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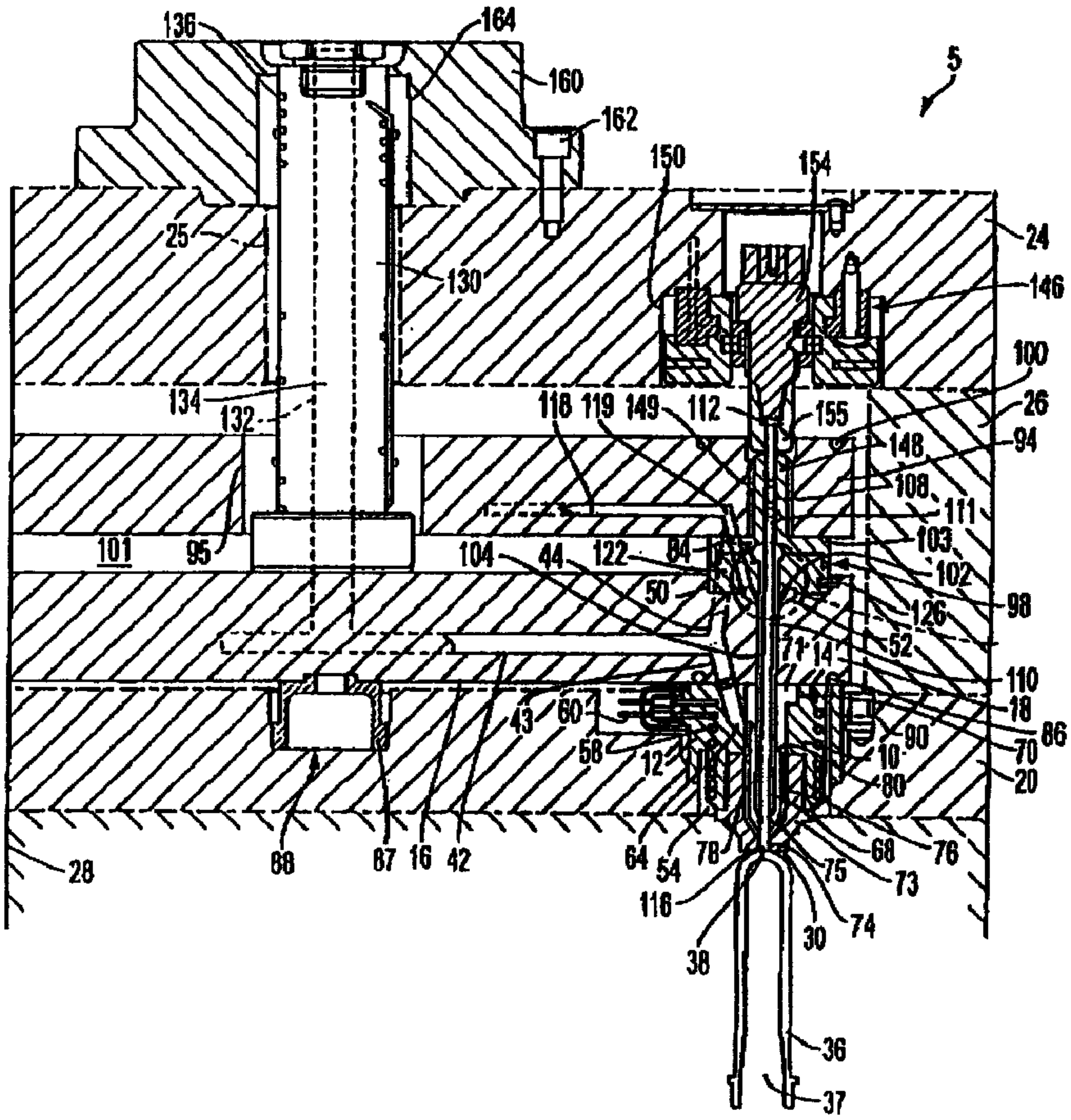
(54) **Titre :** APPAREIL ET PROCEDE DE MOULAGE PAR INJECTION MULTICOUCHE
(54) **Title:** APPARATUS AND METHOD FOR MULTI-LAYER INJECTION MOLDING



(57) **Abrégé/Abstract:**
An injection molding apparatus and method for muli-layer molding of preforms and closures has a central melt channel (78), an annular melt channel (76) radially spaced from the central melt channel (78), and an annular ring channel (106) surrounding the

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(54) Title: APPARATUS AND METHOD FOR MULTI–LAYER INJECTION MOLDING

(57) Abstract

An injection molding apparatus and method for muli–layer molding of preforms and closures has a central melt channel (78), an annular melt channel (76) radially spaced from the central melt channel (78), and an annular ring channel (106) surrounding the central melt channel (78). The central melt channel (78) has a first portion (108) for flow of a first material (200), a second portion (104) for flow of the first material (200) and a second material (300), and a flow extension (105) connecting the first portion (108) and the second portion (104). The flow extension (105) has a flow opening (109) in communication with the annular ring channel (106) for flow of the second material (300). The apparatus and method also include a cavity (36) for receiving flow of the first material (200) and the second material (300) from the central melt channel (78), and for receiving flow of the first material (200) from the annular melt channel (76). In addition, the apparatus and method include a melt passage (42) having a first melt portion (44) in communication with the central melt channel (78), and a second melt portion (43) in communication with the annular melt channel (76).

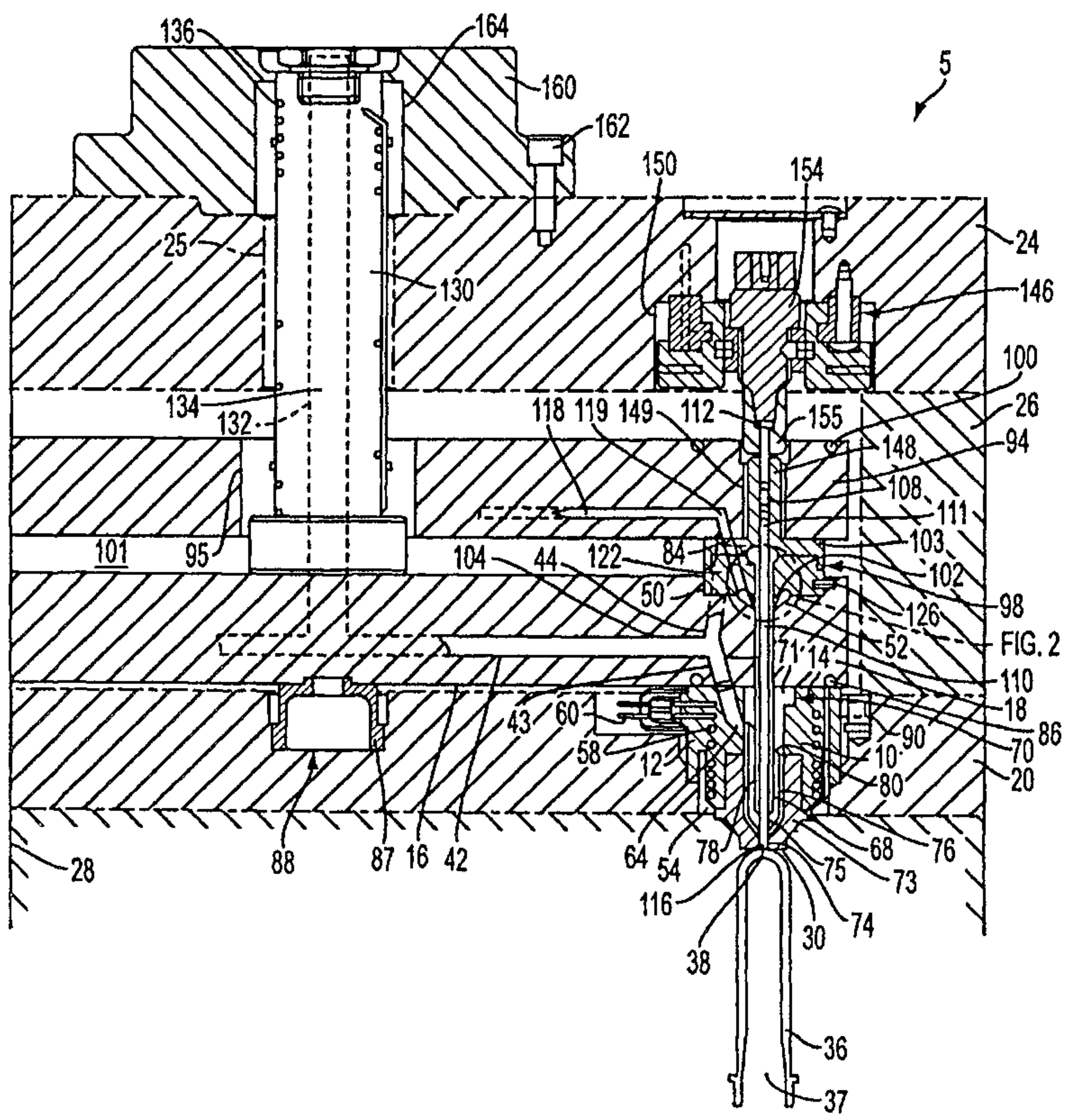

FIG. 2

APPARATUS AND METHOD FOR MULTI-LAYER INJECTION MOLDING

FIELD OF INVENTION

The present invention relates to multi-layer products, and an apparatus and method for the injection molding of same. More specifically, it relates to a three-layer bottle preform and closure, and an apparatus and method for injection molding of same.

BACKGROUND OF THE INVENTION

Multi-cavity injection molding apparatus for making multi-layer molded products, such as protective containers for food, preforms for beverage bottles, and closures, are well-known. One or more layers of one material are typically molded within, or together with, one or more layers of another material, to form the molded product. At least one of these layers is usually a barrier layer formed from a barrier material to protect the contents of the molded product. Since the barrier material is expensive, typically only a very thin barrier layer is used in the molded product. It is also generally desirable to have this thin barrier layer uniformly and evenly distributed (i.e., well-balanced) throughout the molded product to provide the proper protection for the contents of the molded product.

An example of an injection molding apparatus used to make three-layer preforms with thin barrier layers is disclosed in U.S. Patent No. 4,990,301 to Krishnakumar et al. Krishnakumar et al. disclose an injection molding device having multiple and selective melt inlets, passages, channels, and gates, requiring different manifold configurations, for forming multiple layer preforms. In particular, Krishnakumar et al. disclose the use of one large central melt passage and three small annular melt passages flowing into a central channel that opens into a cavity for multi-layer preforms. Depending on the application, either the large central melt passage or one of the three small annular melt passages may be chosen for a barrier material. Krishnakumar et al. inject the barrier material from a selected passage into the cavity, either directly against a cooled portion of preform material previously disposed in the cavity, or after injecting a hot portion of preform material from another passage, in addition to the cooled portion, into the cavity.

There are several problems with the device disclosed by Krishnakumar et al. First, the injection molding device disclosed by Krishnakumar et al. uses multiple melt inlets, passages, channels, and gates that require several different configurations for the same manifold, depending on the application, to make multi-layer preforms. As a result, the injection molding device of Krishnakumar et al. is complex and expensive to both manufacture and operate. Second, injecting a barrier material directly against a cooled portion of preform material previously disposed in a cavity often results in an uneven, or interrupted, barrier layer that does not properly protect the contents of the molded preform. An altered and non-uniform barrier layer may also present problems with blowing out the preform. Third, injecting a barrier material only after injecting a hot portion of preform material, in addition to the cooled portion, into a cavity adds additional time to the injection cycle or production time for the preforms.

Finally, the injection molding device disclosed by Krishnakumar et al. uses large and small passages for the flow of barrier material. The large passage can be problematic, since it can retain too much barrier material at a high temperature, thereby causing the degradation of the barrier material. On the other hand, the small passages can cause high pressure drops for the barrier material as it enters the cavity, thereby damaging or washing out the preform material already in the cavity.

Other examples of injection molding apparatus used to make three-layer preforms with thin barrier layers are disclosed in U.S. Patent No. 4,957,682 to Kobayashi and U.S. Patent No. 4,743,479 to Nakamura et al. Kobayashi discloses a method to form a two material, three layer preform. In a first step, PET is injected through an annular nozzle melt channel into a mold cavity. In a second step, a barrier layer of EVOH is injected through a central melt channel of the same nozzle. Because the thin layer of EVOH is divided only inside the cavity into a core barrier layer within the PET layer, there is no control over the uniformity of the barrier layer in the cavity. Also, the injected barrier layer will most likely damage or washout the PET layer already located in the cavity. Kobayashi also does not provide any means to control the position of the barrier core layer within the preform.

