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(54) Title: SYSTEM AND METHOD FOR REDUCING PRESSURE FLUCTUATIONS IN AN OILFIELD PUMPING SYSTEM

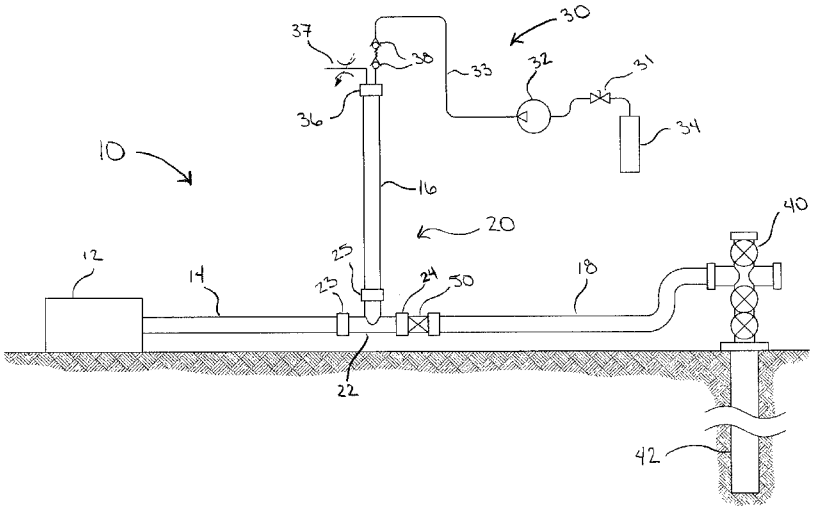


FIG. 1

(57) Abstract: Presented herein is a system, method, and assembly for reducing pressure fluctuations in an oilfield pumping system. The pressure fluctuation dampening assembly includes a junction, a dampening chamber, and a supply of a compressible medium. The compressible medium is supplied so as to form an interface between the fluid and the compressible medium such that a pressure fluctuation of fluid passing through the junction is reduced.

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SYSTEM AND METHOD FOR REDUCING PRESSURE FLUCTUATIONS IN AN OILFIELD PUMPING SYSTEM

BACKGROUND

[0001] The statements made herein merely provide information related to the present disclosure and may not constitute prior art, and may describe some embodiments illustrating the invention.

[0002] Large oilfield operations generally involve any of a variety of positive displacement or centrifugal pumps. Such pumps may be employed in applications for accessing underground hydrocarbon reservoirs. For example, positive displacement pumps are often employed in large scale high pressure applications directed at a borehole leading to a hydrocarbon reservoir. Such applications may include cementing, coiled tubing, water jet cutting, or hydraulic fracturing of underground rock.

[0003] A positive displacement pump such as those described above may be a fairly massive piece of equipment with associated engine, transmission, crankshaft and other parts, operating at between about 200 Hp and about 4,000 Hp. An example of a positive displacement pump, such as triplex or quintuplex pump, is disclosed in commonly assigned PCT Publication No. WO2011/027274, the entire contents of which are hereby incorporated by reference into the current disclosure. A large plunger is driven by the crankshaft toward and away from a chamber in the pump to dramatically affect a high or low pressure thereat. This makes it a good choice for high pressure applications. Indeed, where fluid pressure exceeding a few thousand pounds per square inch (PSI) is to be generated, a positive displacement pump is generally employed. Hydraulic fracturing of underground rock, for example, often takes place at pressures of 6,000 to 20,000 PSI or more to direct an abrasive containing fluid through a borehole such as that noted above to release oil and gas from rock pores for extraction.

[0004] Whether a positive displacement pump as described above, a centrifugal pump, or some other form of pump for large scale or ongoing operations, one frequently encounters wellbores and piping rig ups where significant pressure fluctuations/perturbations are created. These perturbations can lead to violent tremors of oilfield equipment, such as trucks and treating line/iron, which potentially cause damage to equipment, failed jobs, and personal injuries, etc. Such pressure fluctuations/oscillations may be caused by a variety of

phenomena, for example, resonances in the pumps, failed valves, or obstructions (e.g., rocks) in a plunger/valve. These pressure fluctuations produced by pumps can also interfere with or obscure measurements that are important to the course of a job.

[0005] In the field of mud pumps, for example, gas filled rubber bladders are often applied to both the suction and discharge sides of the mud pumps to reduce the large pressure fluctuations associated with duplex single and double acting pumps. While effective, these dampers are impractical to apply to services where significant abrasives, high pressure, and aggressive fluids are employed. Among other possible problems, the bladders of these systems are subject to deterioration when in contact with abrasive fluids at high, fluctuating pressures. One example of a service where significant abrasive, high pressure, and aggressive fluids are employed may be hydraulic fracturing operations or other portable oilfield pumping operations where positive displacement pumps, such as triplex pumps are commonly used. The abrasive nature of fracturing fluid is not only effective in breaking up underground rock, but would also tend to wear out an elastomeric bladder used for dampening. Moreover, the commercially available dampers are only rated up to 10,000 PSI, and would fail rapidly when exposed to the complex acids and hydrocarbons employed in fracturing. Constructing a dampening device for a 15,000 PSI rating would entail radical increases in wall thickness, costly material, and the like. Further, these systems are very limited in the range of gas pre-charge to pumping pressure that they can support. For example, a 3:1 ratio between the pre-charge pressure and the maximum reliable operating pressure represents a desirable ratio. In this case, a damper that will be pressure tested to 15,000 PSI must not be charged to less than 5,000 PSI. With this pre-charge, the damper will have no effect at all below 5,000 PSI. The optimum charge for damping is around 80% of the operating pressure for a bladder type damper. Thus, such a system has a significant lower limitation and also will need to be adjusted from job to job, rather than set up and left in service.

[0006] As such, it would be desirable to have a system and method for suppressing resonances and pressure fluctuations in operations where significant abrasives, high pressures, and aggressive fluids are employed.

SUMMARY

[0007] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or

essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0008] Embodiments of the present disclosure provide a pressure dampening apparatus and method which can dampen pressure perturbations in an oilfield pumping system. In view of the foregoing disadvantages inherent in the known types of methods and systems present in the prior art, certain embodiments disclosed herein address the above and other problems by providing a pressure dampening apparatus and method that does not require the use of a bladder, can be self-adjusting for the optimum operating conditions, and is adapted to be resistant to oilfield chemicals and fluids delivered at high, fluctuating pressures.

[0009] In at least one aspect, embodiments of the disclosure relate to a system for reducing pressure fluctuations, comprising: at least one pump directing fluid through a junction having a first port, a second port, and a third port; a chamber coupled to the third port of the junction; and a supply of a compressible medium in fluid communication with the chamber; wherein the supply of compressible medium provides the compressible medium to the chamber so as to form an interface between the fluid and the compressible medium such that a pressure fluctuation of fluid passing through the junction is reduced.

[0010] In another aspect, embodiments of the disclosure relate to a method for dampening pressure fluctuations in a fluid stream, the method comprising: providing a junction having a first port, a second port, and a third port; connecting the first port to at least one pump, and the second port to a wellbore; connecting a chamber to the third port of the junction; directing a fluid through the junction; supplying a compressible medium to the chamber; and forming an interface between the fluid and the compressible medium so as to reduce a pressure fluctuation in the fluid.

[0011] In yet another aspect, embodiments of the disclosure relate to a pressure fluctuation dampening assembly, comprising: a junction having a first port, a second port, and a third port; a chamber coupled to the third port of the junction, and oriented so as to trap gas; and a gas supply tank in fluid communication with the chamber so as to provide gas to the chamber; wherein gas supplied to the chamber forms an interface between a fluid passing through the junction and the gas such that a pressure fluctuation of the fluid is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Embodiments of a system and method for reducing pressure fluctuations in an oilfield pumping system are described with reference to the following figures. The same numbers are used throughout the figures to reference like features and components. Implementations of various technologies will hereafter be described with reference to the accompanying drawings. It should be understood, however, that the accompanying drawings illustrate only the various implementations described herein and are not meant to limit the scope of various technologies described herein.

[0013] Figure 1 illustrates a simplified, schematic view of an oilfield pumping system in accordance with implementations of various technologies and techniques described herein.

[0014] Figures 2A and 2B illustrate schematic views, partially in cross-section, of a junction in fluid communication with the oilfield pumping system in accordance with implementations of various technologies and techniques described herein.

[0015] Figures 3-6 illustrate schematic variations of the oilfield pumping system in accordance with implementations of various technologies and techniques described herein.

[0016] Figures 7-8 illustrate schematic variations of the oilfield pumping system integrated with at least one pump in accordance with implementations of various technologies and techniques described herein.

