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(54) Titre : MANDRIN DE COEXTRUSION POUR FILIERE D'EXTRUSION
(54) Title: COEXTRUSION MANDREL FOR EXTRUSION DIE

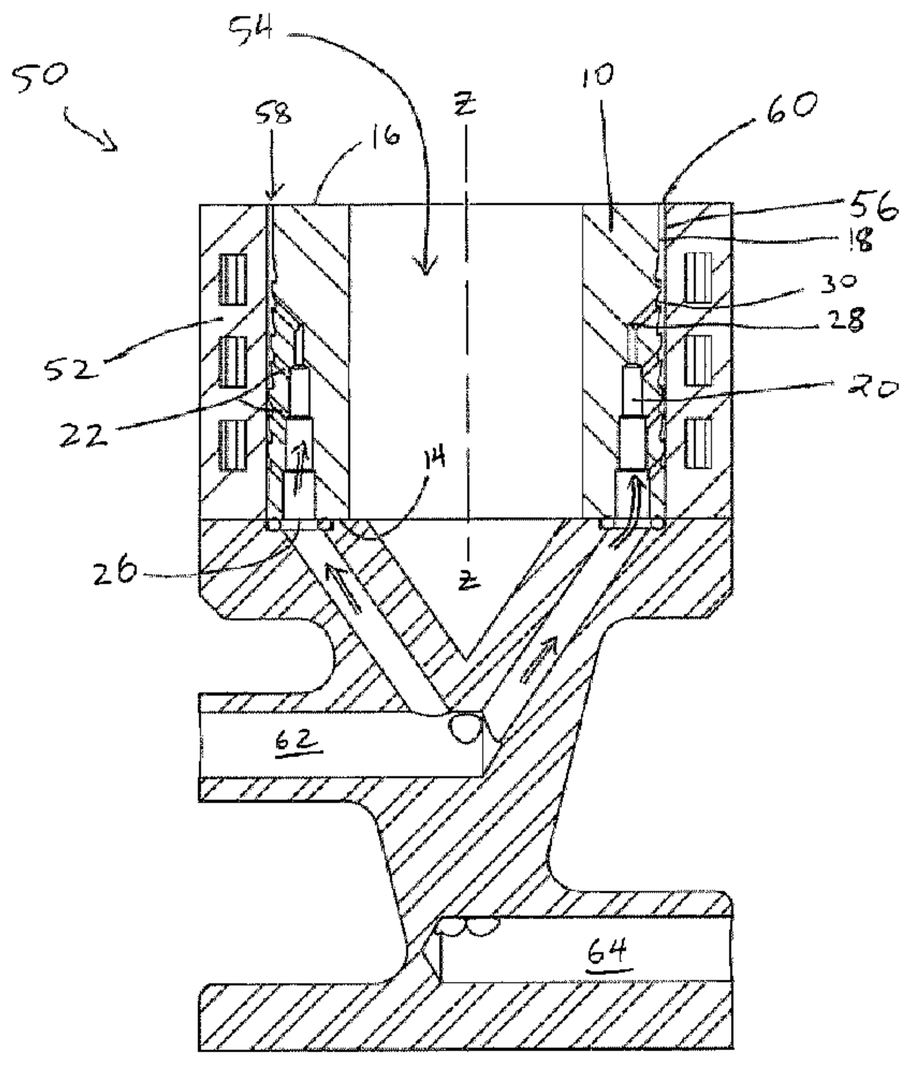

Fig. 3

(57) Abrégé/Abstract:
A mandrel and an extrusion die for the production of multi-layered plastic film. The mandrel includes a body portion with an upper face, a lower face and an exterior surface extending therebetween. Flow distribution passageways are oriented generally longitudinally within the body portion, and are open to the lower face and in fluid communication with a source of resin. Resin channels within the body portion direct resin from the distribution passageways to the exterior surface of the mandrel. Flow distributors positioned on the exterior surface of the mandrel assist in directing the resin about the exterior surface of the mandrel, forming a concentric resin layer, and assist in directing the resin layer into a resin passageway in the extrusion die towards the upper face. The flow distribution passageways, resin channels and flow distributors may also or alternately be on the interior surface of the die.

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[Continued on next page]

(54) Title: COEXTRUSION MANDREL FOR EXTRUSION DIE

(57) Abstract: A mandrel and an extrusion die for the production of multi-layered plastic film. The mandrel includes a body portion with an upper face, a lower face and an exterior surface extending therebetween. Flow distribution passageways are oriented generally longitudinally within the body portion, and are open to the lower face and in fluid communication with a source of resin. Resin channels within the body portion direct resin from the distribution passageways to the exterior surface of the mandrel. Flow distributors positioned on the exterior surface of the mandrel assist in directing the resin about the exterior surface of the mandrel, forming a concentric resin layer, and assist in directing the resin layer into a resin passageway in the extrusion die towards the upper face. The flow distribution passageways, resin channels and flow distributors may also or alternately be on the interior surface of the die.

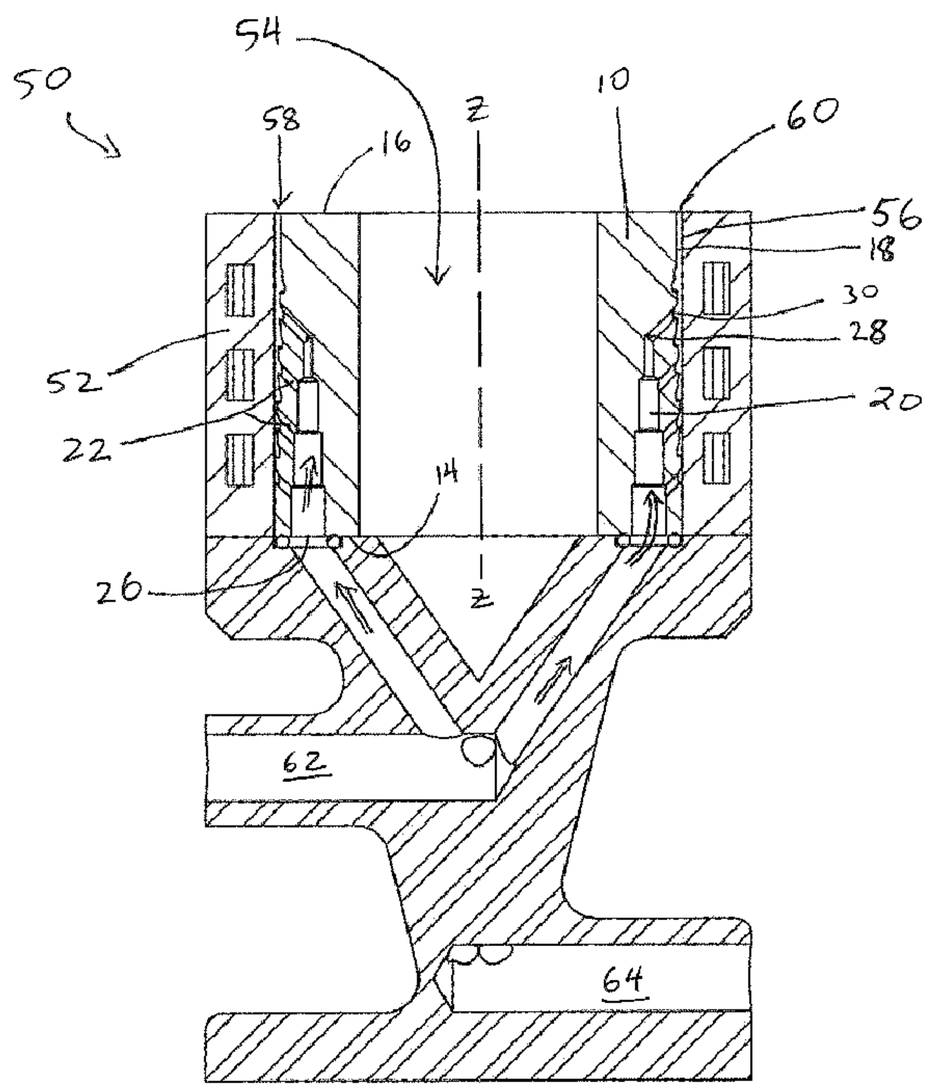

Fig. 3

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TITLE

[0001] Coextrusion Mandrel For Extrusion Die

FIELD

[0002] This invention relates generally to extrusion dies and related mandrels for the extrusion of blown plastic film.

BACKGROUND

[0003] Typically, the more layers a film has, the better the mechanical and barrier properties the film is expected to have. Multilayer blown film technology is used for producing films, for use as shrink film, stretch/silage film, stretch hood film and for producing shipping bags. Films for these applications traditionally have been comprised of 1 to 3 layers. More recently, a 5-layer film has been developed, demonstrating superior mechanical properties. Following this trend, it has been found that further mechanical enhancements can be achieved through the use of even more layers. Unfortunately, the traditional way of increasing the number of layers in a film, where each extruder feeds an individual layer, can be complicated and costly.

[0004] Typical coextrusion dies form an individual layer about a round mandrel before that layer joins other layers. The dies, therefore, have a number of

mandrels equal to the number of layers. As a result, the greater the number of desired layers, the greater the number of required mandrels. The greater the number of mandrels a die has, generally the longer the distance the melt has to travel. The downside of this is that there is more of a chance for the melt to degrade when it is forced to travel over a greater distance. An increased number of mandrels also increases the complexity of the die assembly, making the die more difficult to clean, repair and service. Further, when one extruder is to deliver the melt to multiple layers, commonly, a splitter block has to be used.

[0005] U.S. Patent Pub No. 2013/0243894 A1 discloses a method of creating multiple layers where the melt flows from each extruder and splits to create a plurality of individual layers. Each layer separates from a mandrel or distributing disk before it meets other layers. As a result, the wetted area grows significantly. This has a negative effect on the process as the increase in residence time results in the melt having longer exposure to heat, with the mandrel having poor self-cleaning and high back pressure properties.

[0006] Existing methods of splitting layers and forming a multilayer structure are known in flat die technology. These methods involve sandwiching multiple layers of film simultaneously across the die. Unfortunately, forming a film layer over a round or similar mandrel tends to create a seam line, or lines, which make the multilayer film structure not uniformly distributed.

[0007] Another attempt to split layers before forming is described in US Pat No. 6,409,953 B1. Here, each layer is formed on a round mandrel and distributed over the mandrel in spiral grooves, with the spirals alternating and belonging to different layers. Unfortunately, the layers are not concentric, creating a non-uniform film.

SUMMARY

[0008] The invention, therefore, provides a mandrel for a die used in the production of a multi-layered film, the die having a die body with a longitudinal bore for receiving the mandrel and also having a resin passageway formed between the mandrel and an interior surface of the die body when the mandrel is received within the longitudinal bore, the mandrel comprising a body portion having a longitudinal axis, the body portion having an upper face and a lower face with an exterior surface extending therebetween; one or more flow distribution passageways oriented generally longitudinally within said body portion, said one or more flow distribution passageways open to said lower face of said body portion for fluid communication with a source of resin; a plurality of resin channels within said body portion, said resin channels having a first end in fluid communication with one of said flow distribution passageways and a second end open to said exterior surface of said body portion permitting the flow of resin from said flow distribution passageway to said exterior surface; a plurality of flow distributors positioned on said exterior surface of said body portion, each of said flow distributors operatively

associated with the second end of one of said resin channels and configured to assist in directing resin exiting said resin channel about the exterior surface of said body portion within the resin passageway, wherein resin delivered through said resin channels forms a concentric resin layer about the exterior surface of the body portion, the resin layer directed within the resin passageway toward the upper face of the body portion.