Similarly, Nakamura et al. disclose a method to produce a two material, three layer preform, where PET is injected first through a central melt channel. In contrast, the barrier layer is injected later from a separate annular channel simultaneously with additional PET. The method disclosed by Nakamura et al., however, positions the thin layer of EVOH directly against the cooled portion of PET already in the cavity. As previously explained, this arrangement results in an uneven, non-uniform, and unbalanced barrier layer within the preform.

Accordingly, it would be desirable to have an apparatus and method for injection molding of three-layer preforms or closures that overcomes the problems associated with the prior art by not having multiple melt inlets, passages, channels, and gates, and by having a single configuration for each of its manifolds. An injection molding apparatus and method for injection molding of three-layer preforms or closures without multiple melt inlets, passages, channels, and gates would be relatively simpler and less expensive, both to manufacture and operate.

It would also be desirable to have an apparatus and method for injection molding of three-layer preforms or closures that does not inject a barrier material either directly against a cooled portion of preform material previously disposed in a cavity, or after injecting a hot portion of preform material, in addition to the cooled portion, into the cavity. Such an apparatus and method would provide three-layer preforms or closures with more evenly and uniformly distributed barrier layers, and thus, better protection for the contents of the preforms or closures, without increasing the cycle or production time for the preforms or closures. Moreover, it would also be desirable to have an apparatus and method for injection molding of three-layer preforms or closures that avoids the problems associated with large and/or small passages or channel for barrier material.

In addition, it would be desirable to have an apparatus and method for injection molding of three-layer preforms or closures that is capable of controlling the position of the layer of the barrier material within the preform or closure.

SUMMARY OF THE INVENTION

The present invention provides an injection molding apparatus for multi-layer molding comprising a central melt channel and an annular melt channel radially spaced from the central melt channel. The apparatus also comprises a melt passage having a first melt portion in communication with the central melt channel, and a second melt portion in communication with the annular melt channel.

In addition, the present invention provides an injection molding apparatus for multi-layer molding that comprises a central melt channel having a first portion for flow of a first material, a second portion for flow of the first material and a second material, and a flow extension connecting the first portion and the second portion. The flow extension also has a flow opening. The apparatus further comprises an annular ring channel surrounding the central melt channel for flow of the second material. The annular ring channel is also in communication with the flow opening of the flow extension.

Moreover, the present invention also provides an injection molding apparatus for multi-layer molding comprising a central melt channel for flow of a first material and a second material, and an annular melt channel radially spaced from the central melt channel for flow of the first material. The apparatus also comprises a cavity for receiving flow of the first material and the second material from the central melt channel, and for receiving flow of the first material from the annular melt channel.

The present invention also provides a method for injection molding of multi-layer products comprising the step of injecting a material into a melt passage having a first melt portion and a second melt portion. The method also comprises the step of injecting a first portion of the material from the melt passage through the first melt portion of the melt passage and into a central melt channel. In addition, the method comprises the step of injecting a second portion the material from the melt passage through the second melt portion of the melt passage and into an annular melt channel radially spaced from the central melt channel.

Furthermore, the present invention provides a method for injection molding of multi-layer products comprising the steps of injecting a first material into a central melt channel having a first portion, a second portion, and a flow extension connecting the first and second portions, and injecting a second material into an annular ring channel surrounding the central melt channel. The method also comprises the step of injecting the second material from the annular ring channel into the central melt channel through a flow opening in the flow extension.

The present invention also provides a method for injection molding of multi-layer products comprising the steps of injecting a first material and a second material into a central melt channel, and injecting the first material and the second material from the central melt channel into a cavity. In addition, the method comprises the steps of injecting the first material into an annular melt channel radially spaced from the central melt channel, and injecting the first material from the annular melt channel into the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a valve-gated injection molding apparatus of the present invention for a three layer bottle preform.

FIGS. 2 is an exploded cross-sectional view of a portion of a valve bushing of the injection molding apparatus of FIG. 1.

FIG. 3 is an exploded cross-sectional view of the portion of the valve bushing of FIG. 2.

FIGS. 4A-4E are exploded cross-sectional views of a nozzle and a cavity of the apparatus of FIG.1, illustrating a method of the present invention.

FIG. 5 is an exploded cross-sectional view of FIG. 4C.

FIG. 6 is a cross-sectional view of a three layer bottle preform of the present invention.

FIG. 7 is a cross-sectional view of a three layer closure of the present invention.

FIG. 8 is a cross-sectional view of a thermal-gated injection molding apparatus of the present invention for a three layer bottle preform.

FIG. 9 is a partial cross-sectional view of an alternative front melt distribution manifold of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Turning now to the drawings, FIG. 1 shows a preferred embodiment of a portion of a valve-gated, multi-cavity injection molding apparatus 5 of the present invention with one nozzle 10 for molding three layer bottle preforms, closures, or other products by sequential and simultaneous coinjection. Although only one nozzle is shown in FIG. 1 for ease of illustration, any desirable number of nozzles (i.e., 12, 16, or 48) may be used with the apparatus of the present invention. Preferably, each additional nozzle would have identical features to the nozzle 10 shown in FIG. 1 and described in detail below.

Besides the nozzle 10, the apparatus 5 also comprises a front melt distribution manifold 18, a nozzle retainer plate 20, a back plate 24, a cavity retainer plate 28, and a rear melt distribution manifold 94. Preferably, the nozzle retainer plate 20 and the back plate 24 are joined together with a manifold plate 26. It should also be understood that the apparatus 5 can have a greater or fewer number of plates depending upon the application, and for ease of illustration, only the above-identified plates are shown in FIG. 1.

The nozzle retainer plate 20 is located about an end 87 of a manifold locator 88 between the front melt distribution manifold 18 and the cavity retainer plate 28. The nozzle retainer plate 20 has a nozzle seat opening 54 for receiving the nozzle 10. Preferably, there is a separate nozzle seat opening for every nozzle of the injection molding apparatus. The nozzle retainer plate 20 also preferably has an anti-rotational cam 90 next to the nozzle 10 to prevent the nozzle from rotating within its respective nozzle seat opening 54.

The nozzle 10 has a body 12 with a front tip end 30 and a rear end 14. The nozzle is heated by an integral electrical heating element 58 wrapped around the body 12. The heating element 58 has a terminal 60 positioned near the rear end of the nozzle. The nozzle 10 also has a radial melt channel 64 extending from the rear end 14. In addition, the nozzle 10 has a nozzle gate seal 73 that is secured within the body 12 of the nozzle 10 and forms the front tip end 30. Also, the nozzles gate seal 73 has a front opening 74 to allow material to pass out through the front tip end 30 of the nozzle 10.

The nozzle also has a liner sleeve 70 secured within the nozzle gate seal 73. The liner sleeve 70 has a front opening 75 aligned with and near the front opening 74 of the nozzle gate seal 73, and a rear end 71 corresponding to the rear end 14 of the nozzle 10. Together the liner sleeve 70 and the nozzle seal 73 form an annular melt channel 76 between them that extends throughout the nozzle gate seal 73, and is in fluid communication with the radial melt channel 64. Preferably, the liner sleeve 70 also has an angled flange 80 near the nozzle gate seal 73 to direct the flow of material from the radial melt channel 64 into the annular melt channel 76.

In addition, the liner sleeve 70 has a central bore 68 that extends throughout the body 12 and to the rear end 14 of the nozzle 10. The central bore 68 of the liner sleeve 70 is designed to receive an elongated valve pin 110. The central bore 68 also defines a portion of a central melt channel 78 for the flow of material around the valve pin 110 and through the nozzle 10. As shown in FIG. 1, the annular melt channel 76 is radially spaced from the central melt channel 78.

The valve pin 110 has a body 111, a head 112, and a front tip 116 opposite the head 112. The front tip 116 may be either squared off, as shown in FIGS. 1, 4A-4E, and 5, or tapered (not shown). The front tip 116 is also designed to fit within the front opening 74 of the nozzle gate seal 73. In addition, the valve pin 110 is capable of being moved forward and backward to several different positions, as described in more detail below.

The front melt distribution manifold 18 is positioned on the manifold locator 88 between the nozzle retainer plate 20 and the rear melt distribution manifold 94. The front melt distribution manifold 18 is heated by an integral electrical heating element 86 and has a front face 16 that abuts against the rear end 14 of the nozzle 10. The front melt distribution manifold 18 also has at least one bushing seat opening 50 with a recessed portion 52 for receiving a valve bushing 98, and at least one melt bore 104, with a diameter 104a, in communication with the central bore 68 of the liner sleeve 70. Like the central bore 68, the melt bore 104 is designed to receive the valve pin 110, and defines another portion of the central melt channel 78 for the flow of material around the valve pin 110 and through the front melt distribution manifold 18. Preferably, the front melt distribution manifold 18 has a bushing seat opening 50 and a melt bore 104 for each nozzle 10 used in the apparatus 5.

In addition, the front melt distribution manifold 18 has a first melt passage 42 with a first melt portion 43 extending forward through the front melt distribution manifold 18 and in communication with the radial melt channel 64 of the nozzle 10. The first melt portion 43 allows material to flow from the first melt passage 42 into the radial melt channel 64 and then into the annular melt channel 76 of the nozzle 10. Accordingly, the first melt portion 43, and thus the first melt passage 42, is in communication with the annular melt channel 76 through the radial melt channel 64.

The front melt distribution manifold 18 also has a second melt portion 44 extending backward through the front melt distribution manifold 18 and in communication with the bushing seat opening 50. The second melt portion 44 allows material to flow from the first melt passage 42 backward into the valve bushing 98 seated in the bushing seat opening 50, as explained in more detail below.

As shown in FIG. 1, a melt inlet nozzle 130 abuts against the front melt distribution manifold 18 opposite the nozzle retainer plate 20. The melt inlet nozzle 130 has a central bore 132 partially defining a main melt passage 134 that extends throughout the melt inlet nozzle 130 and into the front melt distribution manifold 18. The main melt passage is in fluid communication with the first melt passage 42 of the front melt distribution manifold 18 and an injection cylinder (not shown) for supplying a preform material 200, such as polyethylene terephthalate ("PET"). The melt inlet nozzle 130 also has a heating element 136.

The apparatus 5 also comprises a rear melt distribution manifold 94 positioned on the manifold locator 88 between, but preferably spaced apart from, the front melt distribution manifold 18 and the back plate 24, as shown in FIG. 1. The rear melt distribution manifold has a central bore 95 for receiving the melt inlet nozzle 130. The rear melt distribution manifold 94 also has a second melt passage 118 in communication with an injection cylinder (not shown) for supplying a barrier material 300, such as nylon or ethylene vinyl alcohol ("EVOH"). The second melt passage 118 also has an L-shaped portion 119 extending forward out the rear melt distribution manifold 94. In addition, the rear melt distribution manifold 94 has a bushing bore 149 aligned with the melt bore 104 of the front melt distribution manifold 18. As described in more detail below, the rear melt distribution manifold 94 is heated by an integral electrical heating element 100 to a lower operating temperature than the front melt distribution manifold 18, and the air space 101 provided between the two manifolds 18, 94 provides thermal separation between them.

The apparatus 5 of the present invention also includes a valve bushing 98 positioned between the manifolds 18, 94, and seated within the bushing seat opening 50 of the first melt distribution manifold 18. In order to facilitate its manufacture, the valve bushing 98 is preferably made of a plurality of components that are brazed together to form a single integral component. As shown in FIG. 1, the valve bushing 98 has a tip protrusion 102 extending forwardly from a middle head portion 103 into the recessed portion 52 of the front melt distribution manifold 18. Together, the tip protrusion 102 and the recessed portion 52 form an annular ring channel 106 between them, as shown in FIG. 2. The annular ring channel 106 surrounds the central melt channel 78. The valve bushing 98 also has an elongated rear stem portion 148 extending rearwardly from the middle head portion 103 through the bushing bore 149 in the rear melt distribution manifold 94. A dowel pin 126 located between the middle head portion 103 and the front melt distribution manifold 18 accurately retains the valve bushing 98 in place and prevents it from rotating.

The valve bushing 98 also has a central bore 108, which extends through the tip protrusion 102, the middle head portion 103, and the stem portion 148. As shown in FIG. 2, similar to the central bore 68 and the melt bore 104, the central bore 108 has a first diameter 108a for receiving the valve pin 110, and defining the a portion of the central melt channel 78 for the flow of material around the valve pin 110 and through the valve bushing 98. The first diameter 108a of the central bore 108 is preferably smaller, however, than the diameter 104 of the melt bore 104. The central bore 108 also has a second diameter 108b for receiving just the valve pin 110, and for preventing the flow of material rearwardly through the valve bushing 98.