[0017] Figure 9 illustrates a simplified, schematic view of another oilfield pumping system in accordance with implementations of various technologies and techniques described herein.

[0018] Figure 10 illustrates a simplified, schematic view of yet another oilfield pumping system in accordance with implementations of various technologies and techniques described herein.

[0019] Figure 11 illustrates a schematic view of another oilfield pumping system having multiple pumps in accordance with implementations of various technologies and techniques described herein.

[0020] Figures 12-13 illustrate schematic variations of the oilfield pumping system having multiple dampening chambers in accordance with implementations of various technologies and techniques described herein.

DETAILED DESCRIPTION

[0021] The discussion below is directed to certain specific implementations. It is to be understood that the discussion below is only for the purpose of enabling a person with ordinary skill in the art to make and use any subject matter defined now or later by the patent "claims" found in any issued patent herein.

[0022] Figure 1 illustrates a simplified, schematic view of an oilfield pumping system 10 for directing fluid to a wellbore 42. Fluid, which may carry oilfield material such as proppant and proppant additives, is pressurized by one or more pumps 12 and directed through a treating line 14 to a pressure dampening device 20.

[0023] Pump(s) 12 may include a variety of pumps known in the art, such as positive displacement pumps, crankshaft driven pumps, hydraulic pressure driven pumps, centrifugal pumps, and the like. Pressurizing the fluid with pump(s) 12 inherently creates perturbations or fluctuations in the fluid.

[0024] The pressure fluctuation dampening assembly, or pressure dampening device 20, is adapted to dampen the perturbations or fluctuations of the fluid. The pressure dampening device 20 comprises a conduit/junction 22, a dampening chamber 16, and a fluid/gas supply system 30. The junction 22 has a first port 23, a second port 24 and a third port 25, shown generally in Figure 1 as a "tee," but as will be seen hereinafter may comprise various shapes and sizes. The first port 23, acting as an inlet section of the junction 22 receives fluid from the pump(s) 12 via the treating line 14. The second port 24, acting as an outlet section of the junction 22 is coupled to a treating line 18 for directing fluid to a wellhead 40 or any other means for delivering treatment, such as a cement head or a coiled tubing reel. The third port 25 of the junction 22 leading in a generally upward/vertical direction is coupled to the dampening chamber 16, which in function acts to reduce the pressure fluctuations of the fluid in coordination with the other elements of the pressure dampening device 20, but in construction the chamber 16 may be a treating line having a cap 36 at the end. The cap 36 may function as a connection between the chamber 16 and the fluid/gas supply system 30.

[0025] The fluid/gas supply system 30 is adapted to supply a compressible medium to the dampening chamber 16 in accordance with the operating conditions (i.e., fluid flow rate, pressure conditions, fluid type, etc.). The compressible medium supplied by the fluid/gas supply system is referred to herein as simply 'gas' as a matter of conciseness, but should be understood to also include liquids that are more compressible than the fluid being pumped.

Examples of the compressible medium may include nitrogen, argon, air, ethyl alcohol, carbon disulfide, ethyl ether and the like. The fluid/gas supply system 30 comprises a gas pump 32 to pressurize gas supplied by a gas supply tank 34. Gas may also be supplied to the pressure dampening device 20 by various means. For example, gas may be supplied via a Dewar containing liquefied gas (e.g. liquid nitrogen); moreover, a nitrogen-rich gas may be supplied via a separating membrane in fluid communication with a compressed air tank. A valve 31 may be used as part of the fluid/gas supply system 30 to control the amount of gas supplied by the gas supply tank 34. The fluid/gas supply system 30 may further comprise at least one check valve 38 along a gas supply line 33 so as to ensure that the fluid does not enter the gas pump 32. A bleed valve 37 may also be fitted to the cap 36 to drain fluid and/or release pressure built up in the chamber 16. The bleed valve 37 may be located elsewhere in the system, and should not be limited to the location shown. It should be noted that while the fluid/gas supply system 30 is shown to be coupled to the dampening chamber 16, the fluid/gas supply system 30 may also be coupled upstream of the junction 22 so that gas travel along with the fluid and be trapped in the dampening chamber 16. It should also be noted that the fluid/gas supply system 30 may include boosting means to sufficiently pressurize the gas into the dampening chamber 16.

[0026] A sonic choke 50 may optionally be located before or after (the latter is shown) the junction 22, or even in both locations. The sonic choke 50, which will be described in more detail hereinafter with reference to Figure 2, provides additional resistance and reflection to pressure fluctuations in the fluid.

[0027] Figure 2A illustrates a schematic view, partially in cross-section, of the junction 22 of Figure 1 in fluid communication with the oilfield pumping system 10. Gas is introduced into the dampening chamber 16 to create a gas filled space, referenced as 19, and a gas to liquid interface 17. As pressure and flow fluctuations pass into the junction 22, the fluctuations produce motions of the interface 17, substantially reducing the magnitude of the fluctuations at the outlet 24. The interface 17 may optionally include an object/device, such as a floating mass or Wier-type device, so as to prevent splashing of the fluid into the chamber 16 and/or lower the resonant frequency of the system. The object/device located at the interface 17 may also be tagged so as to measure the volume of gas/liquid in the chamber 16.

[0028] Any solids, for example oilfield material, in the fluid 15 flowing from the pump(s) 12 may become entrained in the dampening chamber 16. Due in part to the orientation of the dampening chamber 16, gravity will assist any solids in falling out of the dampening chamber 16 and preventing it from being blocked. However, it should be noted that the chamber 16

may be angled in a variety of directions so as to be oriented to trap gas and thereby provide a dampening effect on the pressure fluctuations of the fluid.

[0029] The sonic choke 50 is shown in more detail here in Figure 2A connected between the second port 24 of the junction 22 and the treating line 18 leading to a wellbore 42. The sonic choke 50 functions herein as a differential pressure conduit and may comprise a Venturi having a converging, diverging and throat section (shown herein), an orifice plate, or the like for providing additional reduction to the pressure fluctuations in the fluid 15.

[0030] In operating the oilfield pumping system 10 having a pressure dampening device 20, the chamber 16 may be charged using the gas pump 32 as soon as the system pressure has been brought up near the operating pressure. The chamber 16 can be re-charged at any time the treating pressure is reduced significantly and then raised again. Alternatively, a flow of gas into the chamber 16 may be maintained at all times, or during times where the overall pressure is changing significantly. As the interface 17 moves up and down, excess gas may exit the chamber 16 into the junction 22 and flow downstream eventually into the wellbore 42.

[0031] For example, if the nominal treating pressure is 6,000 PSI, the pressure fluctuations of the fluid 15 may vary between 6,500 PSI and 5,500 PSI. At 6,500 PSI, the gas 19 in the chamber 16 is compressed, moving the interface 17 towards the cap 36, thereby reducing the pressure of the fluid 15 at the outlet 24. Whereas, at 5,500 PSI, for example, the gas 19 in the chamber 16 may compress the fluid, moving the interface 17 towards the junction 22, and possibly releasing gas into the fluid stream 13.

[0032] Figure 2B illustrates a schematic view, partially in cross-section, of a variation of the junction 22, wherein the junction 22 comprises a cavity 26 for collecting a certain amount of solids 13 contained in the fluid so as to act as a barrier against any jetting action created by movement of the interface 17, and further reduce the pressure fluctuation of the fluid 15. The cavity 26 may also lengthen the overall life of the junction 22 and reduce washout, or erosion of the junction 22.

[0033] Figure 3 illustrates a schematic view of another embodiment of the oilfield pumping system 10 wherein the junction 22 is formed as a lateral so that the flow can be substantially aligned with the direction of the motion of the gas to liquid interface in the chamber 16, thereby reducing the pressure fluctuations of the fluid.

[0034] Figure 4 illustrates a schematic view of yet another embodiment of the oilfield pumping system 10 wherein the junction 22 is formed as a double lateral wherein a cavity section 26 opposes the pressure dampening chamber 16 to further reduce fluctuations.

[0035] Figure 5 illustrates a schematic view of another embodiment of the oilfield pumping system 10 wherein the junction 22 is formed as a lateral so that the flow is aligned with the direction of the motion of the gas to liquid interface in the chamber 16.

[0036] Figure 6 illustrates a schematic view of yet another embodiment of the oilfield pumping system 10 wherein the junction 22 is formed as a reversal chamber to reduce erosion due to the change in direction of flow.