[0009] In another aspect there is provided a mandrel for a die used in the production of a multi-layered film, the die having a die body with a longitudinal bore for receiving the mandrel and also having a resin passageway formed between the mandrel and the interior surface of the die body when the mandrel is received within the longitudinal bore. The mandrel comprises a generally cylindrical body portion having a longitudinal axis, the cylindrical body portion having an upper face and a lower face with a generally cylindrical exterior surface extending therebetween. One or more flow distribution passageways is/are oriented generally longitudinally within said cylindrical body portion, and said one or more flow distribution passageways are open to said lower face of said cylindrical body portion for fluid communication with a source of resin. The mandrel further has a plurality of resin channels within said body portion, each of said resin channels having a first end in fluid communication with one of said flow distribution passageways and a second end open to said exterior surface of said body portion permitting the flow of resin from said flow distribution passageway to said exterior surface. The mandrel

also having a plurality of flow distributors positioned on, and extending outwardly from, the exterior surface of said body portion, two or more of said flow distributors positioned adjacently and an approximate equal distance from said lower face along the exterior surface of said body portion, each of said second ends of said resin channels operatively associated with one of the plurality of flow distributors, each flow distributor comprising a pair of upper ledges and a pair of lower ledges. Each upper ledge of a flow distributor is connected to an upper ledge of an adjacent flow distributor such that said connected upper ledges form an upper ring about said exterior surface of said body portion. Said upper ring located is downstream from the second ends of said resin channels associated with adjacent flow distributors. Each lower ledge of a flow distributor is connected to a lower ledge of an adjacent flow distributor such that said connected lower ledges form a lower ring about said exterior surface of said body portion. Said lower ring is located upstream from the second ends of said resin channels associated with adjacent flow distributors. In this way, resin delivered through said resin channels to said exterior surface of said body portion is directed about said exterior surface by said upper and lower rings to form a resin layer.

[0010] In another aspect there is provided a method for producing a multi-layered film using a single mandrel within a die body, where the mandrel has a longitudinal axis and an upper and lower face with an exterior surface therebetween. The mandrel is received within a longitudinal bore of the die body

and forms a resin passageway therebetween. The method comprises introducing resin into the mandrel through one or more flow distribution passageways within the mandrel, directing the resin from the one or more flow distribution passageways through one or more resin channels to the exterior surface of the mandrel; directing the resin to flow about the exterior surface to form a concentric resin layer with flow distributors positioned on the exterior surface of the mandrel, and directing the concentric resin layer within the resin passageway towards the upper face.

[0011] In another aspect there is provided a mandrel for a die used in the production of a multi-layered film, the die having a die body and a resin passageway formed between the mandrel and an interior surface of the die body when the mandrel is received within the die body. The mandrel comprises a body portion having an upper face, a lower face, and an exterior surface therebetween. The mandrel further has a plurality of resin channels in fluid communication with a source of resin and with the exterior surface of said body portion, and a plurality of flow distributors on said exterior surface. Each of said flow distributors operatively associated with one of said resin channels and configured to direct resin exiting said resin channel about the exterior surface of said body portion to form a concentric resin layer about the body portion.

[0012] In another aspect there is provided use of a single mandrel with an annular die to produce a multi-layered film, the mandrel having resin channels to deliver resin to an exterior surface of the mandrel, at a plurality of different distances from a lower face of the mandrel along its longitudinal axis, to produce concentric film layers at each of the said distances, the concentric film layers together forming the multi- layered film.

[0013] In another aspect there is provided a die used in the production of a multi-layered film, the die having a die body with a longitudinal bore for receiving a mandrel and also having a resin passageway formed between the mandrel and an interior surface of the die body when the mandrel is received within the longitudinal bore, the die comprising the die body, further having a longitudinal axis, an upper face, and a lower face with the interior surface extending therebetween and defining the longitudinal bore; one or more flow distribution passageways oriented generally longitudinally within said die body, said one or more flow distribution passageways open to said lower face of said die body for fluid communication with a source of resin; a plurality of resin channels within said die body, each of said resin channels having a first end in fluid communication with one of said flow distribution passageways and a second end open to said interior surface of said die body permitting the flow of resin from said flow distribution passageway to said interior surface; a plurality of flow distributors positioned on said interior surface of said die body, each of said flow distributors operatively associated with the second

end of one of said resin channels and configured to assist in directing resin exiting said resin channel about the interior surface of said die body and within the resin passageway, wherein resin delivered through said resin channels forms a concentric resin layer about the interior surface of the die body, the resin layer directed within the resin passageway toward the upper face of the die body.

[0014] Further aspects of the invention will become apparent from the following description taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of examples, to the accompanying drawings which show exemplary embodiments of the present invention in which:

[0016] Figure 1 is a top perspective view of a mandrel according to an example embodiment of the present invention incorporated into a conventional extrusion die head.

[0017] Figure 2 is a side view of Figure 1.

[0018] Figure 3 is a cross section view of Figure 2 along line A-A.

[0019] Figure 4 is a side view of a mandrel according to another example embodiment of the present invention.

[0020] Figure 5 is a bottom perspective view of the mandrel according to Figure 4 with a portion removed to reveal the mandrel's interior.

[0021] Figure 6 is an enlarged view of portion B of Figure 5.

[0022] Figure 7 is a top perspective view of a mandrel according to yet another example embodiment of the present invention incorporated into an alternate form of a conventional extrusion die head.

[0023] Figure 8 is a cross section view of Figure 7 along line C-C.

[0024] Figure 9 is a side perspective view of the mandrel depicted in Figure 7.

[0025] Figure 10 is an enlarged view of portion D of Figure 9

[0026] Figure 11 is a cross section view of an extrusion die head and a mandrel according to another example embodiment of the present invention.

DESCRIPTION

[0027] The present invention may be embodied in a number of different forms. The specification and drawings that follow describe and disclose some of the specific forms of the invention.

[0028] In the attached drawings, there is shown a mandrel 10 for use in a conventional die assembly 50, which is used in the production of a multi-layered film (not shown). As shown in Figures 1, 2 and 7, die assembly 50 includes a die body 52 having a longitudinal bore 54 for receiving mandrel 10. As best seen in Figures 3 and 8, die body 52 has a die interior surface 56. A resin passageway 58 is formed between the exterior of mandrel 10 and interior surface 56 when mandrel 10 is received within longitudinal bore 54. Resin passageway 58 ends at die lip 60, from which the multi-layered film is extruded.

[0029] In the embodiment of Figure 3, die assembly 50 further include resin sources 62 and 64, which are in fluid communication with mandrel 10. As will be understood by one skilled in the art, one or more resins sources, in fluid communication with mandrel 10, could be used.

[0030] As represented in the particular embodiments of Figures 4, 5 and 9, mandrel 10 comprises a generally cylindrical body or body portion 12 with a longitudinal axis Z. Cylindrical body 12 has a lower face 14 and an upper face 16,

with a generally cylindrical exterior surface 18 extending therebetween. While mandrel 10 is shown as generally cylindrical, it will be understood by one skilled in the art that rather than the generally cylindrical body depicted, mandrel 10 could alternatively be a body of a different shape, including a generally conical shape, frusto-conical shape or have a generally symmetrical surface of revolution.

[0031] As shown in the embodiment depicted in Figure 9, mandrel 10 may further include a base 40. When mandrel 10 is received within longitudinal bore 54, lower face 14 is positioned adjacent to the resin sources, and upper face 16 is positioned adjacent to die lip 60, downstream from lower face 14.

[0032] In the depicted embodiments, mandrel 10 further comprises a plurality of flow distribution passageways 20, a plurality of resin channels 22, and a plurality of flow distributors 24. Multiple flow distribution passageways 20 are situated within body portion 12. In the embodiment shown, flow distribution passageways 20 are orientated generally parallel to longitudinal axis Z and taper in cross-section as they extend from lower face 14 towards upper face 16. As will be understood by one skilled in the art, flow distribution passageways 20 may alternatively be non-parallel to longitudinal axis Z, and may maintain their diameter rather than tapering as they extend from lower face 14 towards upper face 16.

[0033] Flow distribution passageways 20 are open to lower face 14 of body portion 12 at openings 26. When mandrel 10 is used in association with die assembly 50, flow distribution passageways 20 are in fluid communication with the resin sources via openings 26.

[0034] In use, resin (depicted by double arrows in Figures 5 and 8) flows from the resin sources, into mandrel 10 through openings 26, and then into flow distribution passageways 20. Flow distribution passageways 20, in turn, direct the resin to resin channels 22.

[0035] Resin channels 22 are also situated within body portion 12. Resin channels 22 have a first internal end 28 and a second open end 30. Each internal end 28 is open to, and in fluid communication with, at least one flow distribution passageway 20. Each open end 30 is open to mandrel exterior surface 18. As such, multiple open ends 30 exist about the mandrel exterior surface 18. In use, resin from flow distribution passageways 20 enters resin channels 22 via internal ends 28 and is directed to flow distributors 24 through open ends 30. It will be appreciated that while discrete flow distribution passageways 20 and resin channels 22 are shown in the attached drawings, in an alternate embodiment, distribution passageways 20 and resin channels 22 could be in the form of a single passageway or conduit. In a further alternate embodiment, more than one resin channel 22, each with different internal ends 28, may share a common open end 30. That is,

multiple resin channels may delivery rein from more than one distribution passageway to a single open end 30. Further, more than one resin channel 22 can share an internal end 28 may be fluidly connected to more than one open end 30. Flow distributors 24 are positioned on the exterior surface 18 of body portion 12. Each flow distributor 24 is operatively associated with an open end 30 and configured to assist in directing resin, exiting from the corresponding open end, to flow about exterior surface 18 and into resin passageway 58. The flow distributors are preferably arranged in groupings or die layers 38 (discussed in greater detail below). In the particular embodiment shown, individual groups of flow distributors of a die layer are positioned generally equal distance from lower face 14 along the length of body portion 12. Other embodiments and configurations are possible where flow distributors of a die layer are not an equal distance from lower face 14.

[0036] In the depicted embodiment, and as best seen in Figures 6 and 10, flow distributors 24 direct resin via upper and lower ledges 34 and 36. Upper and lower ledges 34 and 36 extend outwardly from exterior surface 18. Each upper and lower ledge 34 and 36 also extends along exterior surface 18 away from an open end 30.

[0037] Lower ledges 36 are situated below (or upstream from) open ends 30. The lower ledges in the embodiment depicted in Figures 4 to 6 are oriented generally perpendicular to the longitudinal axis of mandrel 10. Each lower ledge 36

depicted in Figures 4 to 6 is also connected to the lower ledges adjacent to it, effectively forming a ring about the longitudinal axis of mandrel 10.

