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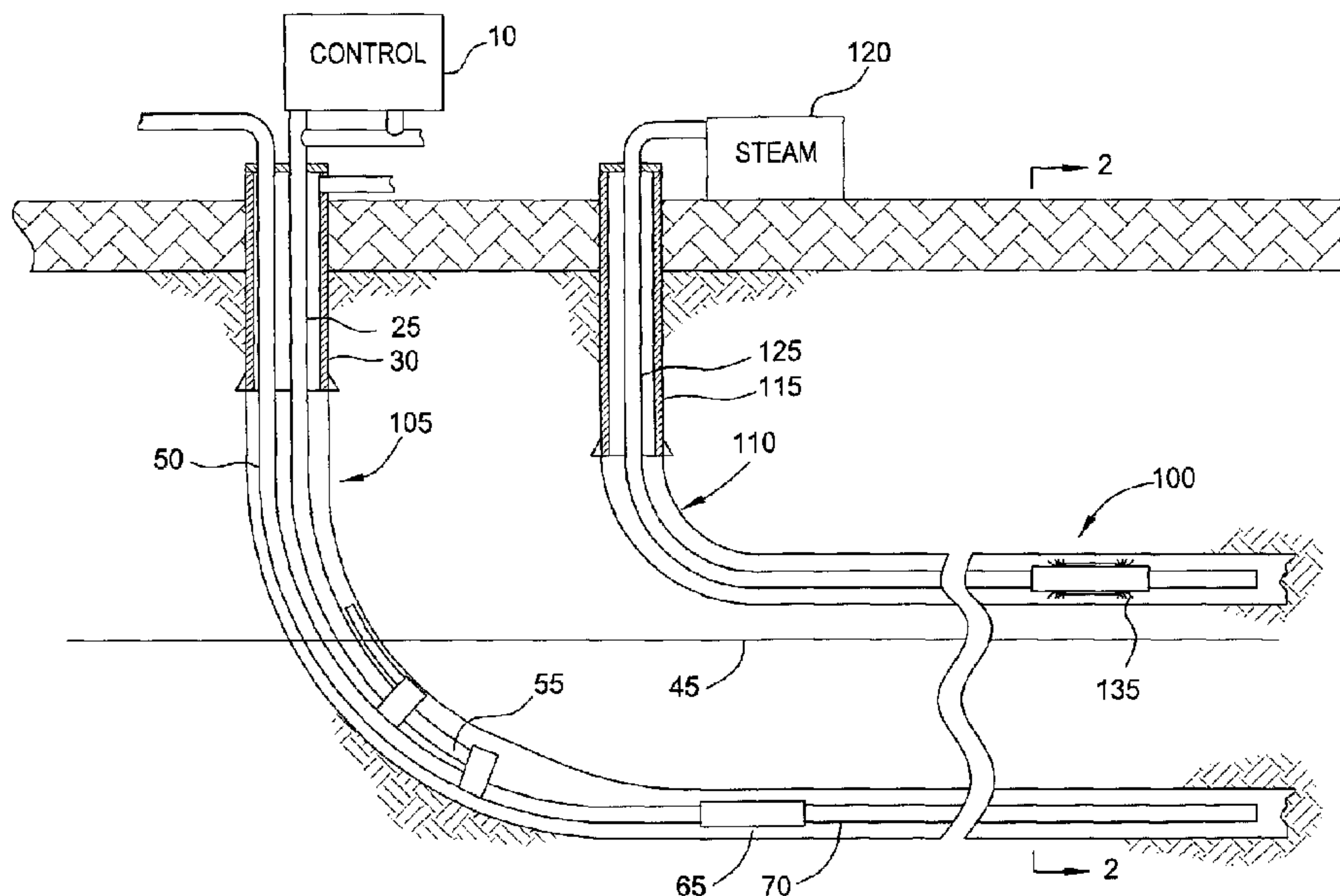
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(54) **Title: STEAM SPLITTER**



(57) **Abrégé/Abstract:**

The present invention generally relates to injecting steam into a wellbore. In one aspect, a device for injecting steam into a surrounding wellbore is provided. The device includes a body having an opening formed in a wall of the body. The body further has a bore configured to communicate steam through the body. The device also includes a sleeve movable in the bore of the body between a first position and a second position, wherein the sleeve in the first position blocks steam from exiting the opening of the body and the sleeve in the second position allows steam to exit the opening of the body. The device further includes a shroud disposed on a portion of the body such that an annulus is formed between the shroud and the body, wherein the annulus is configured to direct steam from the opening in the body toward steam outlets. In another aspect, a method of injecting steam into a wellbore using a steam tubular is provided.

ABSTRACT OF THE DISCLOSURE

The present invention generally relates to injecting steam into a wellbore. In one aspect, a device for injecting steam into a surrounding wellbore is provided.

- 5 The device includes a body having an opening formed in a wall of the body. The body further has a bore configured to communicate steam through the body. The device also includes a sleeve movable in the bore of the body between a first position and a second position, wherein the sleeve in the first position blocks steam from exiting the opening of the body and the sleeve in the second position allows steam to
- 10 exit the opening of the body. The device further includes a shroud disposed on a portion of the body such that an annulus is formed between the shroud and the body, wherein the annulus is configured to direct steam from the opening in the body toward steam outlets. In another aspect, a method of injecting steam into a wellbore using a steam tubular is provided.

STEAM SPLITTER

BACKGROUND OF THE INVENTION

Field of the Invention

Embodiments of the present invention generally relate to artificial lift for hydrocarbon wells. More particularly, the invention relates to a method and an apparatus for injecting steam into a wellbore.

Description of the Related Art

Throughout the world there are major deposits of heavy oils which are not recoverable using ordinary production techniques. These deposits are often referred to as "tar sand" or "heavy oil" deposits due to the high viscosity of the hydrocarbons which they contain. These tar sands may extend for many miles and occur in varying thicknesses of up to more than 300 feet. The tar sands contain a viscous hydrocarbon material, commonly referred to as bitumen, in an amount which ranges from about 5 to about 20 percent by weight of hydrocarbons. Bitumen is usually immobile at typical reservoir temperatures. Although tar sand deposits may lie at or near the earth's surface, generally they are located under a substantial overburden or a rock base which may be as great as several thousand feet thick. In Canada and California, vast deposits of heavy oil are found in the various reservoirs. The oil deposits are essentially immobile and are therefore unable to flow under normal natural drive or primary recovery mechanisms. Furthermore, oil saturations in these formations are typically large, which limits the injectivity of a fluid (heated or cold) into the formation.

Several in situ methods of recovering viscous oil and bitumen have been developed over the years. One such method is called Steam Assisted Gravity Drainage (SAGD). The SAGD operation requires placing a pair of coextensive horizontal wells spaced one above the other at a distance of typically 5-8 meters. The pair of wells is located close to the base of the viscous oil and bitumen. Thereafter, the span of formation between the wells is heated to mobilize the oil

contained within that span by circulating steam through each well at the same time. In this manner, the span of formation is slowly heated by thermal conductance.

