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(54) Title: MANIFOLD BUSHING FOR PROMOTING UNIFORM VELOCITY PROFILES IN SPLIT MELT STREAMS

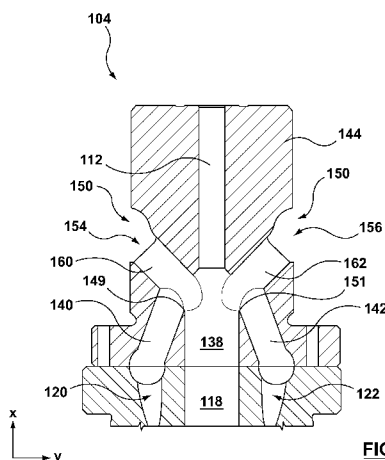


FIG. 5

(57) Abstract: A manifold bushing comprises a bushing body and a primary melt outlet channel in the bushing body configured to accommodate a reciprocable valve stem. A pair of feeder channels in the bushing body is configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel. The bushing body has a plurality of supplementary melt outlet channels. Each of the supplementary melt outlet channels branches from at least one of the primary melt outlet channel and one of the feeder channels.

**MANIFOLD BUSHING FOR PROMOTING UNIFORM VELOCITY PROFILES IN SPLIT
MELT STREAMS**

TECHNICAL FIELD

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The present disclosure relates to manifold bushings, and more particularly to manifold bushings for promoting uniform velocity profiles in split melt streams.

BACKGROUND

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An injection molding apparatus may have a manifold with a melt channel defined therein. The melt channel may convey melt (i.e. melted molding material), such as molten resin or plastic material (e.g. PET), to multiple injection molding locations or drops. At each drop, the manifold may have a receptacle, such as a bore, in which a manifold bushing is received. The manifold bushing may define at least one melt channel for carrying melt towards a gate. The manifold bushing may be used to avoid the need to machine melt channels directly into the manifold. The manifold bushing may be designed to receive and support a valve stem.

An injection molding apparatus may include a nozzle assembly designed to dispense an inner skin melt stream and an outer skin melt stream. The inner and outer skin melt streams may sandwich a core material layer in a molded article that is made using a co-injection process for example. The inner and outer skin melt layers may comprise the same material. The core material layer may comprise the same material as the inner and outer layers or may be comprise a different material. An example of a core material layer is a barrier material (e.g. an oxygen barrier material), which may be intended to protect contents of the molded article from outside contamination (e.g. oxidation). Another example of a core material layer is post-consumer regrind material, which may be used in order to limit material costs.

SUMMARY

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According to one aspect of the present disclosure, there is provided a manifold bushing comprising: a bushing body; a primary melt outlet channel in the bushing body configured to accommodate a reciprocable valve stem; a pair of feeder channels in the bushing body configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel; and a pair of supplementary melt outlet channels flanking the primary melt outlet channel in the bushing body,

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each of the supplementary melt outlet channels branching from at least one of the primary melt outlet channel and a respective one of the pair of feeder channels.

In some embodiments the pair of feeder channels is convergent and the pair of supplementary melt outlet channels is divergent.

In some embodiments an angle of convergence of the pair of feeder channels is greater than an angle of divergence of the pair of supplementary melt outlet channels.

In some embodiments the manifold bushing further comprises a peripheral groove in an exterior of the bushing body, the peripheral groove being configured to receive melt at a melt ingress point midway along its length and to supply the melt to the pair of feeder channels from respective melt egress points at its distal ends, the peripheral groove being declined between the melt ingress point and the melt egress points with respect to a longitudinal axis of the primary melt outlet channel.

In some embodiments the bushing body is cylindrical and the peripheral groove has a half-ellipse shape.

In some embodiments the primary melt outlet channel defines an inner skin melt stream, and the pair of supplementary melt outlet channels defines a pair of outer skin melt streams, for output to a co-injection nozzle assembly.

In some embodiments each of the supplementary melt outlet channels branches from the respective one of the pair of feeder channels and not from the primary melt outlet channel.

In some embodiments each of the supplementary melt outlet channels branches from the primary melt outlet channel and not from either of the feeder channels.

In some embodiments each of the supplementary melt outlet channels branches from a junction between the primary melt outlet channel and the respective one of the pair of feeder channels.

According to another aspect of the present disclosure, there is provided a manifold bushing comprising: a cylindrical bushing body; a primary melt outlet channel disposed axially within the cylindrical bushing body, the primary melt outlet channel configured to accommodate a reciprocable valve stem; a pair of feeder channels in the cylindrical bushing body configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel; and a pair of

supplementary melt outlet channels flanking the primary melt outlet channel, each of the supplementary melt outlet channels branching from at least one of the primary melt outlet channel and a respective one of the pair of feeder channels.

- 5 In some embodiments the pair of feeder channels is convergent and the pair of supplementary melt outlet channels is divergent.

In some embodiments an angle of convergence of the pair of feeder channels is greater than an angle of divergence of the pair of supplementary melt outlet channels.

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In some embodiments the manifold bushing further comprises a peripheral groove in a surface of the cylindrical bushing body, the peripheral groove configured to receive melt at a melt ingress point midway along its length and to supply the melt to the pair of feeder channels from respective melt egress points at its distal ends, the peripheral groove being declined between the melt ingress point and the melt egress points with respect to an axis of the cylindrical bushing body.

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In some embodiments the primary melt outlet channel defines an inner skin melt stream, and the pair of supplementary melt outlet channels defines a pair of outer skin melt streams, for output to a co-injection nozzle assembly.

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In some embodiments each of the supplementary melt outlet channels branches from the respective one of the pair of feeder channels and not from the primary melt outlet channel.

25 In some embodiments each of the supplementary melt outlet channels branches from the primary melt outlet channel and not from either of the feeder channels.

In some embodiments each of the supplementary melt outlet channels branches from a junction between the primary melt outlet channel and the respective one of the feeder channels.

- 30 According to another aspect of the present disclosure, there is provided a manifold bushing comprising: a bushing body; a primary melt outlet channel in the bushing body configured to accommodate a reciprocable valve stem; a pair of feeder channels in the bushing body configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel; and a plurality of supplementary melt outlet channels in the bushing body, each of the supplementary melt outlet channels branching from at least one of the primary melt outlet channel and one of the feeder channels.

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In some embodiments the plurality of supplementary melt outlet channels comprises three or more supplementary melt outlet channels.

- 5 Other features will become apparent from the drawings in conjunction with the following description.

DESCRIPTION OF THE DRAWINGS

- 10 In the figures which illustrate example embodiments,

FIG. 1 is cross-sectional view of an example injection molding apparatus including a manifold bushing;

- 15 FIG. 2 is another cross-sectional view of the injection molding apparatus of FIG. 1;

FIG. 3 is a top perspective view of the manifold bushing of the injection molding apparatus of FIG. 1;

- 20 FIG. 4 is a bottom perspective view of the manifold bushing of FIG. 3;

FIG. 5 is an elevation cutaway view of one-half of the manifold bushing of FIG. 3 revealing an internal structure of the bushing;

- 25 FIG. 6 is a perspective cutaway view of the same portion of the manifold bushing that is shown in FIG. 5;

FIG. 7 is a perspective cutaway view of the manifold bushing of FIG. 3 with a different portion of the bushing being cut away to reveal internal structure;

- 30 FIG. 8 is an elevation cutaway view of one-half of an alternative manifold bushing embodiment revealing an internal structure of the bushing;

- FIG. 9 is an elevation cutaway view of one-half of a further alternative manifold bushing embodiment revealing an internal structure of the bushing; and
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FIG. 10 is an elevation cutaway view of one-half of yet another alternative manifold bushing embodiment revealing an internal structure of the bushing; and

FIGS. 11-13 are perspective views of three alternative shapes of channels within a manifold bushing.

The drawings are not necessarily to scale and may be illustrated by phantom lines, diagrammatic representations and fragmentary views. In certain instances, details that are not necessary for an understanding of the embodiments or that render other details difficult to perceive may have been omitted.

DETAILED DESCRIPTION OF THE NON-LIMITING EMBODIMENT(S)

Referring initially to FIGS. 1 and 2, a portion of an example injection molding apparatus 100, which may be a hot runner, is illustrated in cross section. The injection molding apparatus 100 may be used for molding articles having an inner skin layer and an outer skin layer made from the same material sandwiching an intermediate core layer, e.g. in a co-injection process.

The components illustrated in FIGS. 1 and 2 are not a complete representation of the entire molding apparatus 100. For example, the structure used for conveying barrier material has been largely omitted for the sake of clarity. Thus, FIGS. 1 and 2 illustrate only a subset of components of the injection molding apparatus 100. It will accordingly be appreciated that the injection molding apparatus 100 may include a variety of components not illustrated in FIGS. 1 or 2.