[0038] In contrast to the lower ledges depicted in Figure 6, lower ledges 36 in the embodiment depicted in Figures 9 and 10 are sloped or angled (i.e. are non-perpendicular) relative to the longitudinal axis of mandrel 10. As shown in Figures 9 and 10, lower ledges 36 are arranged in generally symmetrical pairs about each open end 30. Each lower ledge of an individual pair of lower ledges has a lower end and an upper end. The lower ends of an individual pair of lower ledges intersect at a point upstream of related open end 30. Each individual lower ledge of the pair then extends along the surface of mandrel 10, in a direction toward upper face 16, and at an angle relative to the longitudinal axis of the mandrel. As shown in Figures 9 and 10, the lower ledges associated with a particular open end 30 extend toward upper face 16 in generally opposite directions, forming a generally V-shaped structure on the surface of mandrel 10. The upper ends of adjacent pairs of lower ledges meet at an apex. As also shown in Figures 9 and 10, the net effect is a series of connected and adjacent V-shaped pairs of lower ledges that together effectively form a jagged ring about the exterior surface of mandrel 10, where that jagged ring has a generally saw tooth configuration. Since each open end 30 is situated downstream from the intersection of the lower ends of adjacent pairs of lower ledges, material flowing from an open end 30 is directed downstream by the lower ledges. It will thus be appreciated that lower ledges 36 effectively act as a

dam and a flow director, forcing material flowing from open ends 30 downstream and toward upper face 16.

[0039] Upper ledges 34 depicted in Figures 6, 9, and 10 are situated above (or downstream from) open ends 30. Similar to the lower ledges described above, upper ledges 34 are sloped or angled (i.e. are non-perpendicular) relative to the longitudinal axis of mandrel 10. Upper ledges 34 are also arranged in generally symmetrical pairs about each open end 30. Each upper ledge of an individual pair of upper ledges has a lower end and an upper end. The lower ends of an individual pair of upper ledges intersect at a point downstream from related open end 30. Each individual upper ledge of the pair then extends along the surface of mandrel 10, in a direction toward upper face 16, and at an angle relative to the longitudinal axis of the mandrel. The upper ledges associated with a particular open end 30 extend toward upper face 16 in generally opposite directions, forming a generally V-shaped structure on the surface of mandrel 10. The upper ends of adjacent pairs of upper ledges meet at an apex. As also shown in Figures 6, 9, and 10, the net effect is a series of connected and adjacent V-shaped pairs of upper ledges that together effectively form a second jagged ring about the exterior surface of mandrel 10, where that second jagged ring has a generally saw tooth configuration. Since each open end 30 is situated downstream from the intersection of upper ends of adjacent pairs of upper ledges, material flowing from an open end 30 is directed downstream by the upper ledges. It will thus be appreciated that upper ledges 34

effectively act as flow directors, forcing material flowing from open ends 30 downstream and toward upper face 16.

[0040] The combination of the lower ledge pair and the upper ledge pair associated with each open end 30 creates a recess which encourages resin from the open end 30 to flow away from the open end, distributing the resin about exterior surface 18. Each lower and upper ledge pair is connected to the lower and upper ledges of an adjacent flow distributor that is positioned on exterior surface 18 at generally the same distance from lower face 14. Resin flowing from one open end 30 in one direction along its corresponding flow distributor 24 will thus meet resin flowing in the opposite direction along the connected adjacent flow distributor (see double arrows in Figures 6 and 10).Resin channels 22 and their corresponding flow distributors 24 are arranged and positioned on body portion 12 at discrete positions along the length of longitudinal axis Z (i.e. at predetermined distances from lower face 14) such that they form die layers 38 (see Figures 4 and 9). Any one die layer 38 is made up of generally equally spaced resin channels 22 and flow distributors 24. Each of the resin channels and the flow distributors within any single die layer 38 are positioned on mandrel 10 generally at the same distance from lower face 14.

[0041] While in the attached Figures each die layer 38 is depicted as being positioned on body portion 12 generally parallel to lower face 14, one skilled in the art would understand as long as flow distributors 24 in one die layer are in fluid

communication with the adjacent flow distributors within the same die layer via the "rings" formed by the upper and lower ledges, flow distributors 24 in one die layer and the corresponding resin channels may be positioned at differing distances from lower face 14. For example, in an alternative embodiment (not shown), a die layer 38 may be positioned on mandrel 10 at an angle relative to longitudinal axis Z.

[0042] Because the flow distributors in one die layer are in fluid communication with the adjacent flow distributors within the same die layer via the "rings" formed by the upper and lower ledges, when molten or semi-molten resin flows through the resin channels and along the flow distributors around one die layer 38 (as depicted by the arrows in Figures 4, 5, and 9), the resin will form a concentric resin layer (not shown) about exterior surface 18. Assisted by the upper and lower ledges, the concentric resin layer is directed into resin passageway 58, towards upper face 16 and die lip 60.

[0043] While the upper and lower ledges are depicted as straight in the attached figures, either or both ledges may, alternatively, have a curvature to help maintain the velocity of resin as it flows from open ends 30 along the flow distributors about the exterior surface of mandrel 10 toward upper face 16.

[0044] In a further alternative embodiment (not shown), the ledges may form grooves arranged in a straight, curved, or spiral formation about the exterior surface of mandrel 10 such that the flow distributors in any one die layer direct resin about the exterior surface of mandrel 10 toward upper face 16.

[0045] Accordingly, it will be understood by one skilled in the art that flow distributors 24 may be shaped and/or arranged in ways different from that specifically shown in the attached drawings while remaining within the limits of the invention. In each embodiment, resin flowing from open ends 30 in one die layer 38 is directed about mandrel exterior surface 18 to form one resin layer concentric with mandrel 10, which is then directed towards upper face 16.

[0046] Die layers 38 are stacked along longitudinal axis Z from lower end 14 towards upper end 16. Resin flowing from each die layer 38 forms a separate resin layer, which is directed into resin passageway 58. Resin flowing from the die layer closest to lower end 14 forms a resin layer which enters resin passageway 58 first. Each subsequent die layer 38 stacked above then forms a concentric resin layer within the resin layer formed by the die layer below. Accordingly, a plurality of concentric resin layers about mandrel 10 can be simultaneously formed and directed into resin passageway 58 towards upper face 16, and discharged as a multi-layered film (not shown) through die lip 60.

[0047] As additional resin layers are directed into resin passageway 58, it will be understood that the width of resin passageway 58 must increase as it extends towards die lip 60. In the embodiments depicted in Figures 3 and 8, the circumference of die interior surface 56 remains essentially the same. As such, the circumference of mandrel exterior surface 18 decreases as it extends from lower face 14 towards upper face 16. Resin passageway 58 thus increases in width to accommodate the growing number of resin layers within resin passageway 58.

[0048] As will be further understood by one skilled in the art, in order for resin passageway 58 to increase in width, the internal diameter of die surface 56 could instead increase as it extends towards die lip 60, while the diameter of the mandrel exterior surface remains the same between lower face 14 and upper face 16. Alternatively, the internal diameter of die surface 56 could increase while the diameter of the mandrel exterior surface simultaneously decreases.

[0049] As noted earlier, each flow distribution passageways 20 of mandrel 10 can be in fluid communication with different resin sources. According to Figure 3, two different types of resin can be simultaneously fed into mandrel 10 via different flow distribution passageways 20, and delivered by resin channels 22 to form a multi-layered film product (not shown) with layers having different physical and chemical properties. As seen in Figure 8, a number of resin types can be simultaneously fed into mandrel 10 via the flow distribution passageways. As well,

flow distribution passageways 20 can be configured within mandrel 10 such that a wide variety of multi-layered films, with varying resin sequences and a varying number of resin layers, can be created. Multi-layered film products made by using the present invention could have, for example, the following film layer structures, where A, B, and C represent different resin types:

- A-B-C-B-C-B-C;
- A-A-B-B-A-A-B-B-B-A-A-A-B-B-B;
- A-B-B-C-C-C-B-B-A; and
- A-B-C-C-C-C-C-C-C-C-A.

[0050] Of course, each flow distribution passageway could also be in fluid communication with the same resin source so that a multi-layered film product can be formed from n-layers of the same resin, for example: A-A-A-A-A-A-A-A-A-A. Other structures made from other combinations of resins are possible.

[0051] An advantage of the present invention is that only one mandrel is required to form multiple concentric resin layers in a multi-layered film. This generally allows for less bulky, less complicated and less expensive machinery to be used in the film-making process, compared to the conventional system of using multiple mandrels to form multiple-layered film. Another potential advantage of the present invention is that the resulting resin layers, and ultimately the film, made with the described mandrel are concentric and generally uniform in dimension.

[0052] A further potential advantage of the present invention is that its use may assist in streamlining the film-making processes. Use of the described mandrel may shorten the residence time of the resin within the die assembly and reduce the wetted area, which could result in faster production, less opportunity for the melt to degrade, and shorter cleaning times.

[0053] The mandrel described herein is oriented vertically. However, it will be understood that the mandrel could be oriented horizontally or in any one of a variety of other orientations.

[0054] Mandrel 10 has been generally described as a single piece or a unitary component. In an alternative embodiment, the mandrel may be comprised of separate and separable mandrel components, adapted to fit together such that, when assembled, they form mandrel 10. In this way, the mandrel may be disassembled to facilitate cleaning. Die body 52, in like manner, may also be comprised of separate and separable die body components, which are adapted to fit together such that the die body components may be assembled to form die body 52.

[0055] In the die assembly described above, only the mandrel possesses the components necessary to form a resin layer (i.e. the flow distribution passageways, the resin channels, and the flow distributors etc.). In a further alternative

embodiment, shown in Figure 11, both the die body and mandrel 10 may be in fluid communication with the resin sources and comprise the arrangement of components (i.e. the flow distribution passageways and the resin channels etc.) necessary to form a resin layer in the manner described above.

[0056] In the embodiment depicted in Figure 11, a die body 70 shares longitudinal axis Z with mandrel 10. Die body 70 further has a lower face 72 and an upper face 74 with an interior surface 76 extending therebetween. Die body 70 has one or more flow distribution passageways 20 oriented generally longitudinally therein, with the one or more flow distribution passageways 20 open to lower face 72 for fluid communication with source of resin 62, 64. Die body 70 may also have a plurality of resin channels 22, each which has a first end 28 in fluid communication with at least one of the flow distribution passageways 20 and a second end 30 open to interior surface 76, thereby permitting the flow of resin from flow distribution passageway 20 to interior surface 76. A plurality of flow distributors (not shown) may be positioned on interior surface 76 of die body 70. Each flow distributor operatively is associated with second end 30 of one of resin channels 22 and is configured to assist in directing resin exiting resin channel 22 about interior surface 76 and into resin passageway 58. As in the case of mandrel 10 described above, the resin delivered through resin channels 22 of die body 70 forms a concentric resin layer about interior surface 76.

[0057] In the embodiment of Figure 11, both exterior surface 18 of mandrel 10 and interior surface 76 of die body 70 include flow distributors, about which molten resin could simultaneously flow to form separate concentric resin layers or "rings". The flow distributors from both the mandrel and die body direct their respective resin layers into resin passageway 58 towards die lip 60. Such a "hybrid" system may help to reduce the required height of the mandrel when producing a film with a given number of layers, thereby helping to reduce the overall size of the die assembly.

[0058] In a yet further alternative embodiment (not shown), only die body 70 is in fluid communication with the resin sources and posses the above discussed arrangement of components for forming concentric resin layers into resin passageway 58.

[0059] It is to be understood that what has been described are the preferred embodiments of the invention. The scope of the claims should not be limited by the preferred embodiments set forth above, but should be given the broadest interpretation consistent with the description as a whole.

