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(54) Title: CONICAL FLUIDIC OSCILLATOR INSERTS FOR USE WITH A SUBTERRANEAN WELL

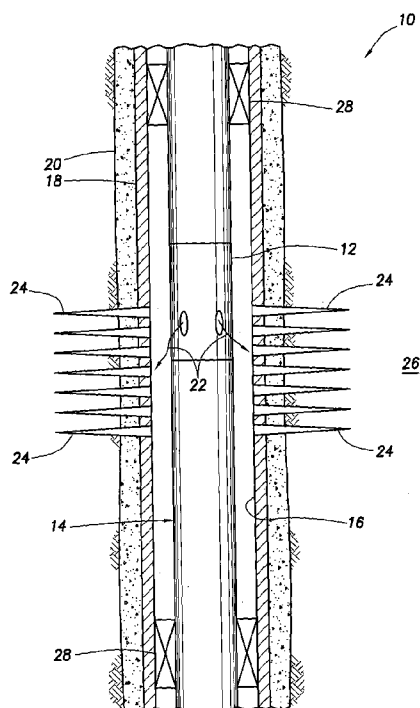


FIG. 1

(57) Abstract: A method of manufacturing a fluidic oscillator insert for use in a subterranean well can include forming the insert with a conical surface thereon, and forming at least one fluidic oscillator on the conical surface. A well tool can include a housing assembly, at least one insert received in the housing assembly, the insert having multiple fluidic oscillators formed therein, and wherein the fluidic oscillators produce oscillations in response to fluid flow through the fluidic oscillators. An insert for use in a well tool can include an exterior conical surface, at least one fluidic oscillator formed on the conical surface, and wherein the fluidic oscillator produces oscillations in response to fluid flow through the fluidic oscillator.



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CONICAL FLUIDIC OSCILLATOR INSERTS FOR USE
WITH A SUBTERRANEAN WELL

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BACKGROUND

This disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in an example described below, more particularly provides improved configurations of fluidic oscillators.

There are many situations in which it would be desirable to produce oscillations in fluid flow in a well. For example, in steam flooding operations, pulsations in flow of the injected steam can enhance sweep efficiency. In production operations, pressure fluctuations can encourage flow of hydrocarbons through rock pores, and pulsating jets can be used to clean well screens. In stimulation operations, pulsating jet flow can be used to initiate fractures in formations. These are just a few examples of a wide variety of possible applications for oscillating fluid flow.

Therefore, it will be appreciated that improvements would be beneficial in the art of manufacturing fluidic oscillator inserts.

SUMMARY

In a first aspect the present invention provides a method of manufacturing a fluidic oscillator insert for use in a subterranean well, the method comprising: forming the insert with a conical surface thereon; and forming at least one fluidic oscillator on the conical surface.

A side of the fluidic oscillator may be closed off by engagement between the insert and a surface formed in a housing assembly. The conical surface may comprise an exterior surface of the insert. Multiple fluidic oscillators may be formed on the conical surface. A flow passage may extend longitudinally through an interior of the insert. The flow passage may be surrounded by the conical surface.

In a second aspect the present invention provides a well tool, comprising: a housing assembly; at least one insert received in the housing assembly, the insert having multiple fluidic oscillators formed therein, and wherein the fluidic oscillators produce oscillations in response to fluid flow through the fluidic oscillators.

The fluidic oscillators may be formed on a conical surface of the insert. The conical surface may comprise an exterior surface of the insert. The insert may engage a conical surface formed in the housing assembly. The sides of the fluidic oscillators may be closed off by engagement between conical surfaces of the insert and housing assembly. A flow passage may extend longitudinally through the insert. The flow passage may be positioned between the fluidic oscillators. The flow passage may be surrounded by a conical surface of the insert.

In a third aspect the present invention provides an insert for use in a well tool, the insert comprising: an exterior conical surface; at least one fluidic oscillator formed on the conical surface, and wherein the fluidic oscillator produces oscillations in response to fluid flow through the fluidic oscillator.

Multiple fluidic oscillators may be formed on the conical surface. The insert may engage a conical surface formed in a housing assembly. A side of the fluidic oscillator may be closed off by engagement between the conical surface of the insert and a housing assembly. A flow passage may extend longitudinally through the insert. The flow passage may be surrounded by the conical surface. The fluidic oscillator may comprise: a fluid input; first and second fluid outputs on opposite sides of a longitudinal axis of the fluidic oscillator, whereby a majority of fluid which flows through the fluidic oscillator exits the fluidic oscillator alternately via the first and second fluid outputs; first and second fluid paths from the fluid input to the respective first and second fluid outputs; and wherein the first and second fluid paths cross each other between the fluid input and the respective first and second fluid outputs.

In the disclosure below, a technique for forming a fluidic oscillator insert is provided which brings improvements to the art. One example is described below in which the insert has multiple fluidic oscillators formed thereon. Another example is described below in which the insert has a conical surface formed thereon.

In one aspect, this disclosure provides to the art a method of manufacturing a fluidic oscillator insert for use in a subterranean well. The method can include forming the insert with a conical surface thereon, and forming at least one fluidic oscillator on the conical surface.

In another aspect, this disclosure provides to the art a well tool. The well tool can include a housing assembly, at least one insert received in the housing assembly, with the insert having multiple fluidic oscillators formed therein.

In yet another aspect, a insert for use in a well tool is provided. The insert can include an exterior conical surface, and at least one fluidic oscillator formed on the conical surface. The fluidic oscillator produces oscillations in response to fluid flow through the fluidic oscillator.

These and other features, advantages and benefits will become apparent to one of ordinary skill in the art upon careful consideration of the detailed description of representative examples below and the accompanying drawings, in which similar elements are indicated in the various figures using the same reference numbers.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representative partially cross-sectional view of a well system and associated method which can embody principles of the present disclosure.

FIG. 2 is a representative partially cross-sectional isometric view of a well tool which may be used in the well system and method of FIG. 1.

FIG. 3 is a representative isometric view of an insert which may be used in the well tool of FIG. 2.

FIG. 4 is a representative elevational view of a fluidic oscillator formed in the insert of FIG. 3, which fluidic oscillator can embody principles of this disclosure.

FIGS. 5-10 are additional configurations of the fluidic oscillator.

FIG. 11 is a representative partially cross-sectional view of the well tool.

FIG. 12 is a representative isometric view of another configuration of the insert.

DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a well system 10 and associated method which can embody principles of this disclosure. In this example, a well tool 12 is interconnected in a tubular string 14 installed in a wellbore 16. The wellbore 16 is lined with casing 18 and cement 20. The well tool 12 is used to produce oscillations in flow of fluid 22 injected through perforations 24 into a formation 26 penetrated by the wellbore 16.

The fluid 22 could be steam, water, gas, fluid previously produced from the formation 26, fluid produced from another formation or another interval of the formation 26, or any other type of fluid from any source. It is not necessary, however, for the fluid 22 to be flowed outward into the formation 26 or outward through the well tool 12, since the principles of this disclosure are also applicable to situations in which fluid is produced from a formation, or in which fluid is flowed inwardly through a well tool.

Broadly speaking, this disclosure is not limited at all to the one example depicted in FIG. 1 and described herein. Instead, this disclosure is applicable to a variety of different circumstances in which, for example, the wellbore 16 is not cased or cemented, the well tool 12 is not interconnected in a tubular string 14 secured by packers 28 in the wellbore, etc.

Referring additionally now to FIG. 2, an example of the well tool 12 which may be used in the system 10 and method of FIG. 1 is representatively illustrated. However, the well tool 12 could be used in other systems and methods, in keeping with the principles of this disclosure.

The well tool 12 depicted in FIG. 2 has an outer housing assembly 30 with a threaded connector 32 at an upper end thereof. This example is configured for attachment at a lower end of a tubular string, and so there is not another connector at a lower end of the housing assembly 30, but one could be provided if desired.

Secured within the housing assembly 30 are three inserts 34, 36, 38. The inserts 34, 36, 38 produce oscillations in the flow of the fluid 22 through the well tool 12.

More specifically, the upper insert 34 produces oscillations in the flow of the fluid 22 outwardly through two opposing ports 40 (only one of which is visible in FIG. 2) in the housing assembly 30. The middle insert 36 produces oscillations in the flow of the fluid 22 outwardly through two opposing ports 42 (only one of which is visible in FIG. 2). The lower insert 38 produces oscillations in the flow of the fluid 22 outwardly through a port 44 in the lower end of the housing assembly 30.

Of course, other numbers and arrangements of inserts and ports, and other directions of fluid flow may be used in other examples. FIG. 2 depicts merely one example of a possible configuration of the well tool 12.

Referring additionally now to FIG. 3, an enlarged scale view of one example of the insert 34 is representatively illustrated. The insert 34 may be used in the well tool 12

described above, or it may be used in other well tools in keeping with the principles of this disclosure.

The insert 34 depicted in FIG. 3 has a fluidic oscillator 50 machined, molded, cast or otherwise formed therein. In this example, the fluidic oscillator 50 is formed into a generally planar side 52 of the insert 34, and that side is closed off when the insert is installed in the well tool 12, so that the fluid oscillator is enclosed between its fluid input 54 and two fluid outputs 56, 58.