The cross section of FIG. 1 is taken along a plane in the X-Y dimension (the "X-Y dimensional plane"), and the cross section of FIG. 2 is taken along a plane in the X-Z dimension (the "X-Z dimensional plane"), where the dimensions X, Y and Z are mutually orthogonal dimensions in three-dimensional space. As such, the cross-sections of FIGS. 1 and 2 are made along mutually orthogonal planes. The planes intersect at axis A, which acts as a longitudinal axis for a nozzle assembly and a manifold bushing of the injection molding apparatus 100 (described below). The X, Y and Z dimensions are represented as Cartesian coordinates in each of FIGS. 1-7.

For clarity, the terms "horizontal," "vertical," "top" or "bottom" used in the description that follows should not be understood to necessarily connote a particular orientation of the disclosed articles during use.

Referring to FIGS. 1 and 2, the injection molding apparatus 100 includes a manifold 102, a manifold bushing 104, and a nozzle assembly 106.

The manifold 102 defines melt channels for conveying a melted molding material, such as molten PET for example, to multiple drops for injection molding. Only one of the melt channels 108 is illustrated in the figures (see FIG. 2). The orientation of the illustrated melt channel 108 is horizontal. The melt channel 108 terminates at a receptacle 110 (e.g. bore) in the manifold 102, which is cylindrical in the illustrated embodiment.

The manifold bushing 104 is an insert shaped to be received within the receptacle 110 of manifold 102. As such, the manifold bushing is cylindrical in the present embodiment. The bushing 104 is configured to receive a melt stream from the terminus of the melt channel 108 and to split it into multiple melt streams to be conveyed to the nozzle assembly 106. One of the split melt streams will be used to form inner skin layer of a co-injected molded article, and of split melt streams will be used to form an outer skin layer of the molded article. More specifically, the manifold bushing 104 of the present embodiment outputs a single inner skin melt stream from a central or axial primary melt outlet channel 138 and two outer skin melt streams from a pair of supplementary melt outlet channels 140, 142 flanking the central channel. The melt channels within the manifold bushing 104 are configured to promote a uniform velocity profile in each of the resultant streams, as will be described.

The manifold bushing 104 also defines a valve stem guide 112 that receives reciprocable valve stem 114 axially through the manifold bushing 104. The valve stem 114 is used to selectively open and close a gate 116 of the nozzle assembly 106 during injection molding. The manifold bushing 104 will be described in greater detail below.

The nozzle assembly 106 is a component that receives the melt streams output by the manifold bushing 104 and conveys them to a gate for co-injection into a molding cavity (not illustrated). The nozzle assembly 106 is aligned with and abuts the manifold bushing 104. The nozzle assembly 106 has an axial passageway 118 whose purpose is twofold. Firstly, the passageway 118 acts as a longitudinal melt channel for the inner skin melt stream received from the primary melt outlet channel 138 of the manifold bushing 104 towards the gate 116. Secondly, the passageway 118 accommodates the reciprocable valve stem 114, which may have a rod or pin shape. Collectively, the cylindrical passageway 118 and valve stem 114 may define an annular inner skin melt channel 124.

The nozzle assembly 106 also defines two opposed outer skin melt channels 120, 122, on opposite sides of the axial passageway 118, for receiving melt from the two supplementary melt outlet channels 140, 142, respectively, of the manifold bushing 104. The melt received via channels 120, 122 is conveyed through the nozzle assembly 106 and is reshaped to form an annular stream at a distal end of the nozzle assembly 106 within annular outer skin melt channel 126. The channels used to reshape the two received outer skin melt streams into a single annular stream are omitted from FIGS. 1 or 2 for the sake of clarity.

The example nozzle assembly 106 of FIGS. 1 and 2 further defines an intermediary annular channel 128 that may be used for conveying an annular layer of core material that will be sandwiched between annular inner and outer skin layers. The nozzle assembly 106 and manifold bushing 104 may define additional channel structures for providing the core material to this channel 128 which are not shown in FIGS. 1 and 2.

The example nozzle assembly 106 of FIGS. 1 and 2 is formed from three nested components, namely a housing 130, an insert 132 that fits over a head portion of the housing 130, and a tip 134 that fits over the insert 104. The nozzle assembly could have a different structure, e.g. may be unitary, in alternative embodiments.

The example manifold bushing 104 is illustrated in perspective view in FIGS. 3 and 4 and in cutaway view in FIGS. 5-7. The manifold bushing 104 has a cylindrical bushing body 144 with a peripherally protruding base 146, a curved exterior face 148, and peripheral groove 150 in face 148 for conveying melted molding material. The bottom of the base 146 acts as a mating surface for the top of the nozzle assembly 106, which in this example is defined by the housing 130. The peripheral groove 150 in the exterior face 148 of the bushing 104 has a central melt ingress point 152 for receiving the melted molding material from a terminus of the manifold melt channel 108 and two melt egress points 154, 156 at its distal ends for supplying melt to inlets of respective feeder channels 160, 162 (see FIG. 5). The melt ingress point is situated midway along a length of the groove 150. The peripheral groove 150 thus splits the melt stream received from melt channel 108 into two substantially equal streams. The peripheral groove 150 may have a curved (e.g. hemispheric) cross-sectional profile, which is perhaps best seen in FIG. 7.

Between the melt ingress point 152 and the melt egress points 154, 156, the peripheral groove 150 is declined with respect to the longitudinal axis A of the primary melt outlet channel 138. In other words, the peripheral groove 150 occupies a plane that is declined with respect to longitudinal central axis A of the manifold bushing 104. In view of the decline, each of the melt egress points 154, 156 is

closer to the base 146 of the manifold bushing 104 (and to an outlet of the primary melt outlet channel 138) than the melt ingress point 152. Because the bushing body 144 is cylindrical, the decline of the peripheral groove 150 on the face of the bushing 104 imparts a part-ellipse shape (a half ellipse in the illustrated example) to the peripheral groove 150.

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The melt channels defined within the bushing body 144 are perhaps best seen in the cutaway views of FIGS. 5-7. As illustrated, the bushing body 144 defines a primary melt outlet channel 138 that, in the present embodiment, is axial and is aligned with valve stem guide 112. The diameter of the primary melt outlet channel 138 is somewhat larger than that of valve stem guide 112 to
10 accommodate melt around the valve stem 114.

The bushing body 144 defines a pair of feeder channels 160, 162 which are configured to supply melt to the primary melt outlet channel 138 from opposite sides of the channel 138. Supplying melt from opposite sides of the channel 138, and thus from opposite sides of the valve stem 114, may promote a
15 uniform velocity profile in the melt stream output from primary melt outlet channel 138, at least in relation to an embodiment in which melt is supplied to a valve stem-containing melt outlet channel from only one side of the channel.

The inventor has observed that, when melt is supplied from only one side of a valve stem in a
20 channel, a seam or join may form in the downstream side of the valve stem as melt wraps around the valve stem and rejoins on the opposite side. Such a join could yield possibly undesirable downstream effects, including a non-uniform melt velocity profile in a downstream nozzle assembly and gate.

More specifically, when melt is supplied from only one side of a valve stem in a channel, the melt flow velocity on the downstream side of the valve stem may be slower than that on the upstream side
25 of the stem. This may in turn yield different melt viscosities on the upstream versus downstream sides of the valve stem, e.g. due to splitting (shear heating) effects or low flow effects (lower flow being more susceptible to the heating or cooling effects the surrounding bushing structure). The resultant annular flow surrounding the valve stem may be asymmetrical. The difference in viscosities, or melt rheology, may cause a leading edge of the resulting flow have an asymmetrical
30 shape (e.g. a “tip” or “slant”). If such a leading edge were to flow into a molding cavity, undesirable molded article characteristics may result. Undesirable characteristics may include incompletely molded articles (“short shots”) or uneven leading edges (“dips” or “slants”, e.g. in the case of co-injected articles).

35 The above-described undesirable downstream effects may be reduced or avoided when melt is introduced from opposite sides of the channel 138 (and thus from opposite sides of the valve stem

114). This may be due to a more uniform or symmetric velocity in the resulting annular flow than in the case when melt is supplied from only one side of a channel.