CLAIMS

I CLAIM:

1. A mandrel for a die used in the production of a multi-layered film, the die having a die body with a longitudinal bore for receiving the mandrel and also having a resin passageway formed between the mandrel and an interior surface of the die body when the mandrel is received within the longitudinal bore, the mandrel comprising:

a body portion having a longitudinal axis, the body portion having an upper face and a lower face with an exterior surface extending therebetween;

one or more flow distribution passageways oriented generally longitudinally within said body portion, said one or more flow distribution passageways open to said lower face of said body portion for fluid communication with a source of resin;

a plurality of resin channels within said body portion, each of said resin channels having a first end in fluid communication with one of said flow distribution passageways and a second end open to said exterior surface of said body portion permitting the flow of resin from said flow distribution passageway to said exterior surface;

a plurality of flow distributors positioned on said exterior surface of said body portion, each of said flow distributors operatively associated with the second end of one of said resin channels and configured to assist in directing resin exiting said resin channel about the exterior surface of said body portion and within the resin passageway,

wherein resin delivered through said resin channels forms a concentric resin layer about the exterior surface of the body portion, the resin layer directed within the resin passageway toward the upper face of the body portion.

2. The mandrel as claimed in claim 1 wherein said plurality of resin channels communicate between said one or more flow distribution passageways and the exterior surface of said body portion at discrete positions along the longitudinal axis of said body portion, thereby delivering resin to said discrete positions to permit the formation of a plurality of concentric resin layers around said body portion and the formation of a multi-layered film product.

3. The mandrel as claimed in claim 2 wherein the resin which forms any single resin layer flows from resin channels which are positioned at an angle to the longitudinal axis of said body portion an approximately equal distance from said lower face.

4. The mandrel as claimed in claim 3 wherein said body portion is generally cylindrical and the circumference of the exterior surface of the body portion is configured such that the width of the resin passageway increases from said lower face toward said upper face.

5. The mandrel as claimed in claim 3 including a plurality of flow distribution passageways, each flow distribution passageway in communication with a different resin source to permit the formation of a multi-layered film product from layers having different physical and/or chemical properties.

6. The mandrel as claimed in claim 3 including a plurality of flow distribution passageways, each said flow distribution passageway in communication with the same resin source to permit the formation of a multi-layered film product from layers of the same resin.

7. The mandrel as claimed in claim 3 wherein each flow distributor is comprised of an upper ledge and a lower ledge, each upper and lower ledge extending outwardly from the exterior surface of said mandrel.

8. The mandrel as claimed in claim 7 wherein the upper ledge has a longitudinal axis at an angle to the longitudinal axis of said body portion.

9. The mandrel as claimed in claim 7 wherein the lower ledge has a longitudinal axis at an angle to the longitudinal axis of the body portion.

10. The mandrel as claimed in claim 7 wherein the longitudinal axis of the lower ledge is perpendicular to the longitudinal axis of the body portion.

11. The mandrel as claimed claim 1, wherein the mandrel comprises multiple separable segments.

12. A mandrel for a die used in the production of a multi-layered film, the die having a die body with a longitudinal bore for receiving the mandrel and also having a resin passageway formed between the mandrel and the interior surface of the die body when the mandrel is received within the longitudinal bore, the mandrel comprising:

a generally cylindrical body portion having a longitudinal axis, the cylindrical body portion having an upper face and a lower face with a generally cylindrical exterior surface extending therebetween;

one or more flow distribution passageways oriented generally longitudinally within said cylindrical body portion, said one or more flow distribution passageways open to said lower face of said cylindrical body portion for fluid communication with a source of resin;

a plurality of resin channels within said body portion, each of said resin channels having a first end in fluid communication with one of said flow distribution passageways and a second end open to said exterior surface of said body portion permitting the flow of resin from said flow distribution passageway to said exterior surface; and

a plurality of flow distributors positioned on, and extending outwardly from, the exterior surface of said body portion, two or more of said flow

distributors positioned adjacently and an approximate equal distance from said lower face along the exterior surface of said body portion, each of said second ends of said resin channels operatively associated with one of the plurality of flow distributors, each flow distributor comprising a pair of upper ledges and a pair of lower ledges,

each upper ledge of a flow distributor connected to an upper ledge of an adjacent flow distributor such that said connected upper ledges form an upper ring about said exterior surface of said body portion, said upper ring located downstream from the second ends of said resin channels associated with adjacent flow distributors, and

each lower ledge of a flow distributor connected to a lower ledge of an adjacent flow distributor such that said connected lower ledges form a lower ring about said exterior surface of said body portion, said lower ring located upstream from the second ends of said resin channels associated with adjacent flow distributors;

wherein resin delivered through said resin channels to said exterior surface of said body portion is directed about said exterior surface by said upper and lower rings to form a resin layer.

13. The mandrel as claimed in claim 12 wherein said plurality of resin channels communicate between one or more of said flow distribution passageways and the exterior surface of said body portion at a plurality of discrete distances from said lower face along the longitudinal axis of said body portion, thereby

delivering resin to adjacent flow distributors at a plurality of pre-determined distances from said lower face to permit the formation of a plurality of concentric resin layers around said body portion and the formation of a multi-layered film product.

14. The mandrel as claimed in claim 13 wherein the resin which forms any single resin layer flows from resin channels which are positioned at an angle to the longitudinal axis of said body portion an equal distance from said lower face.

15. The mandrel as claimed in claim 14 wherein the circumference of the exterior surface of the body portion is configured such that the width of the resin passageway increases from the lower face towards the upper face.

16. The mandrel as claimed in claim 14 including a plurality of flow distribution passageways, each flow distribution passageway in communication with a different resin source to permit the formation of a multi-layered film product from layers having different physical and/or chemical properties.

17. The mandrel as claimed in claim 14 including a plurality of flow distribution passageways, each said flow distribution passageway in communication with the same resin source to permit the formation of a multi-layered film product from layers of the same resin.

18. A method for producing a multi-layered film using a single mandrel within a die body, the mandrel having a longitudinal axis and an upper and lower face with an exterior surface therebetween, the mandrel received within a longitudinal bore of the die body and forming a resin passageway therebetween, the method comprising:

introducing resin into the mandrel through one or more flow distribution passageways within the mandrel;

directing the resin from the one or more flow distribution passageways through one or more resin channels to the exterior surface of the mandrel;

with flow distributors positioned on the exterior surface of the mandrel, directing the resin to flow about the exterior surface to form a concentric resin layer; and

directing the concentric resin layer within the resin passageway towards the upper face.

19. The method of claim 18 further comprising using said resin channel to direct resin to positions along the longitudinal axis of the body portion at discrete distances from said lower face to create a plurality of concentric resin layers that together form the multi-layered film.

20. A mandrel for a die used in the production of a multi-layered film, the die having a die body and a resin passageway formed between the mandrel and an interior surface of the die body when the mandrel is received within the die body, the mandrel comprising:

a body portion having an upper face, a lower face, and an exterior surface therebetween;

a plurality of resin channels in fluid communication with a source of resin and with the exterior surface of said body portion; and

a plurality of flow distributors on said exterior surface, each of said flow distributors operatively associated with one of said resin channels and configured to direct resin exiting said resin channel about the exterior surface of said body portion to form a concentric resin layer about the body portion.

21. The mandrel as claimed in claim 20 including one or more flow distribution passageways within said body portion, said flow distribution passageways in fluid communication with a source of resin and delivering resin from the source to said resin channels.

22. The mandrel as claimed in claim 21 wherein a plurality of flow distributors are arranged adjacently on the exterior surface of said mandrel to form a die layer.

23. Use of a single mandrel with an annular die to produce a multi-layered film, the mandrel having resin channels to deliver resin to an exterior surface of the mandrel, at a plurality of different distances from a lower face of the mandrel along its longitudinal axis, to produce concentric film layers at each of the said distances, the concentric film layers together forming the multi-layered film.

24. A die used in the production of a multi-layered film, the die having a die body with a longitudinal bore for receiving a mandrel and also having a resin passageway formed between the mandrel and an interior surface of the die body when the mandrel is received within the longitudinal bore, the die comprising:

the die body, further having a longitudinal axis, an upper face, and a lower face with the interior surface extending therebetween and defining the longitudinal bore;

one or more flow distribution passageways oriented generally longitudinally within said die body, said one or more flow distribution passageways open to said lower face of said die body for fluid communication with a source of resin;

a plurality of resin channels within said die body, each of said resin channels having a first end in fluid communication with one of said flow distribution passageways and a second end open to said interior surface of

said die body permitting the flow of resin from said flow distribution passageway to said interior surface;

a plurality of flow distributors positioned on said interior surface of said die body, each of said flow distributors operatively associated with the second end of one of said resin channels and configured to assist in directing resin exiting said resin channel about the interior surface of said die body and within the resin passageway,

wherein resin delivered through said resin channels forms a concentric resin layer about the interior surface of the die body, the resin layer directed within the resin passageway toward the upper face of the die body.

25. The die as claimed in claim 24 wherein said plurality of resin channels communicate between said one or more flow distribution passageways and the interior surface of said die body at discrete positions along the longitudinal axis of said die body, thereby delivering resin to said discrete positions to permit the formation of a plurality of concentric resin layers around said die body and the formation of a multi-layered film product.

26. The die as claimed in claim 25 wherein the resin which forms any single resin layer flows from resin channels which are positioned at an angle to the longitudinal axis of said die body approximately equal distance from said lower face.

27. The die as claimed in claim 26 wherein the circumference of the interior surface of the die body is configured such that the width of the resin passageway increases from said lower face toward said upper face.

28. The die as claimed in claim 27 including a plurality of flow distribution passageways, each flow distribution passageway in communication with a different resin source to permit the formation of a multi-layered film product from layers having different physical and/or chemical properties.

29. The die as claimed in claim 28 wherein each flow distributor is comprised of an upper ledge and a lower ledge, each upper and lower ledge extending outwardly from the interior surface of said die body.

30. The die as claimed in claim 29 wherein the upper ledge has a longitudinal axis at an angle to the longitudinal axis of said die body.

31. The die as claimed in claim 29 wherein the lower ledge has a longitudinal axis at an angle to the longitudinal axis of the die body.

32. The die as claimed in claim 29 wherein the longitudinal axis of the lower ledge is perpendicular to the longitudinal axis of the die body.

33. A mandrel according to any one of claims 1-11 in combination with a die according to any one of claims 24-32, wherein the mandrel is received within the longitudinal bore of the die.

34. The die according to claim 24, wherein the mandrel comprises:

a body portion having a longitudinal axis, the body portion having an upper face and a lower face with an exterior surface extending therebetween;

one or more additional flow distribution passageways oriented generally longitudinally within said body portion, said one or more additional flow distribution passageways open to said lower face of said body portion for fluid communication with a source of resin;

a plurality of additional resin channels within said body portion, each of said additional resin channels having a first end in fluid communication with one of said additional flow distribution passageways and a second end open to said exterior surface of said body portion permitting the flow of resin from said additional flow distribution passageway to said exterior surface; and

a plurality of additional flow distributors positioned on said exterior surface of said body portion, each of said additional flow distributors operatively associated with the second end of one of said additional resin channels and configured to assist in directing resin exiting said additional resin channel about the exterior surface of said body portion and within the resin passageway.