The fluid 22 flows into the fluidic oscillator 50 via the fluid input 54, and at least a majority of the fluid 22 alternately flows through the two fluid outputs 56, 58. That is, the majority of the fluid 22 flows outwardly via the fluid output 56, then it flows outwardly via the fluid output 58, then it flows outwardly through the fluid output 56, then through the fluid output 58, etc., back and forth repeatedly.

In the example of FIG. 3, the fluid outputs 56, 58 are oppositely directed (e.g., facing about 180 degrees relative to one another), so that the fluid 22 is alternately discharged from the fluidic oscillator 50 in opposite directions. In other examples (including some of those described below), the fluid outputs 56, 58 could be otherwise directed.

It also is not necessary for the fluid outputs 56, 58 to be structurally separated as in the example of FIG. 3. Instead, the fluid outputs 56, 58 could be different areas of a larger output opening as in the example of FIG. 7 described more fully below.

Referring additionally now to FIG. 4, The fluidic oscillator 50 is representatively illustrated in an elevational view of the insert 34. However, it should be clearly understood that it is not necessary for the fluid oscillator 50 to be positioned in the insert 34 as depicted in FIG. 4, and the fluidic oscillator could be positioned in other inserts (such as the inserts 36, 38, etc.) or in other devices, in keeping with the principles of this disclosure.

The fluid 22 is received into the fluidic oscillator 50 via the inlet 54, and a majority of the fluid flows from the inlet to either the outlet 56 or the outlet 58 at any given point in time. The fluid 22 flows from the inlet 54 to the outlet 56 via one fluid path 60, and the fluid flows from the inlet to the other outlet 58 via another fluid path 62.

In one unique aspect of the fluidic oscillator 50, the two fluid paths 60, 62 cross each other at a crossing 65. A location of the crossing 65 is determined by shapes of walls 64, 66 of the fluidic oscillator 50 which outwardly bound the flow paths 60, 62.

When a majority of the fluid 22 flows via the fluid path 60, the well-known Coanda effect tends to maintain the flow adjacent the wall 64. When a majority of the fluid 22 flows via the fluid path 62, the Coanda effect tends to maintain the flow adjacent the wall 66.

A fluid switch 68 is used to alternate the flow of the fluid 22 between the two fluid paths 60, 62. The fluid switch 68 is formed at an intersection between the inlet 54 and the two fluid paths 60, 62.

A feedback fluid path 70 is connected between the fluid switch 68 and the fluid path 60 downstream of the fluid switch and upstream of the crossing 65. Another feedback fluid path 72 is connected between the fluid switch 68 and the fluid path 62 downstream of the fluid switch and upstream of the crossing 65.

When pressure in the feedback fluid path 72 is greater than pressure in the other feedback fluid path 70, the fluid 22 will be influenced to flow toward the fluid path 60. When pressure in the feedback fluid path 70 is greater than pressure in the other feedback fluid path 72, the fluid 22 will be influenced to flow toward the fluid path 62. These relative pressure conditions are alternated back and forth, resulting in a majority of the fluid 22 flowing alternately via the fluid paths 60, 62.

For example, if initially a majority of the fluid 22 flows via the fluid path 60 (with the Coanda effect acting to maintain the fluid flow adjacent the wall 64), pressure in the feedback fluid path 70 will become greater than pressure in the feedback fluid path 72. This will result in the fluid 22 being influenced (in the fluid switch 68) to flow via the other fluid path 62.

When a majority of the fluid 22 flows via the fluid path 62 (with the Coanda effect acting to maintain the fluid flow adjacent the wall 66), pressure in the feedback fluid path 72 will become greater than pressure in the feedback fluid path 70. This will result in the fluid 22 being influenced (in the fluid switch 68) to flow via the other fluid path 60.

Thus, a majority of the fluid 22 will alternate between flowing via the fluid path 60 and flowing via the fluid path 62. Note that, although the fluid 22 is depicted in FIG. 4 as simultaneously flowing via both of the fluid paths 60, 62, in practice a majority of the fluid 22 will flow via only one of the fluid paths at a time.

Note that the fluidic oscillator 50 of FIG. 4 is generally symmetrical about a longitudinal axis 74. The fluid outputs 56, 58 are on opposite sides of the longitudinal axis 74, the feedback fluid paths 70, 72 are on opposite sides of the longitudinal axis, etc.

Referring additionally now to FIG. 5, another configuration of the fluidic oscillator 50 is representatively illustrated. In this configuration, the fluid outputs 56, 58 are not oppositely directed.

Instead, the fluid outputs 56, 58 discharge the fluid 22 in the same general direction 5 (downward as viewed in FIG. 5). As such, the fluidic oscillator 50 of FIG. 5 would be appropriately configured for use in the lower insert 38 in the well tool 12 of FIG. 2.

Referring additionally now to FIG. 6, another configuration of the fluidic oscillator 50 is representatively illustrated. In this configuration, a structure 76 is interposed between the fluid paths 60, 62 just upstream of the crossing 65.

10 The structure 76 beneficially reduces a flow area of each of the fluid paths 60, 62 upstream of the crossing 65, thereby increasing a velocity of the fluid 22 through the crossing and somewhat increasing the fluid pressure in the respective feedback fluid paths 70, 72.

This increased pressure is alternately present in the feedback fluid paths 70, 72, 15 thereby producing more positive switching of fluid paths 60, 62 in the fluid switch 68. In addition, when initiating flow of the fluid 22 through the fluidic oscillator 50, an increased pressure difference between the feedback fluid paths 70, 72 helps to initiate the desired switching back and forth between the fluid paths 60, 62.

Referring additionally now to FIG. 7, another configuration of the fluidic oscillator 20 50 is representatively illustrated. In this configuration, the fluid outputs 56, 58 are not separated by any structure.

However, a majority of the fluid 22 will exit the fluidic oscillator 50 of FIG. 7 via either the fluid path 60 or the fluid path 62 at any given time. Therefore, the fluid outputs 56, 58 are defined by the regions of the fluidic oscillator 50 via which the fluid 22 exits the 25 fluidic oscillator along the respective fluid paths 60, 62.

Referring additionally now to FIG. 8, another configuration of the fluidic oscillator is representatively illustrated. In this configuration, the fluid outputs 56, 58 are oppositely directed, similar to the configuration of FIG. 4, but the structure 76 is interposed between the fluid paths 60, 62, similar to the configuration of FIGS. 6 & 7.

30 Thus, the FIG. 8 configuration can be considered a combination of the FIGS. 4, 6 & 7 configurations. This demonstrates that any of the features of any of the configurations

described herein can be used in combination with any of the other configurations, in keeping with the principles of this disclosure.

Referring additionally now to FIG. 9, another configuration of the fluidic oscillator 50 is representatively illustrated. In this configuration, another structure 78 is interposed
5 between the fluid paths 60, 62 downstream of the crossing 65.

The structure 78 reduces the flow areas of the fluid paths 60, 62 just upstream of a fluid path 80 which connects the fluid paths 60, 62. The velocity of the fluid 22 flowing through the fluid paths 60, 62 is increased due to the reduced flow areas of the fluid paths.

The increased velocity of the fluid 22 flowing through each of the fluid paths 60, 62
10 can function to draw some fluid from the other of the fluid paths. For example, when a majority of the fluid 22 flows via the fluid path 60, its increased velocity due to the presence of the structure 78 can draw some fluid through the fluid path 80 into the fluid path 60. When a majority of the fluid 22 flows via the fluid path 62, its increased velocity due to the presence of the structure 78 can draw some fluid through the fluid path 80 into the fluid path
15 62.

It is possible that, properly designed, this can result in more fluid being alternately discharged from the fluid outputs 56, 58 than fluid 22 being flowed into the input 54. Thus, fluid can be drawn into one of the outputs 56, 68 while fluid is being discharged from the other of the outputs.

Referring additionally now to FIG. 10, another configuration of the fluidic oscillator 50 is representatively illustrated. In this configuration, computational fluid dynamics modeling has shown that a flow rate of fluid discharged from one of the outputs 56, 58 can be greater than a flow rate of fluid 22 directed into the input 54.

Fluid can be drawn from one of the outputs 56, 58 to the other output via the fluid
25 path 80. Thus, fluid can enter one of the outputs 56, 58 while fluid is being discharged from the other output.

This is due in large part to the increased velocity of the fluid 22 caused by the structure 78 (e.g., the increased velocity of the fluid in one of the fluid paths 60, 62 causes eduction of fluid from the other of the fluid paths 60, 62 via the fluid path 80). At the
30 intersections between the fluid paths 60, 62 and the respective feedback fluid paths 70, 72, pressure can be significantly reduced due to the increased velocity, thereby reducing pressure in the respective feedback fluid paths.

In the FIG. 10 example, a reduction in pressure in the feedback fluid path 70 will influence the fluid 22 to flow via the fluid path 62 from the fluid switch 68 (due to the relatively higher pressure in the other feedback fluid path 72). Similarly, a reduction in pressure in the feedback fluid path 72 will influence the fluid 22 to flow via the fluid path 60 from the fluid switch 68 (due to the relatively higher pressure in the other feedback fluid path 70).