[0037] Figure 7 illustrates a schematic view of an embodiment of the oilfield pumping system 10 wherein the pressure dampening device 20 is integrated directly to the pump(s) 12. In operation, fluid enters the pump(s) 12 via a suction header 62. A suction damper 64 may be integrated into the suction header 62 to smooth out the fluctuations of the flow on the suction side. A pump head 66 may contain valves and a plunger system for delivering fluid at a high pressure (higher than the pressure of the fluid entering the suction header 62) out of a discharge port, referenced herein as 14. The pressure dampening device 20 is fitted to the discharge port 14 so as to reduce the pressure fluctuations of the fluid discharged from the pump(s) 12. As illustrated by the present embodiment, the pressure dampening device 20 may be integrated into multiple locations along the oilfield pumping system 10. While not shown, it should be understood that the pressure dampening device 20 may be integrated into the wellhead 40, wherein the wellhead 40 is adapted to form the junction 22 coupled to the dampening chamber 16 and gas supply system 30.

[0038] Figure 8 illustrates a schematic view of another embodiment of the oilfield pumping system 10 wherein the pressure dampening device 20 is integrated directly to the pump(s) 12. The dampening chambers 16a/16b/16c are coupled to the discharge covers 68a/68b/68c on the pump head 66. Using more than one chamber 16 reduces the length of the chamber 16 required due to a distribution of pressure fluctuation across multiple chambers 16a/16b/16c. Moreover, locating the pressure dampening device 20 closer to the source of the fluctuations may provide an additional benefit in reducing the overall pressure fluctuations of the system 10.

[0039] Figure 9 illustrates a schematic view of yet another embodiment of the oilfield pumping system 10 wherein the chamber 16 is substantially larger in diameter than the treating line. The pressure dampening device 20 comprises an adapter 27 coupled to the third port 25 so as to allow the installation of the chamber 16 that is substantially larger in diameter than the treating line.

[0040] Figure 10 illustrates a simplified, schematic view of an oilfield pumping system 10 wherein the sonic choke 50 is placed upstream of the junction 22 so as to dampen the pressure fluctuations of the fluid prior to forming an interface between the fluid and the gas.

[0041] Figure 11 illustrates a schematic view of another embodiment of the oilfield pumping system 10 wherein two groups of pumps direct pressurized fluid through a pressure dampening device 20 having multiple inlets 23a/23b and outlets 24c/24d. One or more sonic chokes 50a/50b/50c/50d may be place on the inlets 23a/23b and outlets 24c/24d to further dampen the pressure fluctuations.

[0042] Figures 12 and 13 illustrate schematic views of embodiments of the oilfield pumping system 10 depicting a pressure dampening device 20 having multiple dampening chambers 16a/16b/16c coupled to the third ports 25a/25b/25c of the junctions 22a/22b/22c. Similar to the function of the arrangement in Figure 8, the array of chambers 16a/16b/16c may be employed to reduce the length of the chambers 16a/16b/16c. Figure 12 shows that the gas supply system 30 may be connected to each chamber 16a/16b/16c with a common gas supply line 33. Whereas, Figure 13 shows that the gas supply system 30 may be connected to any one of the chambers (shown here as 16a), upstream of the junctions 22b and 22c such that gas fed into chamber 16a will be carried by the fluid into the subsequent chambers 16b and 16c. Moreover, shown in Figure 13 is a change in elevation of the junctions 22a/22b/22c that may aid in distribution of the gas in the chambers 16a/16b/16c.

[0043] The preceding description has been presented with reference to some embodiments. Persons skilled in the art and technology to which this disclosure pertains will appreciate that alterations and changes in the described structures and methods of operation can be practiced without meaningfully departing from the principle, and scope of this application. For example, while the junction 22 is shown as having ports and connections with treating line, it

should be understood that the junction may be integrated with flow lines to be one piece. In addition, the gas supply system Accordingly, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

CLAIMS

What is claimed is:

1. A system for reducing pressure fluctuations, comprising:
at least one pump directing fluid through a junction having a first port, a second port, and a third port;
a chamber coupled to the third port of the junction; and
a supply of a compressible medium in fluid communication with the chamber;
wherein the supply of compressible medium provides the compressible medium to the chamber so as to form an interface between the fluid and the compressible medium such that a pressure fluctuation of fluid passing through the junction is reduced.

2. The system of claim 1, wherein the chamber is oriented so as to trap gas.

3. The system of claim 2, wherein the chamber is substantially vertical.

4. The system of claim 1, wherein the interface is movable in response to the pressure fluctuation of the fluid.

5. The system of claim 1, wherein the first port is in communication with a fluid end of a pump, and the second port is in communication with a wellbore.

6. The system of claim 1, wherein the junction is a tee-junction.

7. The system of claim 1, wherein a sonic choke is couple to at least one of the first port and the second port.

8. The system of claim 1, wherein the pump is a positive displacement pump.

9. The system of claim 1, wherein the fluid is an oilfield fluid used in an oilfield operation selected from the group consisting of hydraulic fracturing, cementing, drilling, testing, measuring, stimulating, working over, completing, and producing.

10. The system of claim 1, wherein the junction is a portion of the at least one pump.

11. The system of claim 1, wherein the first port and the second port are substantially aligned.

12. The system of claim 1, wherein the first port and the second port are substantially nonaligned.

13. The system of claim 1, wherein a pressure in the junction is at least 10,000 PSI.

14. The system of claim 1, wherein a pressure in the junction is at least 15,000 PSI.

15. A method for dampening pressure fluctuations in a fluid stream, the method comprising:

providing a junction having a first port, a second port, and a third port;

connecting the first port to at least one pump, and the second port to a wellbore;

connecting a chamber to the third port of the junction;

directing a fluid through the junction;

supplying a compressible medium to the chamber; and

forming an interface between the fluid and the compressible medium so as to reduce a pressure fluctuation in the fluid.

16. The method of claim 15, wherein the fluid is an oilfield fluid used in an oilfield operation selected from the group consisting of hydraulic fracturing, cementing, drilling, testing, measuring, stimulating, working over, completing, and producing.

17. The method of claim 15, wherein the compressible medium is supplied upstream of the junction.

18. A pressure fluctuation dampening assembly, comprising:

a junction having a first port, a second port, and a third port;

a chamber coupled to the third port of the junction, and oriented so as to trap gas; and

a gas supply tank in fluid communication with the chamber so as to provide gas to the chamber;

wherein gas supplied to the chamber forms an interface between a fluid passing through the junction and the gas such that a pressure fluctuation of the fluid is reduced.