After the oil in the span of the formation is sufficiently heated, the oil may be displaced or driven from one well to the other, establishing fluid communication
5 between the wells. At this point, the steam circulation through the wells is terminated, and steam injection at less than formation fracture pressure is initiated through the steam injection well while the production well is opened to produce draining liquid. As the steam is injected, a steam chamber is formed as the steam rises and contacts cold oil immediately above the upper injection well. The steam
10 gives up heat and condenses; the oil absorbs heat and becomes mobile as its viscosity is reduced, allowing the heated oil to drain downwardly under the influence of gravity toward the production well.

A steam generator is located at the surface of the steam injection well. The steam generator is configured to generate and inject steam down a steam tubular
15 into the steam injection well. The steam tubular includes several steam splitters to distribute the steam in predetermined sections in the well. Generally, the steam splitter is a fluid communication device that selectively injects steam into the surrounding wellbore. The conventional steam splitter can be opened or closed based on the steam requirements during the SAGD operation. To close the
20 conventional steam splitter, an isolation insert must be inserted in the steam splitter. For example, if the steam tubular includes three steam splitters that need to be closed, then three isolation inserts must be run into the well, each on a separate trip into the well. In other words, three separate trips into the well are required to close the three steam splitters. In a similar manner, to open the steam splitters, a separate
25 trip into the well is required for each conventional steam splitter to remove the isolation insert. As a result, multiple trips are required into the wellbore to open and close the conventional steam splitters. Therefore, there is a need for an improved steam splitter that can be operated without the need of multiple trips into the well.

SUMMARY OF THE INVENTION

The present invention generally relates to injecting steam into a wellbore. In one aspect, a device for injecting steam into a surrounding wellbore is provided. The device includes a body having an opening formed in a wall of the body. The body
5 further has a bore configured to communicate steam through the body. The device also includes a sleeve movable in the bore of the body between a first position and a second position, wherein the sleeve in the first position blocks steam from exiting the opening of the body and the sleeve in the second position allows steam to exit the opening of the body. The device further includes a shroud disposed on a portion of
10 the body such that an annulus is formed between the shroud and the body, wherein the annulus is configured to direct steam from the opening in the body toward steam outlets.

In another aspect, a method of injecting steam into a wellbore using a steam tubular is provided. The steam tubular includes a first steam splitter device and a
15 second steam splitter device. The method includes the step of opening the first steam splitter device and the second steam splitter device. The method further includes the step of pumping steam down the steam tubular and into the wellbore through the first steam splitter device and the second steam splitter device. The method also includes the step of closing the second steam splitter device.
20 Additionally, the method includes the step of pumping steam down the steam tubular and into the wellbore through the first steam splitter device.

In a further aspect, a method of injecting steam into a wellbore and transporting wellbore fluid out the wellbore using a tubular is provided. The tubular includes a plurality of steam splitter devices. The method includes the step of
25 opening one or more steam splitter devices. The method further includes the step of pumping steam down the tubular and into the wellbore through the one or more steam splitter devices. The method also includes the step of closing the one or more steam splitter devices. Further, the method includes the step of opening at least one steam splitter device. Additionally, the method includes the step of transporting

wellbore fluid up through the tubular which enters through the at least one steam splitter.

BRIEF DESCRIPTION OF THE DRAWINGS

5 So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to
10 other equally effective embodiments.

Figure 1 illustrates a partial cross-sectional view of a steam splitter device disposed in a steam injection well for use in a Steam Assisted Gravity Drainage (SAGD) operation.

15 Figure 2 illustrates a cross-sectional view of the steam injection well and a production well of the SAGD operation.

Figure 3 illustrates a view of the steam splitter device in a closed position.

Figure 4 illustrates a view of the steam splitter device in an opened position.

Figures 5 and 6 illustrate views of the steam splitter device being moved to the opened position by a shifting tool.

20 Figures 7 and 8 illustrate views of the steam splitter device being moved to the closed position by the shifting tool.

Figure 9 illustrates a partial cross-sectional view of multiple steam splitter devices disposed in the steam injection well.

DETAILED DESCRIPTION

The present invention generally relates to a steam splitter device for injecting steam into a wellbore. The device will be described herein in relation to a Steam Assisted Gravity Drainage (SAGD) having two wellbores. It is to be understood, however, that the device may also be used in other wellbore operations, such as in the production wellbore as an inflow production device, without departing from principles of the present invention. To better understand the novelty of the device of the present invention and the methods of use thereof, reference is hereafter made to the accompanying drawings.

Figure 1 illustrates a partial cross-sectional view of a steam splitter device 100 disposed in a steam injection well 110 for use in a Steam Assisted Gravity Drainage (SAGD) operation. In a typical SAGD operation, there are two coextensive horizontal wells, a production well 105 and the steam injection well 110. As shown in Figure 1, the steam injection well 110 includes casing 115 on the vertical portion of the wellbore. A steam generator 120 is located at the surface of the steam injection well 110 to inject steam 135 down a steam tubular 125 and through the steam splitter device 100 of the present invention. As will be described herein, the steam splitter device 100 can be selectively moved between a closed position (Figure 3) and an opened position (Figure 4) any number of times.

The production well 105 is lined with casing 30 on the vertical portion of the wellbore and a screen or a slotted liner (not shown) on the horizontal portion of the wellbore. The production well 105 includes production tubing 50 disposed within the vertical portion for transporting oil to the surface of the well 105. A pump 55 is disposed close to the lower end of the production tubing 50 and is in a substantially horizontal position near the lowest point of the well 105. A control mechanism 10 is disposed at the surface of the production well 105 to control the pump 55. The control mechanism 10 typically provides a hydraulic signal to the pump 55 through one or more control conduits (not shown), which are housed in a coil tubing 25. Additionally, one or more pumps 65 may be attached to a fluid conduit 70 to

encourage fluid flow from the toe of the production well 105 to the heel of the production well.

Figure 2 illustrates a cross-sectional view of the steam injection well 110 and the production well 105 of the SAGD operation. As steam 135 is injected in the upper injection well 110 through the steam splitter device 100, it rises and contacts the cold oil immediately thereabove. As the steam 135 gives up heat and condenses, the oil absorbs the heat and becomes mobile as its viscosity is reduced. The condensate and heated oil thereafter drain under the influence of gravity towards the production well 105. From the production well 105, the oil is transported to the surface using the pumps 55, 65. In the SAGD operation, the condensate and heated liquid oil occupy an area depicted by shape 40. The top of the shape 40 is called a liquid level 45. Due to the steam 135, oil flows inwardly along drainage lines into the area 40. The vertical location of the drainage lines corresponds to the height of the liquid level 45. During the SAGD operation, the liquid level 45 will rise and fall depending on the amount and location of oil in the reservoir.

Figure 3 illustrates a view of the steam splitter device 100 in a closed position. The steam splitter device 100 includes a body 155 having a bore 150. As shown, steam 135 from the steam generator 120 flows through the bore 150 of the body 155 from one end of the body 155 to the other end when the steam splitter device 100 is the closed position. A shroud 160 is placed around a portion of the body 155. The shroud 160 is offset from the body 155 by a plurality of spacer members 165. An annulus 170 is formed between the shroud 160 and the body 155. The annulus 170 is connected to steam outlets 205, which are used for fluid communication to the surrounding wellbore when the steam splitter device 100 is in the opened position. In one embodiment, the shroud 160 is attached to the body 155 by a heat shrink process.