One difference between the FIGS. 9 & 10 configurations is that, in the FIG. 10 configuration, the feedback fluid paths 70, 72 are connected to the respective fluid paths 60, 62 downstream of the crossing 65. Computational fluid dynamics modeling has shown that this arrangement produces desirably low frequency oscillations of flow from the outputs 56, 58, although such low frequency oscillations are not necessary in keeping with the principles of this disclosure.

Referring additionally now to FIG. 11, another configuration of the well tool 12 is representatively illustrated. In this configuration, the housing assembly 30 has both upper and lower connectors 32 for interconnecting the well tool 12 in the tubular string 14. In other examples, the housing assembly 30 could be configured for connection at a lower end of the tubular string 14 (as in the configuration of FIG. 2).

In the configuration of FIG. 11, the inserts 34, 36, 38 are similarly constructed, in that each is arranged to discharge the fluid 22 laterally outward. Thus, the inserts 34, 36, 38 can be the same type of insert, although in other examples the inserts may differ from each other, other numbers of inserts (including one) may be used, etc.

In one unique aspect of the well tool 12, an exterior conical surface 80 is formed on each of the inserts 34, 36, 38. The conical surface 80 sealingly engages respective interior conical surfaces 82 formed in the housing assembly 30.

The sealing engagement between the conical surfaces 80, 82 is enhanced by pressure differentials longitudinally across the inserts 34, 36, 38 due to flow of the fluid 22 through the well tool 12. The use of conical surfaces 80, 82 also provides for convenient assembly of the well tool 12.

Engagement between the conical surfaces 80, 82 also closes off outer sides of the fluidic oscillators 50 formed on the conical surfaces 80. Thus, there is no need for an additional member to enclose the fluidic oscillators 50. However, it is not necessary for the conical surfaces 80, 82 to fully sealingly engage each other (for example, partial sealing

engagement could be adequate in some examples, etc.), and an additional member could be provided to close off the outer sides of the fluidic oscillators 50, if desired.

Note that the term “conical” is used herein to indicate a surface which is at least partially in the form of a cone. The surfaces 80, 82 are more precisely frusto-conical in form, and so it should be understood that the term “conical” as used herein encompasses frusto-conical surfaces.

Referring additionally now to FIG. 12, one of the inserts 34 is representatively illustrated apart from the remainder of the well tool 12. In this view, it may be clearly seen that multiple fluidic oscillators 50 are formed on the conical surface 80. However, the insert 34 can have any number of fluidic oscillators 50 (including one) formed thereon in keeping with the principles of this disclosure.

The fluidic oscillators 50 depicted in FIG. 12 are of the FIG. 8 configuration. However, any type, or combination of types, of fluidic oscillators 50 may be used in other examples.

A flow passage 84 extends longitudinally through the insert 34. The flow passage 84 allows some of the fluid 22 to flow through the insert 34 to the other inserts 36, 38 in the housing assembly 30. However, it is not necessary for the flow passage 84 to be provided in the insert 34 (for example, if no other insert receives the fluid 22 downstream of the insert 34, etc.).

It can now be fully appreciated that the above disclosure provides several advancements to the art of manufacturing fluidic oscillator inserts. The inserts 34, 36, 38 described above allow for convenient assembly into the housing assembly 30 of the well tool 12, and allow for multiple fluidic oscillators 50 to be formed on each insert.

The above disclosure provides to the art a method of manufacturing a fluidic oscillator insert 34 for use in a subterranean well. The method can include forming the insert 34 with a conical surface 80 thereon, and forming at least one fluidic oscillator 50 on the conical surface 80.

A side of the fluidic oscillator 50 may be closed off by engagement between the insert 34 and a surface 82 formed in a housing assembly 30.

The conical surface 80 may comprise an exterior surface of the insert 34.

Multiple fluidic oscillators 50 can be formed on the conical surface 80.

A flow passage 84 may extend longitudinally through an interior of the insert 34. The flow passage 84 may be surrounded by the conical surface 80.

Also described above is the well tool 12 which can comprise a housing assembly 30, at least one insert 34 received in the housing assembly 30, with the insert 34 having multiple
5 fluidic oscillators 50 formed therein. The fluidic oscillators 50 produce oscillations in response to fluid 22 flow through the fluidic oscillators 50.

The fluidic oscillators 50 can be formed on a conical surface 80 of the insert 34. The conical surface 80 may comprise an exterior surface of the insert 34.

The insert 34 can engage a conical surface 82 formed in the housing assembly 30.

10 Sides of the multiple fluidic oscillators 50 may be closed off by engagement between conical surfaces 80, 82 of the insert 34 and housing assembly 30.

A flow passage 84 may be positioned between the fluidic oscillators 50.

The above disclosure also provides an insert 34 for use in a well tool 12, with the insert 34 comprising an exterior conical surface 80, and at least one fluidic oscillator 50
15 formed on the conical surface 80. The fluidic oscillator 50 can produce oscillations in response to fluid 22 flow through the fluidic oscillator 50.

The fluidic oscillator 50 can include a fluid input 54, and first and second fluid outputs 56, 58 on opposite sides of a longitudinal axis 74 of the fluidic oscillator 50, whereby a majority of fluid 22 which flows through the fluidic oscillator 50 exits the fluidic
20 oscillator 50 alternately via the first and second fluid outputs 56, 58. The fluidic oscillator 50 can also include first and second fluid paths 60, 62 from the input 54 to the respective first and second fluid outputs 56, 58, with the first and second fluid paths 60, 62 crossing each other between the fluid input 54 and the respective first and second fluid outputs 56, 58.

25 It is to be understood that the various examples described above may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of the present disclosure. The embodiments illustrated in the drawings are depicted and described merely as examples of useful applications of the principles of the disclosure, which are not limited to any specific
30 details of these embodiments.

In the above description of the representative examples of the disclosure, directional terms, such as “above,” “below,” “upper,” “lower,” etc., are used for convenience in referring to the accompanying drawings.

Of course, a person skilled in the art would, upon a careful consideration of the above
5 description of representative embodiments, readily appreciate that many modifications, additions, substitutions, deletions, and other changes may be made to these specific embodiments, and such changes are within the scope of the principles of the present disclosure. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the present
10 invention being limited solely by the appended claims and their equivalents.

CLAIMS:

1. A method of manufacturing a fluidic oscillator insert for use in a subterranean well, the method comprising:
 - forming the insert with a conical surface thereon; and
 - 5 forming at least one fluidic oscillator on the conical surface.
2. A method according to claim 1, wherein a side of the fluidic oscillator is closed off by engagement between the insert and a surface formed in a housing assembly.
3. A method according to claim 1 or 2, wherein the conical surface comprises an exterior surface of the insert.
- 10 4. A method according to any preceding claim, wherein multiple fluidic oscillators are formed on the conical surface.
5. A method according to any preceding claim, wherein a flow passage extends longitudinally through an interior of the insert.
6. A method according to claim 5, wherein the flow passage is surrounded by
15 the conical surface.
7. A well tool, comprising:
 - a housing assembly;
 - at least one insert received in the housing assembly, the insert having multiple fluidic oscillators formed therein, and
 - 20 wherein the fluidic oscillators produce oscillations in response to fluid flow through the fluidic oscillators.
8. A well tool according to claim 7, wherein the fluidic oscillators are formed on a conical surface of the insert.
9. A well tool according to claim 8, wherein the conical surface comprises an
25 exterior surface of the insert.
10. A well tool according to any one of claims 7 to 9, wherein the insert engages a conical surface formed in the housing assembly.
11. A well tool according to any of claims 7 to 10, wherein sides of the fluidic oscillators are closed off by engagement between conical surfaces of the insert and housing
30 assembly.
12. A well tool according to any one of claims 7 to 11, wherein a flow passage extends longitudinally through the insert.

13. A well tool according to claim 12, wherein the flow passage is positioned between the fluidic oscillators.

14. A well tool according to claim 12 or 13, wherein the flow passage is surrounded by a conical surface of the insert.

5 15. An insert for use in a well tool, the insert comprising:
an exterior conical surface;
at least one fluidic oscillator formed on the conical surface, and
wherein the fluidic oscillator produces oscillations in response to fluid flow through the fluidic oscillator.

10 16. An insert according to claim 15, wherein multiple fluidic oscillators are formed on the conical surface.

17. An insert according to claim 15 or 16, wherein the insert engages a conical surface formed in a housing assembly.

15 18. An insert according to any one of claims 15 to 17, wherein a side of the fluidic oscillator is closed off by engagement between the conical surface of the insert and a housing assembly.

19. An insert according to any one of claims 15 to 18, wherein a flow passage extends longitudinally through the insert.

20 20. An insert according to claim 19, wherein the flow passage is surrounded by the conical surface.

21. An insert according to any one of claims 15 to 20, wherein the fluidic oscillator comprises:

a fluid input;

25 first and second fluid outputs on opposite sides of a longitudinal axis of the fluidic oscillator, whereby a majority of fluid which flows through the fluidic oscillator exits the fluidic oscillator alternately via the first and second fluid outputs;

first and second fluid paths from the fluid input to the respective first and second fluid outputs; and

30 wherein the first and second fluid paths cross each other between the fluid input and the respective first and second fluid outputs.