19. The assembly of claim 18, wherein the first port and the second port are substantially aligned.

20. The assembly of claim 18, wherein the first port and the second port are substantially nonaligned.

21. The assembly of claim 18, wherein the junction is a tee-junction.

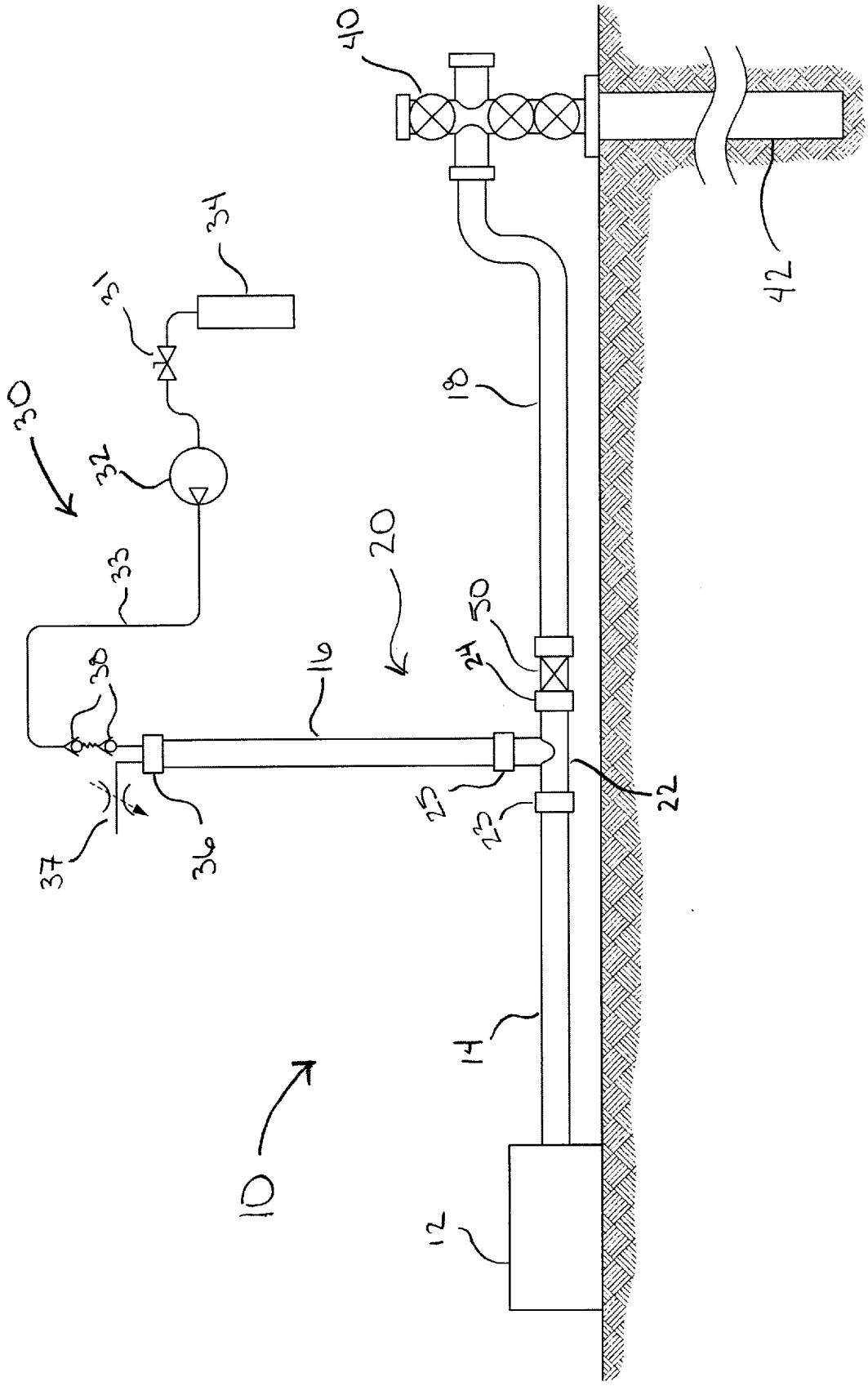