A sleeve 175 is disposed inside the body 155. The sleeve 175 is selectively movable between a first position and a second position within the body 155. The sleeve 175 in the first position is shown in Figure 3 and corresponds to the steam

splitter device 100 in the closed position. The sleeve 175 in the second position is shown in Figure 4 and corresponds to the steam splitter device 100 in the opened position. The sleeve 175 includes a restraining device 215 which is configured to maintain the sleeve 175 in the first position or the second position after the sleeve
5 175 has moved to the respective position. In one embodiment, the restraining device 215 is a double collet arrangement which interacts to restrain or provide resistance to the movement of the sleeve 175 when it is in the first position or the second position.

The sleeve 175 includes a plurality of slots 180 that are configured to act as a fluid passageway when the steam splitter device 100 is in the opened position
10 (Figure 4). In the embodiment shown in the Figure 3, the slots 180 are spiral slots, which are constructed and arranged to prevent accidental engagement with engagement members 85 of a shifting tool 75 (Figures 5-8) when the shifting tool 75 moves through a bore 210 of the sleeve 175. In another embodiment, the slots 180 are longitudinal slots. In a further embodiment, a plurality of holes is formed in the
15 sleeve 175 that may be used instead of the slots 180 or in addition to the slots 180. The sleeve 175 further includes seals 130 that straddle an opening 190 in the body 155 when the steam splitter device 100 is in the closed position. The seals 130 are configured to substantially prevent steam 135 from flowing out through the opening 190 in the body 155 and into the annulus 170 when the steam splitter device 100 is in
20 the closed position. The sleeve 175 further includes a first shoulder profile 185 and a second shoulder profile 195 at each end.

Figure 4 illustrates a view of the steam splitter device 100 in the opened position. As shown, the sleeve 175 has moved from the first position to the second position. In the second position, the slots 180 in the sleeve 175 are aligned with the
25 opening 190 in the body 155, thus creating a fluid pathway between the bore 150 and the surrounding wellbore. The steam 135 generated by the steam generator is pumped down the steam tubular and into the steam splitter device 100. A portion of the steam 135 is directed into the surrounding wellbore, and another portion of the steam 135 moves through the steam splitter device 100. The portion of the steam
30 directed into the surrounding wellbore flows through the bore 155, the slots 180, the

opening 190, the annulus 170, and subsequently out through the steam outlets 205. As set forth herein in relation to the SAGD operation, the steam 135 rises and contacts the cold oil immediately thereabove. As the steam 135 gives up heat and condenses, the oil absorbs the heat and becomes mobile as its viscosity is reduced.

5 The condensate and heated oil thereafter drain under the influence of gravity towards the production well. From the production well, the oil is transported to the surface using the pumps.

Figures 5 and 6 illustrate views of the steam splitter device 100 being moved to the opened position. The shifting tool 75 is positioned in the steam splitter device
10 100 using a conveyance member 80, such as coiled tubing, slickline or tractor, to move the steam splitter device 100 from the closed position (Figure 5) to the opened position (Figure 6). The steam splitter device 100 may be opened (Figures 5 and 6) and/or closed (Figures 7 and 8) by deploying the shifting tool 75 into the steam injection well in a single trip. The ability to open and/or close the steam splitter
15 device 100 in a single trip is particularly advantageous when multiple steam splitter devices are located in the steam injection well (Figure 9). For instance, the shifting tool 75 is deployed into the steam injection well in a single trip to open or close any number of steam splitters depending on the steam requirements during the SAGD operation. This arrangement allows for better control of the distribution of steam 135
20 within the steam injection well.

The shifting tool 75 includes a plurality of engagement members 85, such as dogs, that are configured to engage the first shoulder profile 185 of the sleeve 175. The engagement members 85 are movable between a retracted position and an extended position by hydraulic pressure (or electric control). The engagement
25 members 85 are shown in the retracted position in the shifting tool 75 illustrated by dashed lines in Figure 5, and the engagement members 85 are shown in the extended position in the shifting tool 75 illustrated by solid lines in Figure 5. The engagement members 85 of the shifting tool 75 may have a profile that is configured to mate with a mating profile on the first shoulder profile 185 and the second shoulder
30 profile 195 at each end of the sleeve 175.

The shifting tool 75 is moved through the bore 150 of the body 155 and into the bore 210 of the sleeve 175 in the direction indicated by arrow 95 by applying a force on the conveyance member 80. After the shifting tool is located within the bore 210 of the sleeve 175, the shifting tool 75 is moved through the bore 210 of the sleeve 175 in an opposite direction indicated by arrow 90 by applying a force on the conveyance member 80 until the engagement members 85 of the shifting tool 75 contact and engage the first shoulder profile 185 of the sleeve 175 as shown in Figure 5. Next, the sleeve 175 and the shifting tool 75 are urged through the bore 150 of the body 155, as shown in Figure 6, until an end of the sleeve 175 is positioned proximate a shoulder 140 in the body 155. Thereafter, the engagement members 85 of the shifting tool 75 may be disengaged from the first shoulder profile 185 of the sleeve 175 by retracting the engagement members 85 into the body of the shifting tool 75 through hydraulic (or electric) means or by urging the shifting tool 75 in the direction indicated by arrow 90 which causes the engagement members 85 to move radially inward to disengage from the first shoulder profile 185 of the sleeve 175. The shifting tool 75 may then be removed from the steam splitter device 100. At this point, the steam splitter device 100 is in the opened position, and thus steam 135 is directed out through the steam splitter device 100 into the surrounding wellbore as shown in Figures 1 and 4.

Figures 7 and 8 illustrate views of the steam splitter device 100 being moved to the closed position by the shifting tool 75. To move the steam splitter device 100 from the opened position (Figure 7) to the closed position (Figure 8), the shifting tool 75 is positioned in the steam splitter device 100 using the conveyance member 80. The shifting tool 75 is moved through the bore 150 of the body 155 and into the bore 210 of the sleeve 175 in the direction indicated by arrow 95 by applying a force on the conveyance member 80 until the engagement members 85 of the shifting tool 75 contact and engage the second shoulder profile 195 of the sleeve 175 as shown in Figure 7. Next, the sleeve 175 and the shifting tool 75 are urged through the bore 150 of the body 155, as shown in Figure 8, until an end of the sleeve 175 is positioned proximate a shoulder 145 in the body 155. Thereafter, the engagement members 85 of the shifting tool 75 may be disengaged from the second shoulder

profile 195 of the sleeve 175 by retracting the engagement members 85 into the body of the shifting tool 75 through hydraulic (or electric) means or by urging the shifting tool 75 in the direction indicated by arrow 95 which causes the engagement members 85 to move radially inward. The shifting tool 75 may then be removed from the steam splitter device 100. At this point, the steam splitter device 100 is in the closed position, and thus steam 135 is directed through the steam splitter device 100 as shown in Figure 3.