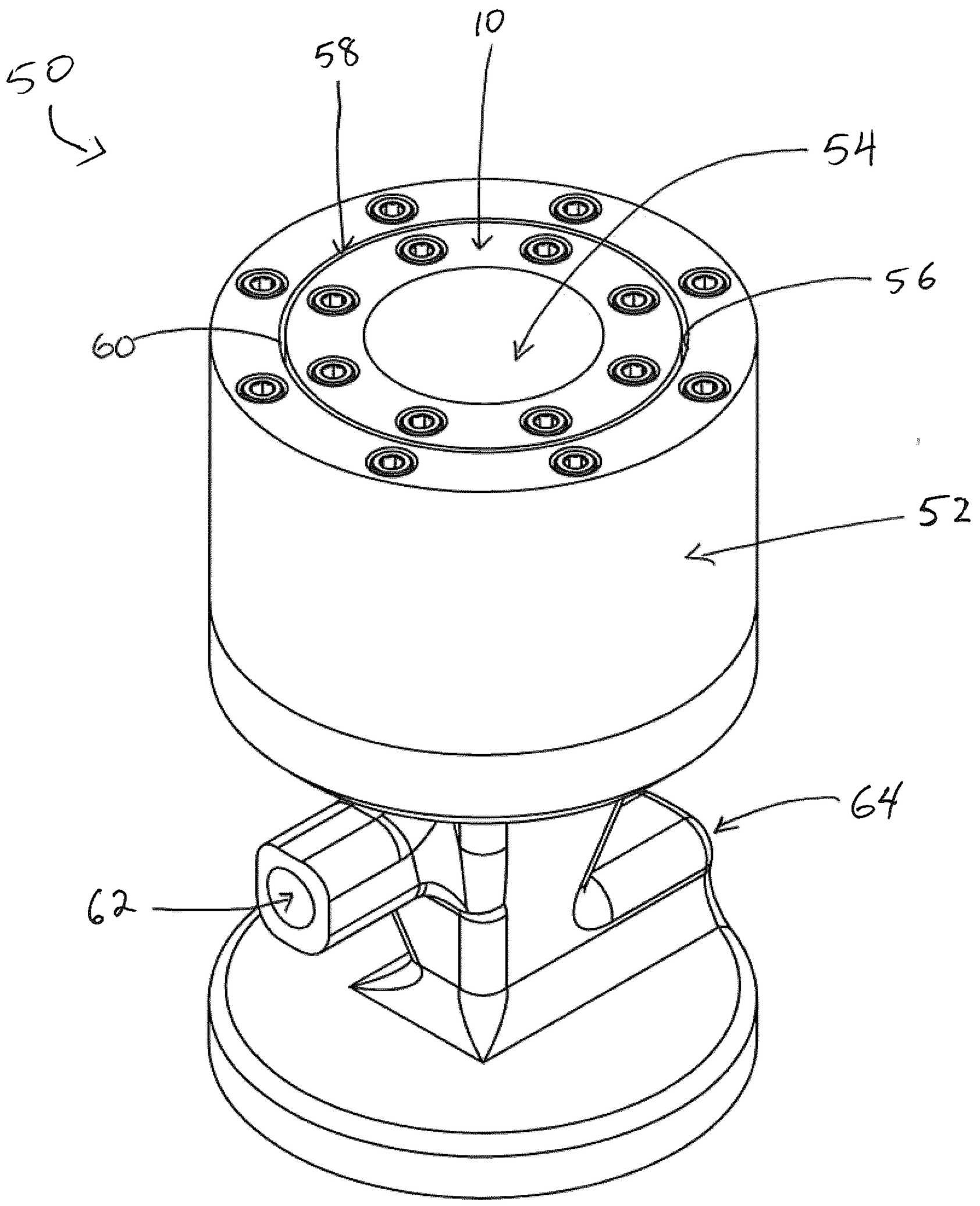

Fig. 1

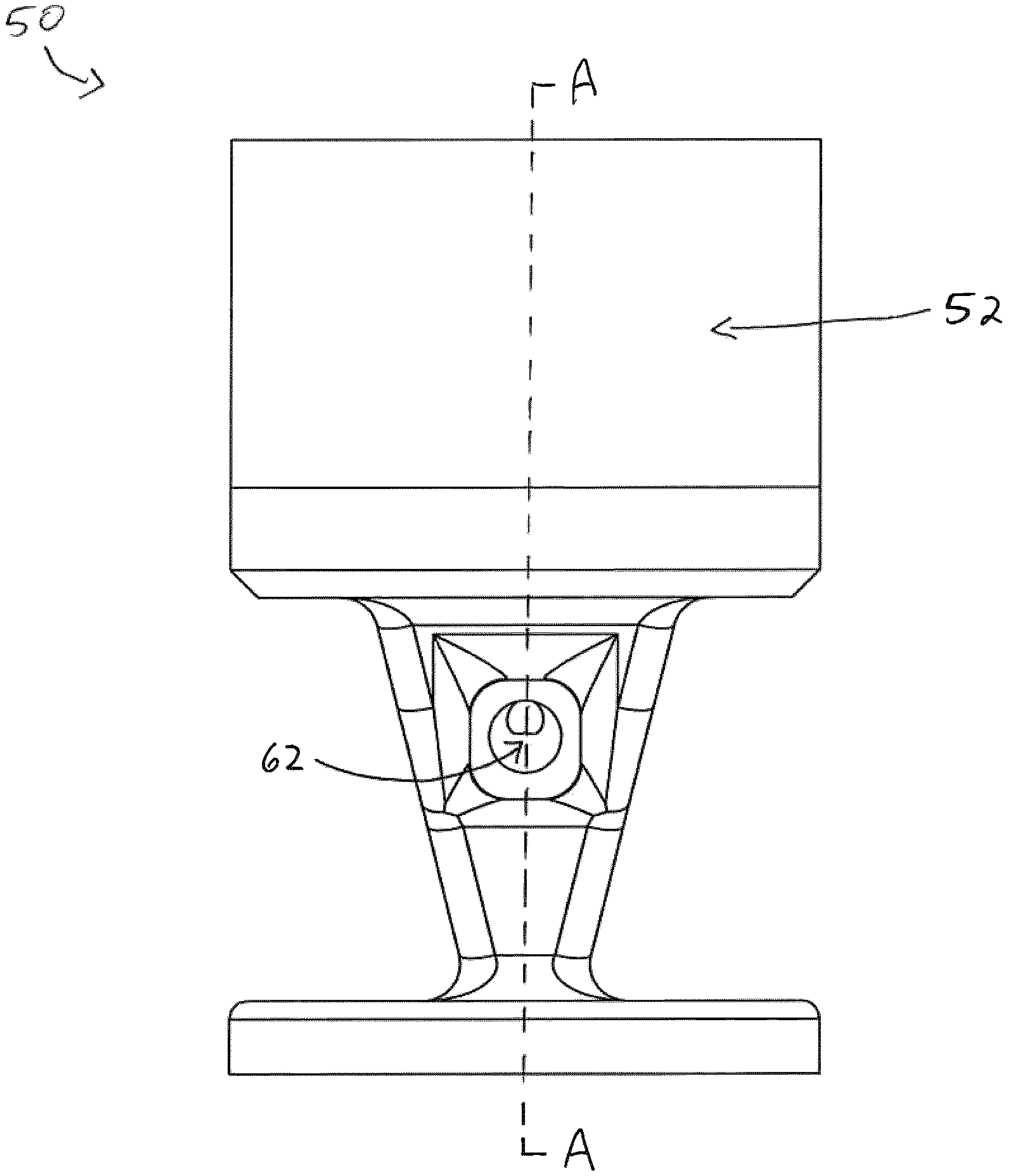

Fig. 2

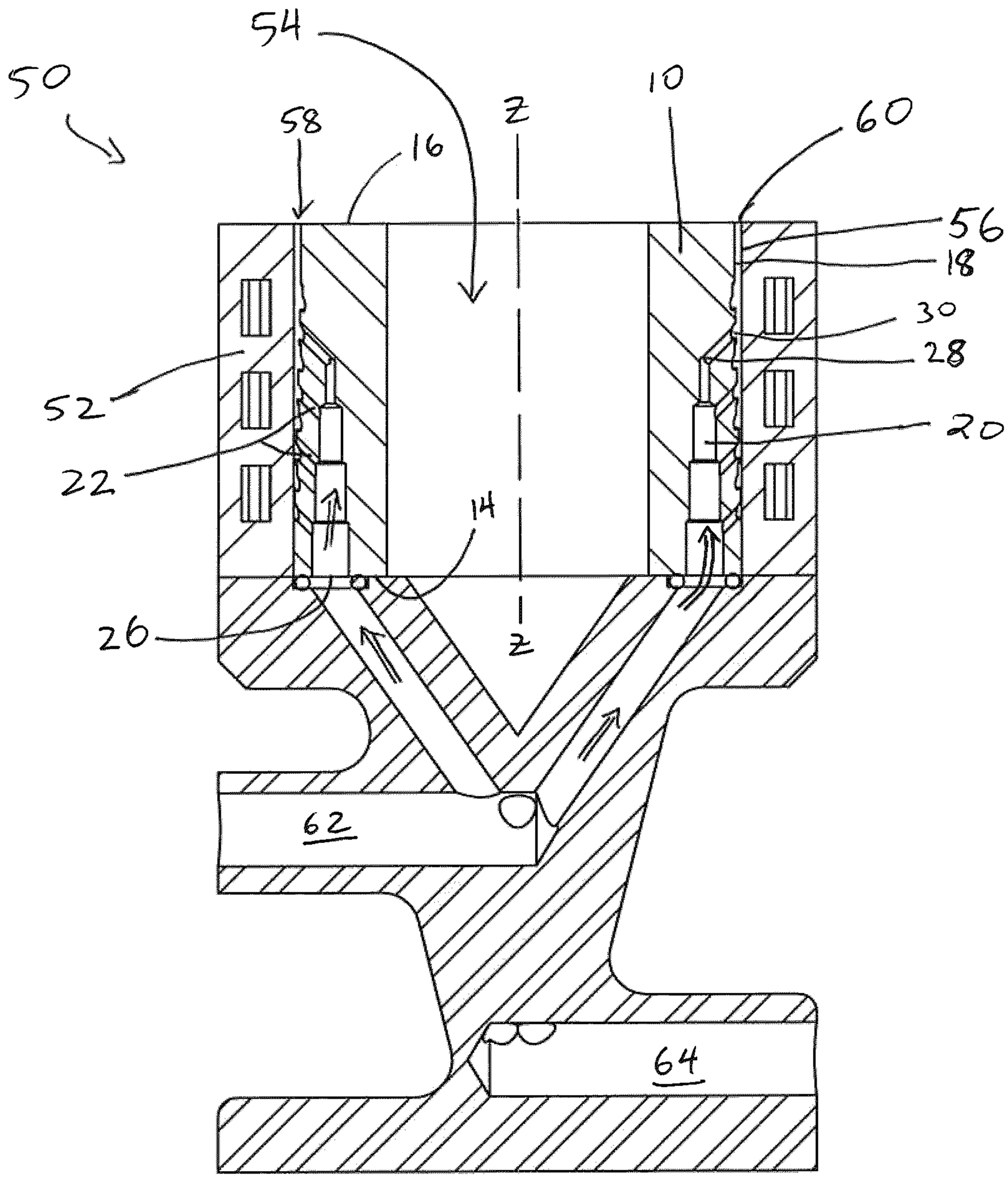

Fig. 3