As shown in FIG. 3, the central bore 108 of the valve bushing 98 and the melt bore 104 of the front melt distribution manifold 18 are joined together with a flow extension 105, which also forms a portion of the central melt channel 78. The flow extension 105 has an annular flow opening 109 in communication with the annular ring channel 106. Preferably, the annular flow opening 109 is sized to be substantially equal to the difference between the diameters 104a, 108a of the melt bore 104 and the central bore 108, respectively. In other words, the width of the central melt channel 78 is preferably increased to accommodate the additional material flow from the annular ring channel 106, without interrupting or affecting the flow of other material in the central melt channel. It should also be understood that the amount of material flowing from the annular ring channel 106 may be controlled by increasing (i.e., more flow) or decreasing (i.e., less flow) the size of the annular flow opening 109.

As shown in FIGS. 1-2, the valve bushing 98 has an L-shaped first transitional melt passage 122 and a second transitional melt passage 84. The first transitional melt passage 122 is aligned and in communication with both the second melt portion 44 of the front melt distribution manifold 18 and an annular passage 123 in the middle head portion

103 of the valve bushing 98. The annular passage 123 is also in communication with the central bore 108 of the valve bushing 98, as best shown in FIG. 2. Accordingly, the second melt portion 44, and thus the first melt passage 42, is in communication with the central melt channel 78 through the first transitional melt passage 122 and the annular passage 123.

The second transitional melt passage 84 is in communication with both the L-shaped portion 119 of the second melt passage 118 and an annular ring groove 107 disposed around the tip protrusion 102 of the valve bushing 98. The annular ring groove 107 is also in communication with the annular ring channel 106, as best shown in FIG. 2. Accordingly, the L-shaped portion 119, and thus the second melt passage 118, is in communication with the annular ring channel 106 through the second transitional melt passage 84 and the annular ring groove 107.

The back plate 24 of the apparatus 5 of the present invention is positioned on the manifold locator 88 next to the rear melt distribution manifold 94 opposite the front melt distribution manifold 18. The back plate 24 has a central bore 25 aligned with the central bore 95 of the rear melt distribution manifold 94 for receiving the melt inlet nozzle 130. In addition, a locating ring 160 is preferably attached with one or more bolts 162 to the back plate 24 opposite the rear melt distribution manifold 94. The locating ring 160 also has a central bore 164 aligned with the central bore 25 of the back plate 24 for receiving the melt inlet nozzle 130.

The back plate 24 preferably has a piston seat opening 150 aligned with the bushing bore 149 of the rear melt distribution manifold 94. An actuating mechanism 146 is positioned within the piston seat opening 150. The actuating mechanism 146 comprises a piston cylinder 154 and an end cap 155 for connecting the head 112 of the valve pin 110 to the piston cylinder 154. During operation of the actuating mechanism 146, the piston cylinder 154 and the end cap 155 may extend into a portion of the bushing bore 149, as shown in FIG. 1. The piston cylinder 154 is preferably driven by controlled fluid pressure (i.e., from oil or water) applied through one or more ducts (not shown). It should be understood that while only a hydraulic actuating mechanism is described and shown herein, other types of actuating mechanisms, such as electro-mechanical mechanisms, can be used with the apparatus of the present invention.

Driving the piston cylinder 154 forward causes the valve pin 110 to move forward toward the cavity retainer plate 28. Moving the piston cylinder 154 all the way forward causes the front tip end 116 of the valve pin 110 to be seated within the front opening 74 of the nozzle gate seal 73, thereby cutting off fluid communication between the melt channels 76, 78 and the front opening 74 of the nozzle gate seal 73. On the other hand, driving the piston cylinder 154 backward causes the valve pin 110 to move backward away from the cavity retainer plate 28. Moving the piston cylinder 154 backward past the front opening 74 of the nozzle gate seal 73 causes the front tip end 116 of the valve pin 110 to be withdrawn from the front opening 74 of the nozzle gate seal 73, thereby establishing fluid communication between the annular melt channel 76 and the front opening 74 of the nozzle gate seal 73. In addition, moving the piston cylinder 154 backward past the front opening 75 of the liner sleeve 70 causes the front tip end 116 of the valve pin 110 move backward past the front opening 75 of the liner sleeve 70, thereby establishing fluid communication between not only the annular melt channel 76 and the front opening 74 of the nozzle gate seal 73, but also between the central melt channel 78 and the front opening 74 of the nozzle gate seal 73.

As shown in FIGS. 1 and 5, the cavity retainer plate 28 of the present invention has a cavity 36 around a mold core 37. The cavity 36 has a cavity opening 38 aligned with the front opening 74 of the nozzle gate seal 73. The cavity 36 may have any number of shapes and configurations depending on the desired product to be molded. As shown in FIG. 1, the cavity preferably, but not necessarily, has the shape of a bottle preform with a threaded end. It should be understood that by altering the cavity 36, one may mold other bottle preforms of different shapes and configurations, or products different from bottle preforms, such as closures, and the present invention is not limited to the molding of only the bottle preform shown or even other types of preforms.

It should also be understood that the apparatus 5 of the present invention, especially its nozzles, may also have one or more heating systems, cooling systems, and insulative air spaces to maintain the proper temperatures for its components and the materials flowing through the apparatus. Examples of suitable heating systems, cooling systems, and insulative air spaces for the apparatus of the present invention are described in U.S. Patent No. 6,062,841 entitled "Spruce Gated Five Layer Injection Molding Apparatus," filed on November 13, 1997, as well as U.S. Patent Nos. 5,094,603, 5,135,377, and 5,223,275 to Gellert.

The operation of the apparatus of the present invention will now be described with particular reference to FIGS. 4A-4E and 5. While the formation of only a three layer bottle preform is shown in the drawings and described below, it should be understood that other types of three layer preforms or products different than preforms, such as closures, with different material characteristics, may be the resulting products of the apparatus and method of the present invention.

As shown in FIG. 4A, the method of the present invention begins with the valve pin fully inserted through the front opening 74 of the nozzle gate seal 73 by the forward motion of the piston cylinder 154. As a result, fluid communication between the annular melt channel 76, the central melt channel 78, and the front opening 74 of the nozzle gate seal 73 is cutoff. In this position, the valve pin is identified by the reference numeral 110a. Electrical power is then applied to the heating elements 58, 86, 136 of the nozzle 10, the front melt distribution manifold 18, and the melt inlet nozzle 130, respectively, to heat them to an operating temperature for the preform material disposed within the main melt passage 134 and the first melt passage 42. If PET is used for the preform material, the preferred operating temperature is about 565°F.

Next, the valve pin is pulled out of the front opening of the nozzle gate seal by the backward motion of the piston cylinder, as shown in FIG. 4B. As a result, fluid communication is established between the annular melt channel and the front opening of the nozzle gate seal, but not between the central melt channel and the front opening of the nozzle gate seal. In this position, the valve pin is identified by the reference numeral 110b.

Injection pressure is then applied to the main melt passage 134 to force a first portion 200a of preform material through the first melt passage 42 and into the first melt portion 43. From there, the first portion 200a of preform material flows through the radial melt channel 64 aligned with the first melt portion 43, into the annular melt channel 76, out the front opening 74 of the nozzle gate seal 73, and into the cavity opening 38. Injection pressure is applied until the first portion 200a of preform material fills the cavity 36, as shown in FIG. 4B. The first portion 200a of preform material begins to cool as it fills the cavity 36.

Electrical power is then applied to the heating element 100 in the rear melt distribution manifold 94 to heat it to an operating temperature for the barrier material 300 disposed within the second melt passage 118. If nylon is used for the barrier material, the preferred operating temperature is about 400°F. Next, the valve pin is pulled out of the front opening 75 of the liner sleeve 70 by the backward motion of the piston cylinder, as shown in FIG. 4C. As a result, fluid communication is established between not only the annular melt channel and the front opening of the nozzle gate seal, but also between the central melt channel and the front opening of the nozzle gate seal. In this position, the valve pin is identified by the reference numeral 110c.

Injection pressure is then applied to the main melt passage 134 to force a second portion 200b of preform material through the first melt passage 42 and into the second melt portion 44, and a third portion 200c of preform material through the first melt passage 42 and into the first melt portion 43. From there, the second portion 200b of preform material flows through the L-shaped first transitional melt passage 122 aligned with the second melt portion 44 and into the annular passage 123 of the valve bushing 98, and the third portion 200c of preform material flows through the radial melt channel 64 aligned with the first melt portion 43 and into the annular melt channel 76. The second portion 200b of preform material also flows from the annular passage 123 into the central melt channel 78 and around the valve pin 110 toward the cavity 36.

At about the same time, injection pressure is applied to the barrier material 300 in the second melt passage 118 to force the barrier material through the second melt passage 118 and into its L-shaped portion 119. From there, the barrier material 300 flows into the second transitional melt passage 84, through the annular ring groove 107, and into the annular ring channel 106. As best shown in FIG. 3, the barrier material 300 flows from the annular ring channel 106, through the flow opening 109, and into the flow extension 105. The barrier material 300 then joins and surrounds the flow of the second portion 200b of the preform material in the central melt channel 78. Since the flow opening 109 is preferably sized to be substantially equal to the difference between the diameters 104a, 108a of the melt bore 104 of the front melt distribution manifold 18 and the central bore 108 of the valve bushing 98, respectively, the flow of the barrier material does not interrupt the flow of the second portion of the preform material. As a result, the flow pressure of the second portion of the preform material before the flow extension is substantially the same as the flow pressure of the second portion of the preform material after the flow extension. In addition, since the barrier material flows together with the second portion 200b of the preform material through the central melt channel 78, as best shown in FIG. 5, degradation and pressure drop problems causes by too large or too small of channels for the barrier material are avoided.

Together, the barrier material 300 and the second portion 200b of the preform material flow through the central melt channel 78 and around the valve pin 110, and out the front opening 75 of the liner sleeve 70. Here, the barrier material 300 and the second portion 200b of the preform material are joined and surrounded by the third portion 200c of the preform material flowing from the annular melt channel 76. At this point, the third portion 200c of the preform material, the barrier material 300, and the second portion 200b of the preform material are all still hot. Together, the third portion 200c of the preform material, the barrier material 300, and the second portion 200b of the preform material simultaneously flow out the front opening 74 of the nozzle gate seal 73, and into the cavity opening 38. The simultaneous flow of these materials helps reduce the cycle or production time for the resulting perform. Next, the third portion 200c of the hot preform material, the hot barrier material 300, and the second portion 200b of the hot preform material split the first portion 200a of the cooled preform material in the cavity 36, as shown in FIGS. 4C and 5. Injection pressure is applied to the first and second melt passages 42, 118 until the cavity 36 is completely filled with material.

As best shown in FIG. 5, the barrier material 300 is surrounded by, and embedded within, the second and third portions 200b, 200c of hot preform material as the barrier material 300 flows into the cavity 36. As a result, the second and third portions 200b, 200c of hot preform material insulate the barrier material 300 from the first portion 200a of cooled preform material already in the cavity 36. This arrangement provides an evenly and uniformly distributed layer of barrier material within the resulting preform.

In addition, since the barrier material 300 is surrounded by the second and third portions 200b, 200c of the hot preform material, the distribution and position of the barrier material 300 within the cavity is properly controlled. In other words, the distribution and positioning of the barrier material 300 is not solely dependent on the cavity, the mold core, and/or the cooled preform material already present in the cavity. Instead, the distribution and positioning of the barrier material for the cavity, and thus the resulting preform, is controlled and balanced by the melt channels before the barrier material enters the cavity 36. The position of the barrier material within the cavity, and thus the resulting preform, may also be set and controlled by manipulating the timing, temperature, and pressure as known in the art. This arrangement ensures that the barrier material will be correctly positioned and balanced within the cavity, and avoids the unbalanced distribution and positioning of the barrier material within the cavity that can be caused, for example, by misalignment or shifting of the mold core 37.

After the cavity 36 is filled, the valve pin is moved forward by the piston cylinder to cutoff material flow and fluid communication between the central melt channel and the front opening of the liner sleeve, as shown in FIG. 4D. As shown in FIG. 4E, the piston cylinder continues to move the valve pin forward until the valve pin is fully inserted into the front opening of the nozzle gate seal, thereby also cutting off material flow and fluid communication between the annular melt channel and the front opening of the nozzle gate seal. Since the valve pin shuts off the flow of material out of the nozzle, it is not necessary to release the injection pressure applied to the preform or barrier material. Once the cavity is filled and the material flow has stopped, the preform continues to cool until the material has solidified enough to be ejected from the cavity.