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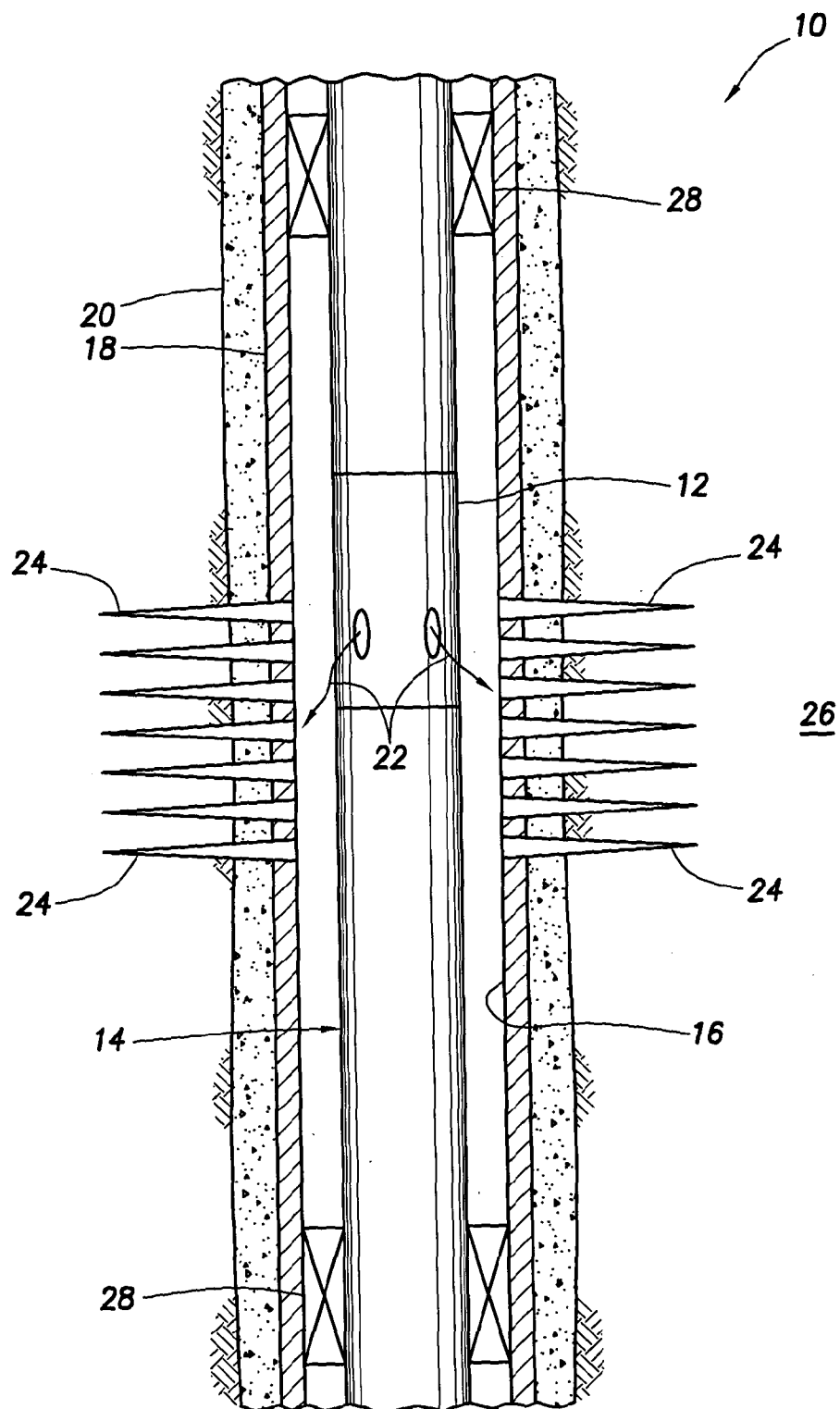
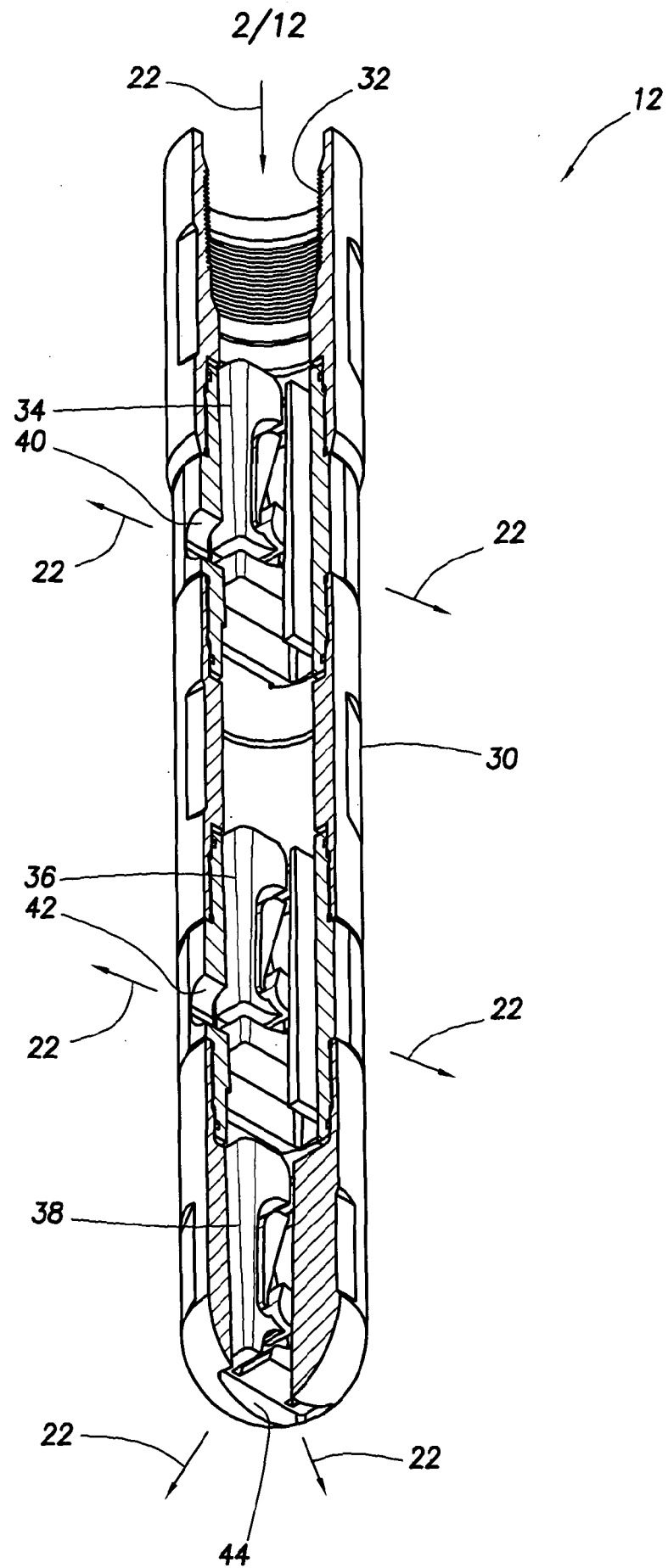