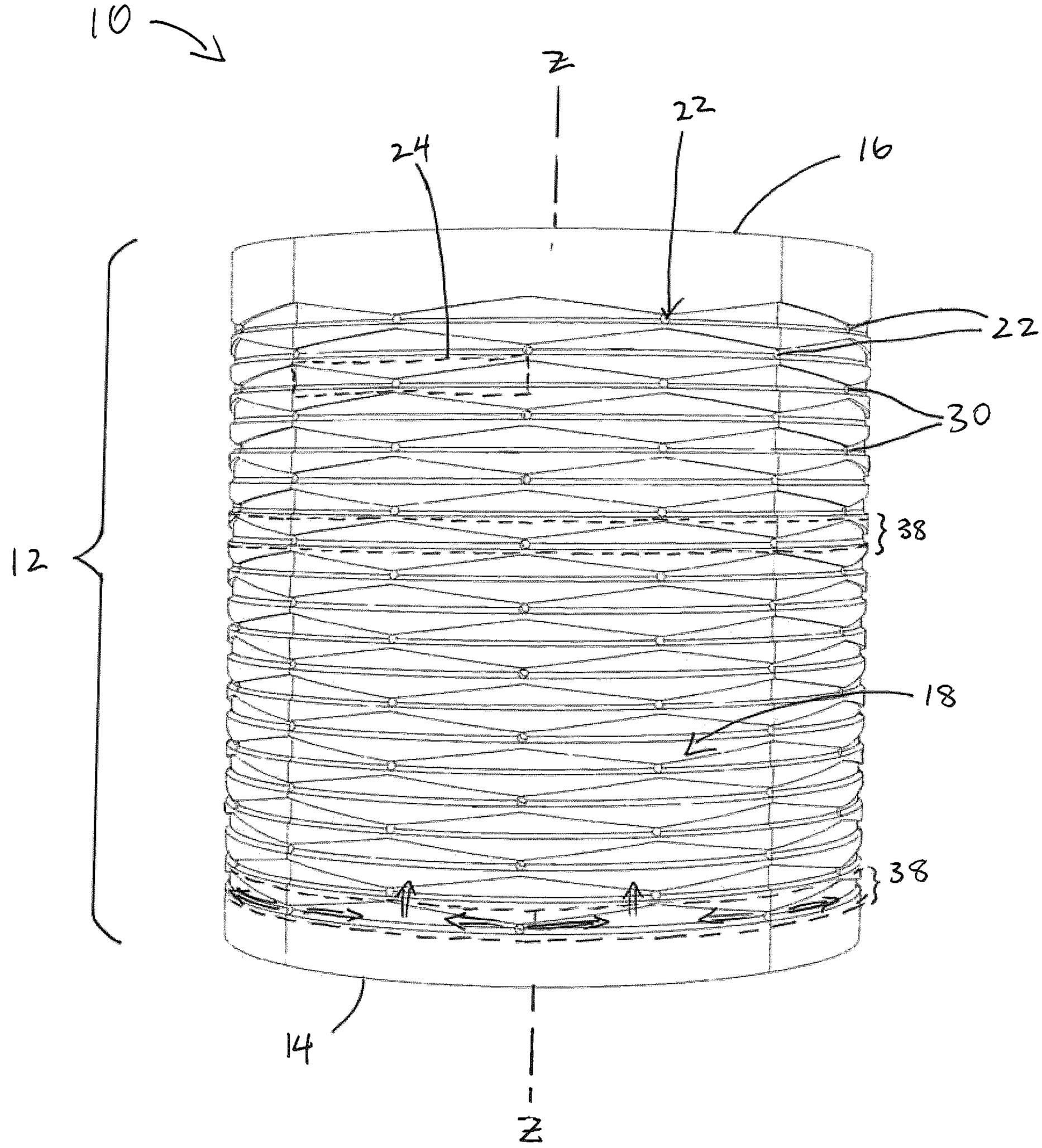

Fig. 4

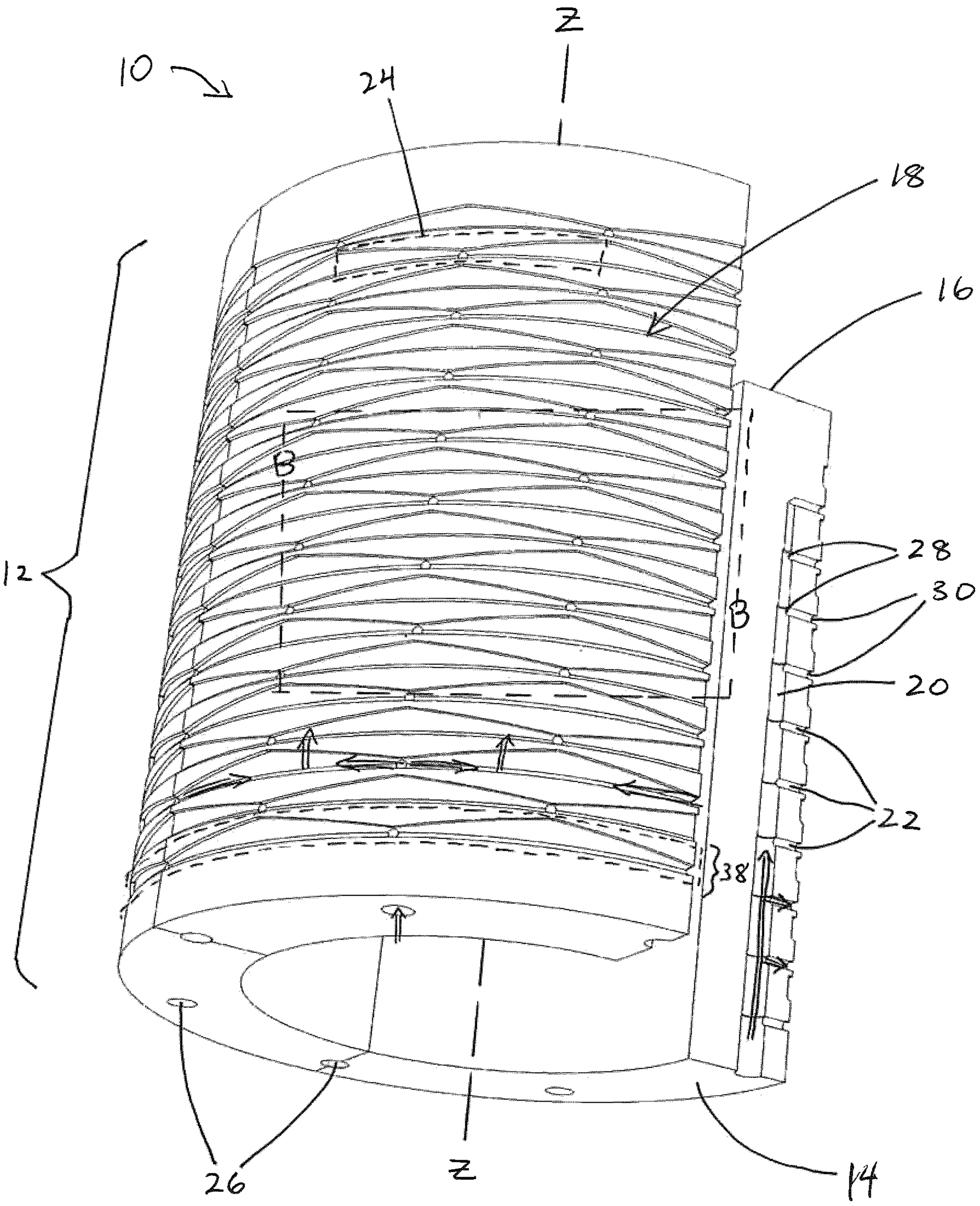

Fig. 5

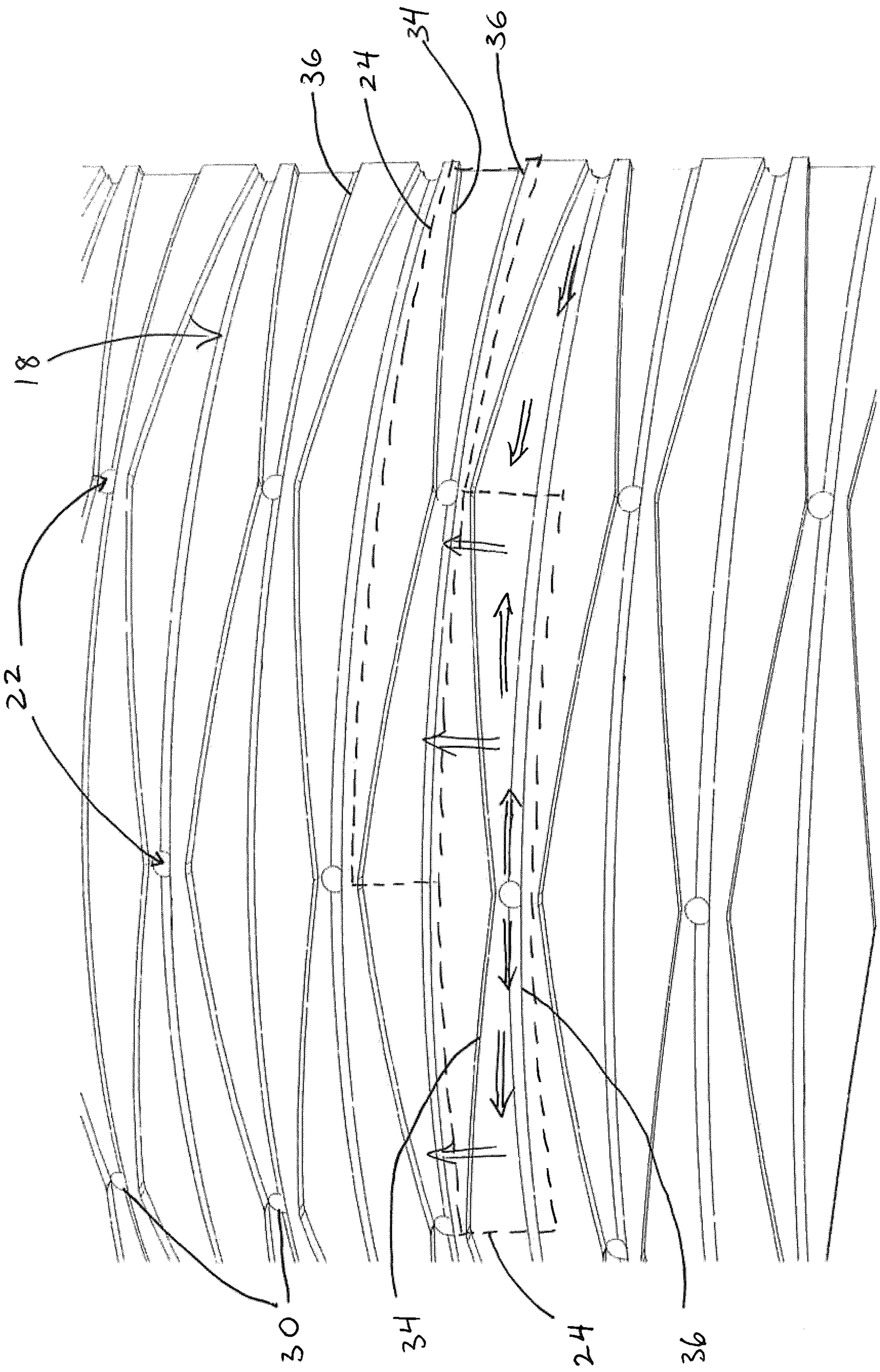

Fig. 6.