As illustrated in FIGS. 5 and 6, the feeder channels 160, 162 are convergent, i.e. are inclined towards one another as they approach the primary melt outlet channel 138. The incline of the feeder channels may limit or mitigate pressure drop within the manifold bushing 104 during operation, e.g. in relation to embodiments in which the feeder channels are strictly radial (i.e. not inclined). Mitigating pressure drop may limit the amount of energy required to force melted molding material through injection molding apparatus 100, which may limit operating costs in some embodiments. The feeder channels are not necessarily inclined in all embodiments or may be differently inclined in alternative embodiments.

A pair of supplementary melt outlet channels 140, 142 flanks the primary melt outlet channel 138 in the bushing body 138. In the present embodiment, each of the supplementary melt outlet channels 140, 142 branches from a respective one of the feeder channels 160, 162. In alternative embodiments, the supplementary melt outlet channels may branch from only the primary melt outlet channel or from a junction between the primary melt outlet channel and a respective one of the pair of feeder channels. This is discussed in more detail below. In view of the narrow angle between each of supplementary melt outlet channels 140, 142 and primary melt outlet channel 138 in the present embodiment, sharp or “feathered” edges 149, 151 are formed within the bushing body 144.

The supplementary melt outlet channels 140, 142 may promote a uniform velocity profile the resultant outer skin melt streams for the following reasons. When melt flows through a melt channel, the melt will generally be hottest around a periphery of the stream due to shear heating effects. In a cylindrical channel, this may be envisioned as a hot peripheral sleeve of melt that is generally symmetric about the periphery of the channel. When such a melt stream is split into two, the hot melt sleeve is also split, such that the thermal profiles of the split streams may become asymmetric. Because thermal effects may be tied to velocity effects (given the relationship between temperature and viscosity in melted molding materials such as resins), the velocity profile of the split melt streams may be asymmetric in view of the asymmetry of the thermal profiles of the split melt streams. This may lead to undesirable molded article characteristics, e.g. due to uneven or asymmetric melt flow, as discussed above.

In the present embodiment, the melt stream is split by the supplementary melt outlet channels 140, 142 within the manifold bushing 104. By splitting the stream within the manifold bushing 104, a distance between the split and the gate 116 may be maximized or increased, at least in relation to a

split made closer to the gate. As a result, the split melt streams may have more time to redevelop a uniform thermal and/or velocity profile in comparison to apparatuses in which the split is within the nozzle assembly. The manifold bushing 104 may thereby promote uniform velocity profiles in the split outer skin melt streams of injection molding apparatus 100.

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It will be appreciated that the manifold bushing 104 may thus promote a uniform velocity profile in both of an inner skin melt stream and a pair of outer skin melt streams.

As illustrated in FIGS. 5 and 6, the supplementary melt outlet channels 140, 142 are divergent, i.e. are inclined away from one another or are arranged so as to spread apart in the downstream direction of melt flow, in the illustrated embodiment. In the illustrated example, the angle of divergence of the supplementary melt outlet channels 140, 142 is less than the angle of convergence of the feeder channels 160, 162 (i.e. the supplementary melt outlet channels are closer to a vertical orientation within the bushing than the feeder channels). This may vary between embodiments.

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Various alternative embodiments are possible.

For example, the manifold bushing 104 described above is cylindrical. Other embodiments of manifold bushings may have different shapes. Generally the manifold bushing will have a complementary shape to its associated receptacle within the manifold.

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In some embodiments of the manifold bushing, the base may not protrude like base 146 of FIG. 3.

A supplementary melt outlet channel can branch either solely from the primary melt outlet channel, solely from a feeder channel, or both (i.e. from a junction between the primary melt outlet channel and a feeder channel). In the example shown in FIGS. 5 and 6, the supplementary melt outlet channels 140, 142 branch solely from their respective feeder channels 160, 162. A variation of this design is shown in FIG. 8.

Referring to FIG. 8, an alternative embodiment of manifold bushing is illustrated in elevation cutaway view. As illustrated, the bushing body 244 of manifold bushing 204 defines a central primary melt outlet channel 238 that is aligned with a valve stem guide 212. The bushing body 244 further defines a pair of feeder channels 260, 262, similar to feeder channels 160, 162 described above, which are configured to supply melt to the primary melt outlet channel 238 from opposite sides of the channel 238. As in the previously described embodiment, each of the supplementary melt outlet channels 240, 242 of the present embodiment branches from a respective one of the feeder

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channels 260, 262. However, in this embodiment the branch points are further away from the central primary melt outlet channel 238 than in the previous embodiment. As a result, the orientation of each of the supplementary melt outlet channels 240, 242 is closer to vertical than that of the previously described supplementary melt outlet channels 140, 142.

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A tapered edge 249, 251 is formed within the bushing body 244 between each respective supplementary melt outlet channel 240, 242 and its respective feeder channel 260, 262. It will be appreciated that the edges 249, 251 are less sharp than the edges 149, 151 between the supplementary melt outlet channels 160, 162 and the primary melt outlet channel 138 of the previously described
10 embodiment. As a result, the edges 249, 251 of manifold bushing 204 may be less susceptible to wear or damage during use than the edges 149, 151 of the earlier described embodiment. The reason is that wear or damage of edges between branching channels may be more prevalent when the edges are thin (i.e. when the angle between branching or merging channels is narrow).

15 In general, the angle formed between branching channels (e.g. between a supplementary melt outlet channel and either of a feeder channel or a primary melt outlet channel) within a particular embodiment may be a design choice that is based on a compromise between competing interests: maximizing component strength (resistance to wear or damage) and another interest, such as limiting stagnation or low flow regions. If the former is considered more important, the angle may be
20 increased; if the latter is considered more important, the angle may be decreased.

Moreover, if a bushing embodiment is intended for use in a multi-drop mold, the range of angles that a designer may implement between a pair of branching or merging melt channels may depend, at least in part, upon the pitch of the mold. A larger pitch may permit the diameter and/or height of the
25 bushing body to be increased, which may in turn provide a greater range of possible angles from which to choose for arriving at a suitable compromise between component strength and another benefit, such as beneficial flow (as described above).

An alternative embodiment of manifold bushing in which supplementary melt outlet channels branch
30 solely from a primary melt outlet channel is shown in FIG. 9. As illustrated, a bushing body 344 of the manifold bushing 304 of FIG. 9 defines a central primary melt outlet channel 338 that is aligned with a valve stem guide 312. A pair of feeder channels 360, 362 is configured to supply melt to the primary melt outlet channel 338 from opposite sides of the channel 338. Each of a pair of opposing supplementary melt outlet channels 340, 342 extends horizontally from the primary melt outlet
35 channel 338 at a right angle thereto. In this embodiment, no sharp or highly tapered edges are formed

within the bushing body 244 between the supplementary melt outlet channels 340, 342 and another channel. This may promote component strength, as discussed above.

An alternative embodiment of manifold bushing in which each supplementary melt outlet channel branches from a junction between the primary melt outlet channel and a respective one of the pair of feeder channels is shown in FIG. 10. As illustrated, a bushing body 444 of the manifold bushing 404 of FIG. 10 defines a central primary melt outlet channel 438 that is aligned with a valve stem guide 412. A pair of feeder channels 460, 462 is configured to supply melt to the primary melt outlet channel 438 from opposite sides of the channel 438. Each of a pair of opposing supplementary melt outlet channels 440, 442 branches from a respective junction 441, 443 between the primary melt outlet channel 438 and a respective feeder channel 460, 462. In this embodiment, no sharp or highly tapered edges are formed within the bushing body 444 between the supplementary melt outlet channels 440, 442 and another channel. This may promote component strength, as discussed above.

As will be appreciated from the above-described embodiments, the supplementary melt outlet channels are not necessarily inclined in all embodiments and, if inclined, may be differently inclined between embodiments. The shape of supplementary melt outlet channels may also vary between embodiments. In some embodiments, the supplementary melt outlet channels may be purely cylindrical, like the example supplementary melt outlet channel 180 of FIG. 11. In some embodiments, the supplementary melt outlet channels may be curved, like the example supplementary melt outlet channel 182 of FIG. 12. In some embodiments, the supplementary melt outlet channels may have a transitional shape like the example supplementary melt outlet channel 184 of FIG. 13, which has a circular inlet 186 and a partly annular outlet 188. Other shapes are possible.

The feeder channels may also adopt various shapes, including shapes similar to those shown in FIGS. 11 to 13 for the supplementary melt outlet channels. The cross-sectional shape of feeder channels may vary between embodiments, and may include circular, square, polygonal with rounded corners, oval cross sectional or other shapes.

Similarly, the cross-sectional shape of the primary melt outlet channel may vary between embodiments and may include circular, square, polygonal with rounded corners, oval, or other cross-sectional shapes. The shapes need not necessarily be symmetric. The valve stem will typically be centrally disposed within the cross-sectional profile of a primary melt outlet channel, although this is not absolutely required.