FIG. 1

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FIG.2



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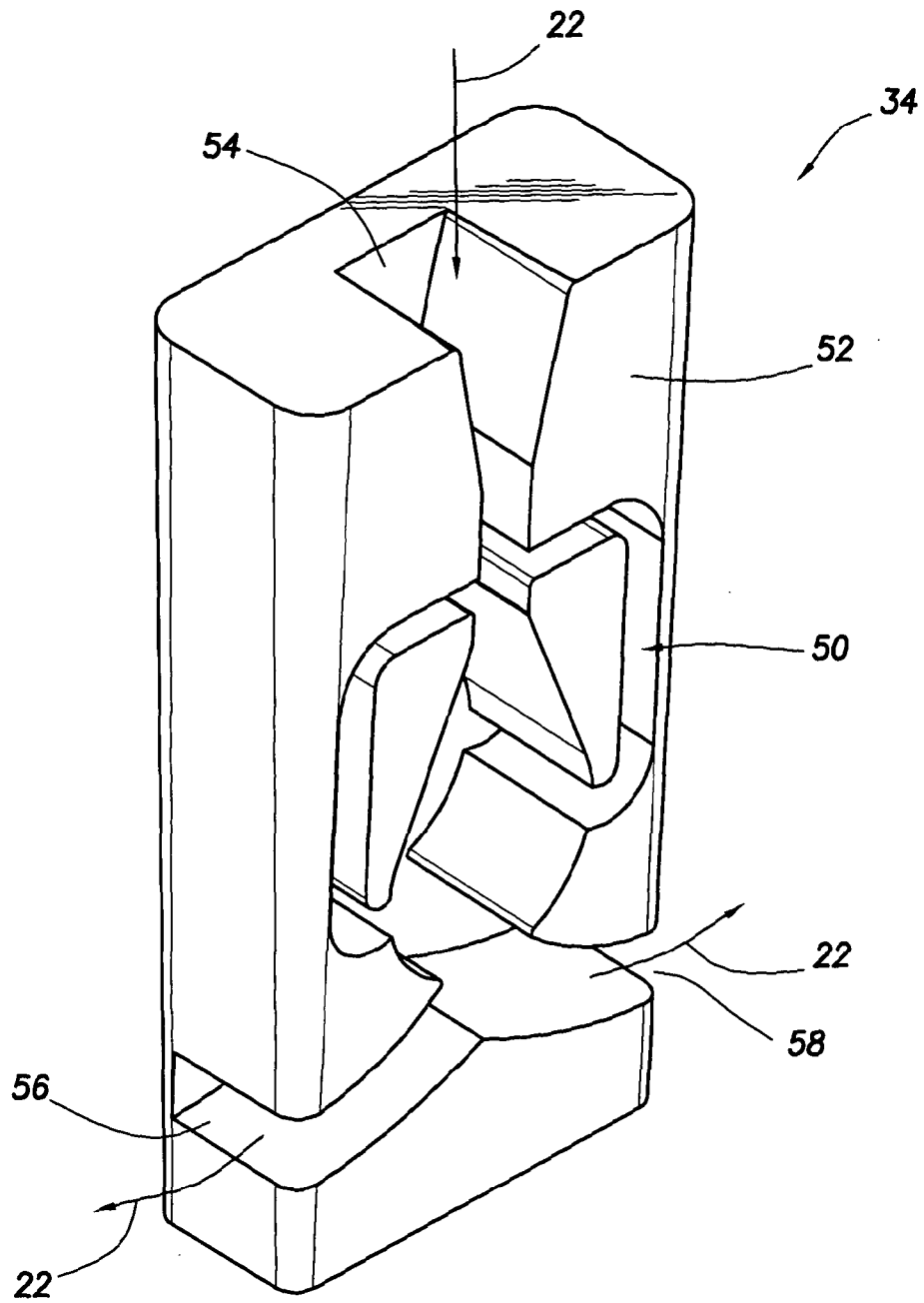


FIG.3

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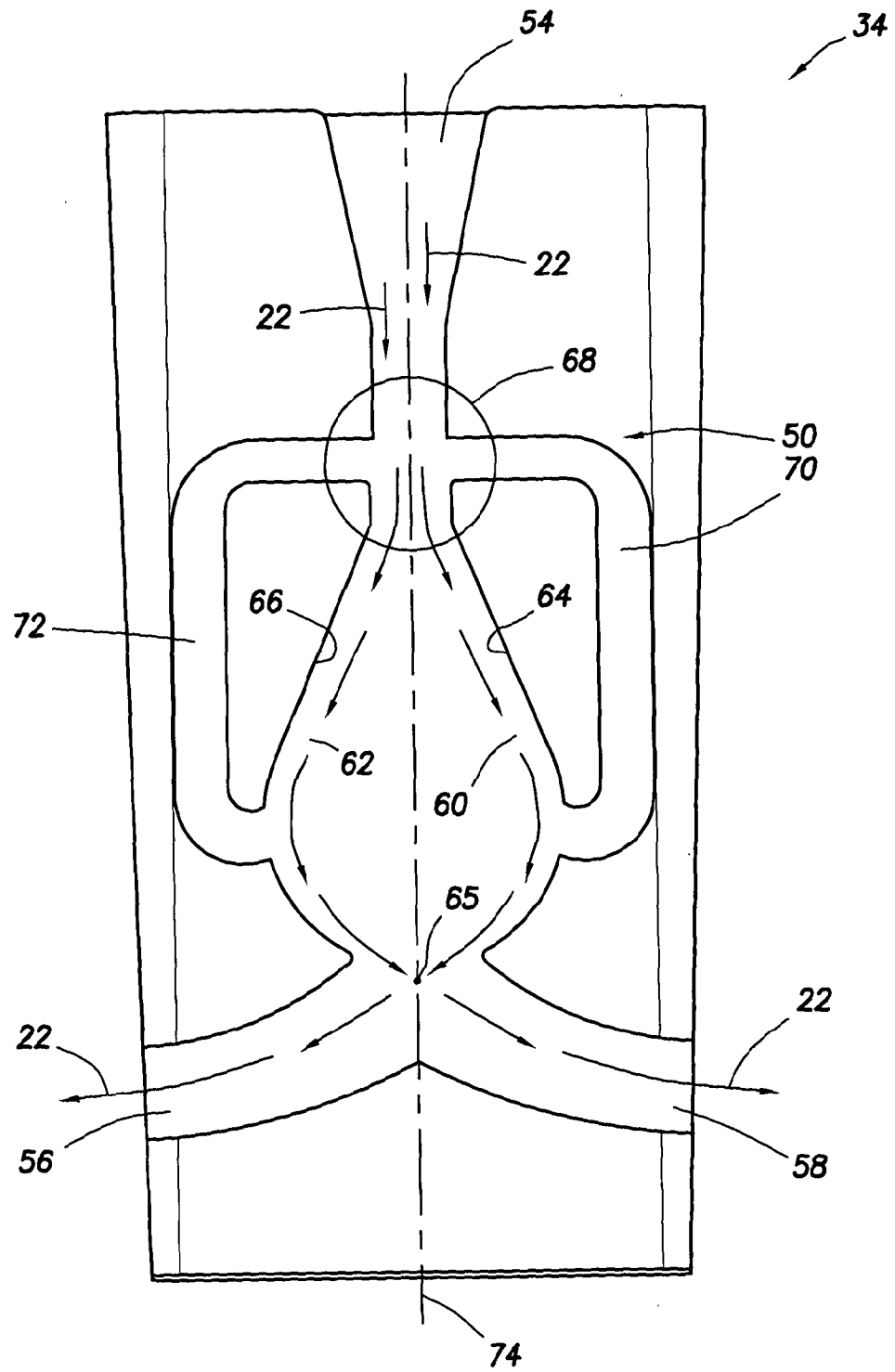


FIG. 4

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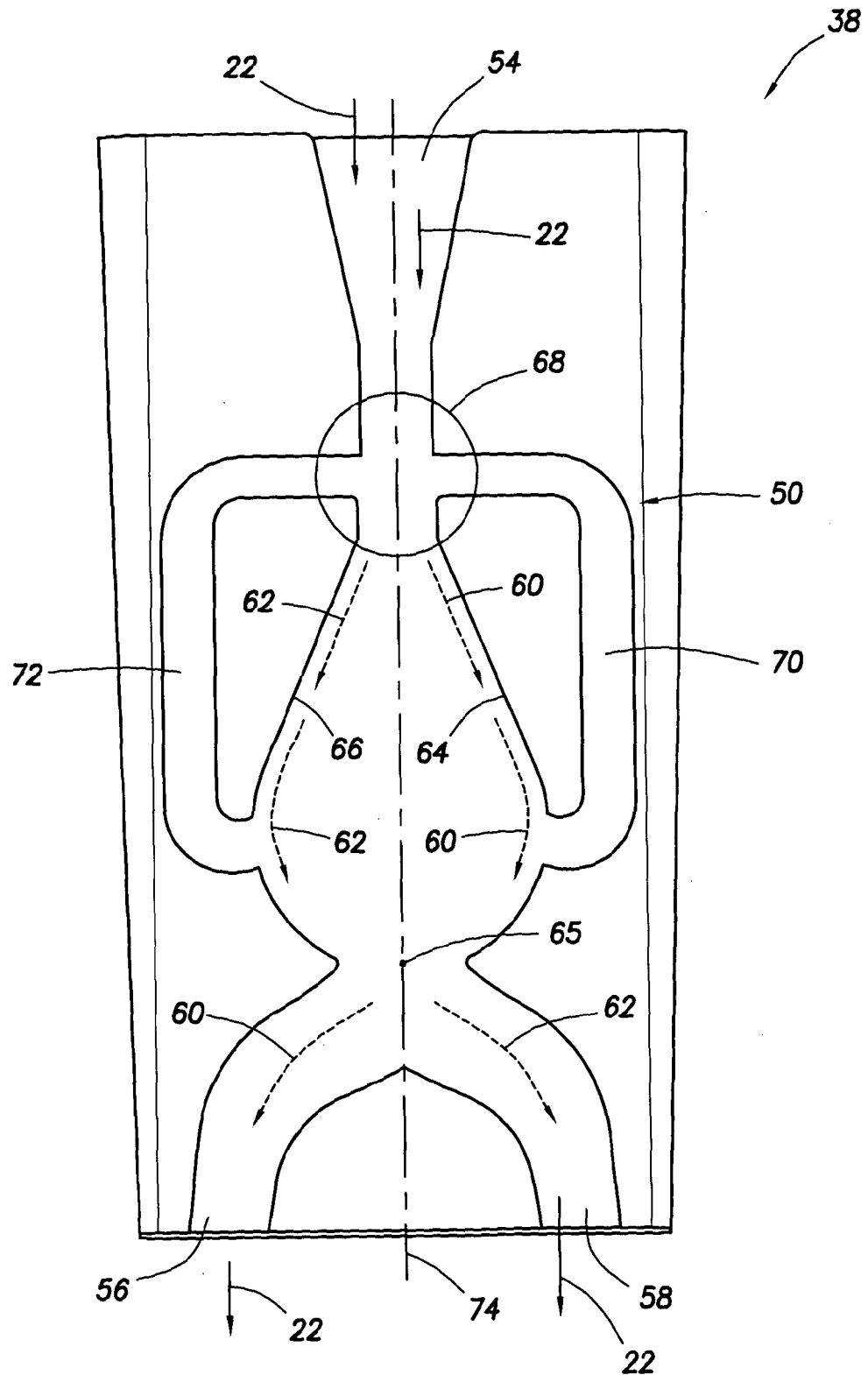