FIG. 1

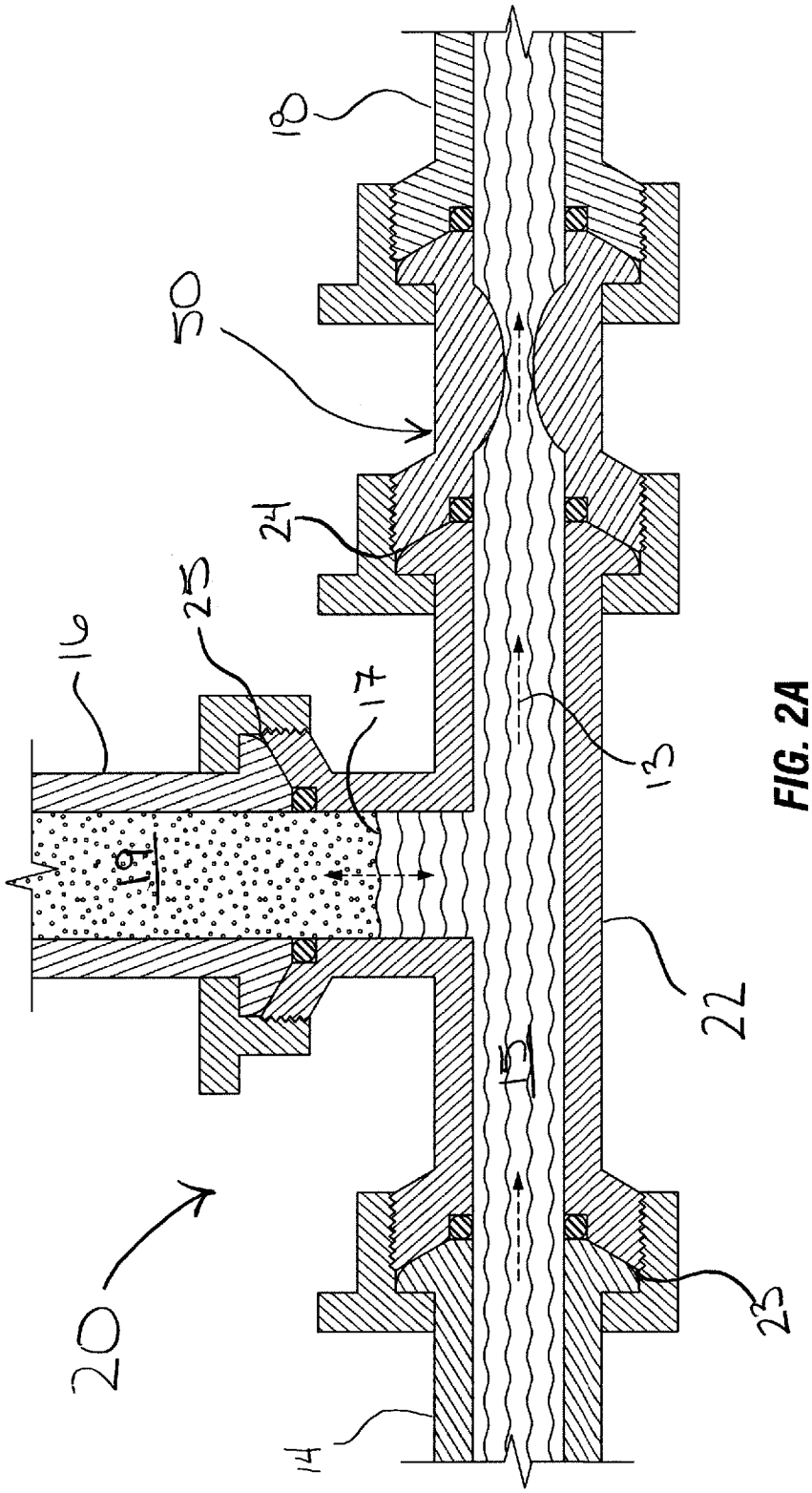


FIG. 2A

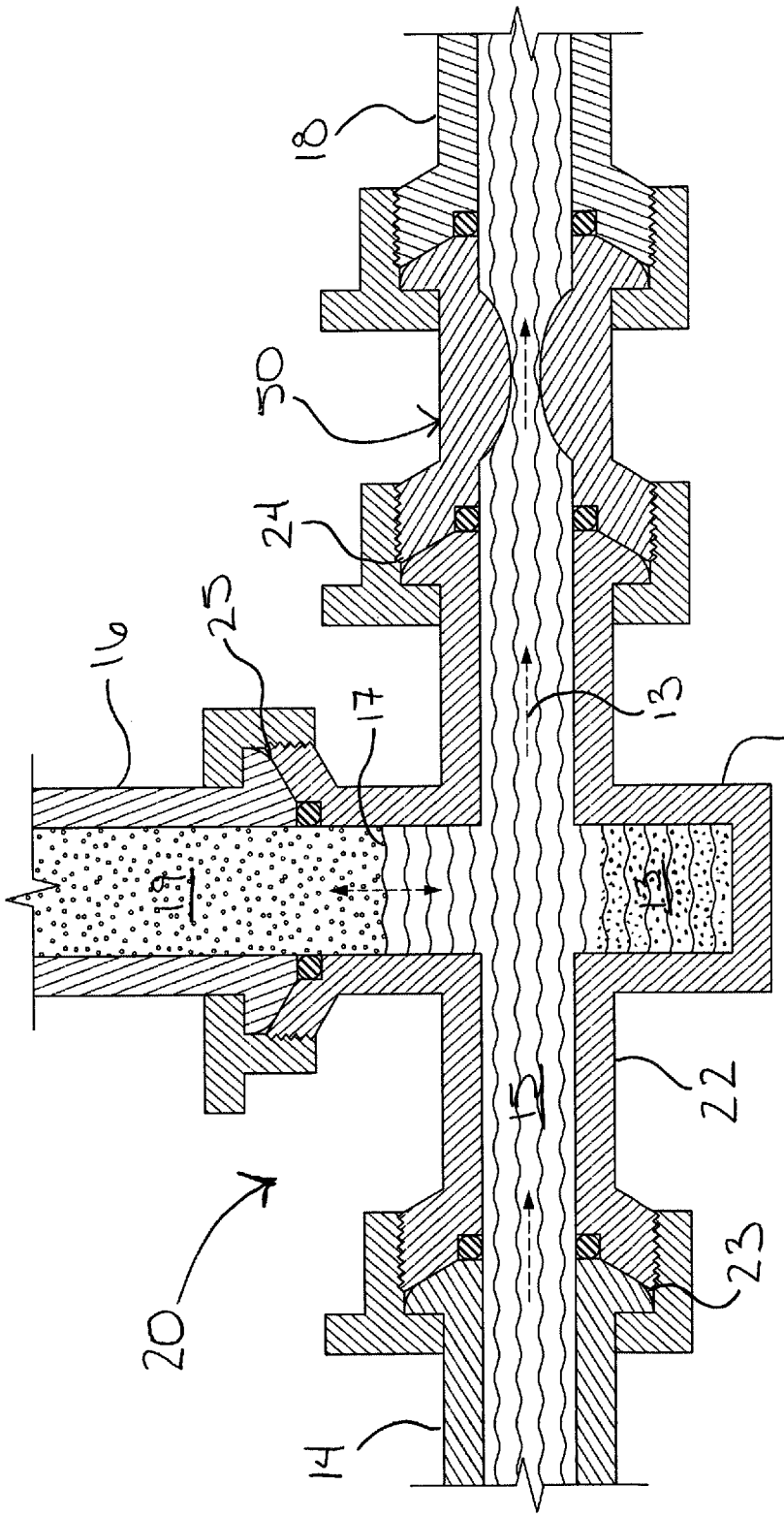


FIG. 2B

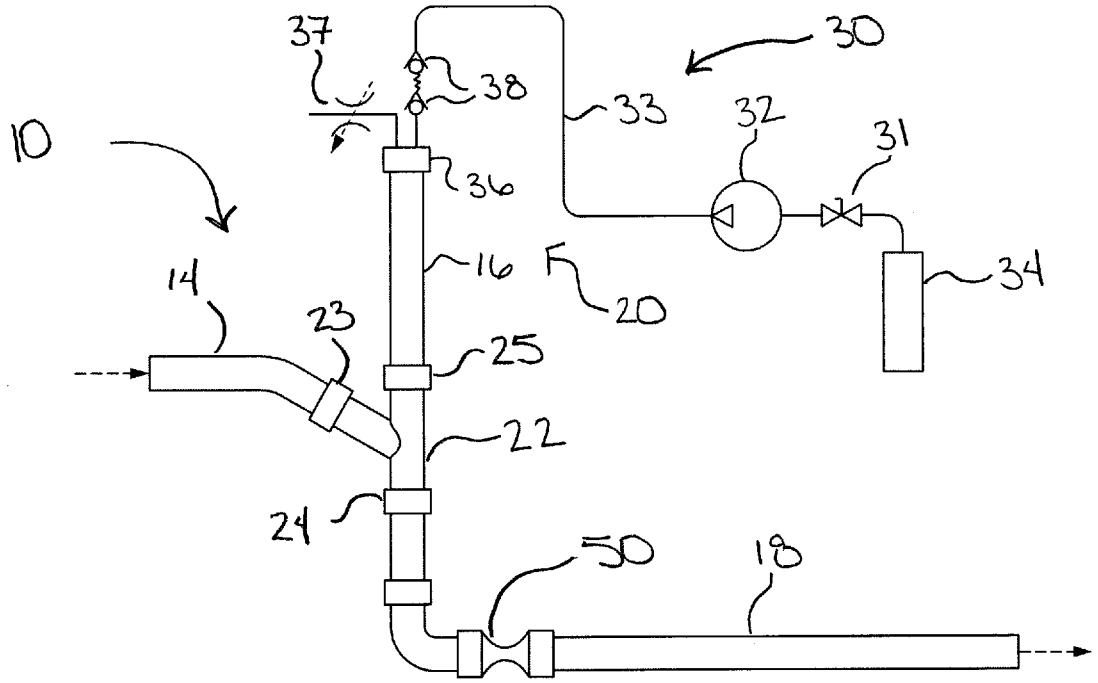

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FIG. 3

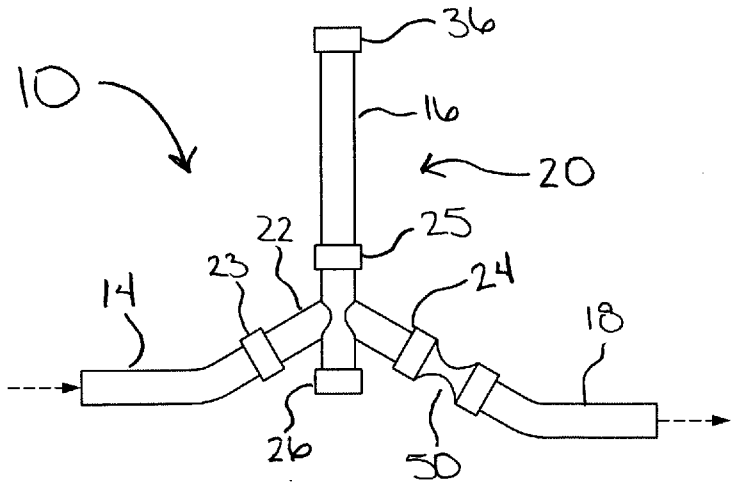

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FIG. 4