Depending upon the shape of a channel, the channel can be manufactured using an appropriate one of a variety of techniques, such as by drilling or by way of electrical discharge machining (EDM) for example.

- 5 The peripheral groove of a manifold bushing may have various profile (cross-sectionals) shapes, such as hemispheric, trapezoidal, square or rectangular. Polygonal cross-sectional shapes may have rounded corners.

- 10 The number of supplementary melt outlet channels may be greater than two in some embodiments. In embodiments having more than two supplementary melt outlet channels, the supplementary melt outlet channels may branch from either or both of a primary melt outlet channel and a feeder channel. In some embodiments, multiple supplementary melt outlet channels may branch from a single feeder channel (whether or not the supplementary melt outlet channels also branch from the primary melt outlet channel. Supplementary melt outlet channels may be symmetrically arranged, or equally
15 spaced, about a primary melt outlet channel.

Other modifications may be made within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A manifold bushing (104, 204, 304, 404) comprising:
 - a bushing body (144, 244, 344, 444);
 - a primary melt outlet channel (138, 238, 338, 438) in the bushing body configured to accommodate a reciprocable valve stem;
 - a pair of feeder channels (160, 162, 260, 262, 360, 362, 460, 462) in the bushing body configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel; and
 - a pair of supplementary melt outlet channels (140, 142, 240, 242, 340, 342, 440, 442) flanking the primary melt outlet channel in the bushing body, each of the supplementary melt outlet channels branching from at least one of the primary melt outlet channel and a respective one of the pair of feeder channels.
2. The manifold bushing of claim 1 wherein the pair of feeder channels is convergent and wherein the pair of supplementary melt outlet channels is divergent.
3. The manifold bushing of claim 2 wherein an angle of convergence of the pair of feeder channels is greater than an angle of divergence of the pair of supplementary melt outlet channels.
4. The manifold bushing of any one of claims 1 to 3 further comprising a peripheral groove (150, 250, 350, 450) in an exterior (148) of the bushing body, the peripheral groove being configured to receive melt at a melt ingress point (152) midway along its length and to supply the melt to the pair of feeder channels from respective melt egress points (154, 156) at its distal ends, the peripheral groove being declined between the melt ingress point and the melt egress points with respect to a longitudinal axis of the primary melt outlet channel.
5. The manifold bushing of claim 4 wherein the bushing body is cylindrical and wherein the peripheral groove has a half-ellipse shape.
6. The manifold bushing of claim 1 wherein the primary melt outlet channel defines an inner skin melt stream, and the pair of supplementary melt outlet channels defines a pair of outer skin melt streams, for output to a co-injection nozzle assembly (106).

7. The manifold bushing of any one of claims 1 to 6 wherein each of the supplementary melt outlet channels branches from the respective one of the pair of feeder channels and not from the primary melt outlet channel.
8. The manifold bushing of any one of claims 1 to 6 wherein each of the supplementary melt outlet channels branches from the primary melt outlet channel and not from either of the feeder channels.
9. The manifold bushing of any one of claims 1 to 6 wherein each of the supplementary melt outlet channels branches from a junction between the primary melt outlet channel and the respective one of the pair of feeder channels.
10. A manifold bushing (104, 204, 304, 404) comprising:
 - a cylindrical bushing body (144, 244, 344, 444);
 - a primary melt outlet channel (138, 238, 338, 438) disposed axially within the cylindrical bushing body, the primary melt outlet channel configured to accommodate a reciprocable valve stem;
 - a pair of feeder channels (160, 162, 260, 262, 360, 362, 460, 462) in the cylindrical bushing body configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel; and
 - a pair of supplementary melt outlet channels (140, 142, 240, 242, 340, 342, 440, 442) flanking the primary melt outlet channel, each of the supplementary melt outlet channels branching from at least one of the primary melt outlet channel and a respective one of the pair of feeder channels.
11. The manifold bushing of claim 10 wherein the pair of feeder channels is convergent and wherein the pair of supplementary melt outlet channels is divergent.
12. The manifold bushing of claim 11 wherein an angle of convergence of the pair of feeder channels is greater than an angle of divergence of the pair of supplementary melt outlet channels.
13. The manifold bushing of any one of claims 10 to 12 further comprising a peripheral groove (150, 250, 350, 450) in a surface (148) of the cylindrical bushing body, the peripheral groove configured to receive melt at a melt ingress point (152) midway along its length and to supply the melt to the pair of feeder channels from respective melt egress points (154, 156) at its

distal ends, the peripheral groove being declined between the melt ingress point and the melt egress points with respect to an axis of the cylindrical bushing body.

14. The manifold bushing of claim 10 wherein the primary melt outlet channel defines an inner skin melt stream, and the pair of supplementary melt outlet channels defines a pair of outer skin melt streams, for output to a co-injection nozzle assembly.
15. The manifold bushing of any one of claims 10 to 14 wherein each of the supplementary melt outlet channels branches from the respective one of the pair of feeder channels and not from the primary melt outlet channel.
16. The manifold bushing of any one of claims 10 to 14 wherein each of the supplementary melt outlet channels branches from the primary melt outlet channel and not from either of the feeder channels.
17. The manifold bushing of any one of claims 10 to 14 wherein each of the supplementary melt outlet channels branches from a junction between the primary melt outlet channel and the respective one of the feeder channels.
18. A manifold bushing (104, 204, 304, 404) comprising:
 - a bushing body (144, 244, 344, 444);
 - a primary melt outlet channel (138, 238, 338, 438) in the bushing body configured to accommodate a reciprocable valve stem;
 - a pair of feeder channels (160, 162, 260, 262, 360, 362, 460, 462) in the bushing body configured to supply melt to the primary melt outlet channel from opposite sides of the primary melt outlet channel; and
 - a plurality of supplementary melt outlet channels (140, 142, 240, 242, 340, 342, 440, 442) in the bushing body, each of the supplementary melt outlet channels branching from at least one of the primary melt outlet channel and one of the feeder channels.
19. The manifold bushing of claim 18 wherein the plurality of supplementary melt outlet channels comprises three or more supplementary melt outlet channels.

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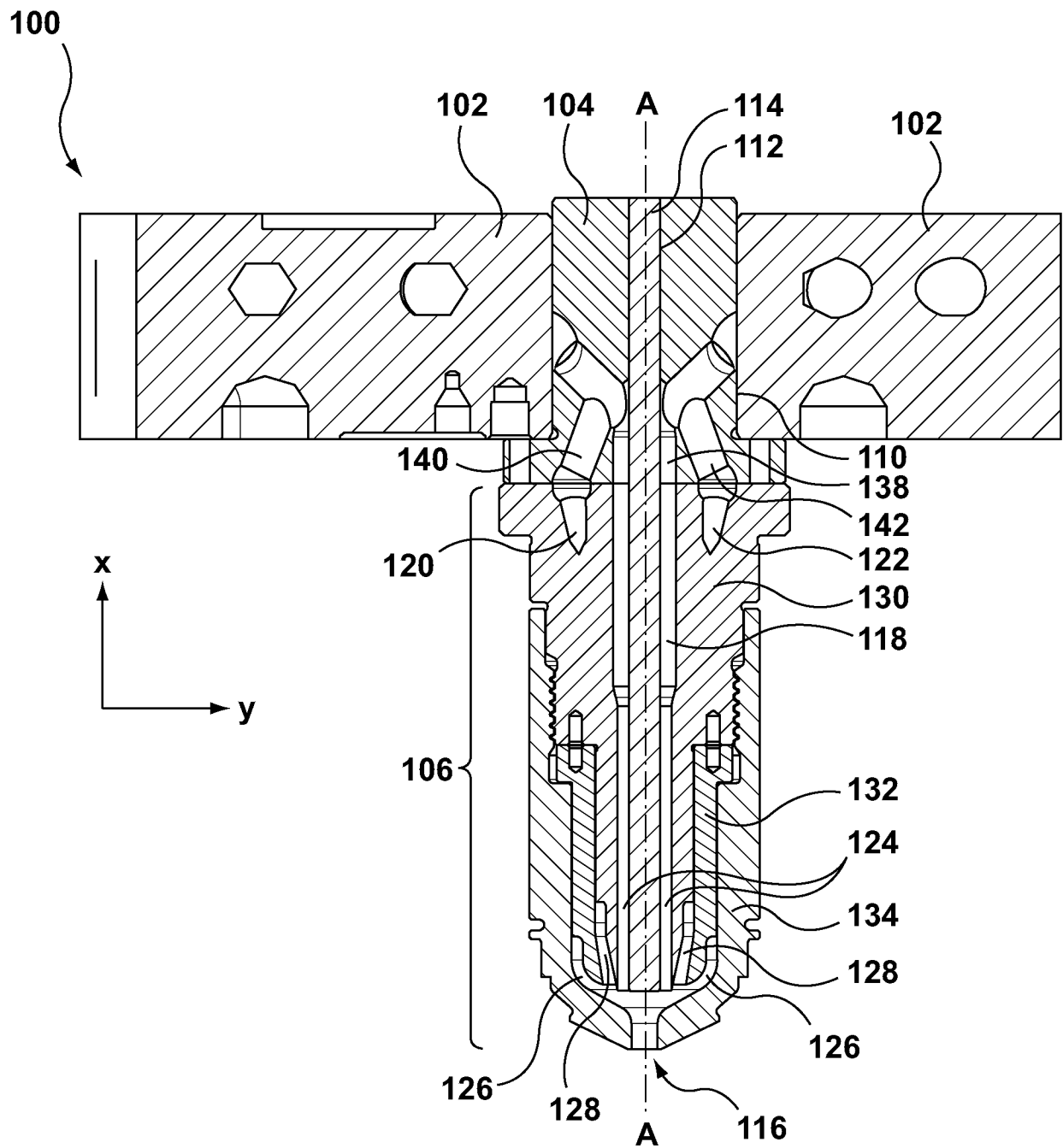