FIG.5

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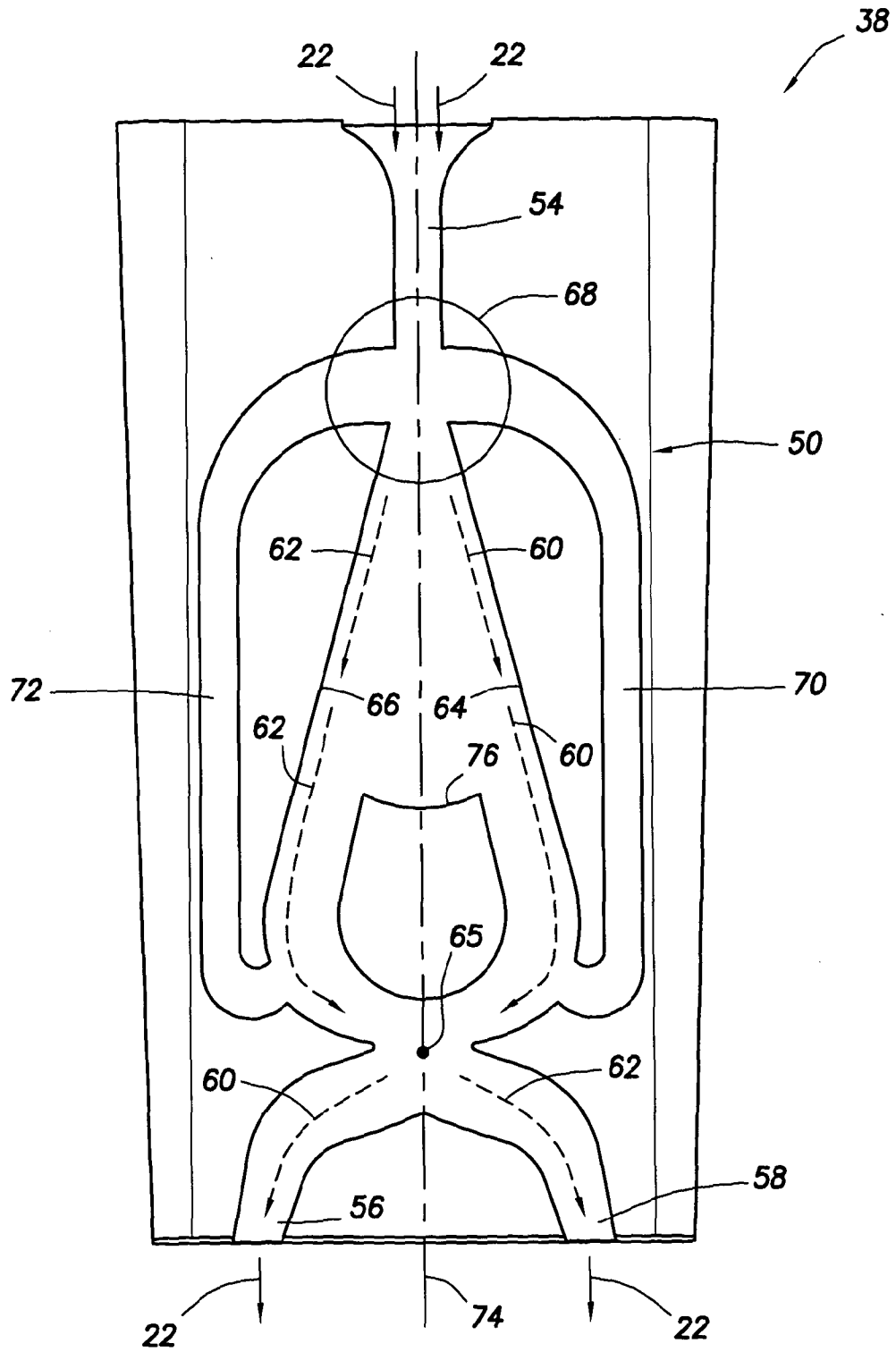


FIG. 6

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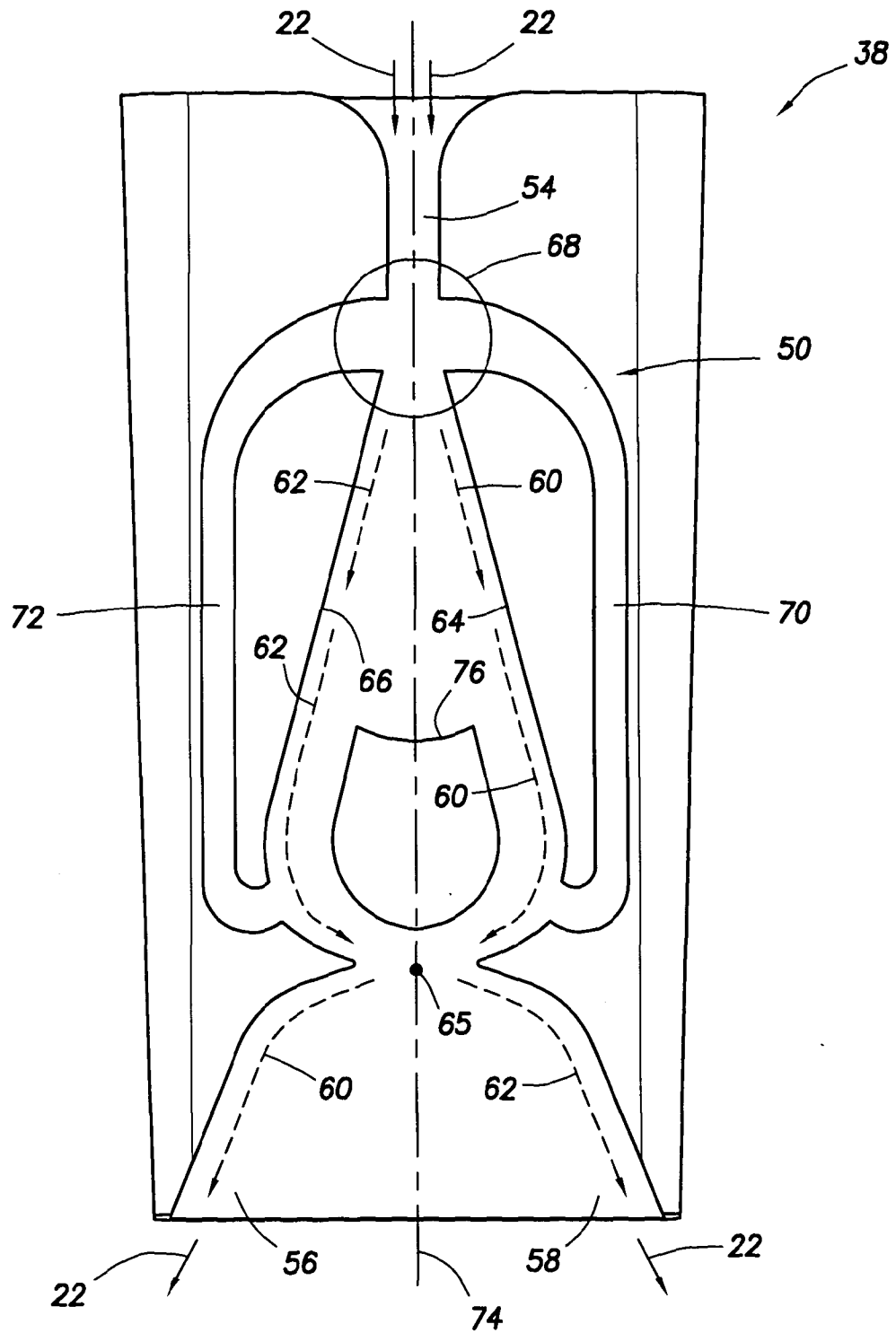