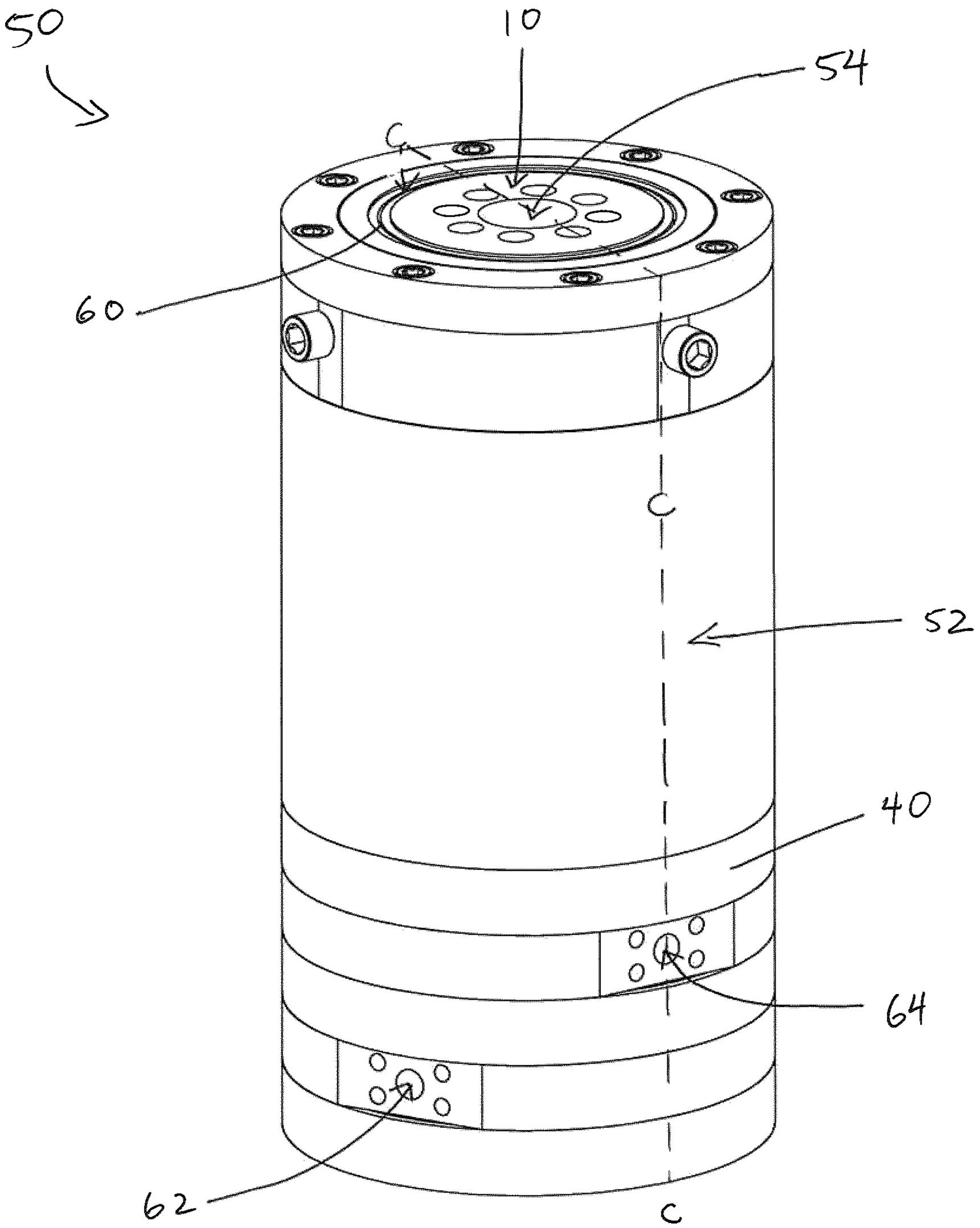

Fig. 7

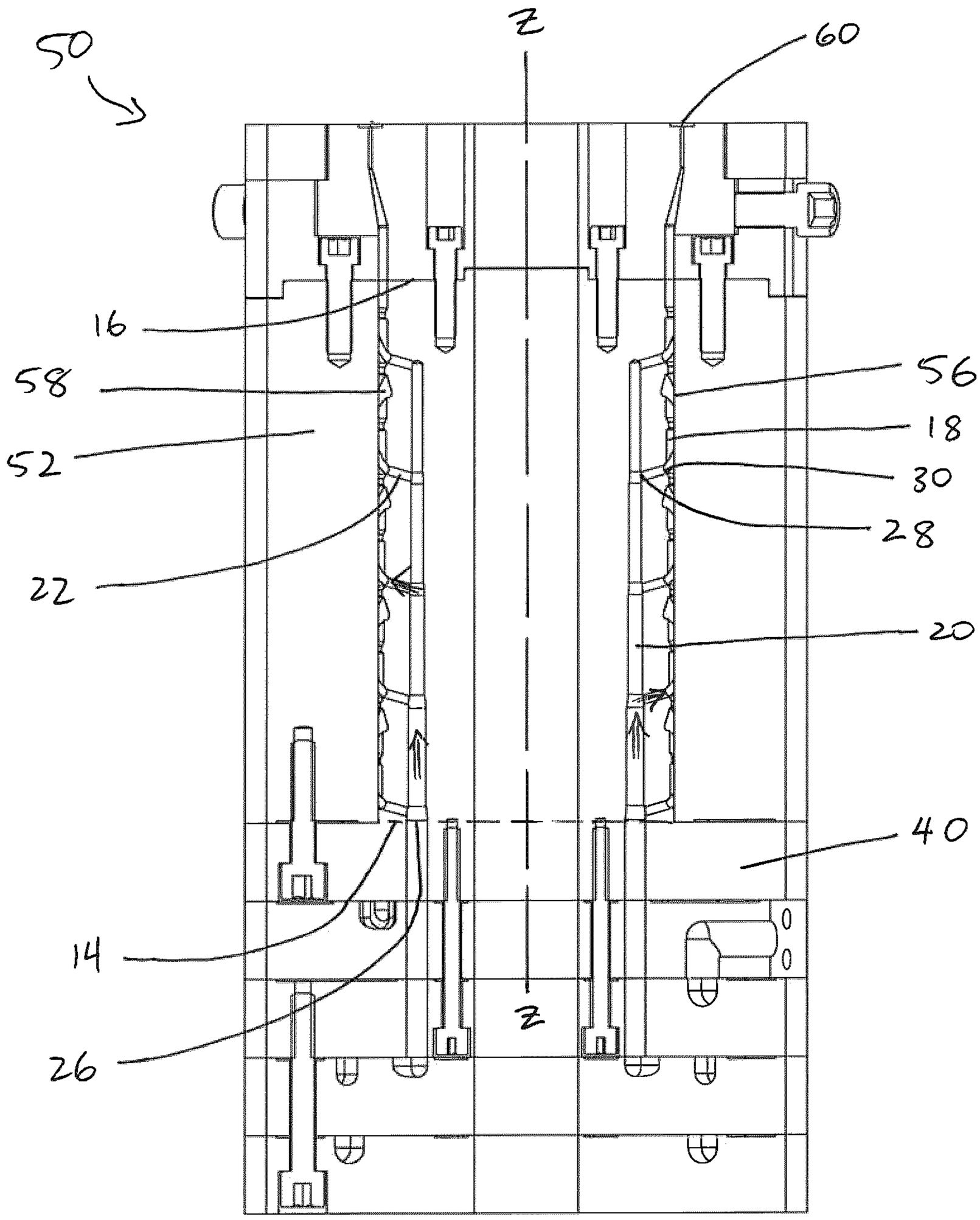

Fig. 8

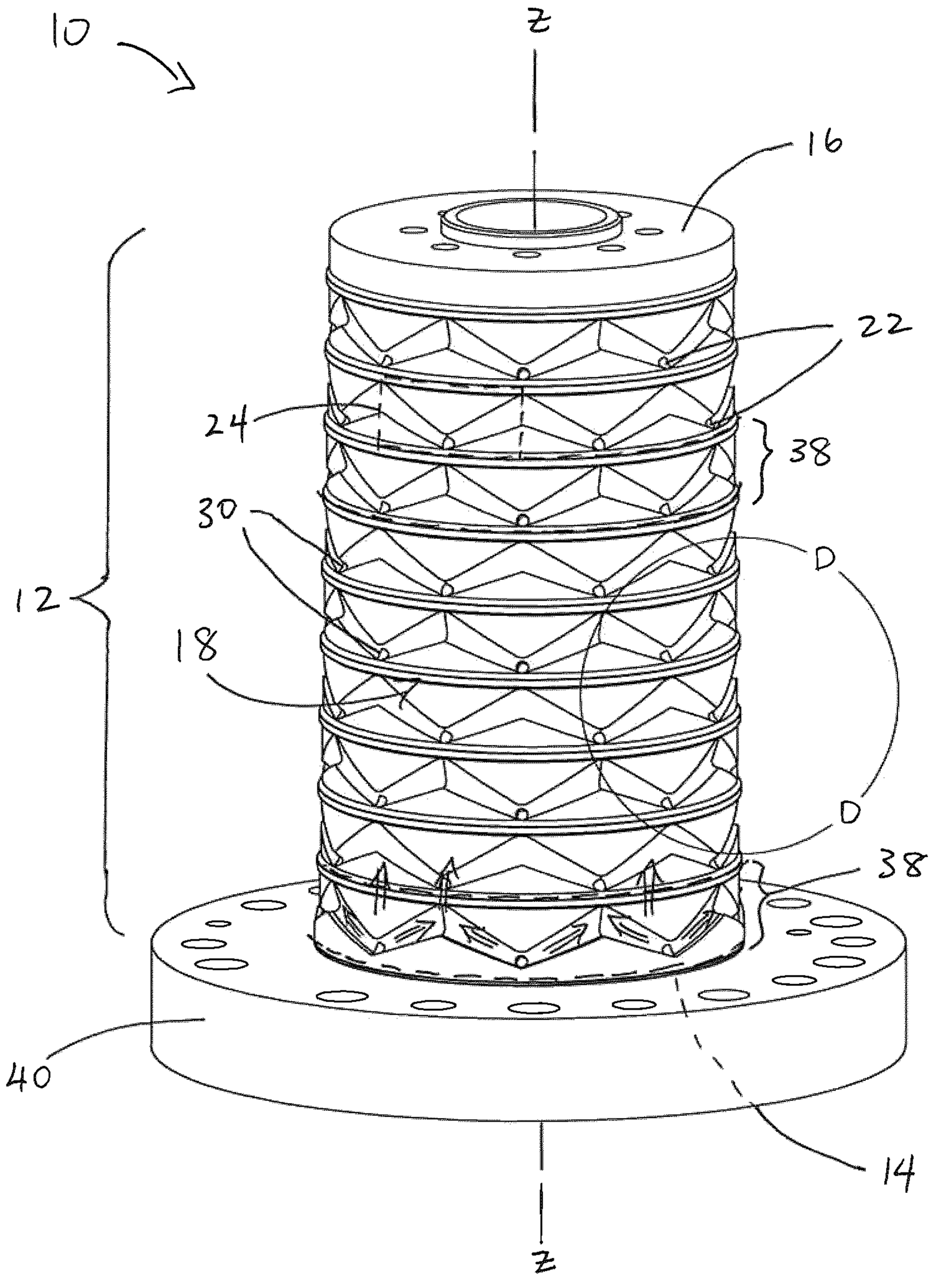

Fig. 9