FIG. 1

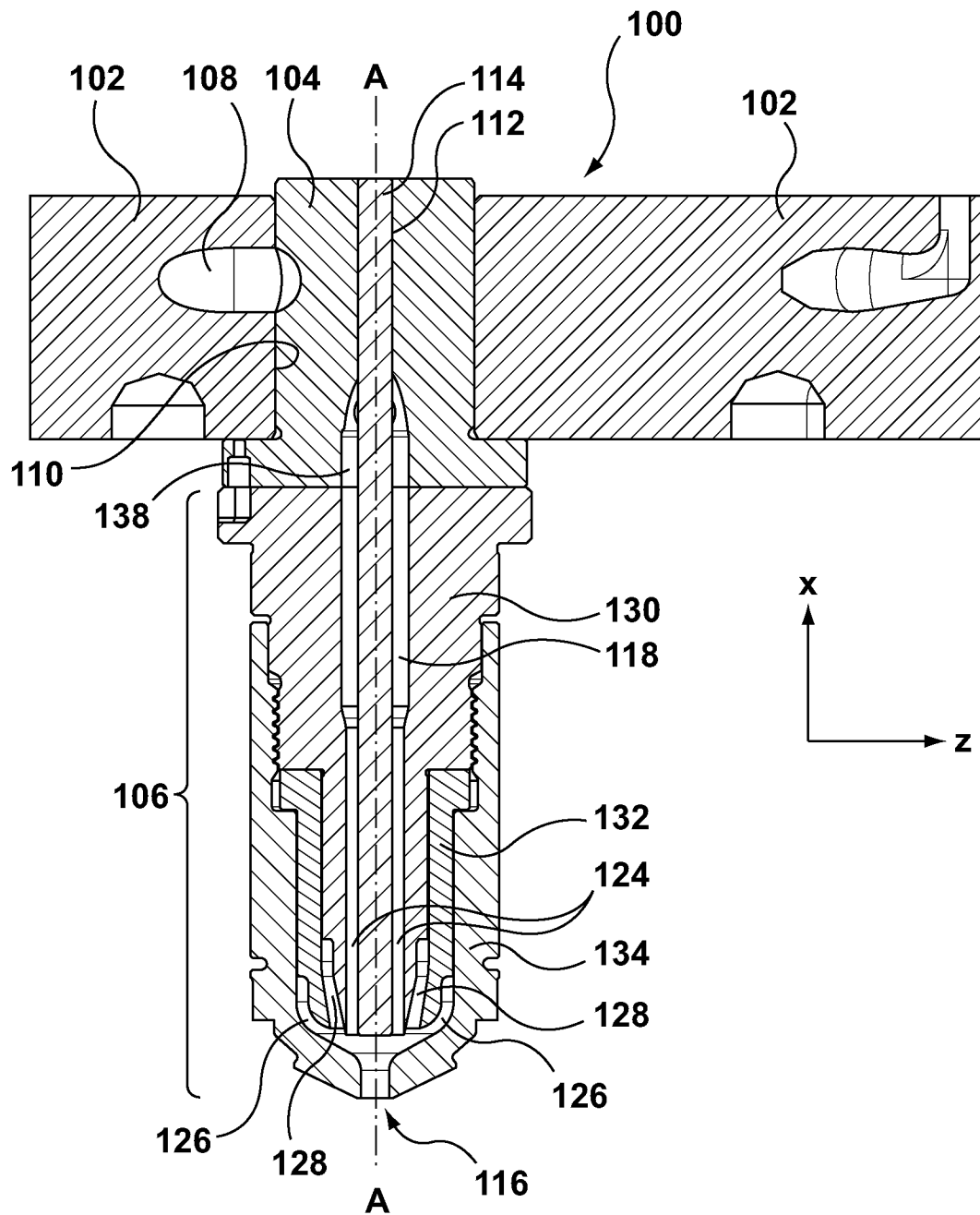


FIG. 2

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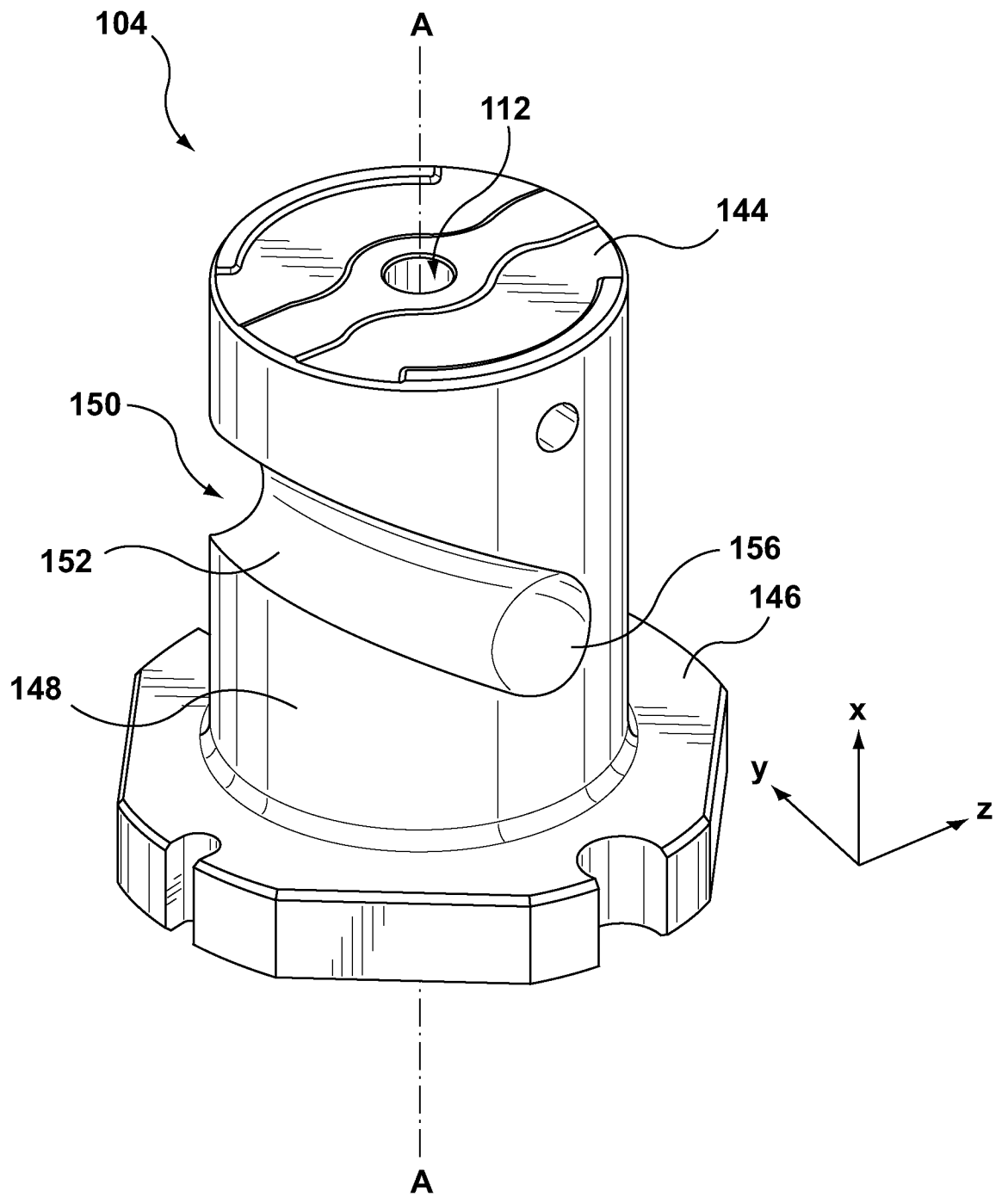