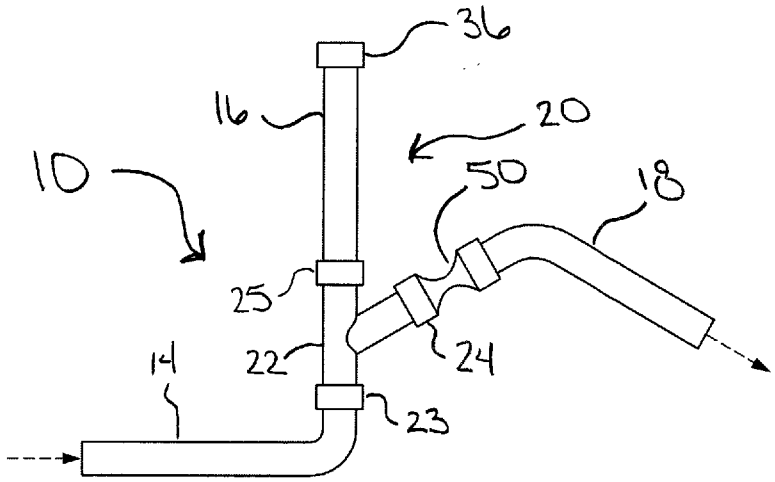


FIG. 5

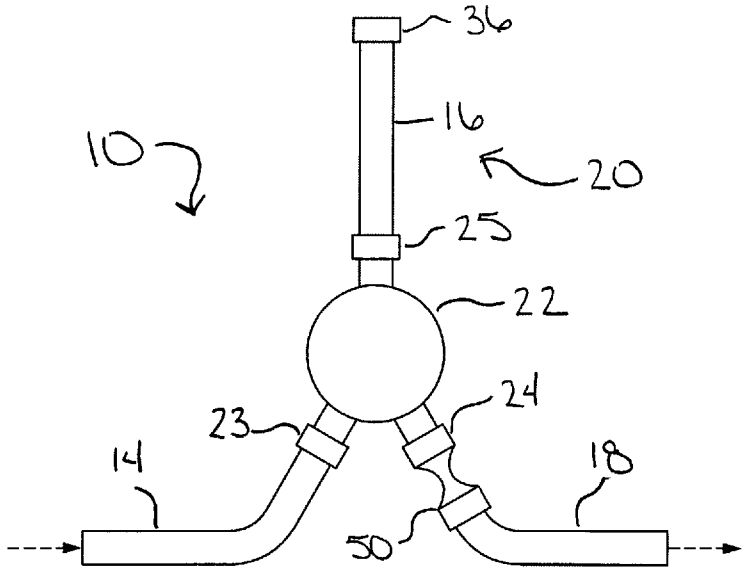


FIG. 6

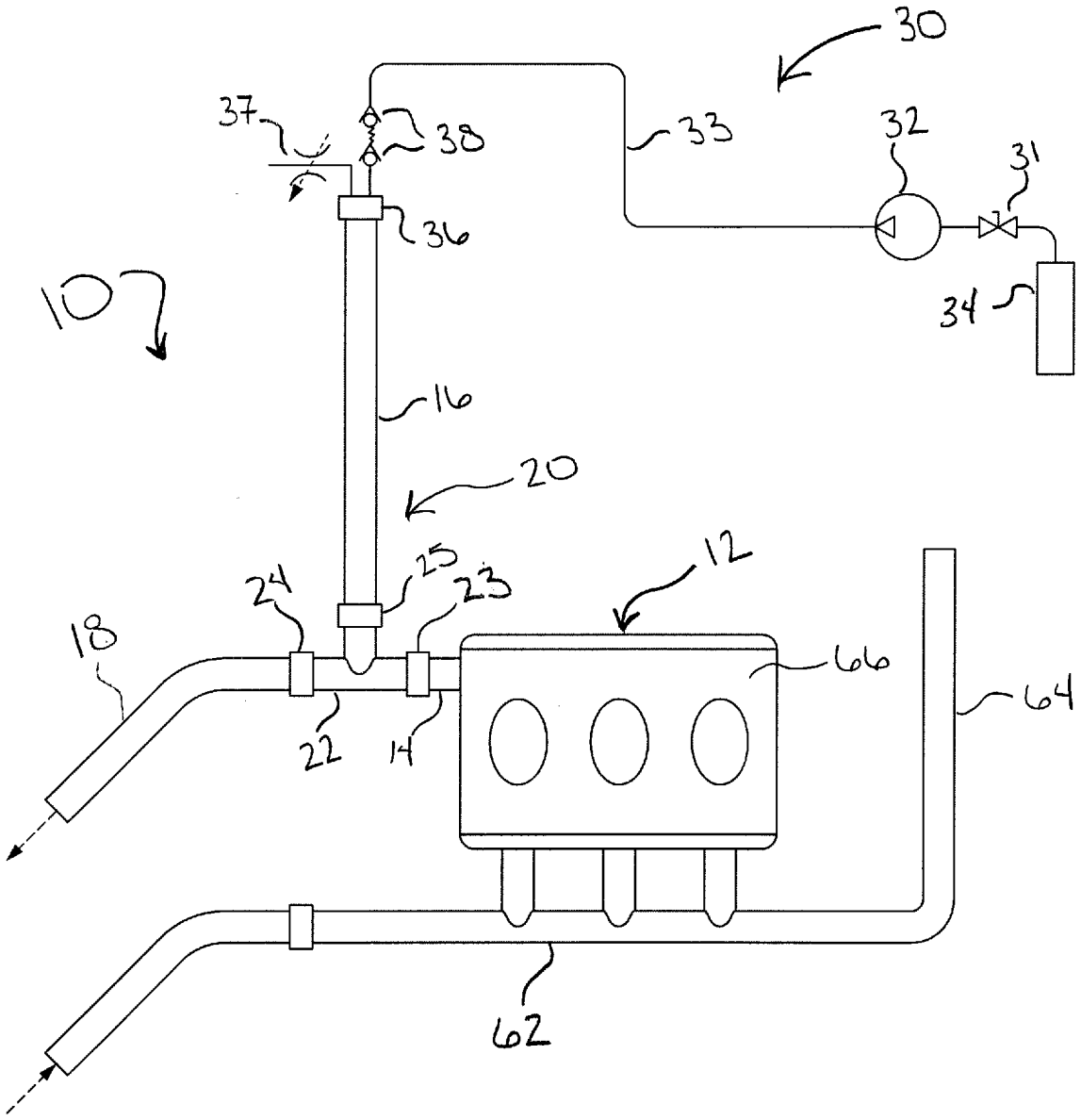


FIG. 7

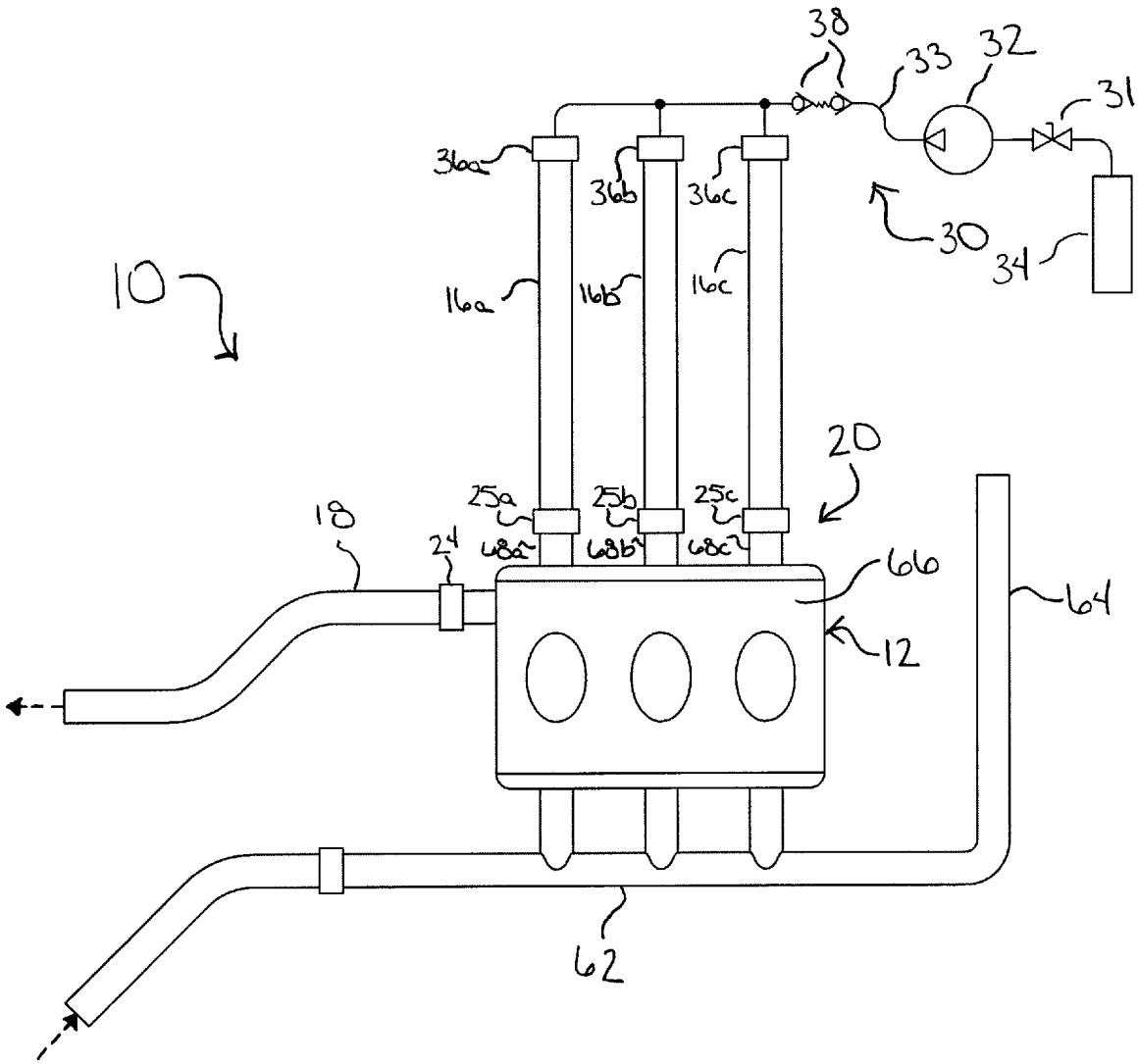

38
33
32
31
36a
36b
36c
30
34
10
16a
16b
16c
20
25a
25b
25c
18
24
68a
68b
68c
66
64
12
62