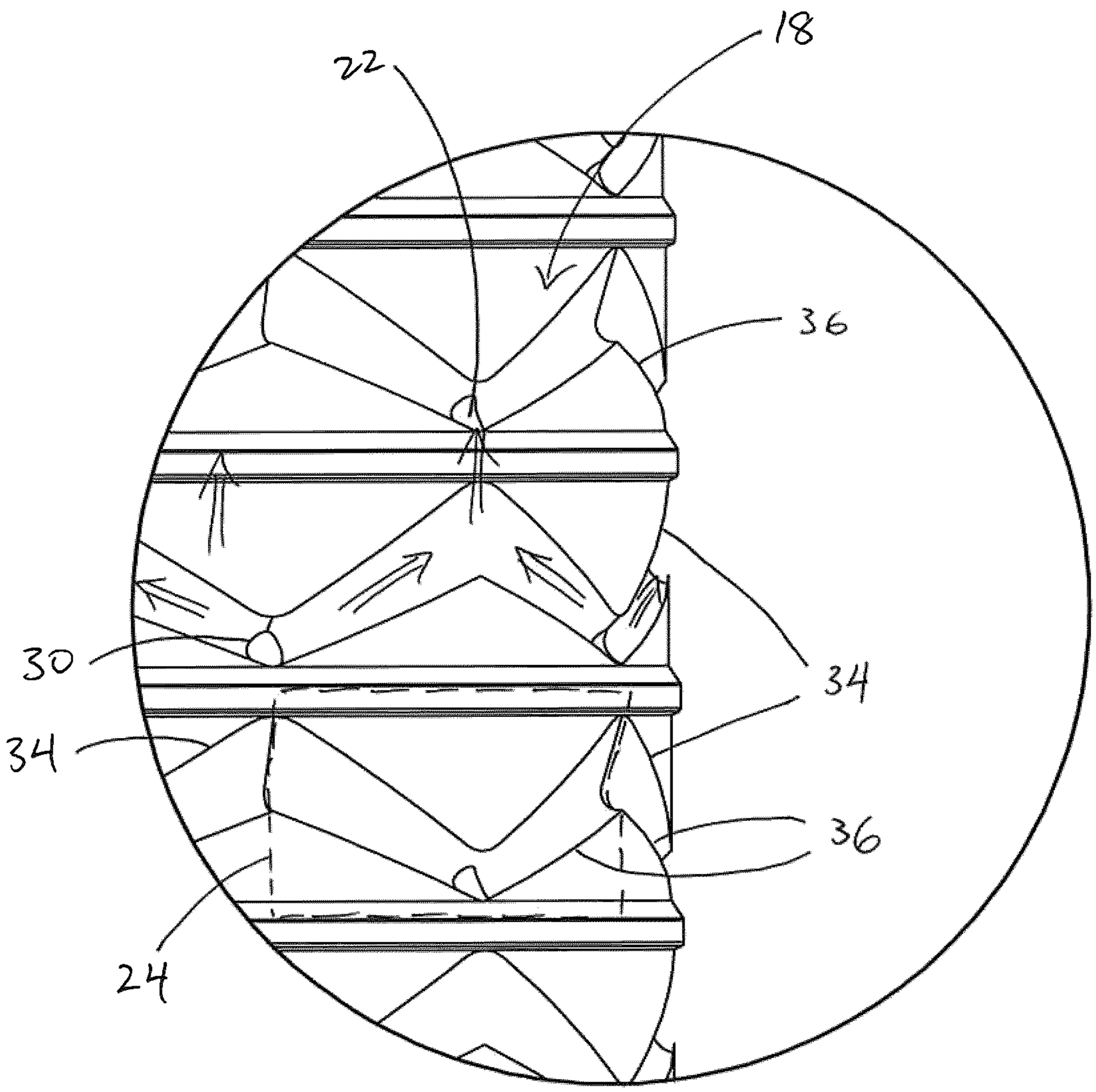

Fig. 10

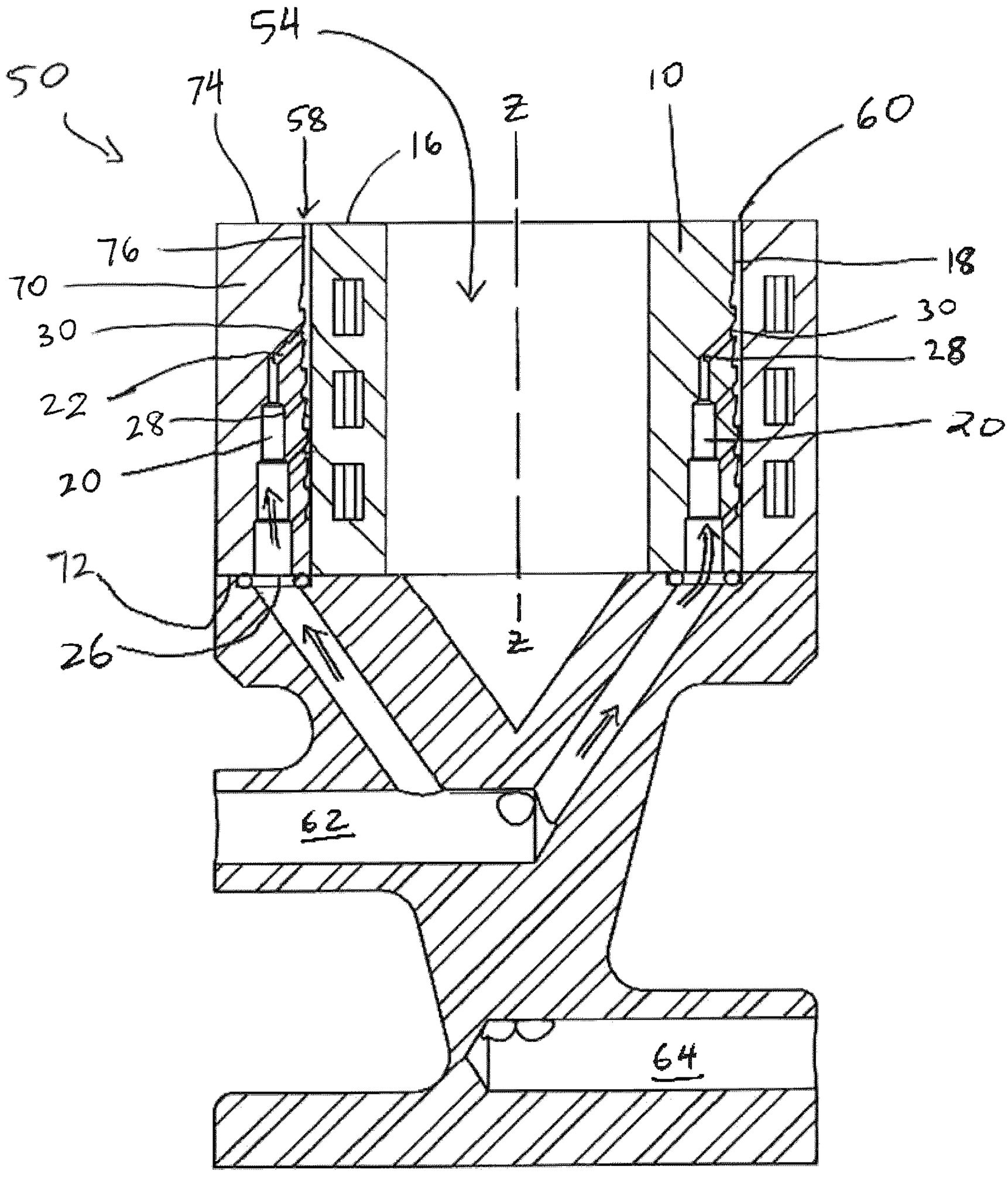

Fig. 11.

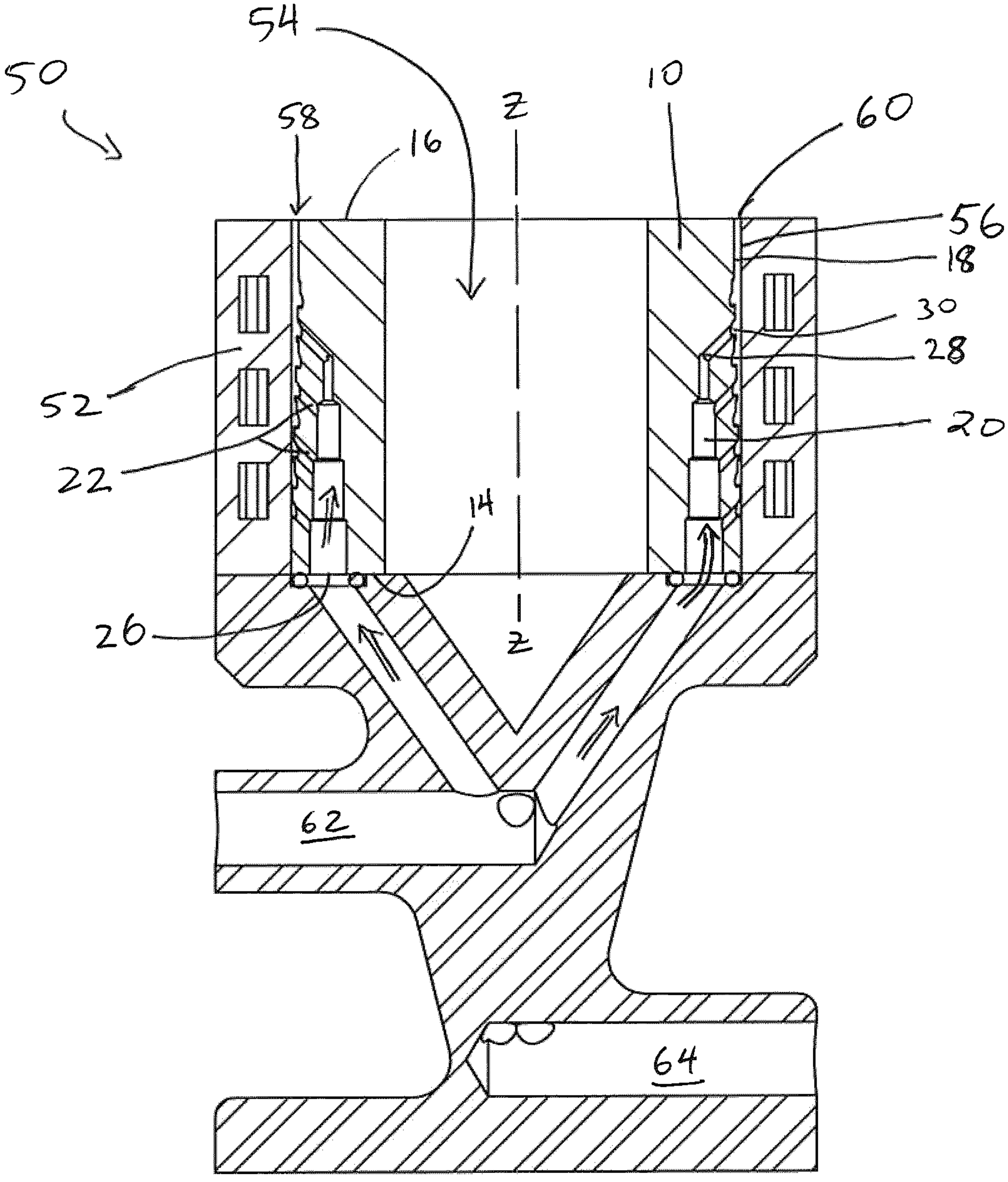

Fig. 3