Figure 9 illustrates a partial cross-sectional view of multiple steam splitter devices 100A-D disposed in the steam injection well 110. Each steam splitter device 100 can be selectively moved between the closed position (Figure 3) and the opened position (Figure 4) any number of times in a similar manner as described herein. The ability to open or close selective steam splitter devices 100A-D allows for better control of the distribution of steam 135 within the steam injection well 110. For example, if more steam is needed proximate the steam splitters 100A, 100C, then steam splitters 100A, 100C may be moved to the opened position while the steam splitters 100B, 100D remain in the closed position as shown in Figure 9. In another example, if more steam is needed proximate the steam splitter 100D, then steam splitter 100D may be moved to the opened position while the steam splitters 100A, 100B, and 100C remain in the closed position. In other words, any number of steam splitters 100A-D may be moved to the opened position or closed position depending on the steam requirements during the SAGD operation. Further, the steam splitters 100A-D may be opened and/or closed by using the shifting tool 75 in a single trip into the steam injection well 110. For instance, the shifting tool 75 is deployed into the steam injection well one time (e.g., single trip) to open or close any number of steam splitters depending on the steam requirements during the SAGD operation. The single trip arrangement saves time and is more cost efficient as compared to multiple trips required to operate the conventional steam splitter. As a result, the single trip arrangement allows for better control of the distribution of steam 135 within the steam injection well.

In another embodiment, the steam splitter device 100 may be used in a single well (e.g., wedge well) to inject steam and produce the wellbore fluid. Rather than two wells as shown in Figure 1, the SAGD operation includes the single well. In this arrangement, the steam splitter device 100 may be used to inject steam into the single well during the steam injection operation, and the steam splitter device 100 may also be used to receive wellbore fluid during the production operation. In this manner, the steam splitter device 100 may be used to selectively manage control of the steam injected into the single well and selectively manage control of the inflow of produced wellbore fluid.

In one embodiment, a device for injecting steam into a surrounding wellbore is provided. The device includes a body having an opening formed in a wall of the body. The body further having a bore configured to communicate steam through the body; The device also includes a sleeve movable in the bore of the body between a first position and a second position, wherein the sleeve in the first position blocks steam from exiting the opening of the body and the sleeve in the second position allows steam to exit the opening of the body. The device further includes a shroud disposed on a portion of the body such that an annulus is formed between the shroud and the body, wherein the annulus is configured to direct steam from the opening in the body toward steam outlets. In one aspect, the sleeve includes a plurality of slots that are configured to substantially align with the opening formed in the wall of the body when the sleeve is in the second position.

In another embodiment, a method of injecting steam into a wellbore using a steam tubular is provided. The steam tubular includes a first steam splitter device and a second steam splitter device. The method includes the step of opening the first steam splitter device and the second steam splitter device. The method further includes the step of pumping steam down the steam tubular and into the wellbore through the first steam splitter device and the second steam splitter device. The method also includes the step of closing the second steam splitter device. Additionally, the method includes the step of pumping steam down the steam tubular and into the wellbore through the first steam splitter device. In one aspect, a shifting

tool is run into the wellbore to open and close the first steam splitter device and the second steam splitter device. In a further aspect, the first steam splitter device and the second steam splitter device are opened by the shifting tool in a single trip into the wellbore. In a further aspect, the second steam splitter device is disposed closer
5 to the end of the steam tubular than the first steam splitter device.

In another embodiment, a method of injecting steam into a wellbore and transporting wellbore fluid out of the wellbore using a tubular is provided. The tubular includes a plurality of steam splitter devices. The method includes the step of opening one or more steam splitter devices. The method further includes the step of
10 pumping steam down the tubular and into the wellbore through the one or more steam splitter devices. The method also includes the step of closing the one or more steam splitter devices. Further, the method includes the step of opening at least one steam splitter device. Additionally, the method includes the step of transporting wellbore fluid up through the tubular which enters through the at least one steam
15 splitter. In one aspect, the one or more steam splitter devices are opened by a shifting tool in a single trip into the wellbore. In another aspect, each steam splitter device includes a sleeve member that is movable between a first closed position and a second opened position.

While the foregoing is directed to embodiments of the present invention, other
20 and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. A method of injecting steam into a wellbore using a steam tubular, the steam tubular having a first steam splitter device and a second steam splitter device, the
5 method comprising:
opening the first steam splitter device and the second steam splitter device;
pumping steam down the steam tubular and into the wellbore through the first steam splitter device and the second steam splitter device;
closing the second steam splitter device; and
10 pumping steam down the steam tubular and into the wellbore through the first steam splitter device.
2. The method of claim 1, wherein a shifting tool is run into the wellbore to operate the first steam splitter device and the second steam splitter device.
15
3. The method of claim 2, wherein the first steam splitter device and the second steam splitter device are opened by the shifting tool in a single trip into the wellbore.
4. The method of claim 2, wherein the second steam splitter device is closed by
20 the shifting tool while the first steam splitter device is open.
5. The method of claim 2, further comprising opening the second steam splitter device and closing the first steam splitter device.
- 25 6. The method of claim 5, wherein the second steam splitter device is opened and the first steam splitter device is closed by the shifting tool in a single trip into the wellbore.
7. The method of claim 5, wherein the second steam splitter device is disposed
30 closer to the end of the steam tubular than the first steam splitter device.

8. A method of injecting steam into a wellbore and transporting wellbore fluid out of the wellbore using a tubular, the tubular having a plurality of steam splitter devices, the method comprising:

opening one or more steam splitter devices;

5 pumping steam down the tubular and into the wellbore through the one or more steam splitter devices;

closing the one or more steam splitter devices;

opening at least one steam splitter device; and

10 transporting wellbore fluid up through the tubular which enters through the at least one steam splitter.

9. The method of claim 8, wherein the one or more steam splitter devices are opened by a shifting tool in a single trip into the wellbore.

15 10. The method of claim 8, wherein the one or more steam splitter devices are closed by a shifting tool in a single trip into the wellbore.

20 11. The method of claim 8, wherein each steam splitter device includes a sleeve member that is movable between a first closed position and a second opened position.

12. The method of claim 11, wherein the sleeve member includes a plurality of spiral slots that align with an opening of the steam splitter device when the sleeve is in the second opened position.