FIG. 8

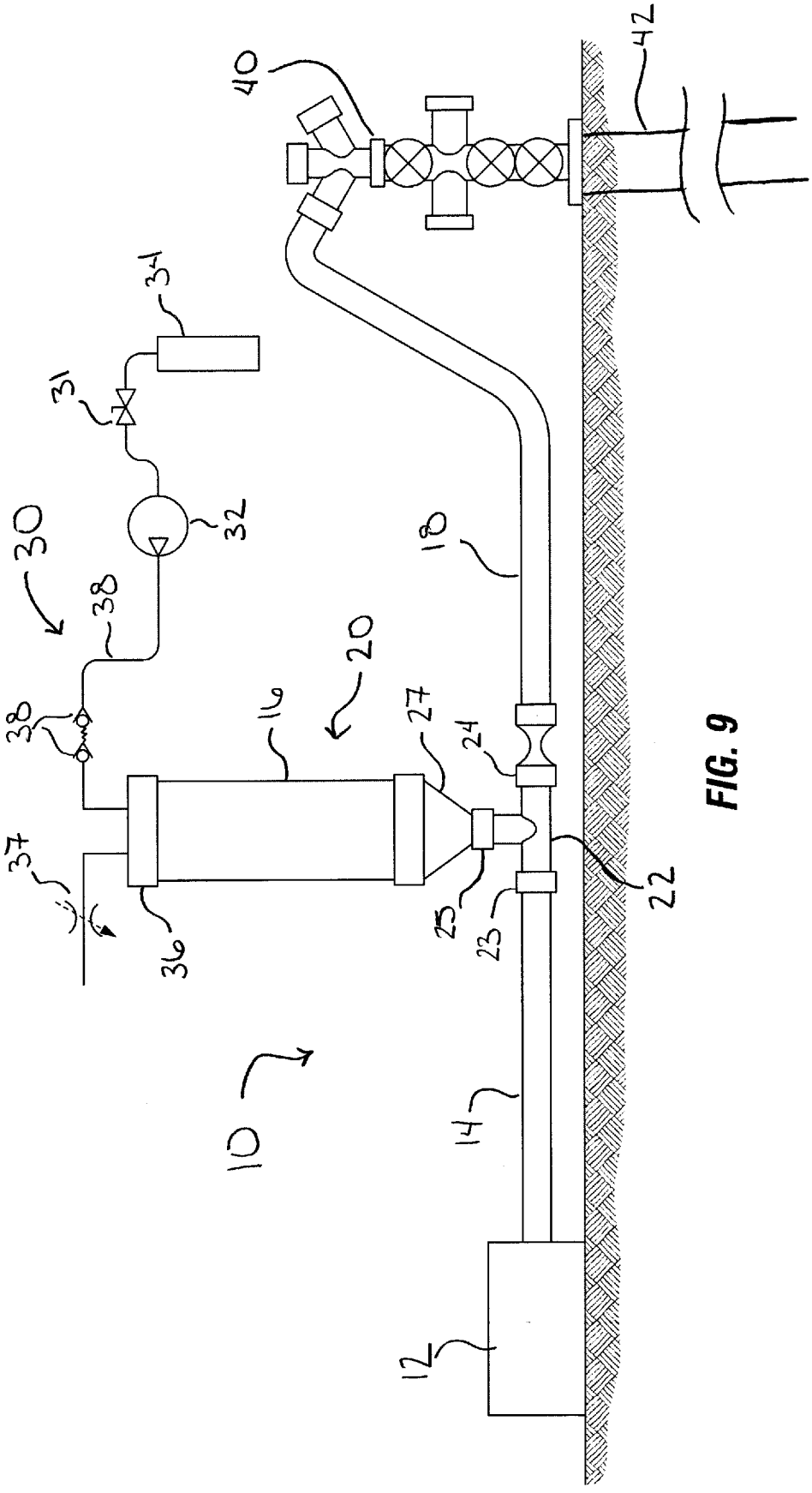


FIG. 9

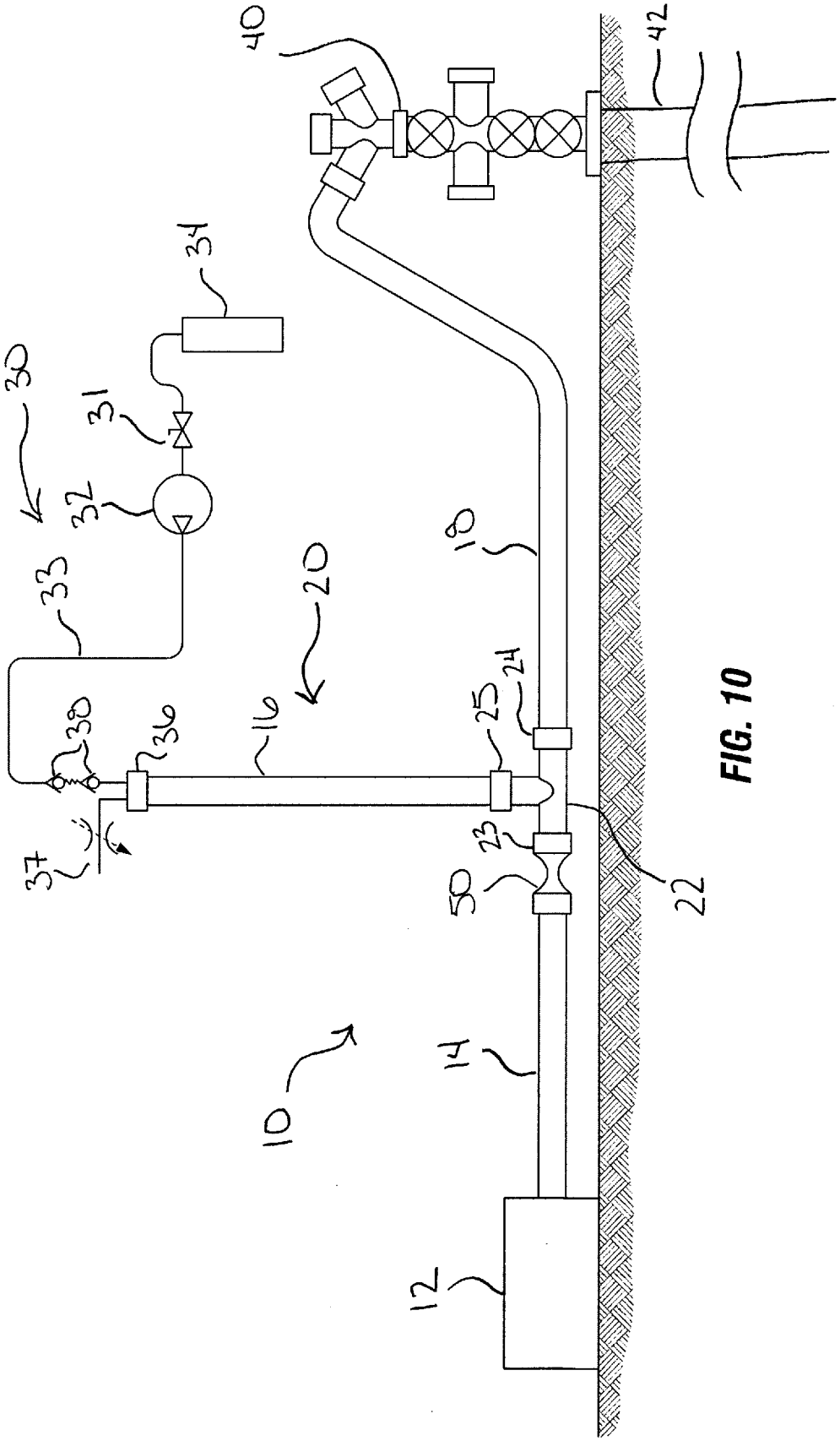


FIG. 10

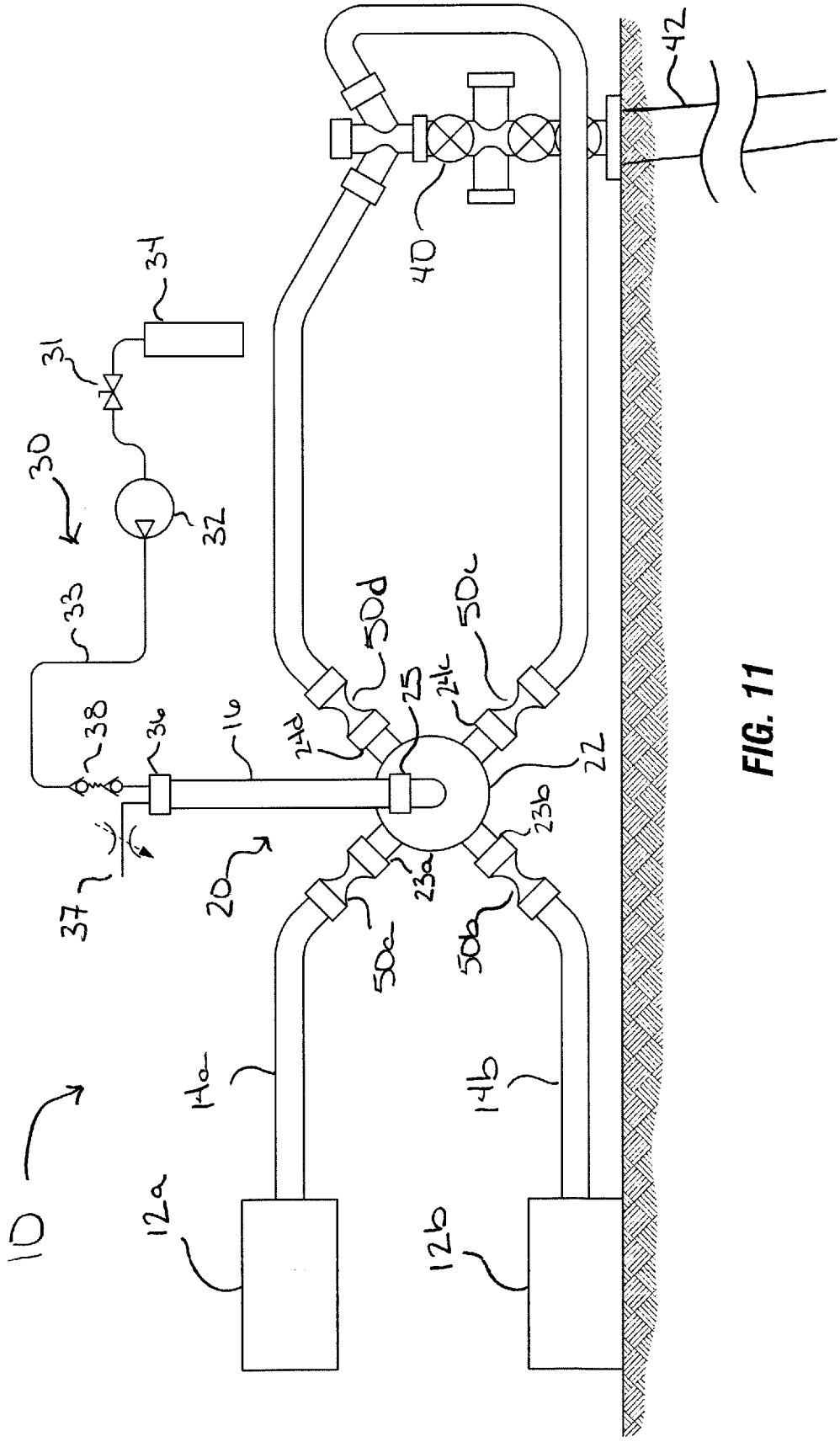

42
40
34
31
30
32
33
38
36
16
24d
25
24c
50d
50c
22
23b
23a
20
37
50a
50b
14a
14b
12a
12b
10