As a result of the apparatus and method of the present invention, a bottle preform 170 may be created, as shown in FIG. 6. The bottle preform 170 has a first open end 171 and a second closed end 172 spaced from and opposite of the first open end. Preferably, but not necessarily, the first open end 171 has threads 173. The bottle preform 170 also has an outer layer 174 of preform material, such as PET, an inner layer 175 of preform material, such as PET, and a core layer 176 of barrier material, such as nylon or EVOH, between the outer and inner layers 174, 175 of preform material. The core layer 176 of barrier material preferably extends substantially throughout the bottle preform 170, as shown in FIG. 6. Each layer 174, 175, 176 has several properties, including, but not limited to, thickness, weight, and percentage of total volume ("volume percentage").

By altering the timing and/or the amount of preform or barrier material, the properties of the outer, inner, and core layers 174, 175, 176 may also be altered. For instance, by injecting a larger amount of the first, second, and/or third portions 200a, 200b, 200c of the preform material into the cavity 36, thicker and heavier outer and/or inner layers 174, 175 of preform material may be formed. Assuming a constant total volume for the cavity, and thus the bottle preform 170, the volume percentage of the preform material will be increased, while the volume percentage of the barrier material 300 will be decreased. On the other hand, by injecting a larger amount of barrier material into the cavity, a thicker and heavier core layer 176 of barrier material may be formed. Assuming once again a constant total volume for the cavity, and thus the bottle preform, the volume percentage of the barrier material will be increased, while the volume percentage of the preform material will be decreased.

As a result of the apparatus and method of the present invention, a closure 180 may also be created, as shown in FIG. 7. The closure 180 may be made with the same apparatus and method as the bottle perform 170, with the exception that the preform material (i.e., PET) is preferably replaced with a closure material, such as polypropylene. The closure 180 has a base 181 and an annular flange 182 extending outward from the base. The annular flange 182 has an inner side 183, preferably, but not necessarily, with threads 184. The closure 180 also has an outer layer 185 of closure material, such as polypropylene, an inner layer 186 of closure material, such as polypropylene, and a core layer 187 of barrier material, such as nylon or EVOH, between the outer and inner layers 185, 186 of closure material. The core layer 187 of barrier material preferably extends substantially throughout the base 181 of the closure 180, as shown in FIG. 7. Each layer 185, 186, 187 has several properties, including, but not limited to, thickness, weight, and percentage of total volume ("volume percentage").

By altering the timing and/or the amount of closure or barrier material, the properties of the outer, inner, and core layers 185, 186, 187 may also be altered. For instance, by injecting a larger amount of the first, second, and/or third portions of the closure material into the cavity, thicker and heavier outer and/or inner layers 185, 186 of closure material may be formed. Assuming a constant total volume for the cavity, and thus the closure 180, the volume percentage of the closure material will be increased, while the volume percentage of the barrier material will be decreased. On the other hand, by injecting a larger amount of barrier material into the cavity, a thicker and heavier core layer 187 of barrier material may be formed. Assuming once again a constant total volume for the cavity, and thus the closure, the volume percentage of the barrier material will be increased, while the volume percentage of the closure material will be decreased.

As an alternative to the valve-gated apparatus 5 shown in FIGS. 1-5 and described above, FIG. 8 shows a preferred embodiment of a portion of a thermal-gated, multi-cavity injection molding apparatus 405 of the present invention. The apparatus 405 is identical to, and operates in the same manner as, the apparatus 5, with only a few exceptions. To avoid redundancy and unnecessary repetition, only the differences between the apparatus 405 and the apparatus 5 will be discussed in detail below. Similarly, for ease of illustration, only some of the components of the apparatus 405 are identified by reference numerals in FIG. 8. Preferably, the non-identified components of the apparatus 405 are identical to the corresponding components of the apparatus 5. In addition, it should be understood that, like the apparatus 5, the apparatus 405 may be used to create both the bottle preform 170 and the closure 180 shown in FIGS. 6-7 and described above.

The primary difference between the apparatus 405 and the apparatus 5 is that the apparatus 405 does not have a valve pin. As a result, the apparatus 405 is manipulated by controlling the injection pressure applied to the first and second melt passages, rather than by controlling the valve pin. In other words, instead of moving a valve pin forward and backward to cutoff and establish the flow of material, the apparatus 405 uses increases and decreases in the injection pressure to cutoff or establish the flow of material. Otherwise, the operation and method of the apparatus 405 is the same as the operation and method of the apparatus 5.

Since the apparatus 405 does not use a valve pin, certain components of the apparatus 5 are no longer necessary for the apparatus 405. For instance, the back plate 424 of the apparatus 405 does not have a piston seat opening 150 or an actuating mechanism 146. Likewise, the rear melt distribution manifold 494 of the apparatus 405 does not have a bushing bore 149. Moreover, the valve bushing 498 of the apparatus 405 does not have a stem portion 148, and the valve bushing 498 has a central bore 508, with only one diameter 108a, that does not extend past the annular passage 123.

FIG. 9 shows a partial view of another embodiment of a front melt distribution manifold 618 of the present invention. The front melt distribution manifold 618 is identical to, and operates in the same manner as, the front melt distribution manifold 18 described above and shown in FIGS. 1 and 8, with only a few exceptions. In order to avoid redundancy and unnecessary repetition, only the differences between the front melt distribution manifold 618 and the front melt distribution manifold 18 will be discussed in detail below.

As shown in FIG. 9, the front melt distribution manifold 618 comprises a bridge section 705, a sub-manifold section 710 spaced from the bridge section 705, and a melt link 715 joining the bridge section 705 and the sub-manifold section 710. The bridge section 705 has a bridge passage 707 in communication with the main melt passage 134 of the melt inlet nozzle 130, the sub-manifold section 710 has a sub-manifold passage 713 in communication with the first melt passage 42, and the melt link 715 has a link passage 717 in communication with both the bridge passage 707 and the sub-manifold passage 713. An example of a suitable melt link for use with the present invention is disclosed in U.S. Patent No. 5,843,361.

A conventional melt mixer 719 (or static mixer) is also positioned in the link passage 717, as shown in FIG. 9. During operation of the present invention, the use of PET for the preform material may generate a certain amount of undesirable acetaldehyde ("AA"). In addition, non-uniform shear stress may take place during the flow of the preform material or the barrier material through the melt channels of the manifolds and/or the nozzle. This non-uniform shear stress can create a non-uniform temperature distribution across the preform or barrier material, thereby creating difficulties with uniformly filling the cavity 36 with the preform and the barrier material. The melt mixer 719, however, addresses these problems and helps to prevent them from occurring or reduce their effects. Specifically, the melt mixer 719 helps reduce the amount of AA generated and improve the temperature uniformity across the material flow. Any of the melt mixers or static mixers known in the prior art may be adapted for use with the present invention. Examples of suitable melt mixers or static mixers are disclosed in U.S. Patent No. 4,541,982, U.S. Patent No. 4,965,028, U.S. Patent No. 5,262,119, and Applicant's DE 3201710 application.

Although a melt mixer is shown only in the link passage of the melt link for the front melt distribution manifold, it should be understood that melt mixers or static mixers may be used in a number of different locations throughout the apparatus of the present invention. For instance, a melt mixer may be positioned in a link passage of a melt link for the rear melt distribution manifold 94. In addition, melt mixers may be positioned in the transitional melt passages 84, 122 of the valve bushing 98 and/or in the radial melt channel 64 of the nozzle 10.

The apparatus and methods of the present invention may be applied with particular advantage to preforms and closures for bottles or containers. It should also be readily apparent from the forgoing description and accompanying drawings that the injection molding apparatus and method of the present invention are an improvement over the prior art. For instance, the apparatus and method of the present invention do not require multiple melt inlets, passages, channels, and gates. Instead, the apparatus and method of the present invention only uses two injection cylinders, two melt passages, and one gate to create three-layer preforms and closures. As a result, the present invention overcomes the disadvantages associated with the prior art injection molding devices and methods by providing a multi-layer injection molding apparatus and method that are relatively simple and inexpensive to both manufacture and operate.

The present invention also overcomes the disadvantages of the prior art injection molding devices and methods by surrounding the barrier material with hot preform material before injecting it into the cavity, thereby avoiding injection of the barrier material directly against a cooled portion of preform material previously disposed in the cavity. Consequently, the present invention provides a three-layer perform and closure with a more evenly and uniformly distributed barrier layer with better protection characteristics. Similarly, unlike the prior art, since the present invention injects the barrier material simultaneously with its surrounding hot preform material, rather than after first injecting hot preform material into the cavity, the cycle time for the preforms or closures is minimized and not increased.

Those skilled in the art to which the invention pertains may make modifications and other embodiments employing the principles of this invention without departing from its spirit or essential characteristics, particularly upon considering the foregoing teachings. For instance, the threads of the bottle preform and/or the closure may be eliminated entirely or replaced with some other fastening feature. In addition, any desirable shape and configuration may be used for the cavity and the resulting bottle preform and/or closure, depending on manufacturing and consumer preferences. Likewise, manufacturing and consumer preferences may also dictate the timing and number of cycles for the operation of the apparatus and methods of the present invention. Accordingly, the described embodiments are to be considered in all respects only as illustrative and not restrictive and the scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. Consequently, while the invention has been described with reference to particular embodiments, modifications of structure, sequence, materials and the like would be apparent to those skilled in the art, yet still fall within the scope of the invention.

CLAIMS:

1. An injection molding apparatus for multi-layer molding comprising:

a central melt channel passing through a manifold and a nozzle;

an annular melt channel radially spaced from the central melt channel;

a first melt passage in a manifold, the first melt passage having a first melt portion in communication with the annular melt channel, and a second melt portion in communication with the central melt channel, the first and second melt portions being joined in the manifold; and

a second melt passage communicating with the central melt channel in the manifold.

2. The injection molding apparatus of claim 1 further comprising an annular ring channel communicatively connecting the second melt passage with the central melt channel.

3. The injection molding apparatus of claim 1 further comprising a cavity for receiving flow of a first material and a second material from the central melt channel, and for receiving flow of the first material from the annular melt channel.

4. The injection molding apparatus of claim 1 further comprising an moveable valve member adapted to seal the central melt channel.

5. The injection molding apparatus of claim 4 wherein the movable valve member is adapted to also selectively seal the annular melt channel.

6. An injection molding apparatus for multi-layer molding comprising:

a nozzle having a central bore passing therethrough;

a central melt channel having a first portion for flow of a first material, a second portion for flow of the first material and a second material, and a flow extension connecting the first portion and the second portion, at least part of the second portion of the central melt channel being defined by the central bore of the nozzle, the flow extension having a flow opening positioned upstream of the central bore of the nozzle; and

an annular ring channel around the central melt channel for flow of the second material, the annular ring channel being in communication with the central melt channel via the flow opening of the flow extension.

7. The injection molding apparatus of claim 6 wherein the first portion of the central melt channel has a first diameter, and the second portion of the central melt channel has a second diameter greater than the first diameter.

8. The injection molding apparatus of claim 6 further comprising a cavity for receiving flow of the first material and the second material from the central melt channel simultaneously.

9. The injection molding apparatus of claim 6 further comprising a moveable valve member positioned within the central melt channel, the moveable valve member capable of cutting off flow of the first and second materials from the central melt channel.

10. The injection molding apparatus of claim 9 wherein the first and second materials flow along the moveable valve member in the second portion of the central melt channel.

11. The injection molding apparatus of claim 6 wherein the second portion of the central melt channel maintains flow of the first material and flow of the second material in a side-by-side orientation.

12. An injection molding apparatus for multi-layer molding comprising;

a central melt channel for a flow of a first material and a second material, the central melt channel defined at least in part by a central bore running through the entire length of a nozzle;

an annular melt channel radially spaced from the central bore in the nozzle for flow of the first material; and

a cavity for receiving flow of the first material and the second material from the central bore, and for receiving flow of the first material from the annular melt channel wherein the first and second materials flow together through the entire length of the central bore of the nozzle.

13. The injection molding apparatus of claim 12 further comprising a moveable valve member positioned within the central bore, the movable valve member capable of cutting off flow of the first and second materials from the central bore into the cavity, the movable valve member also capable of cutting off flow of the first material from the annular melt channel into the cavity.

14. The injection molding apparatus of claim 12 wherein the central melt channel is capable of maintaining flow of the first material and flow of the second material in a side-by-side orientation.