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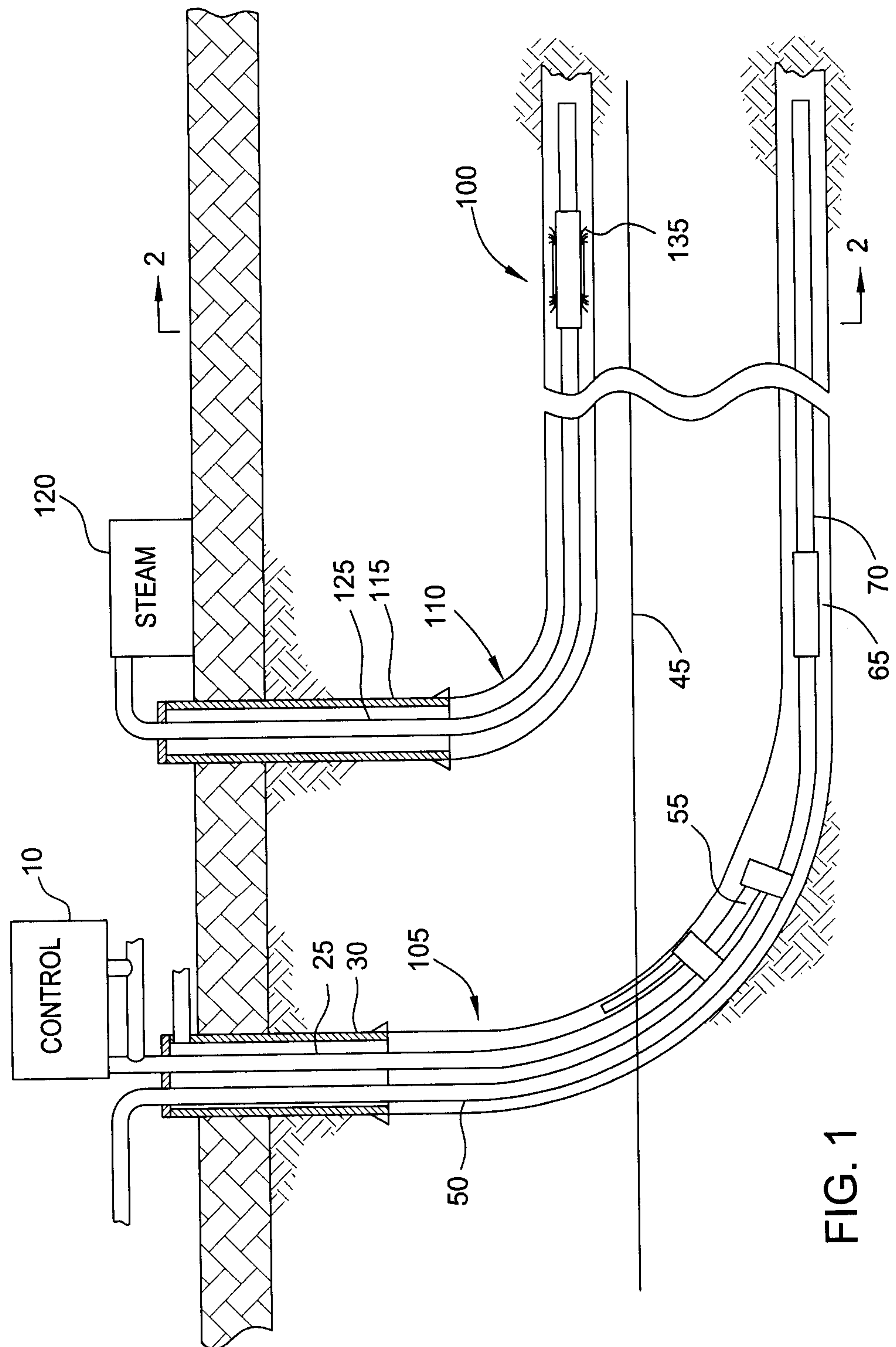