FIG. 7

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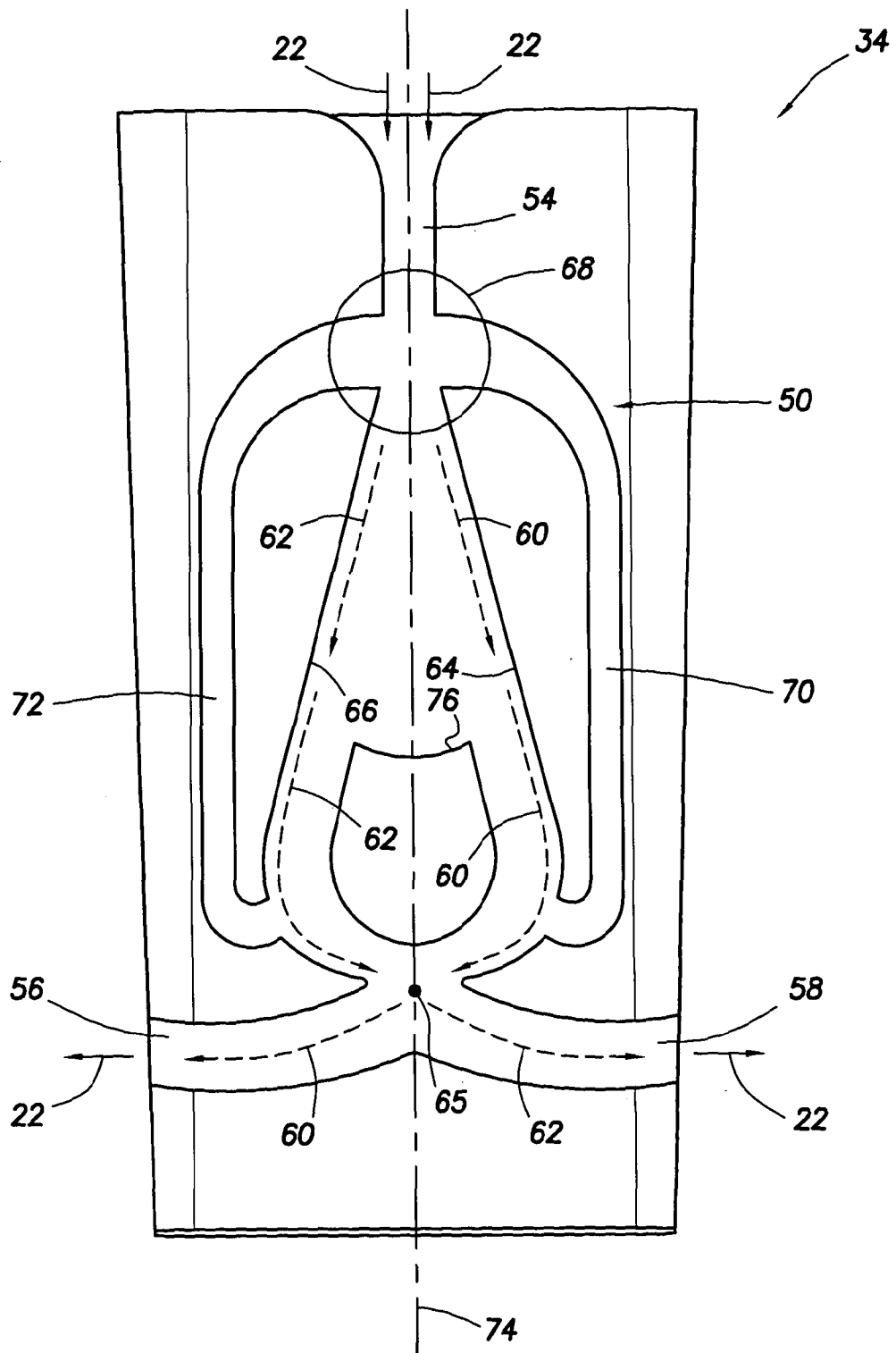


FIG. 8

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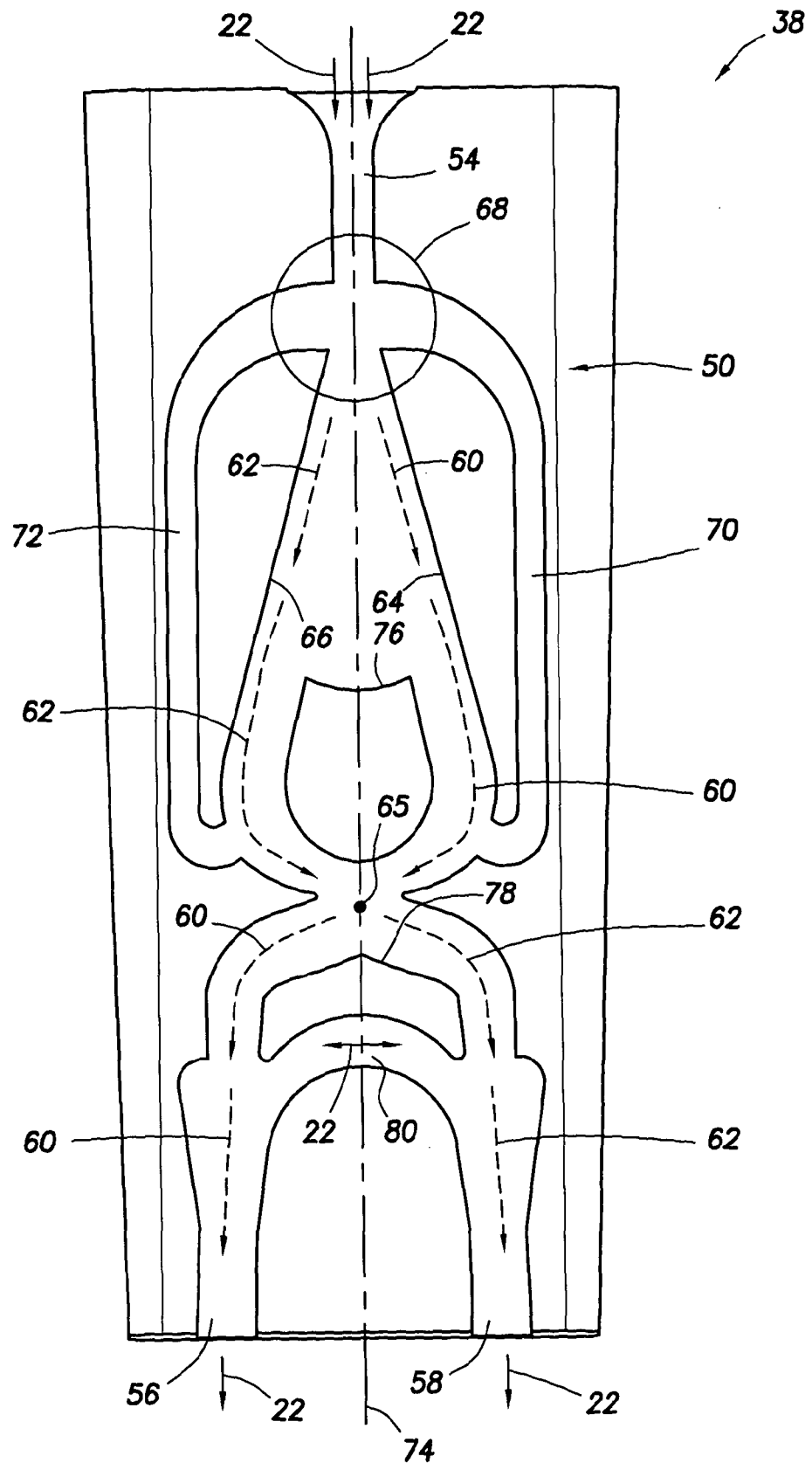