15. A method for injecting molding of multi-layer products comprising the steps of:

injecting a first material from an annular melt channel into a cavity, and then

injecting the first material and a second material through a central melt channel into the cavity, the annular melt channel being disposed around said central melt channel, the central melt channel running through the entire length of a nozzle,

wherein the first and second materials flow together through the entire lenth of the central bore of the nozzle.

16. The method of claim 15 further comprising the step of blocking flow of the first and second materials from the central melt channel with a moveable valve member.

17. The method of claim 15 wherein the first material is either polyethylene terephthalate or polypropylene.

18. The method of claim 17 wherein the second material is either nylon or ethylene vinyl alcohol.

19. The method of claim 15 wherein the first material is either polyethylene terephthalate or polypropylene, and the second material is either nylon or ethylene vinyl alcohol.

20. A method for injection molding of multi-layer products comprising the steps of:

(a) injecting a first material into an annular melt channel radially spaced from a central melt channel;

(b) blocking the central melt channel with a valve pin to prevent flow therefrom into a cavity;

(c) injecting the first material and a second material into the central melt channel;

(d) injecting the first material from the annular melt channel into the cavity; and

(e) withdrawing the valve pin and injecting the first material and the second material from the central melt channel into the cavity,

wherein step (d) is commenced before step (e) is commenced.

21. The method of claim 20 further comprising the step of simultaneously injecting the first and second materials from the central melt channel into the cavity.

22. The method of claim 20 further comprising the step of cutting off flow of the first material from the annular melt channel with the movable valve member.

23. The method of claim 20 wherein step (d) is being performed when step (e) is commenced.

24. The injection molding apparatus of claim 1, further comprising a manifold containing at least a portion of the first melt passage.

25. The injection molding apparatus of claim 1, further comprising a nozzle containing at least a portion of the central melt channel and at least a portion of the annular melt channel.

26. The injection molding apparatus of claim 6, further comprising an annular melt channel for the flow of the first material, the annular melt channel being in connection with the central melt channel, at least a portion of the annular melt channel being positioned within the nozzle and in communication with a front opening in the nozzle, the annular melt channel being in communication with the central melt channel near the front opening in the nozzle.

27. The injection molding apparatus of claim 6, wherein the first and second materials flow together through the entire length of the central bore of the nozzle.

28. An injection molding apparatus for multi-layer molding comprising;

a nozzle having a central melt channel and an annular melt channel radially spaced from the central melt channel;

a first manifold to guide a first material toward the nozzle;

a first melt passage positioned within the first manifold for flow of the first material, the first melt passage being split within the first manifold into a first melt branch and a second melt branch, the first melt branch being in connection with the central melt channel, and the second melt branch being in connection with the annular melt channel;

a second manifold to guide a second material toward the nozzle; and a second melt passage positioned within the second manifold for flow of the second material, the second melt passage being in connection with the central melt channel.

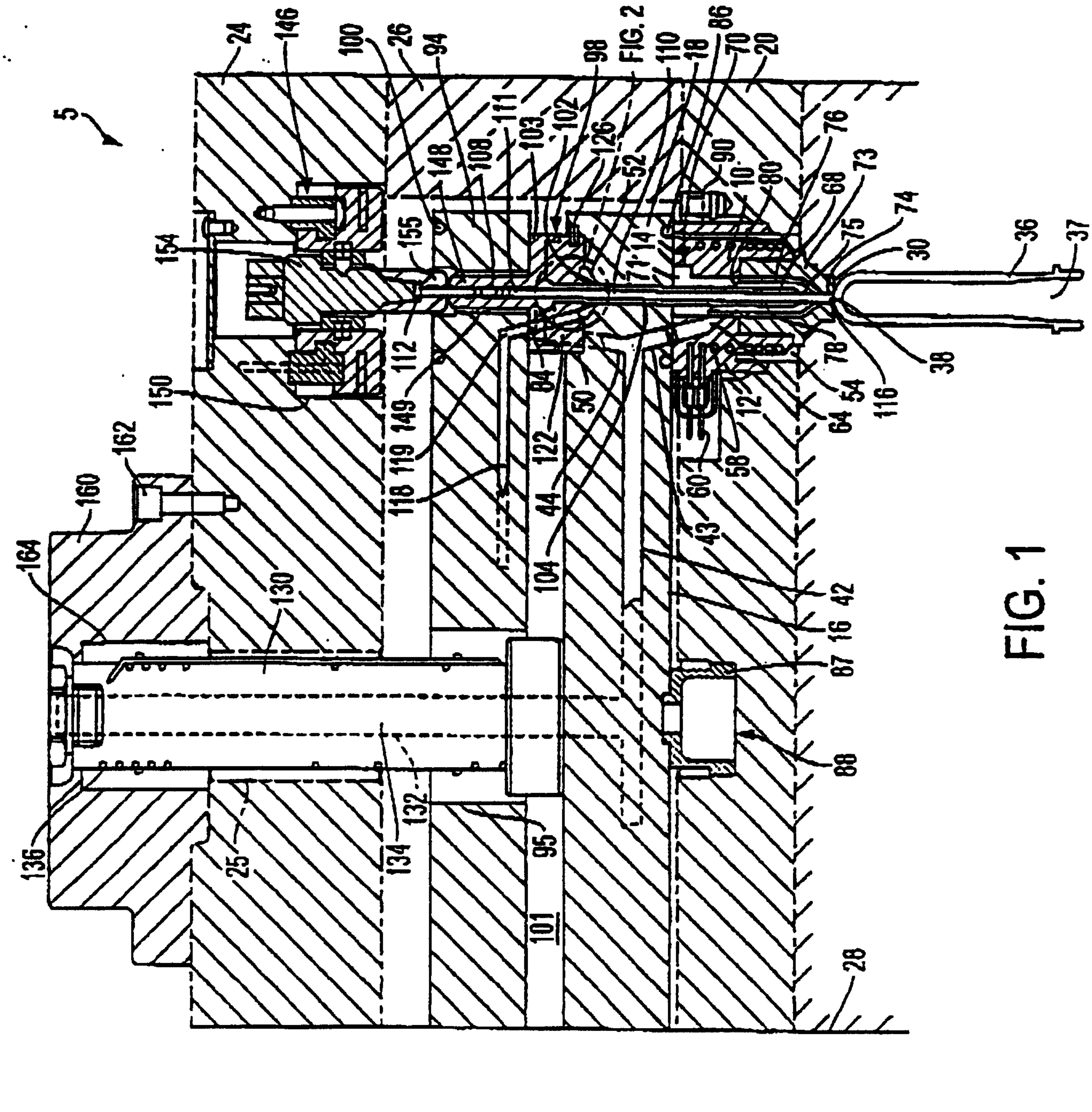

FIG. 1

AMENDED SHEET

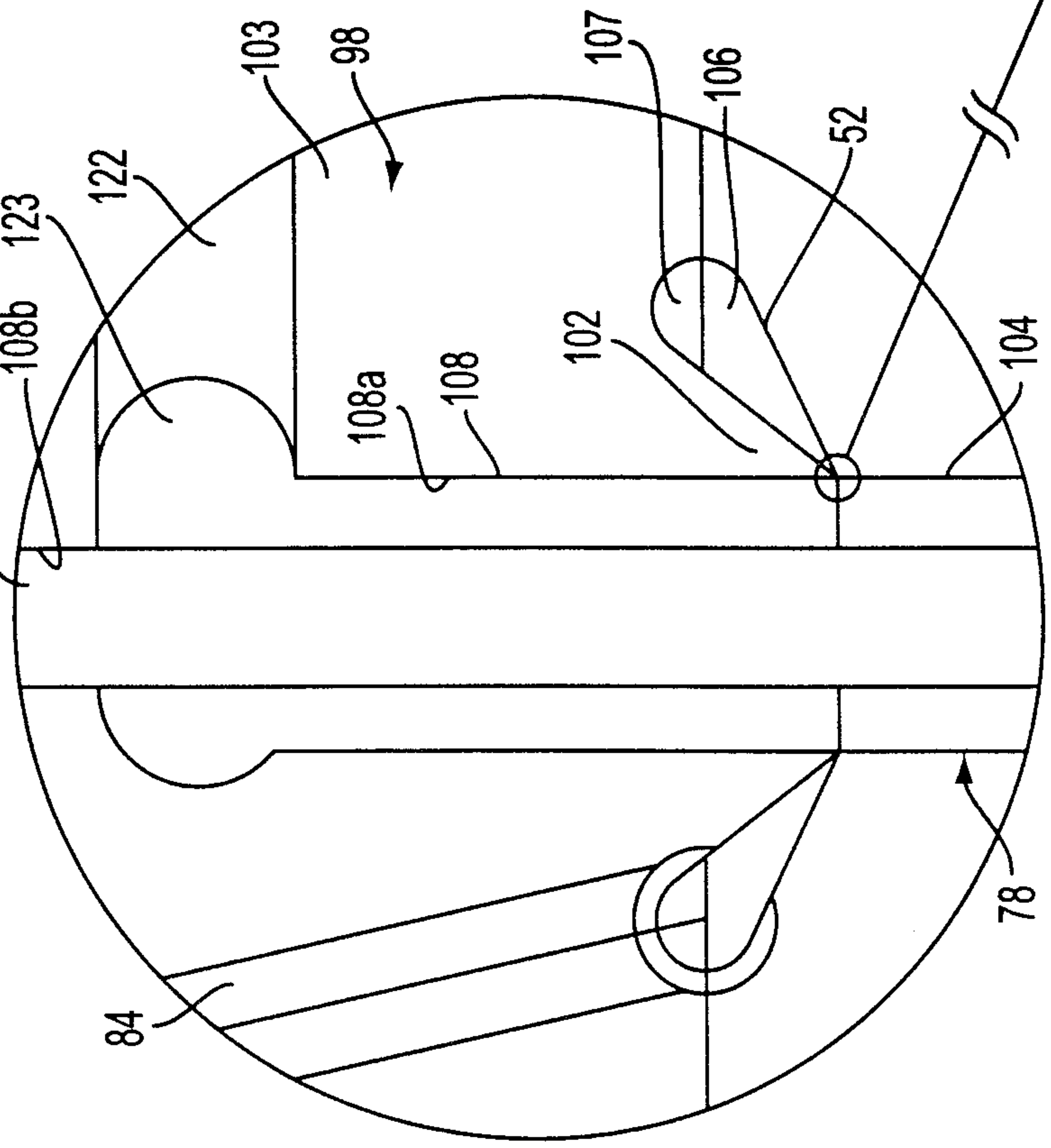
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FIG. 2

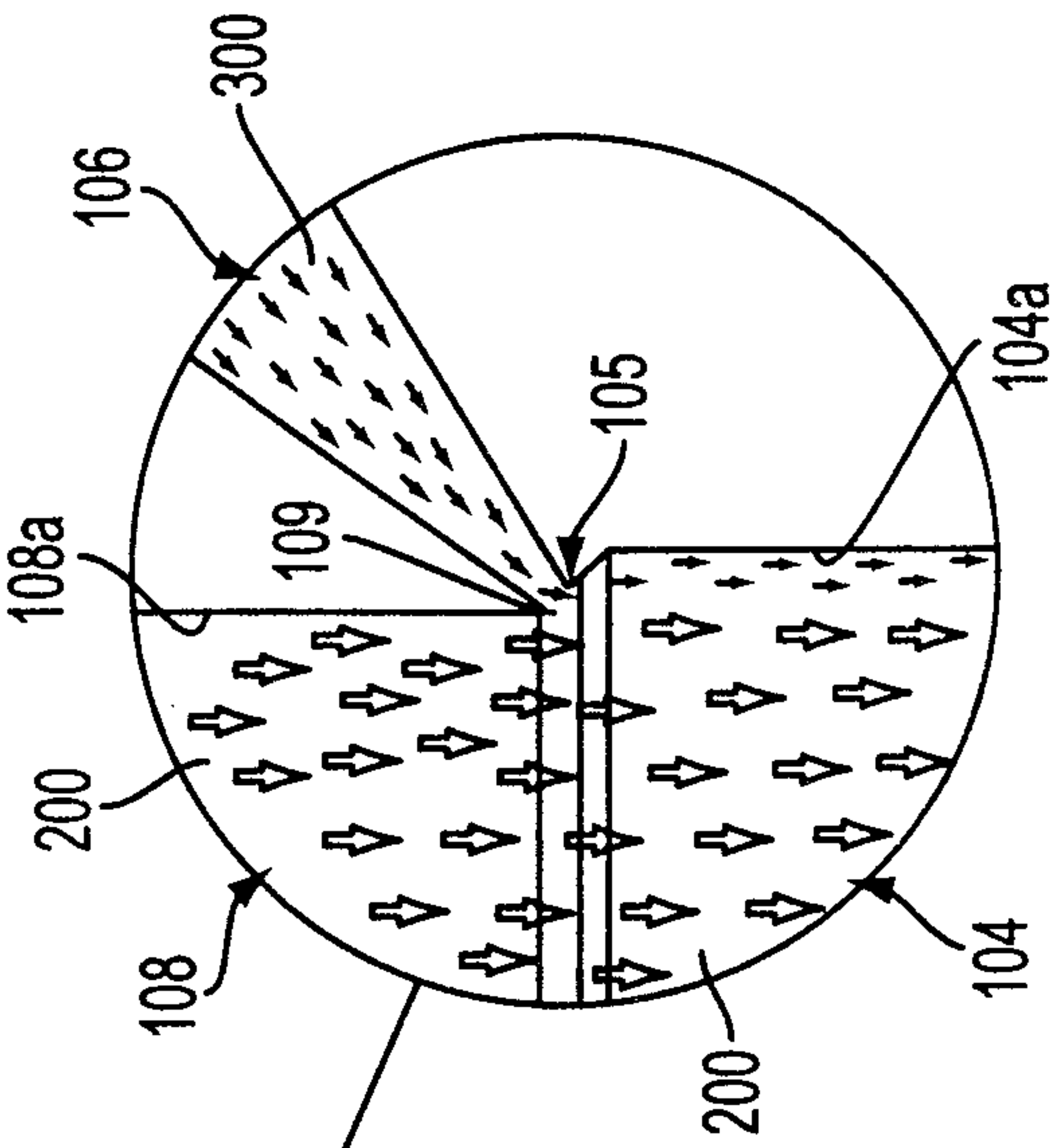
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FIG. 3

