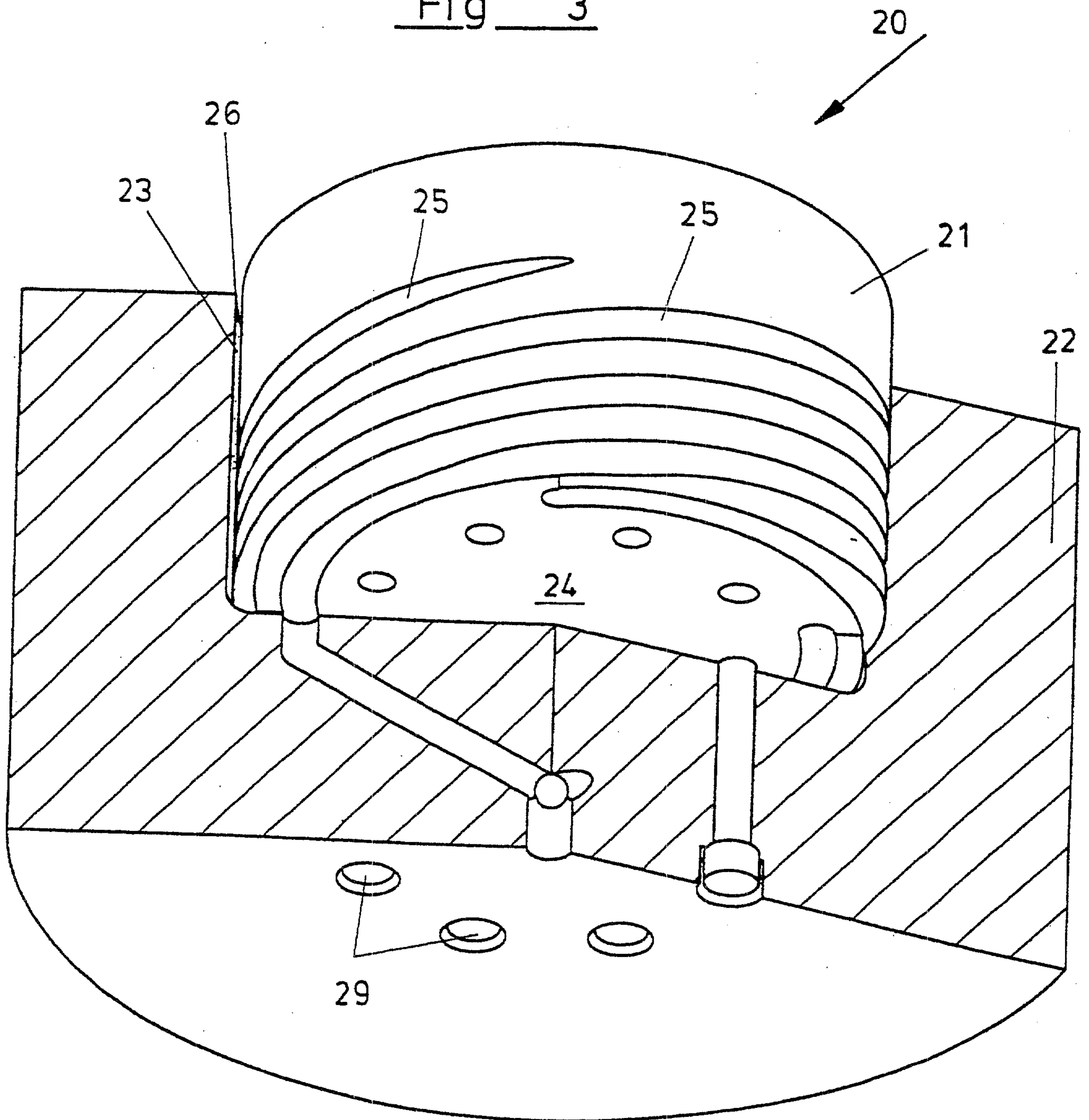


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Fig 2

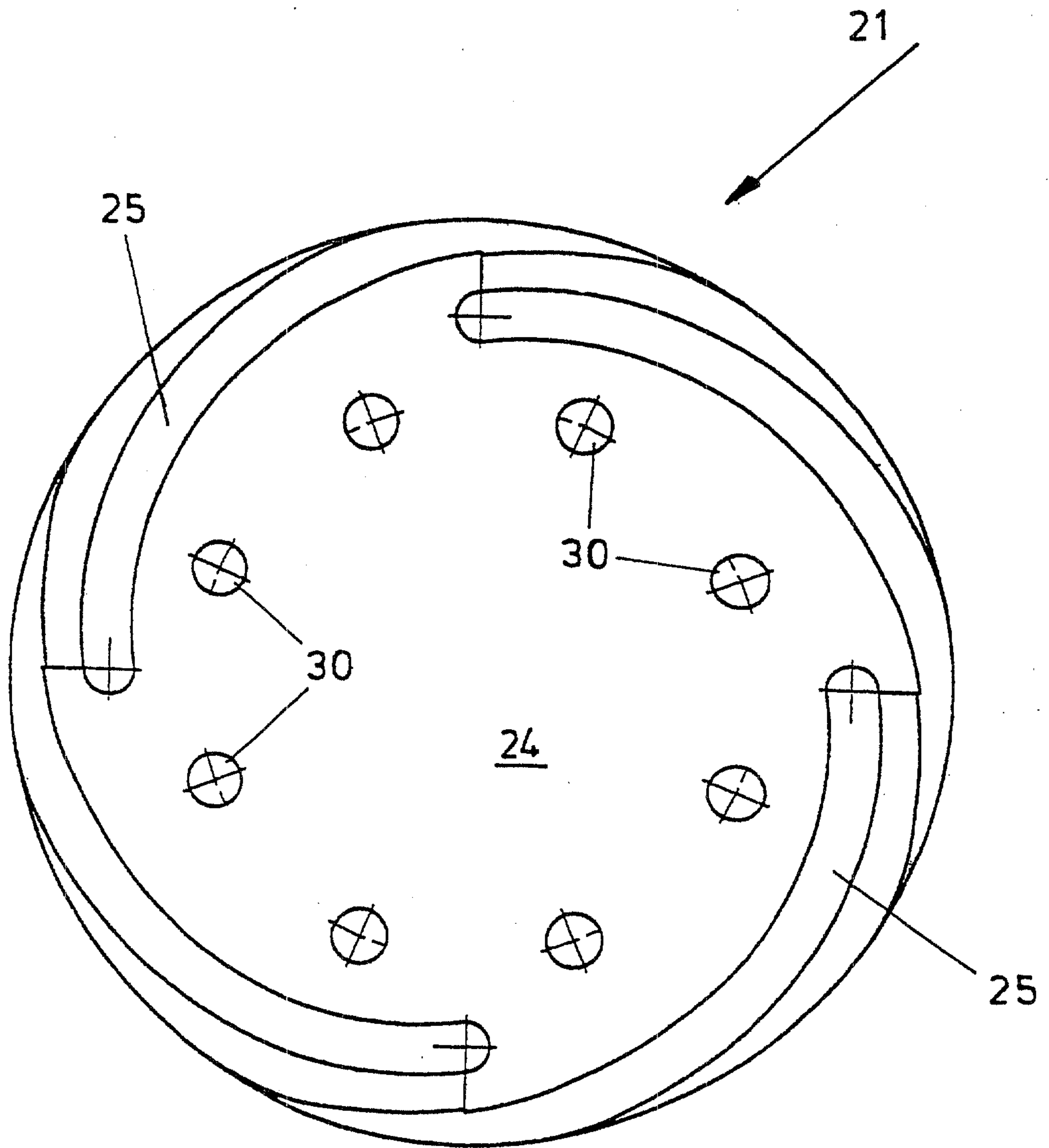