FIG. 3

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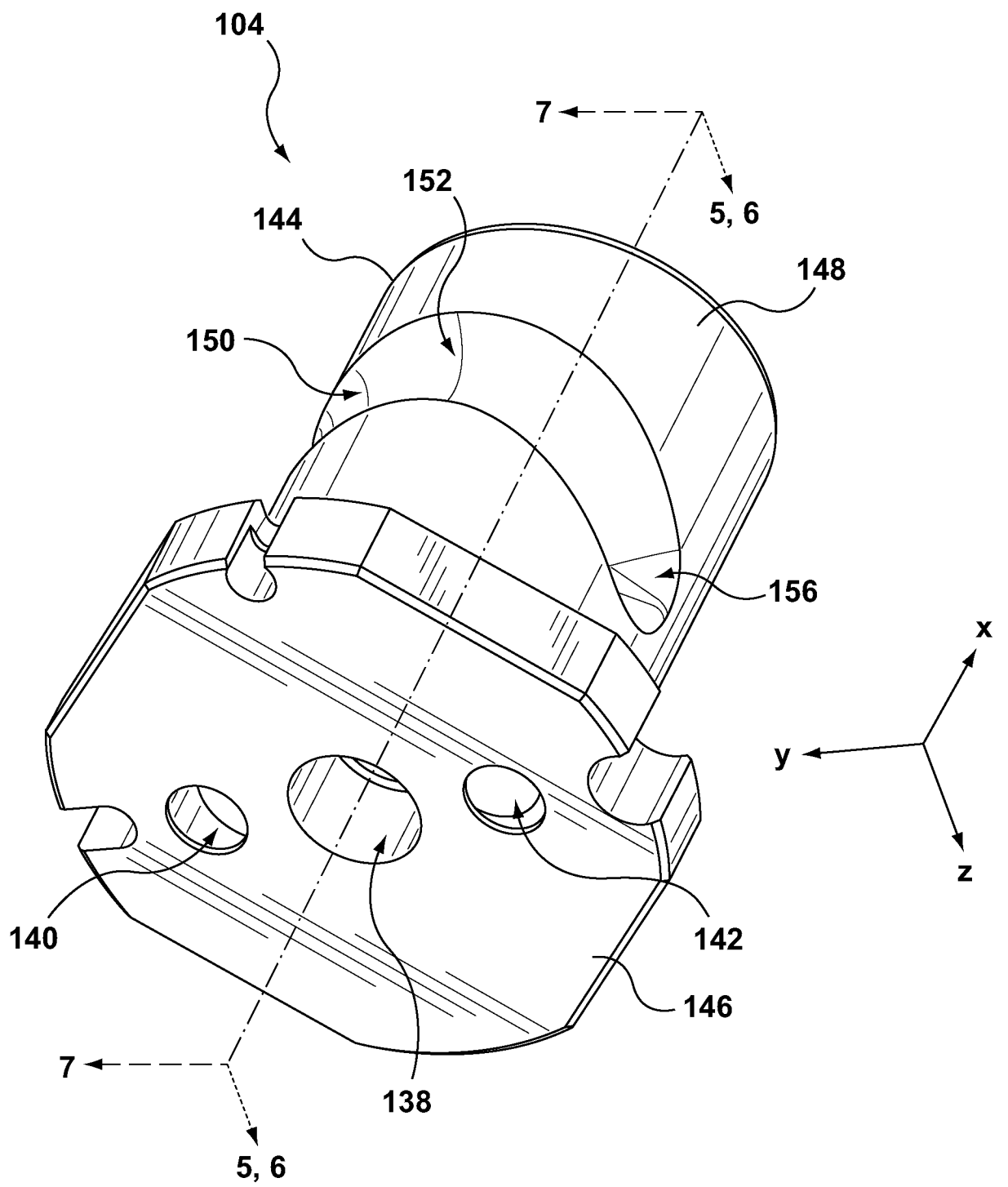


FIG. 4

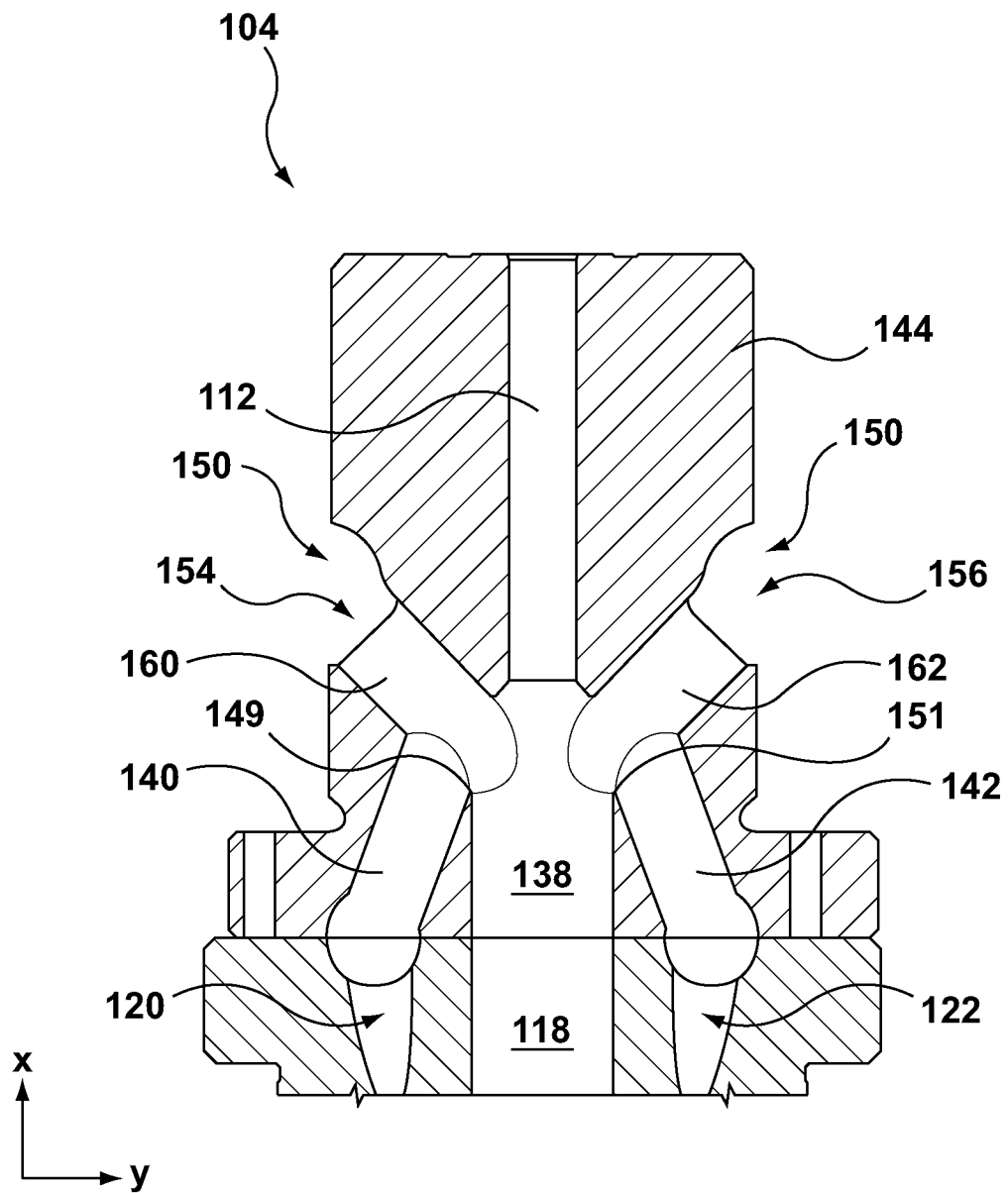
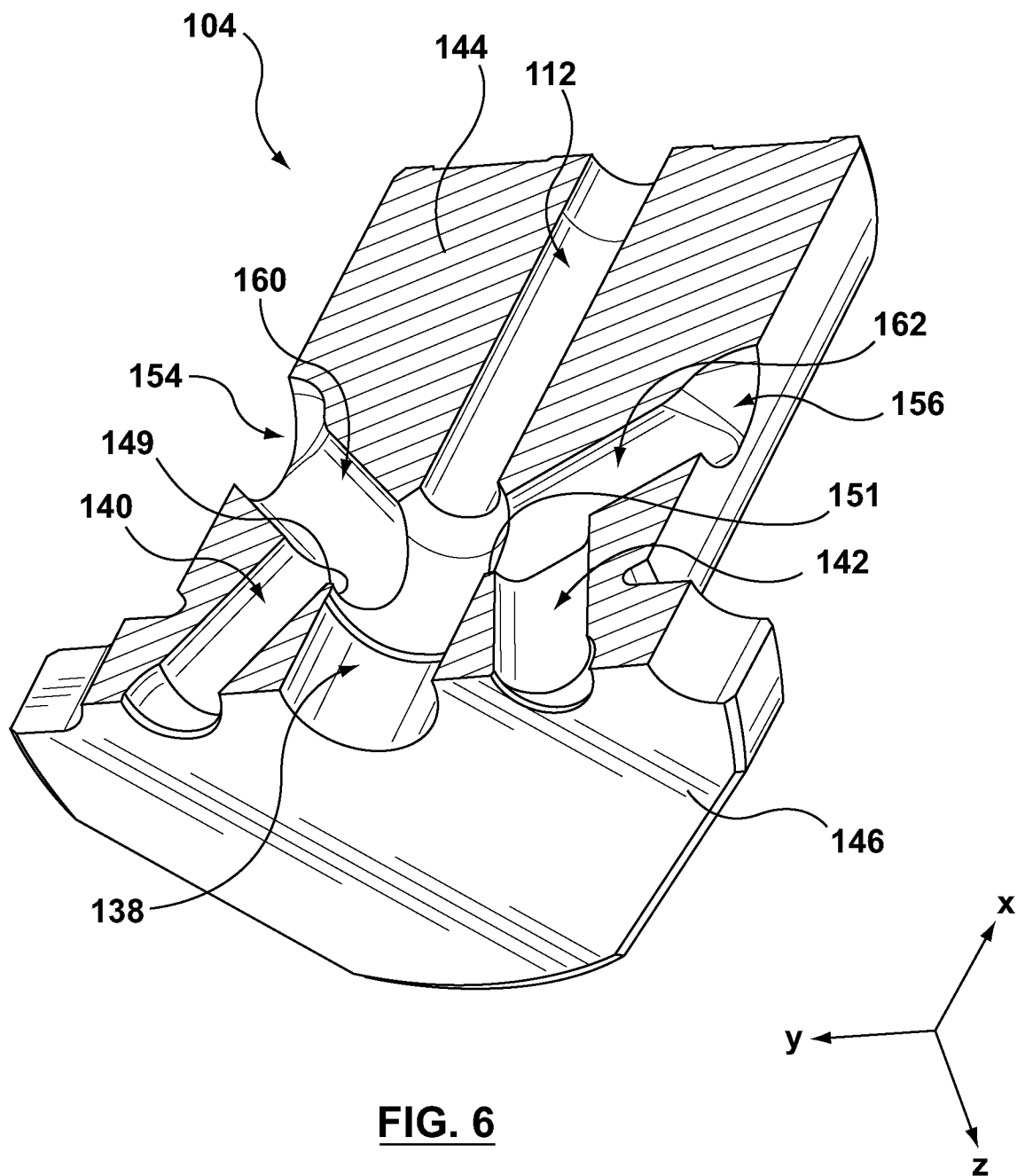