FIG. 1

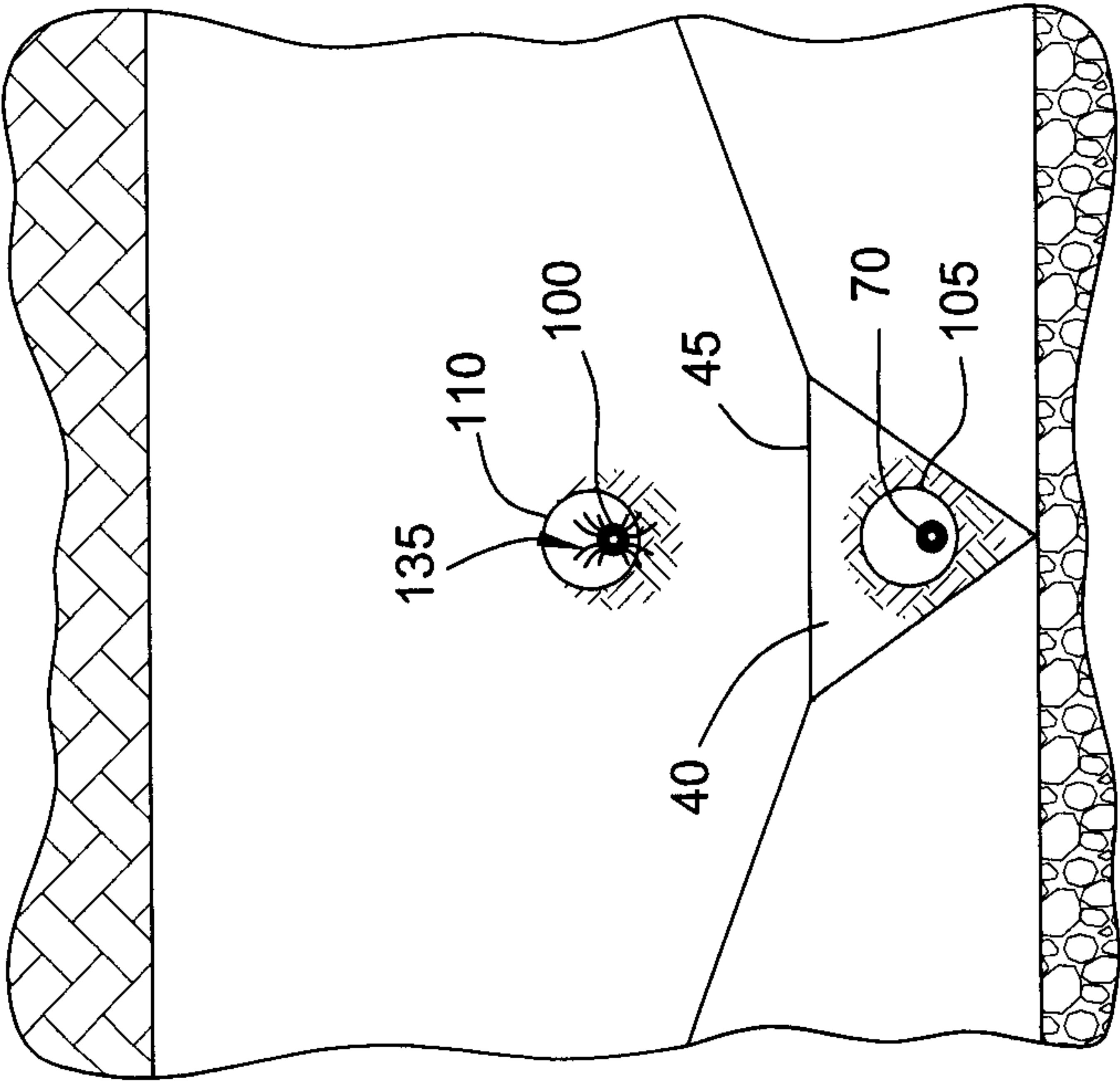
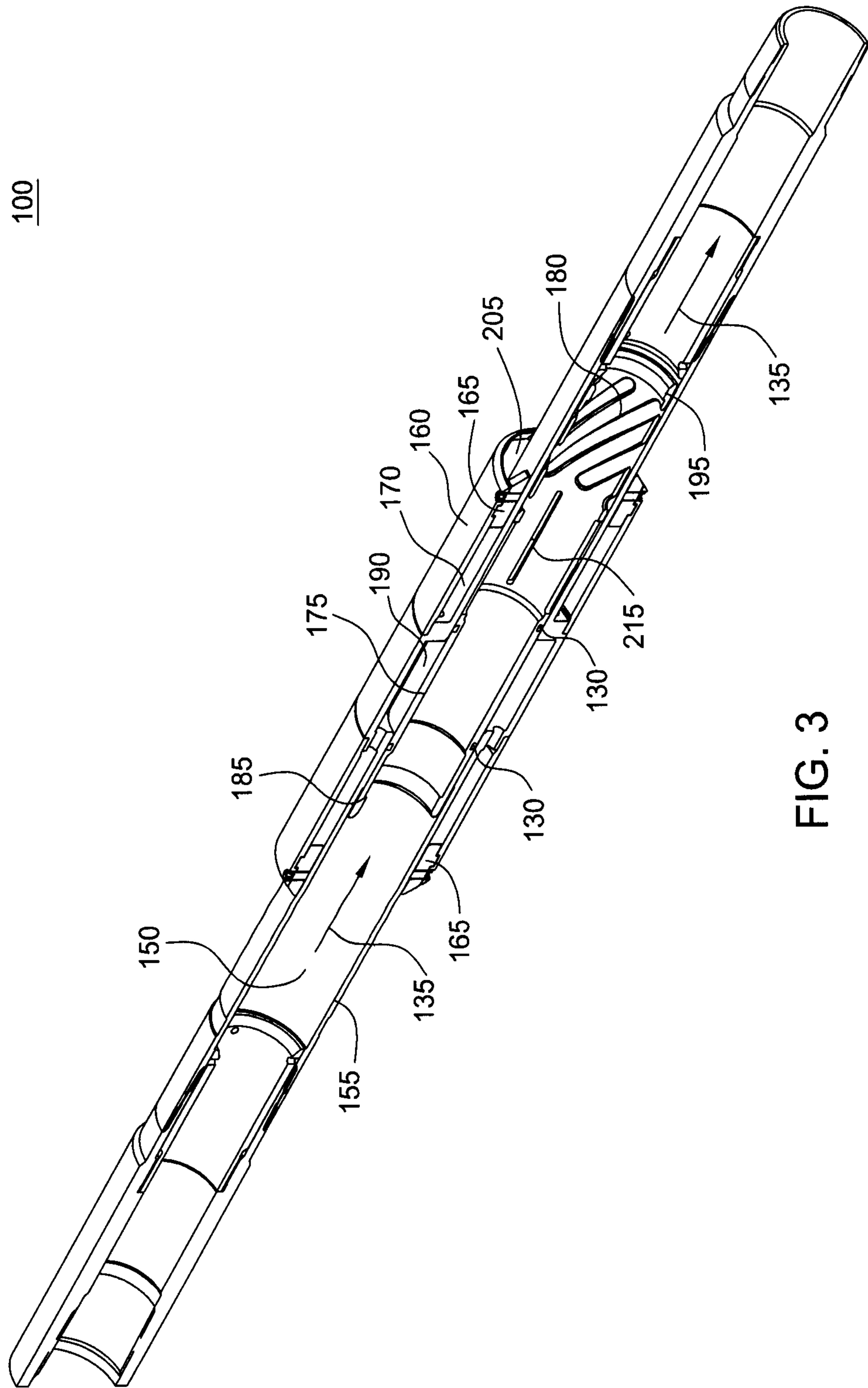