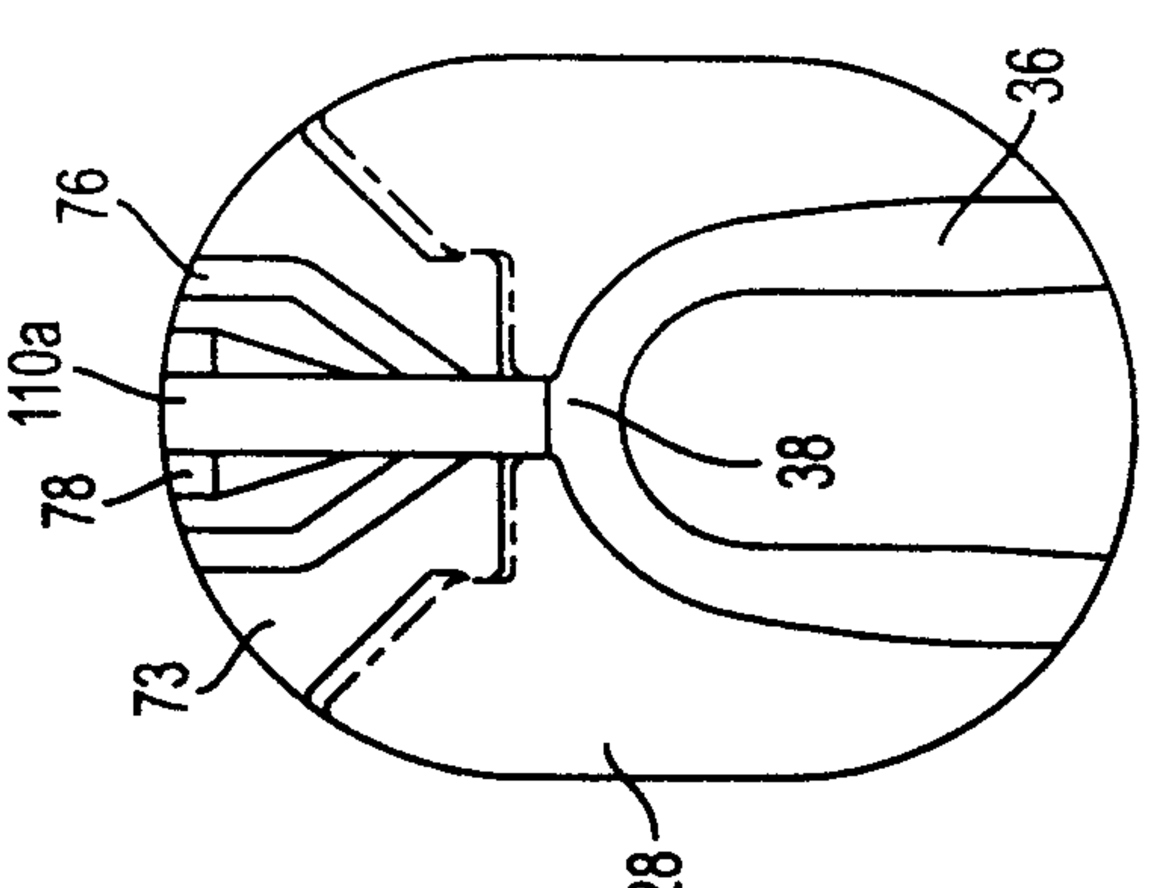


FIG. 4A

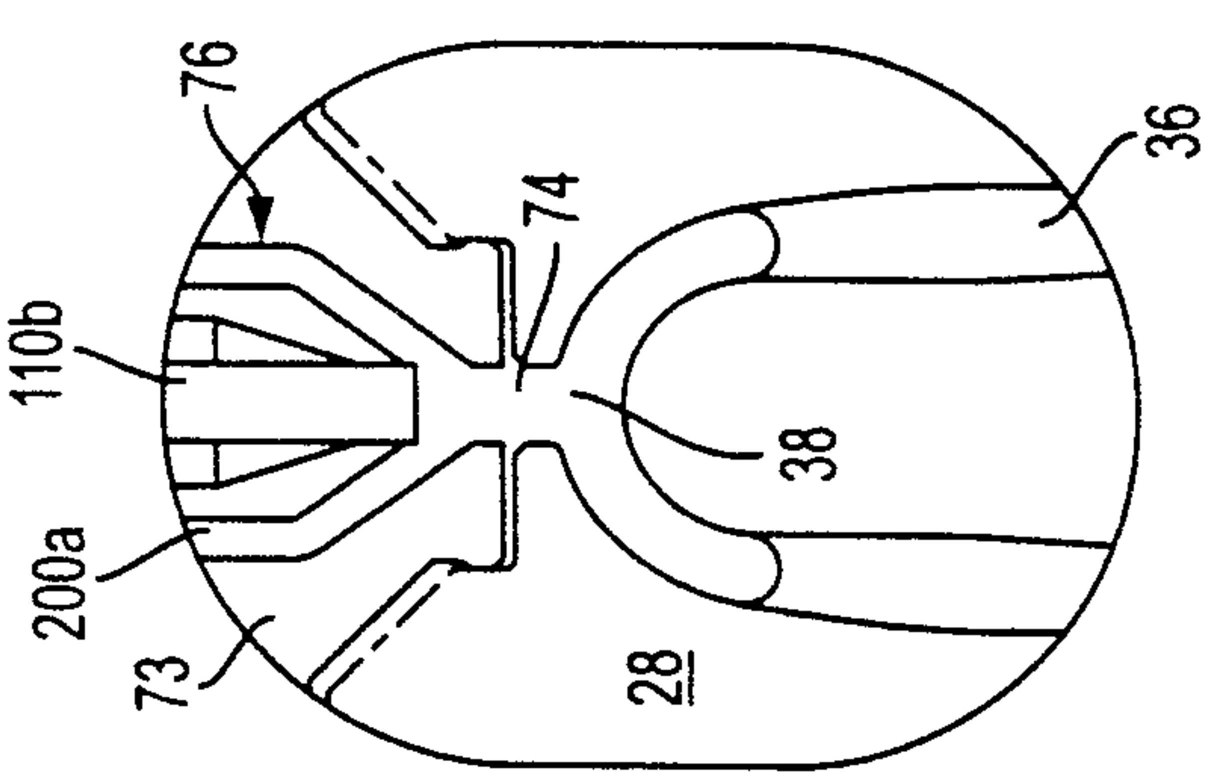


FIG. 4B

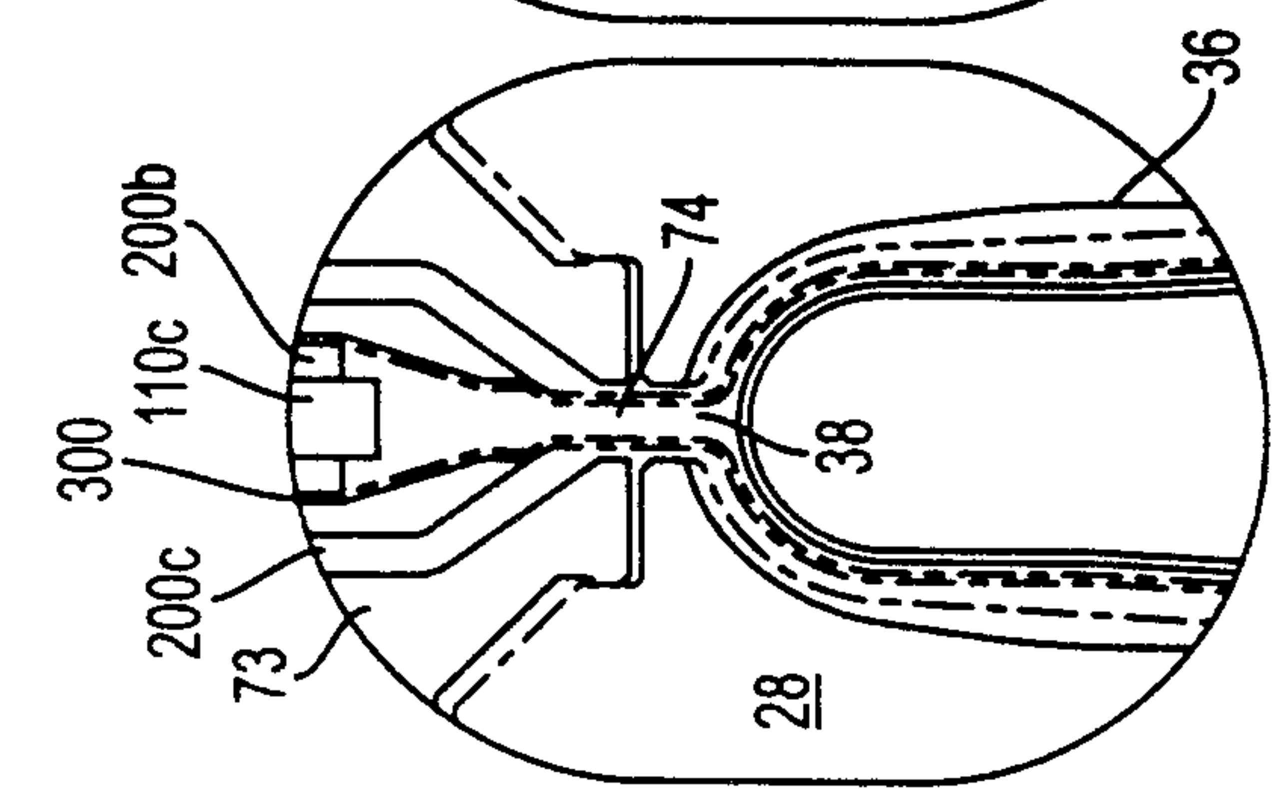


FIG. 4C

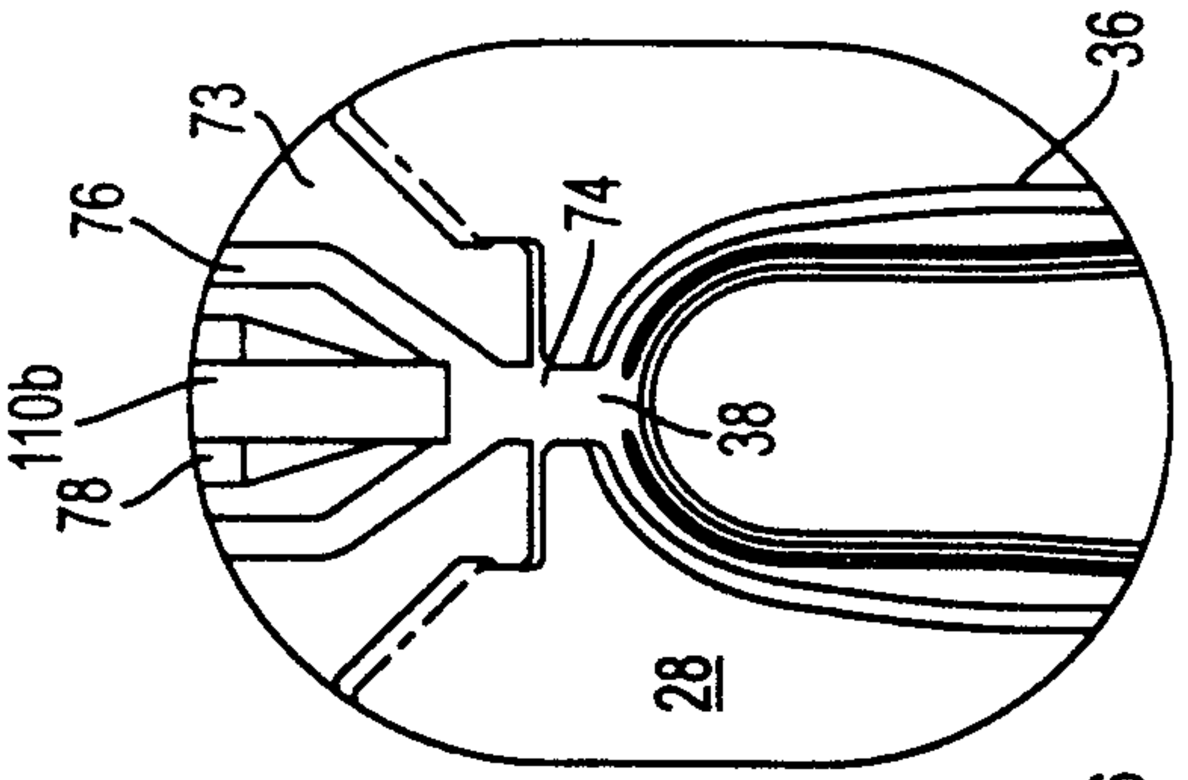


FIG. 4D