FIG. 11

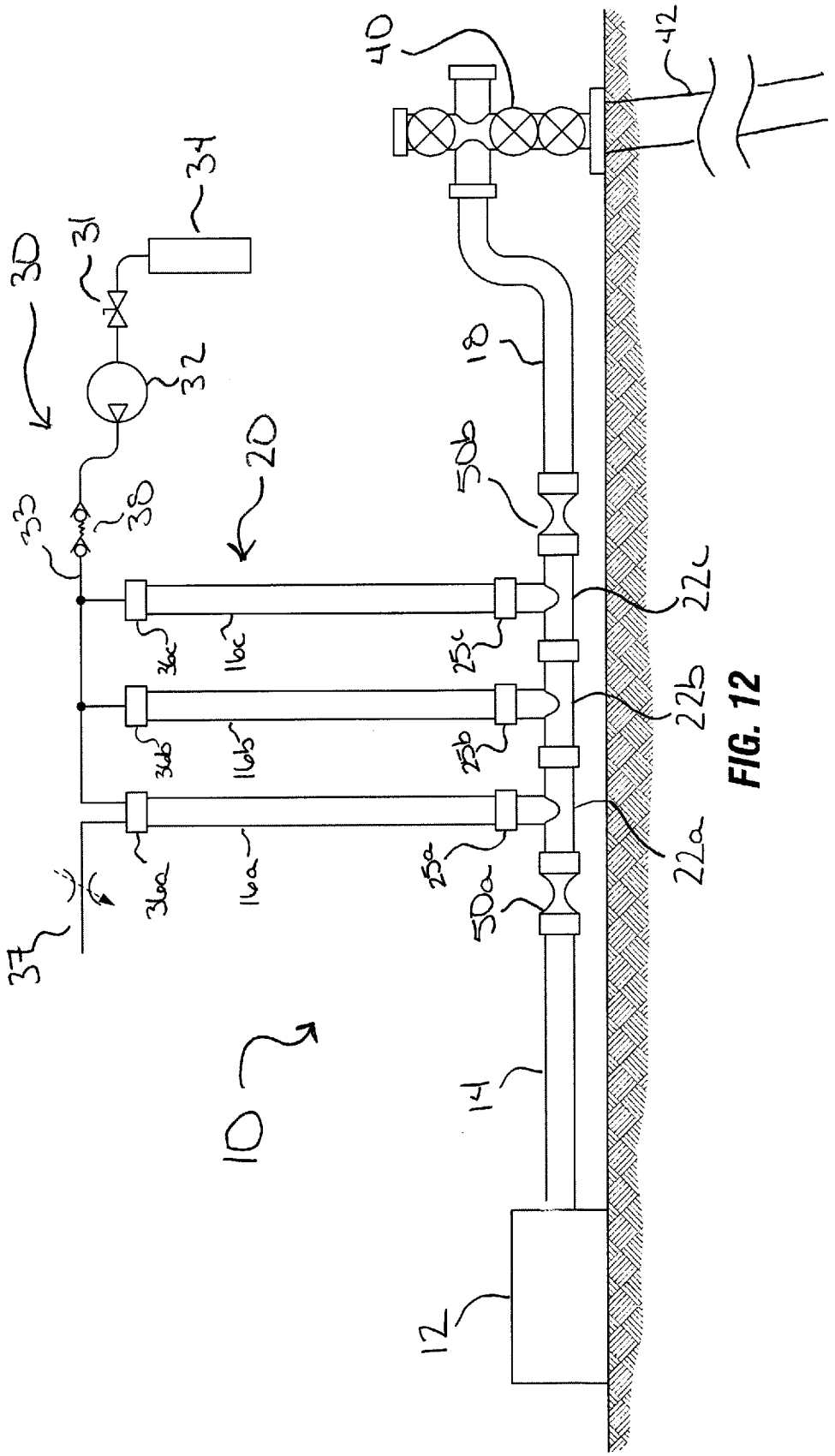

40
42
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31
30
32
18
20
50b
22c
16c
25c
36c
22b
16b
25b
36b
22a
25a
36a
16a
50a
37
10
14
12

FIG. 12

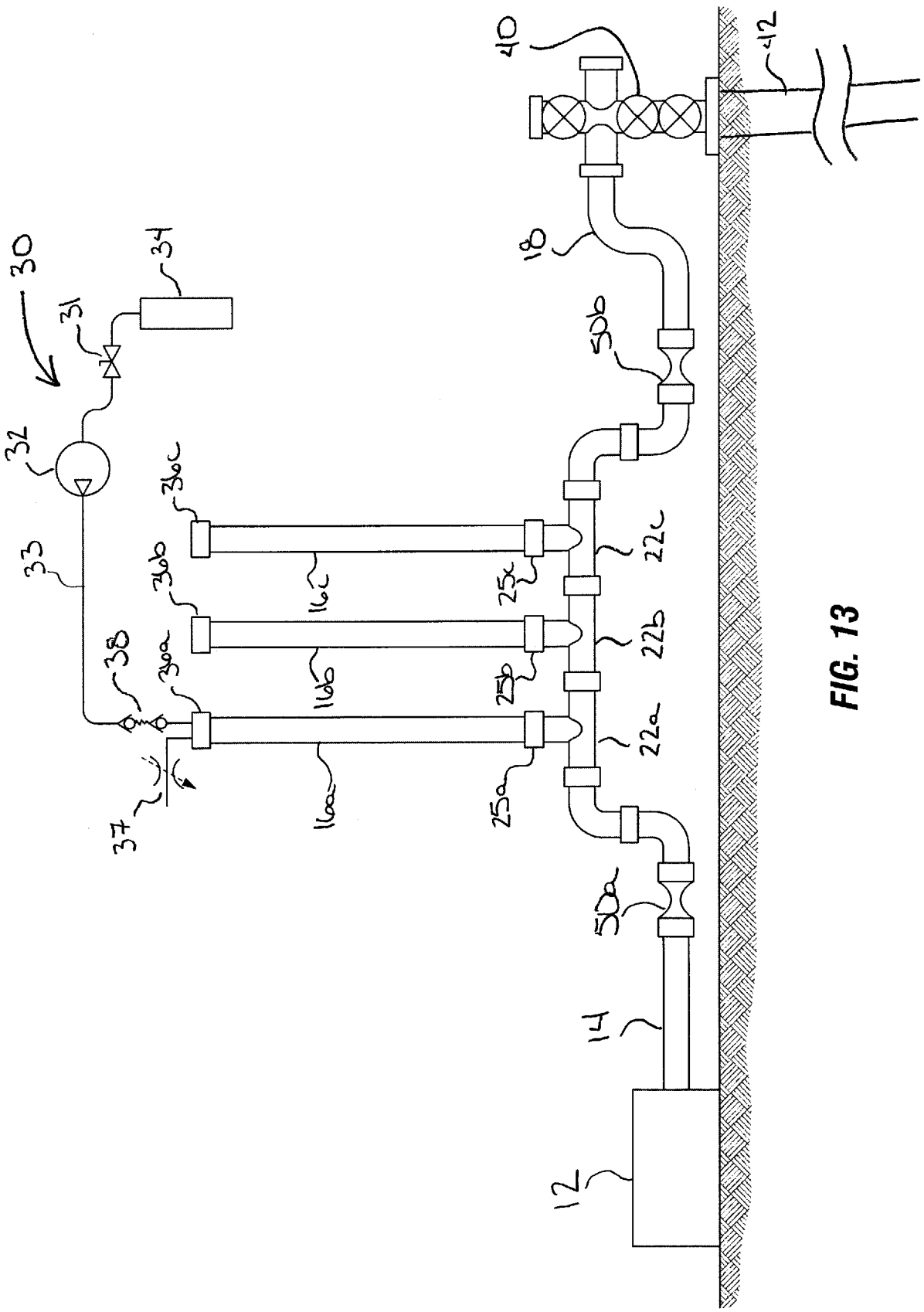

30
31
34
32
33
36c
36b
36a
38
37
16c
16b
16a
25c
25b
25a
22c
22b
22a
50b
50a
18
40
42
14
12

FIG. 13