FIG. 5

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**FIG. 6**

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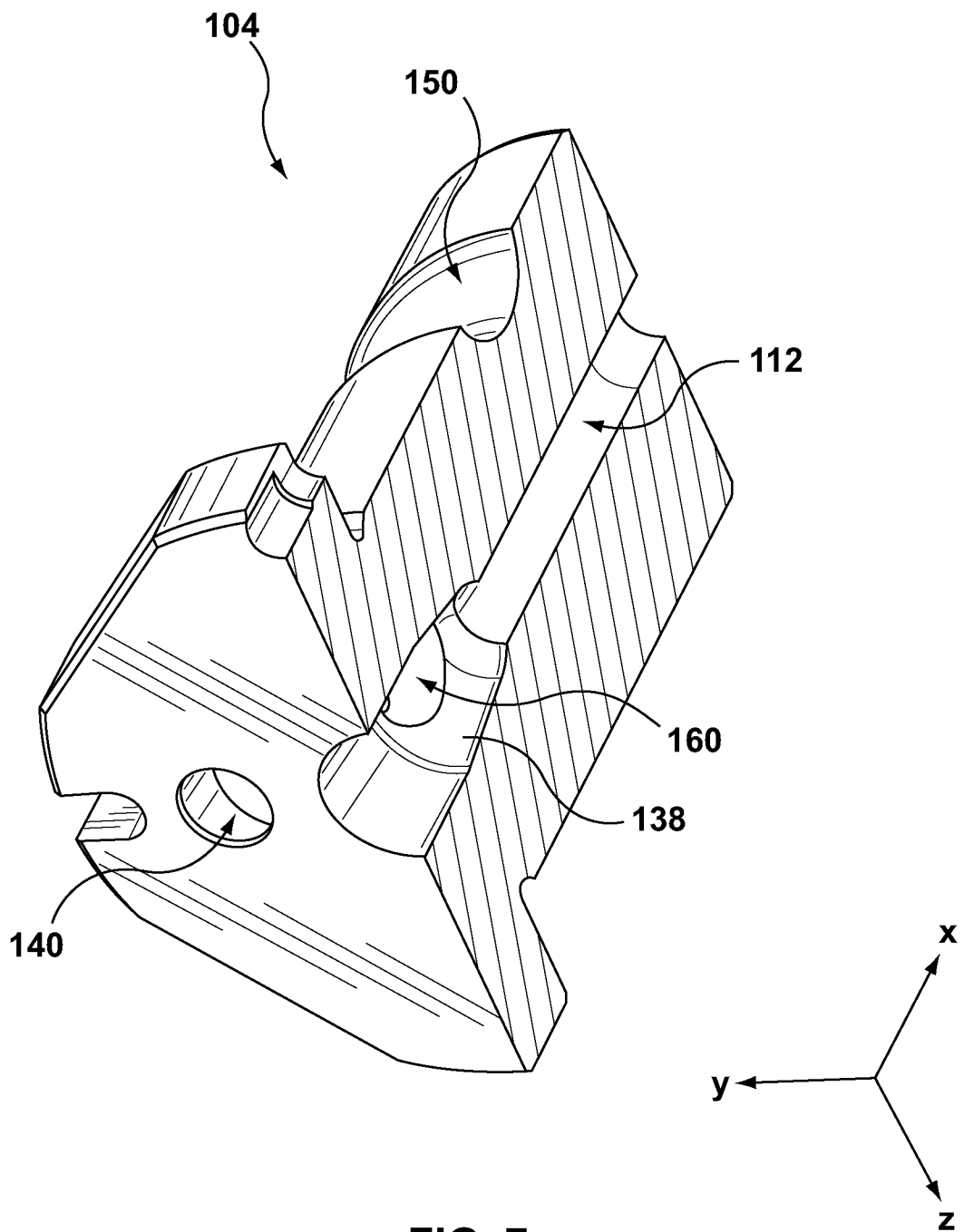


FIG. 7

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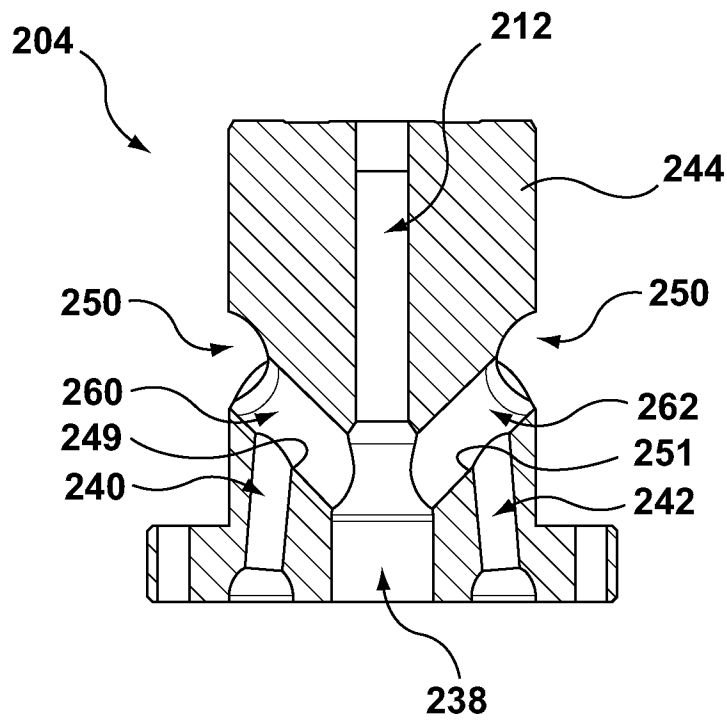