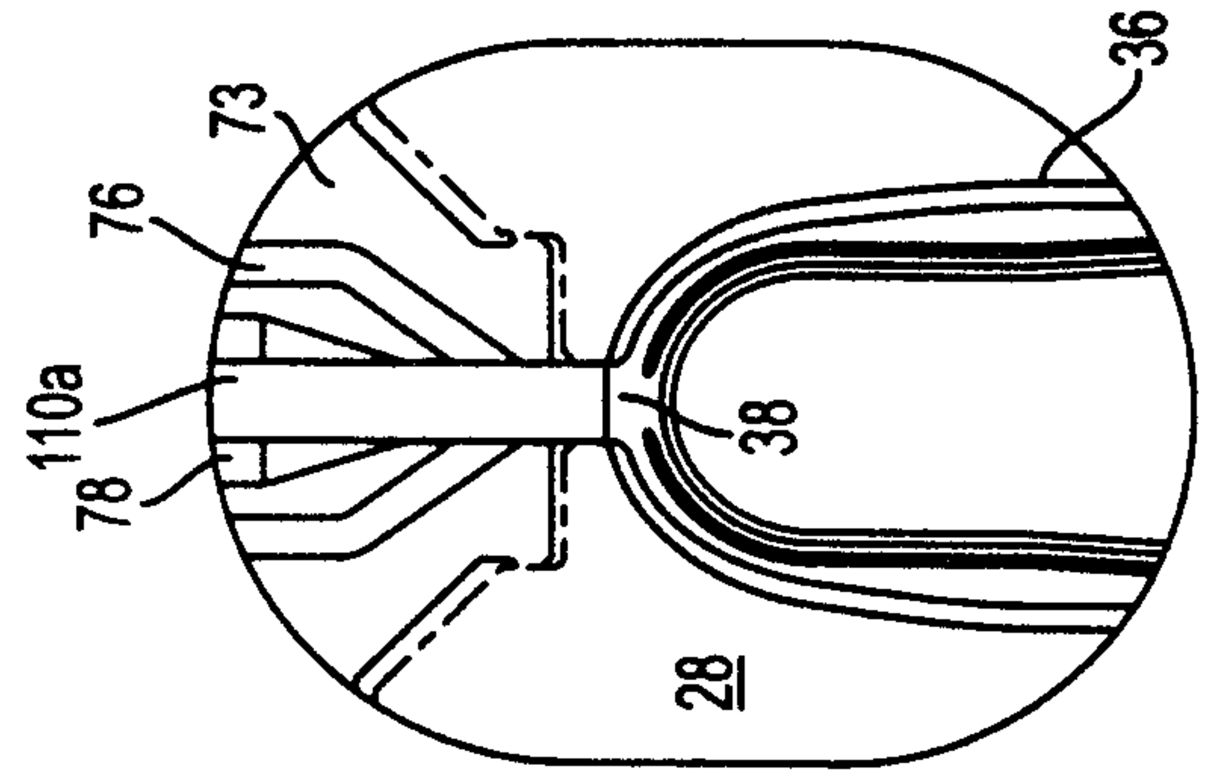
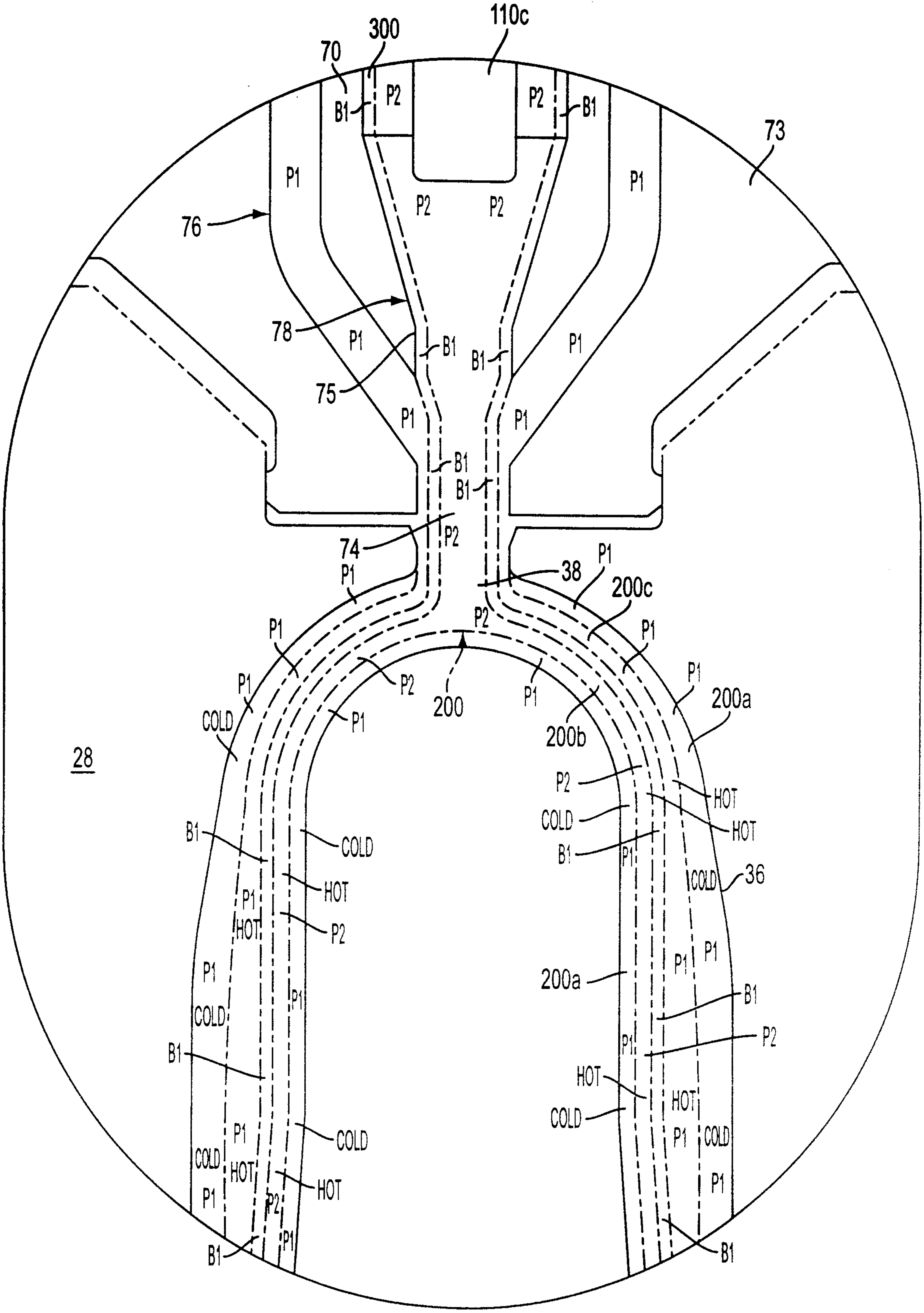


FIG. 4E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P1
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FIG. 5