FIG.9

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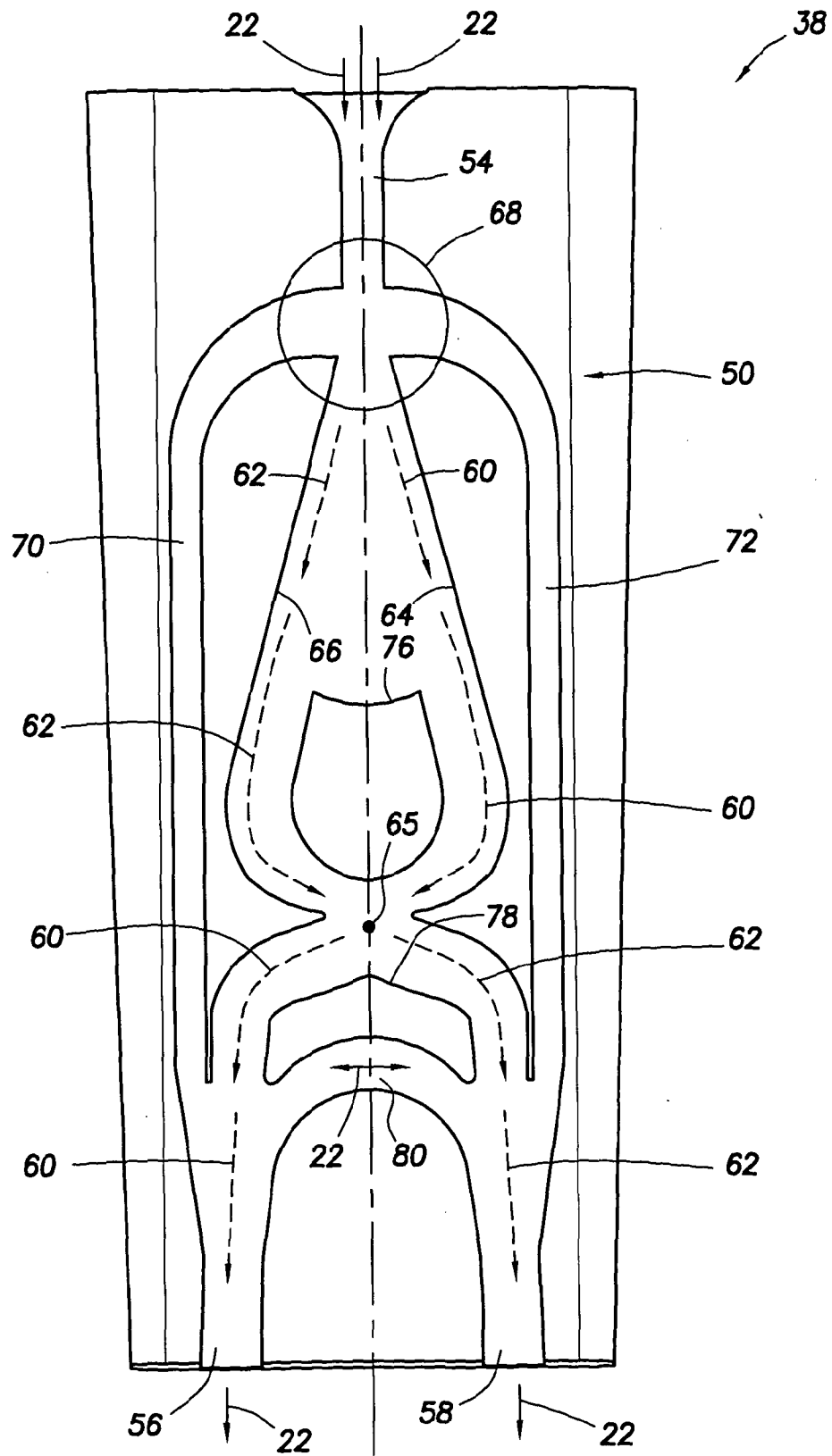
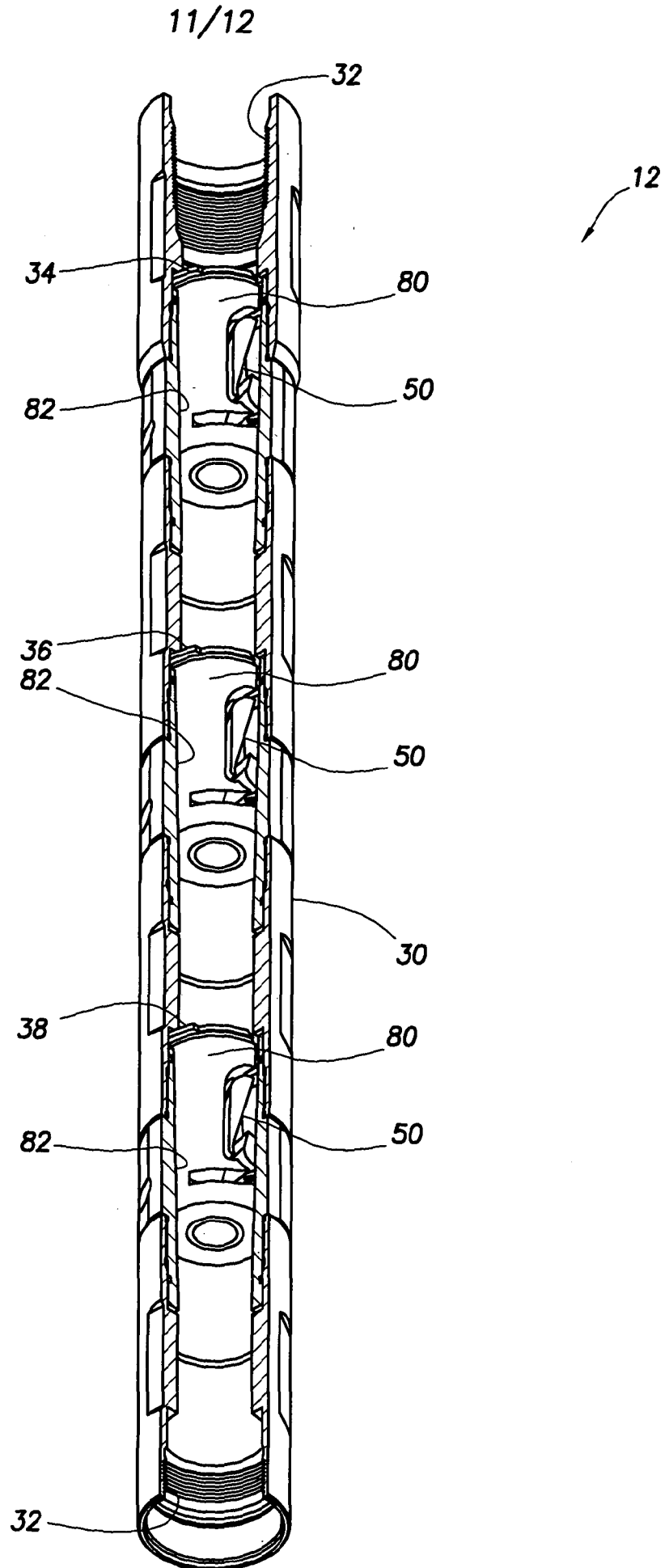


FIG. 10

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FIG. 11



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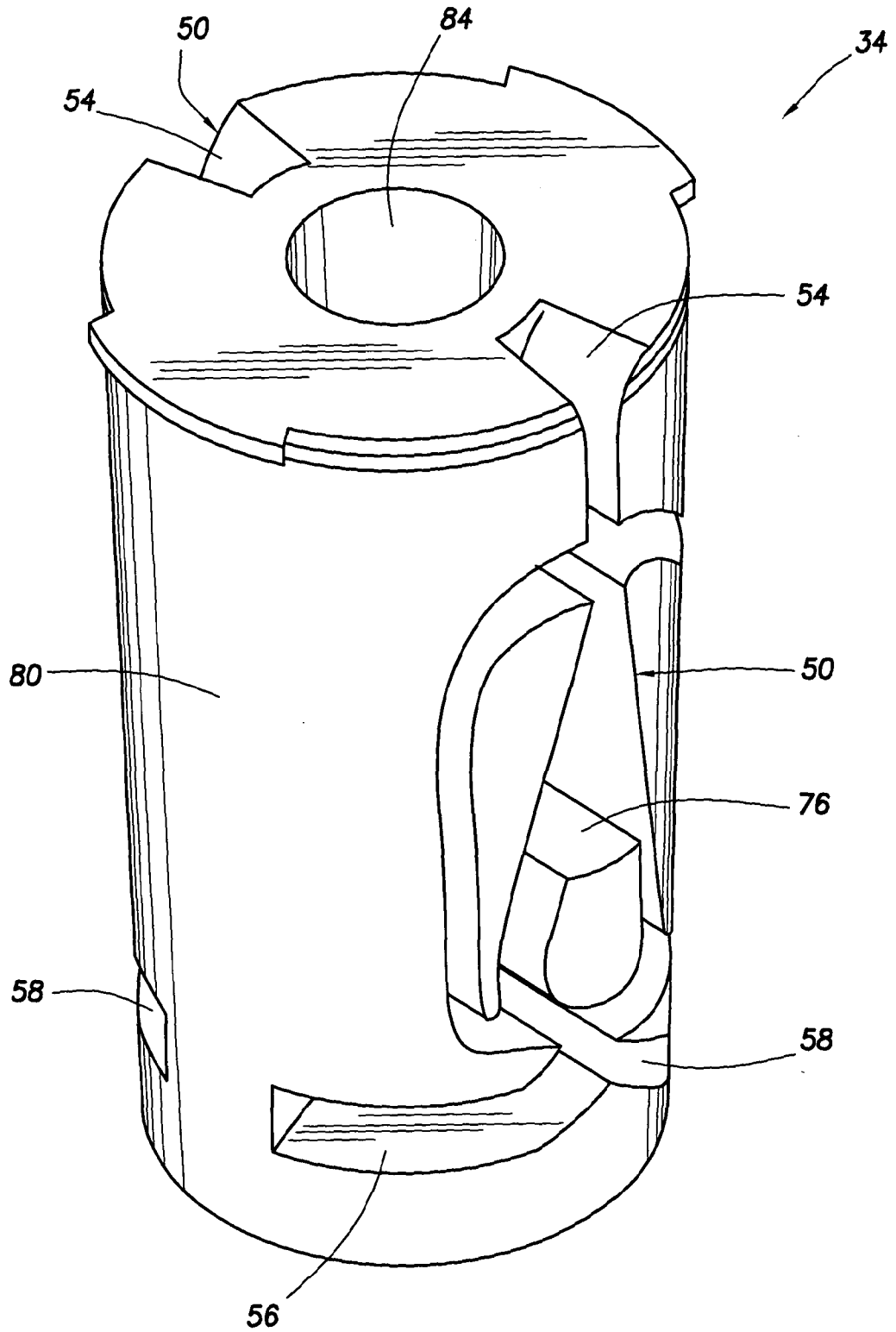


FIG. 12

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