FIG. 2

100



100

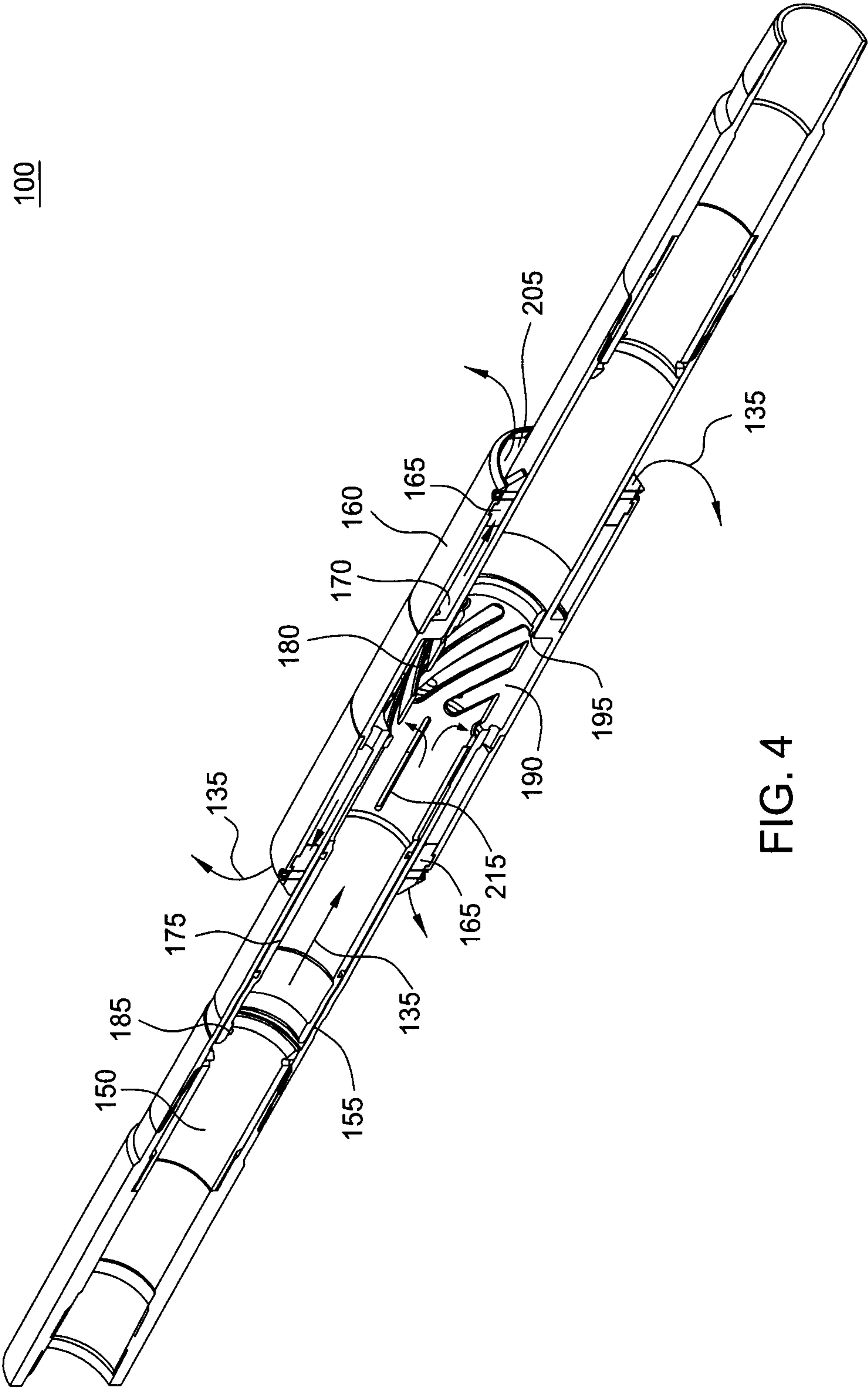


FIG. 4

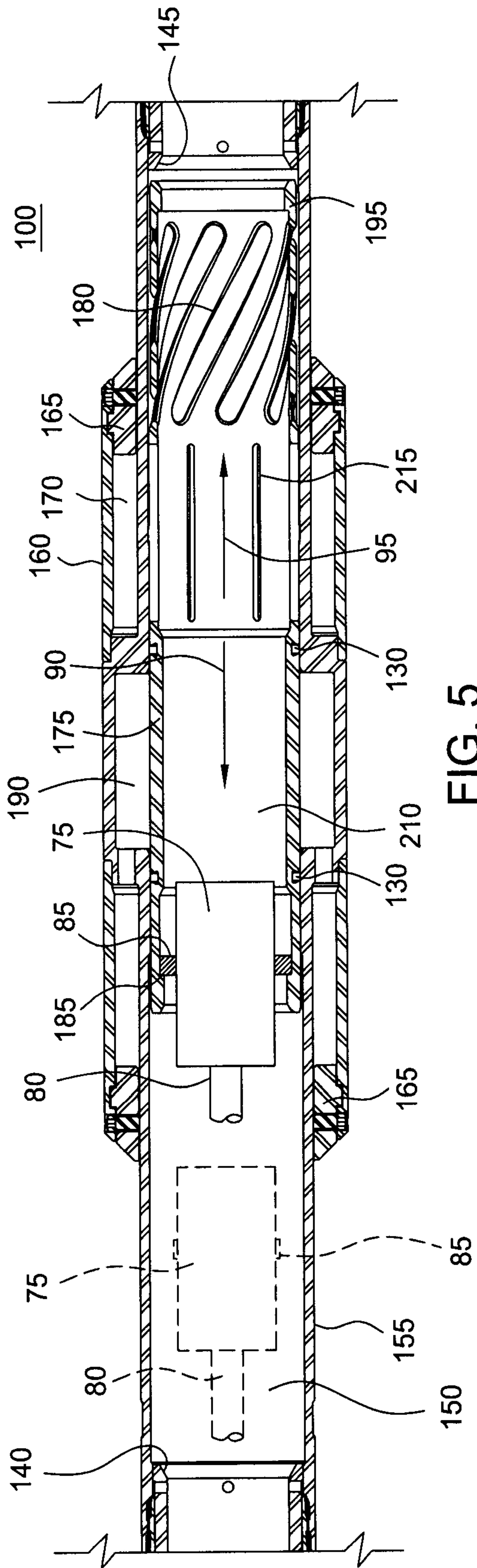


FIG. 5

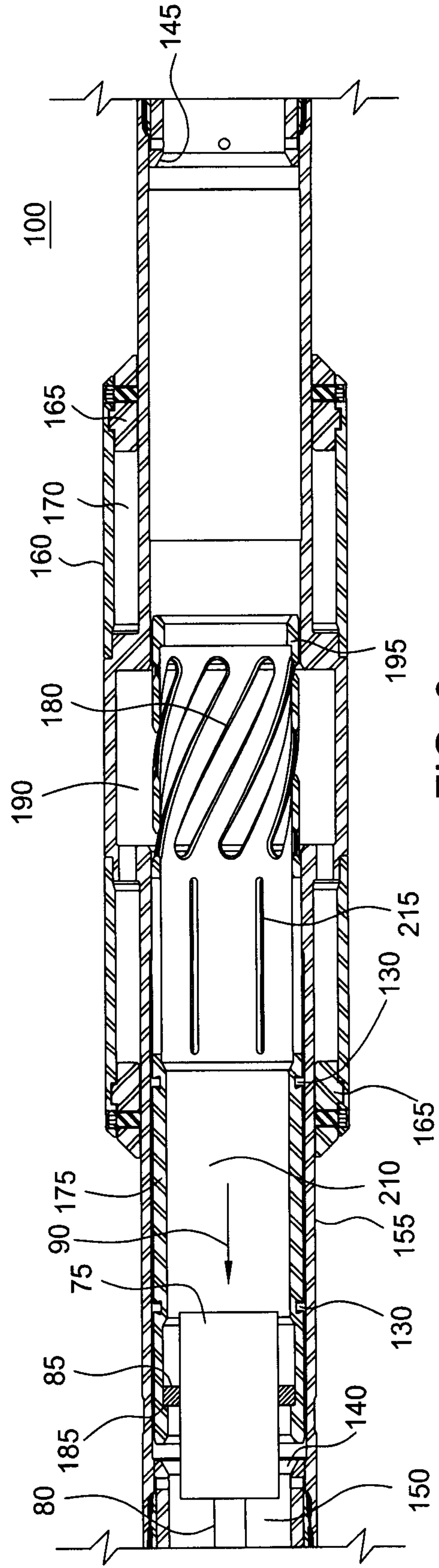


FIG. 6