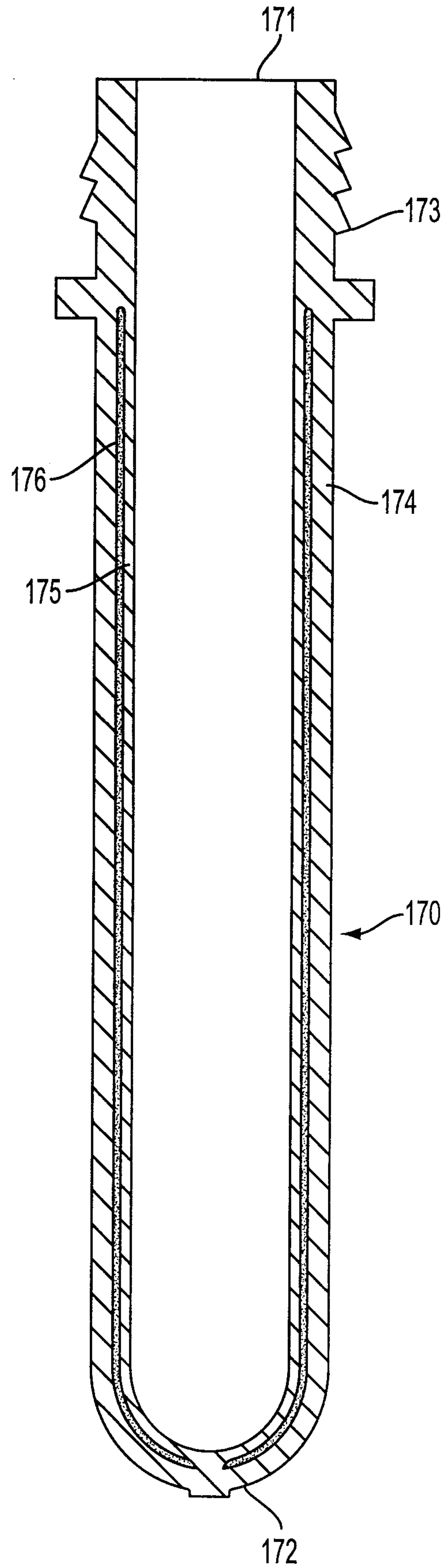


FIG. 6

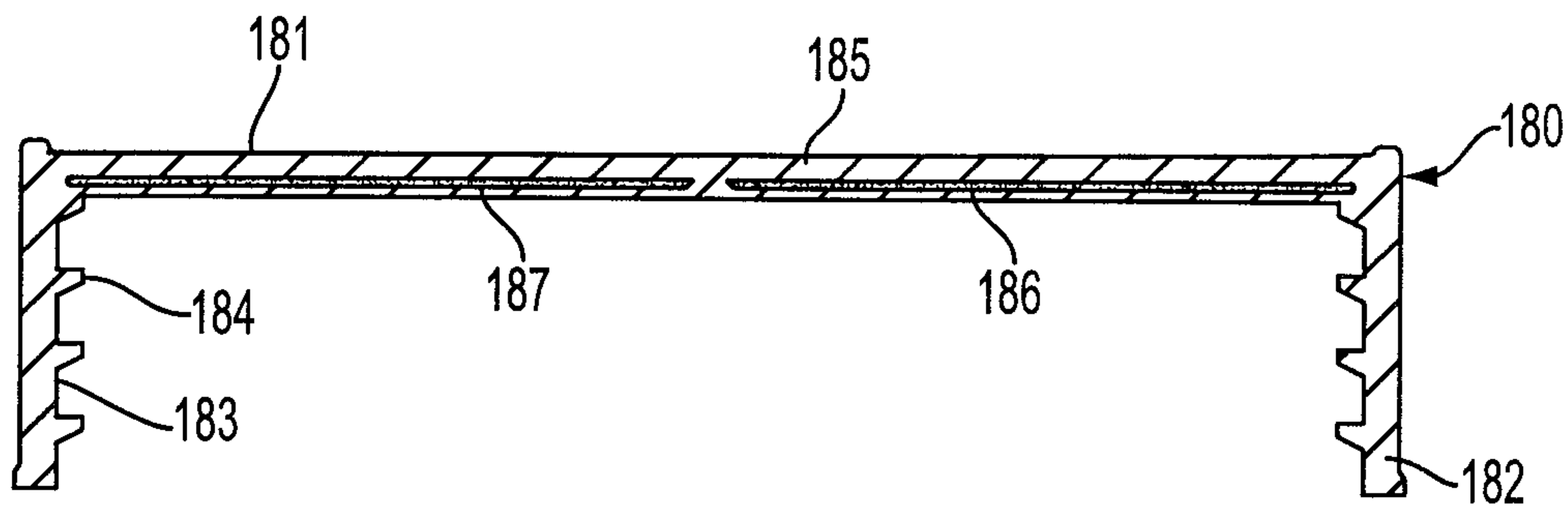
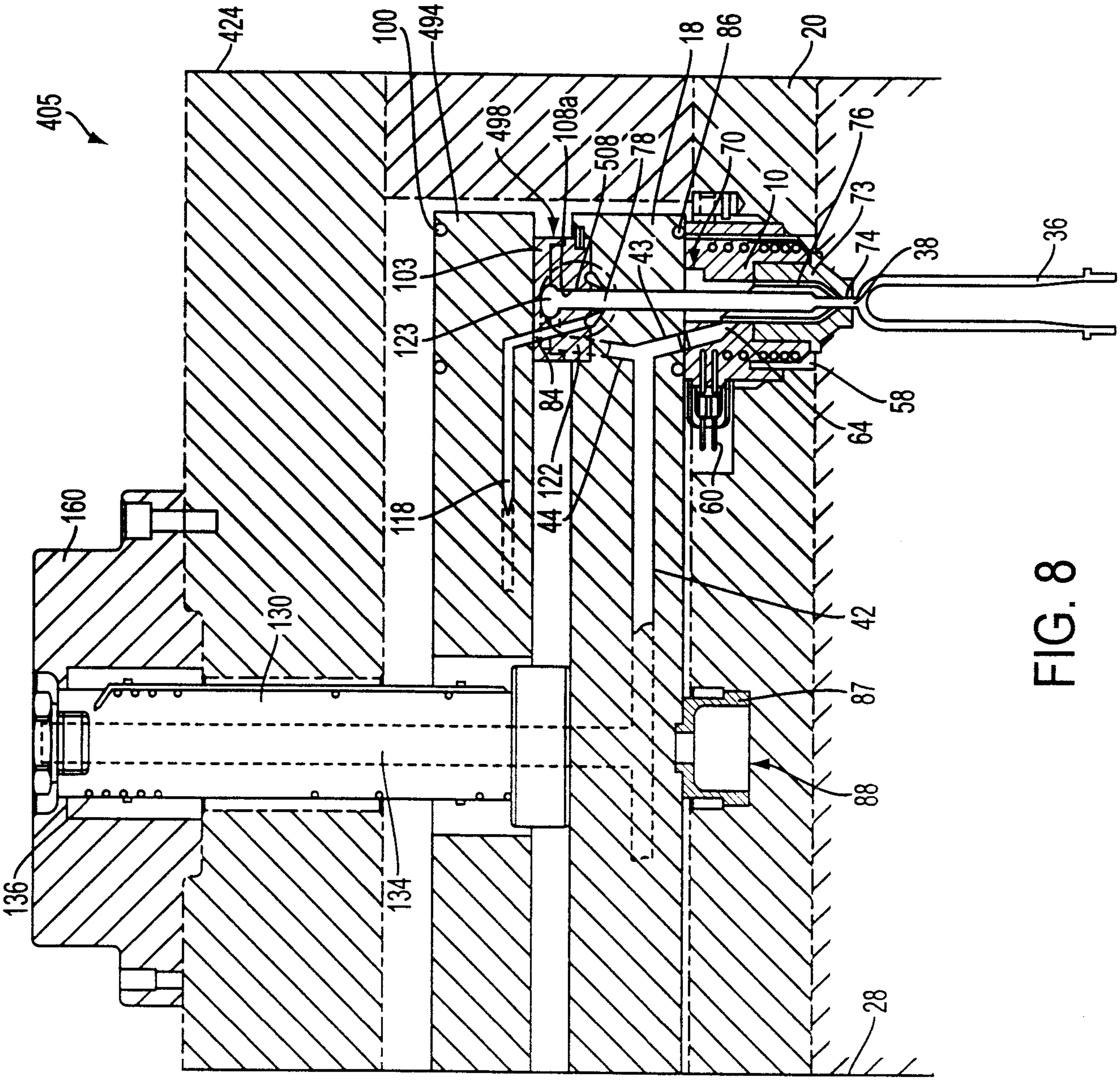


FIG. 7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74
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88
136
134
28

FIG. 8

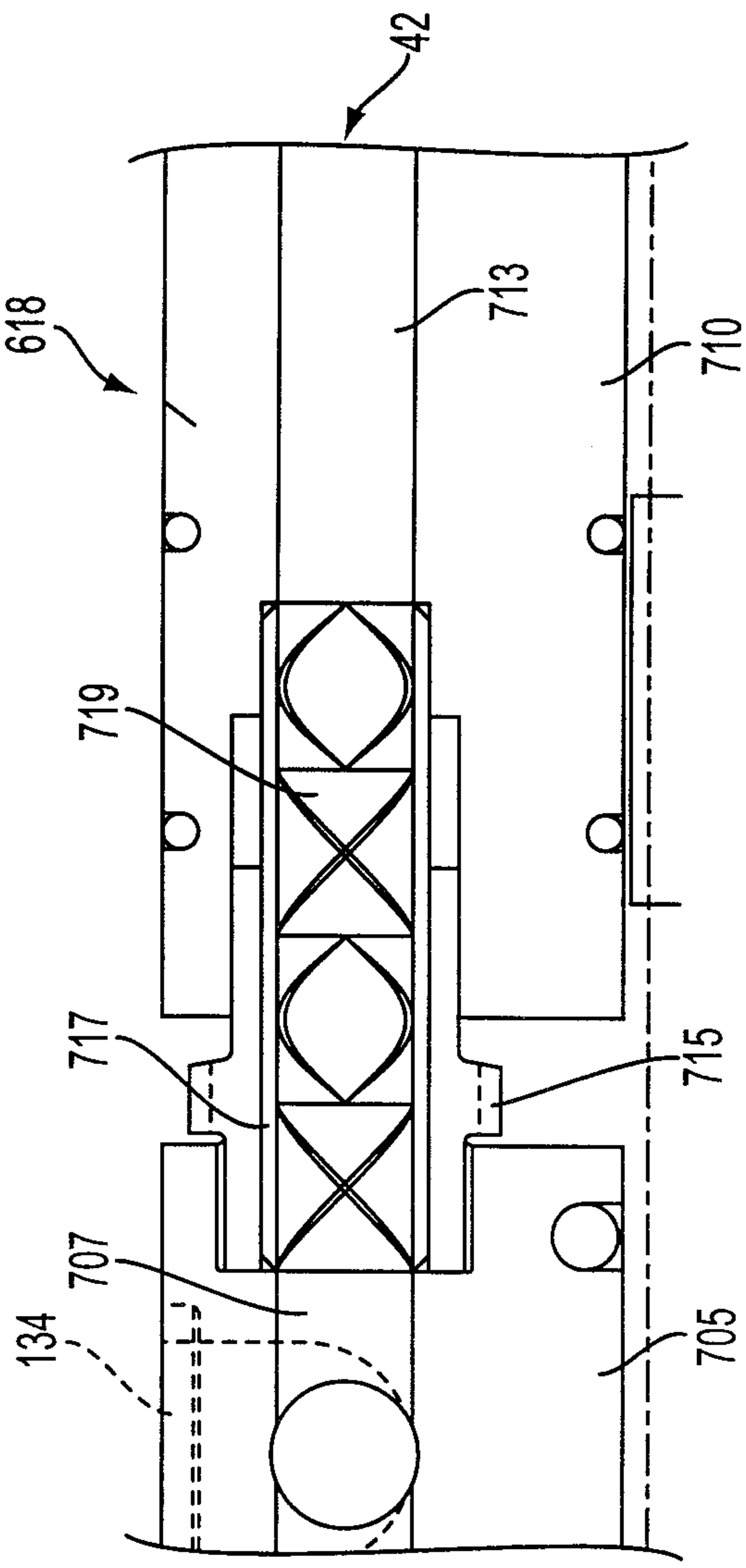
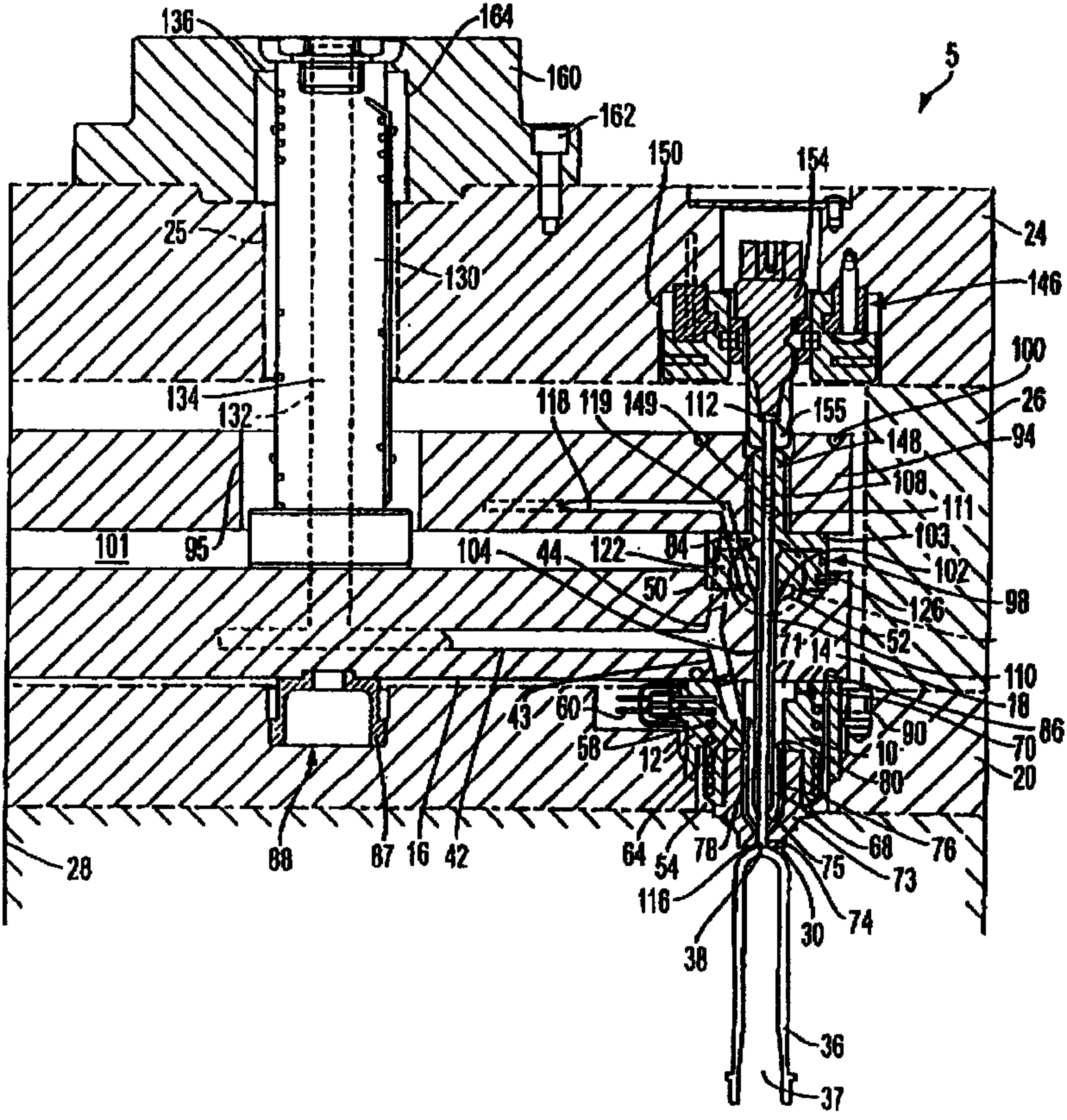


FIG. 9



5
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111
101
95
104
44
122
84
103
102
50
98
126
52
71
14
110
18
43
60
86
90
70
58
12
10
80
20
28
88
87
16
42
64
54
78
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