FIG. 8

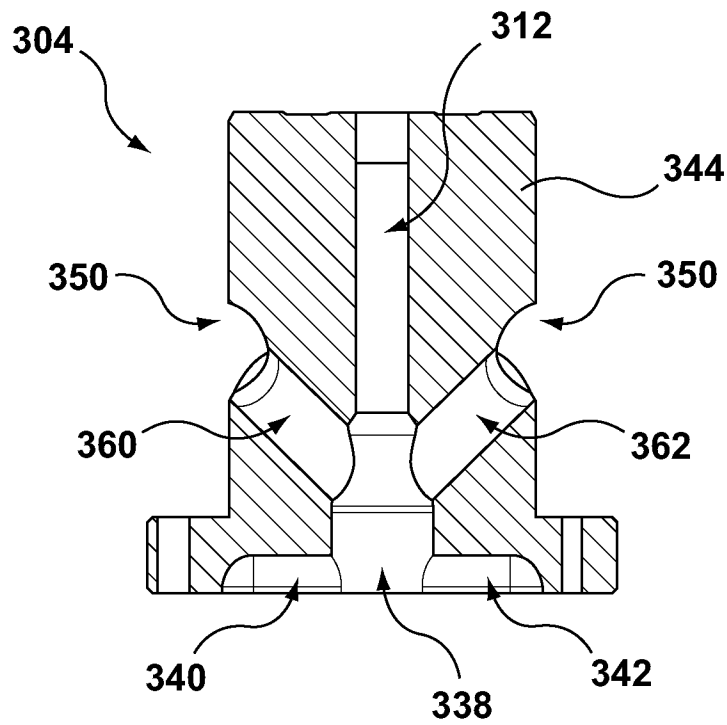


FIG. 9

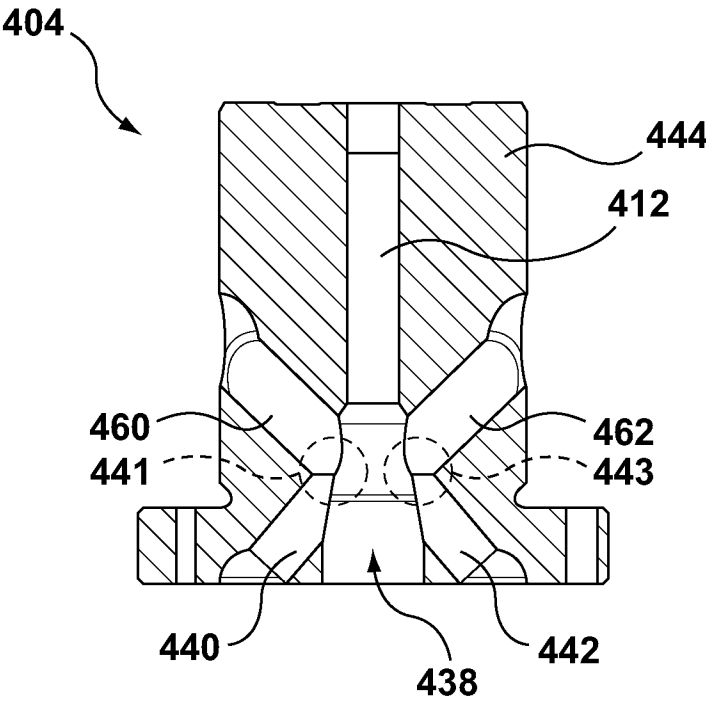


FIG. 10

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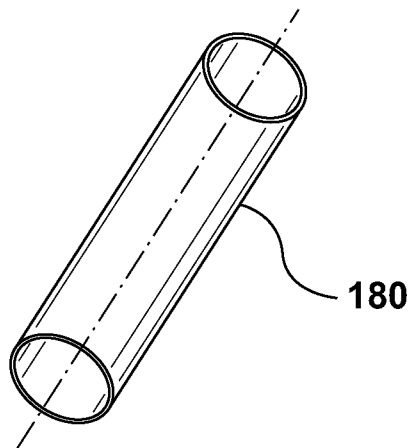


FIG. 11

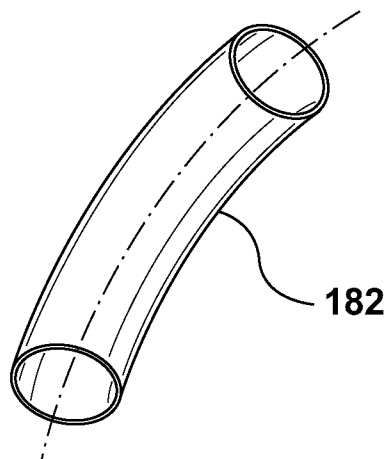


FIG. 12

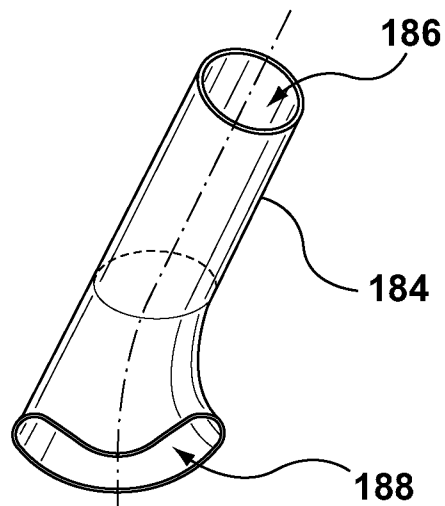


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA2016/050005

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **B29C 45/18** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: **B29C 45/*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel-Orbit (Fampat) with key words, such as: mould, mold, manifold, distribut*, channel, flow, bushing and melt.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7866974 B2 (BLAIS, P. R. et al.) 11 January 2011 (11-01-2011) *whole document*	1-19
A	US 6524093 B2 (BOUTI, A.) 25 February 2003 (25-02-2003) *whole document*	1-19
A	US 6669462 B1 (JENKO, E.) 30 December 2003 (30-12-2003) *whole document*	1-19

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier application or patent but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	"T" "X" "Y" "&"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art document member of the same patent family
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Date of the actual completion of the international search
09 March 2016 (09-03-2016)

Date of mailing of the international search report
09 March 2016 (09-03-2016)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
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Gatineau, Quebec K1A 0C9
Facsimile No.: 819-953-2476

Authorized officer

Pengfei Zhang (819) 639-7928

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2016/050005

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
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US 6524093 B2	25 February 2003 (25-02-2003)	US2002081348A1 AU2332202A CA2430649A1 CA2430649C EP1341660A1 JP2004520189A JP4516271B2 US2002071888A1 US6679697B2 WO0245938A1	27 June 2002 (27-06-2002) 18 June 2002 (18-06-2002) 13 June 2002 (13-06-2002) 08 April 2008 (08-04-2008) 10 September 2003 (10-09-2003) 08 July 2004 (08-07-2004) 04 August 2010 (04-08-2010) 13 June 2002 (13-06-2002) 20 January 2004 (20-01-2004) 13 June 2002 (13-06-2002)
US 6669462 B1	30 December 2003 (30-12-2003)	US6669462B1 AT256545T AU3718401A AU2001237184B2 AU2001237184C1 BR0110449A CA2406060A1 CA2406060C CN1429146A CN1190307C DE60101579D1 DE60101579T2 EP1289731A1 EP1289731B1 JP2003533370A JP3830820B2 PT1289731E WO0187570A1	30 December 2003 (30-12-2003) 15 January 2004 (15-01-2004) 26 November 2001 (26-11-2001) 06 May 2004 (06-05-2004) 03 March 2005 (03-03-2005) 08 April 2003 (08-04-2003) 22 November 2001 (22-11-2001) 11 April 2006 (11-04-2006) 09 July 2003 (09-07-2003) 23 February 2005 (23-02-2005) 29 January 2004 (29-01-2004) 04 November 2004 (04-11-2004) 12 March 2003 (12-03-2003) 17 December 2003 (17-12-2003) 11 November 2003 (11-11-2003) 11 October 2006 (11-10-2006) 30 April 2004 (30-04-2004) 22 November 2001 (22-11-2001)