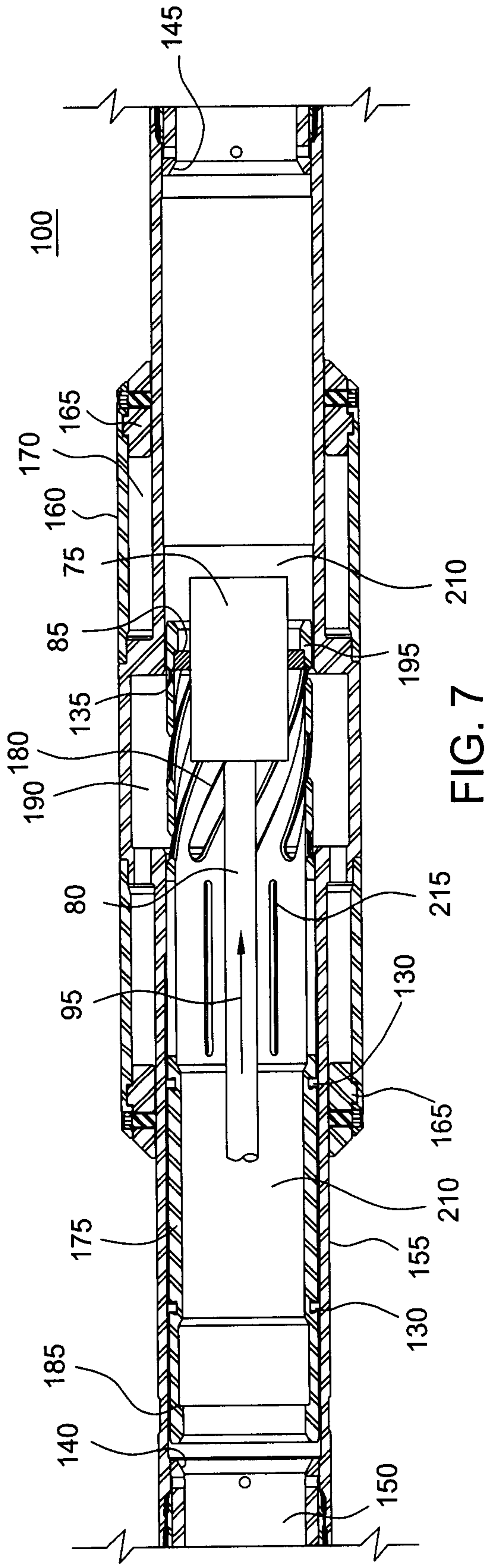


FIG. 7

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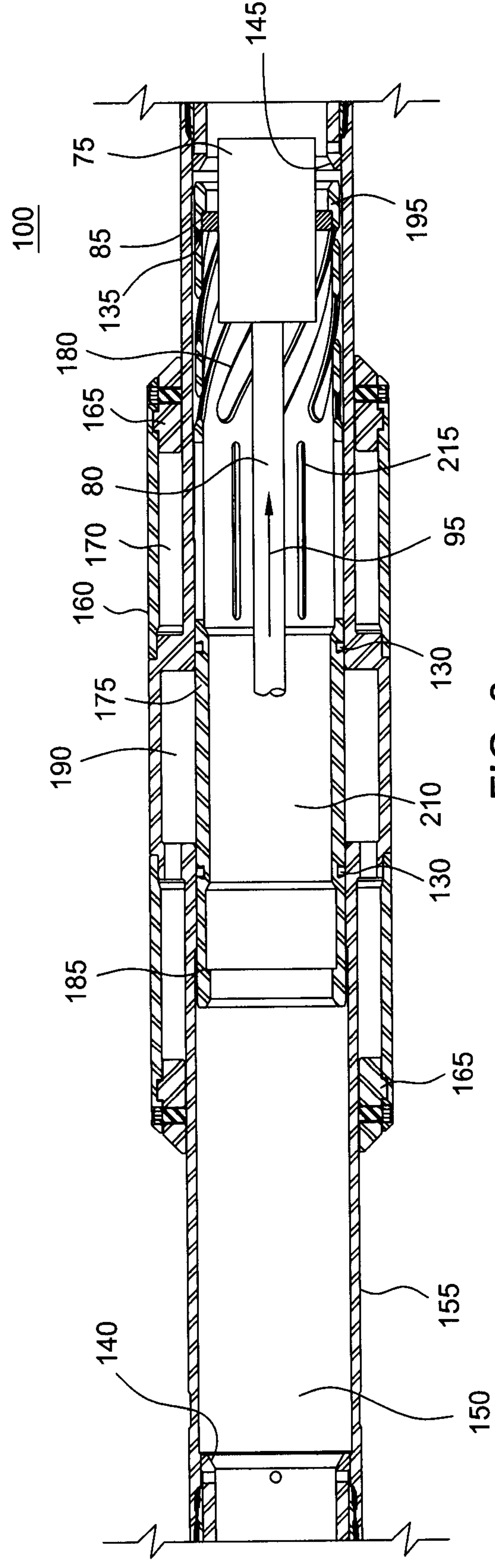


FIG. 8

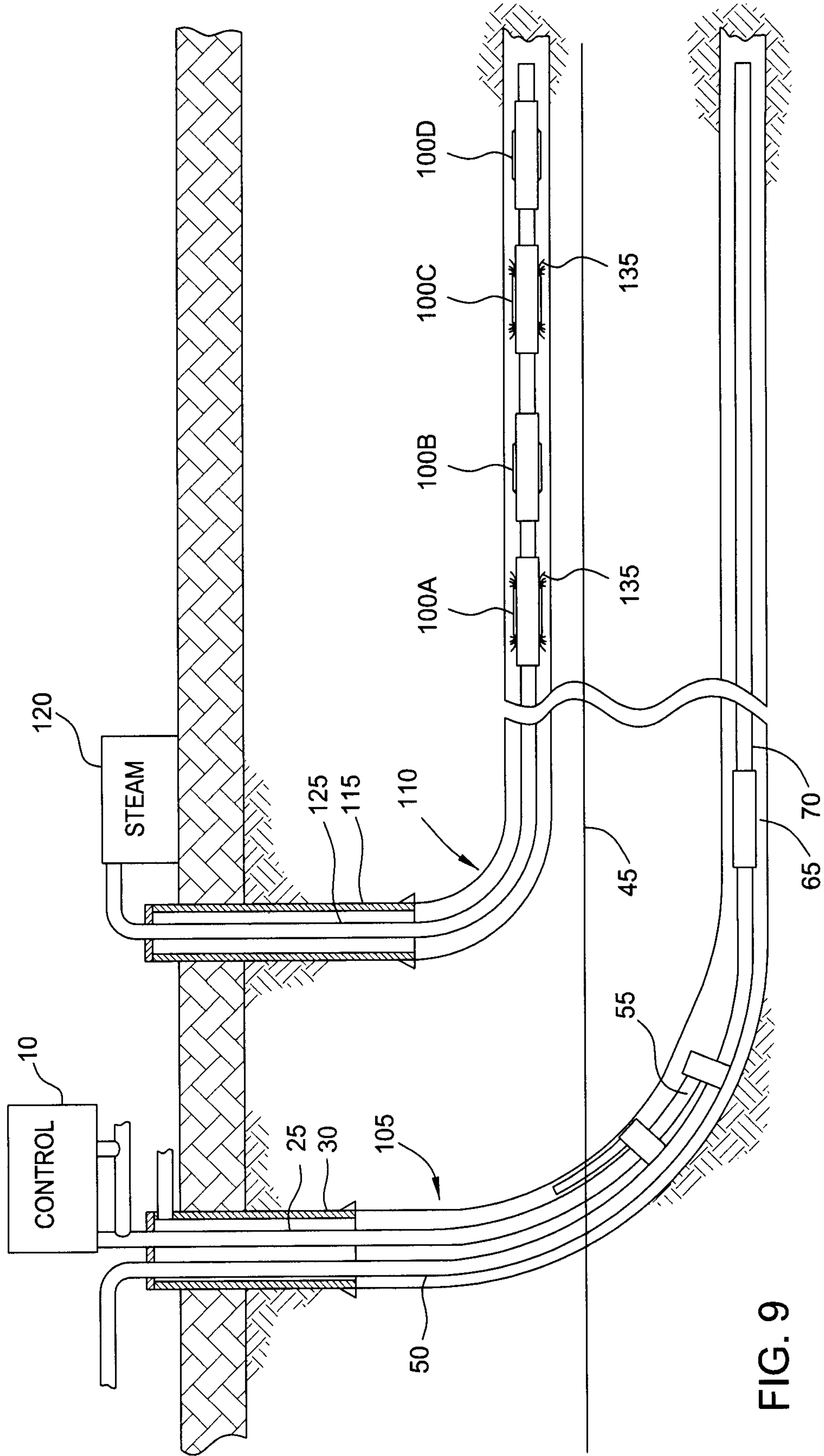


FIG. 9