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Fig 3

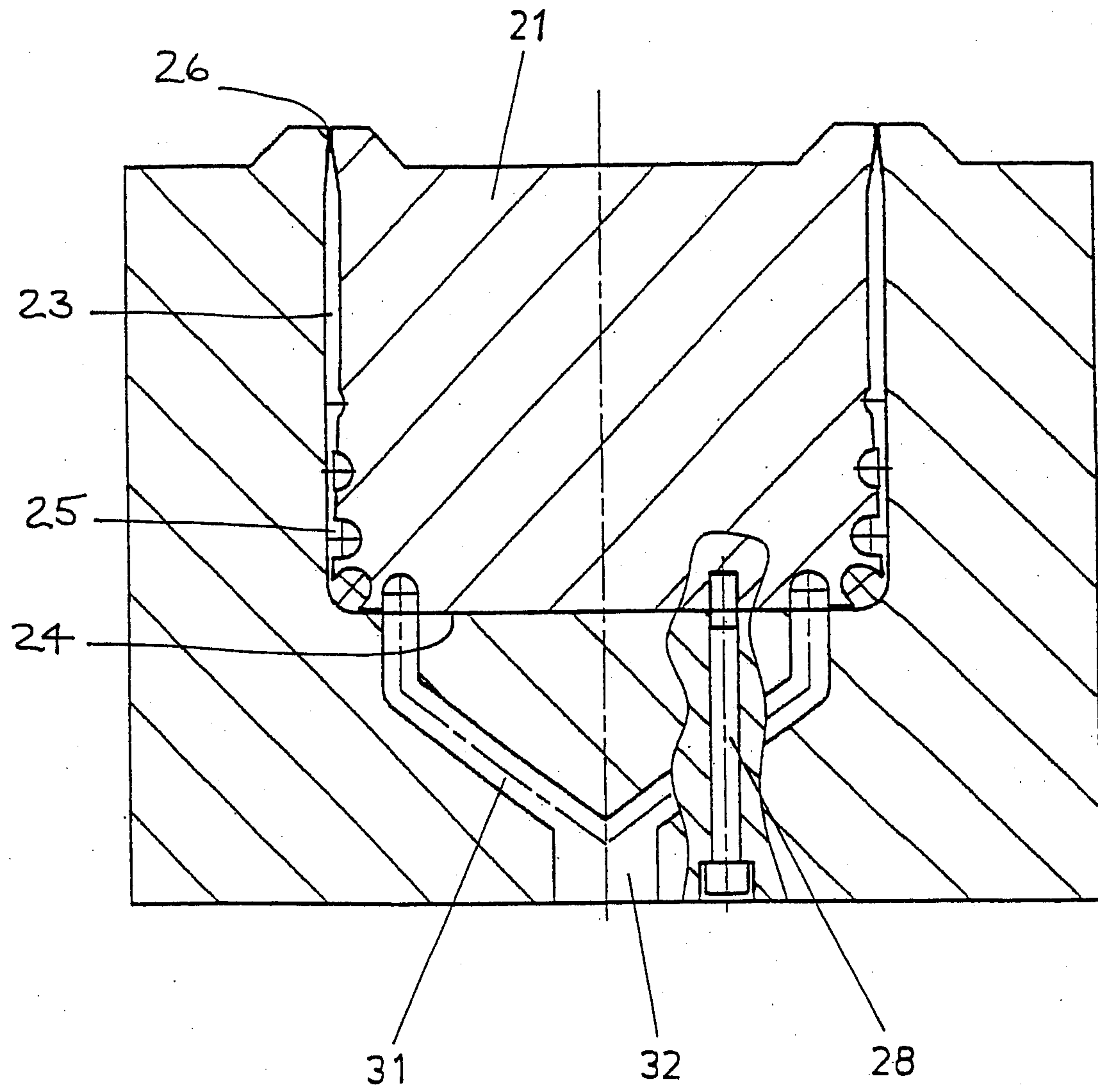


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Fig 4



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Fig 5

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Fig 6

