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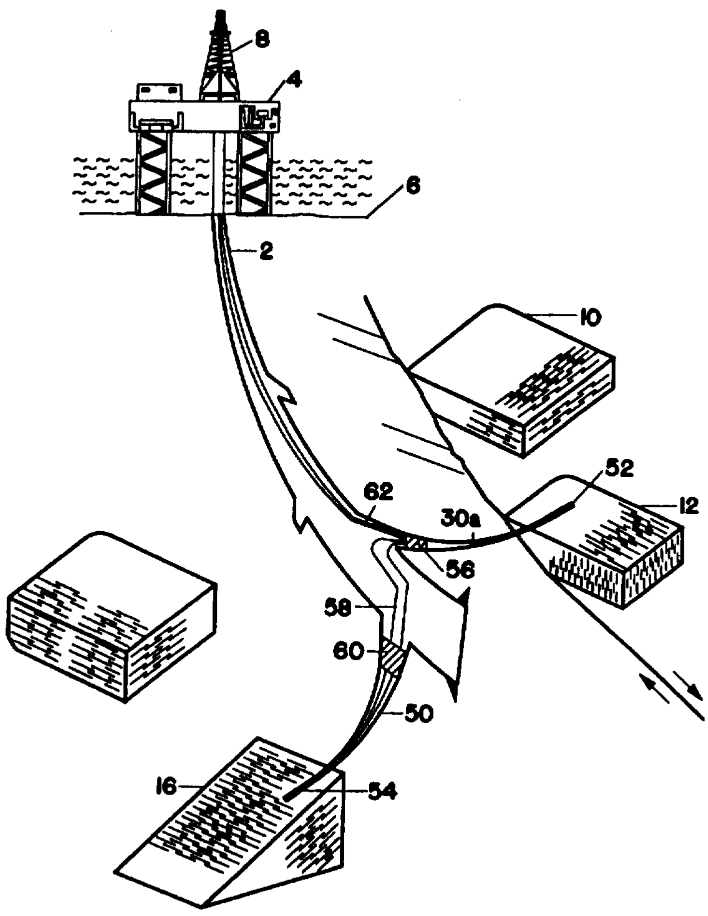
(54) Title: HYDROCARBON PRODUCTION USING MULTILATERAL WELL BORES

(57) Abstract

A system for producing a field having several reservoirs (10, 12, 14) and an aquifer (16) is described. Branch well bores (30) are drilled from the main well bore (2) towards the different reservoirs. One of the branches may contain a downhole separator for separating oil and water, the water being re-injected either into aquifer (16) or into the aquifer associated with the different reservoirs; another of the branches may contain a downhole separator for separating oil and gas, the gas being re-injected into the gas cap associated with the different reservoirs; another of the branches may contain a downhole storage device for storing chemicals for treatment against corrosion, scale, paraffin wax, hydrogen sulfide etc.; another of the branches may contain a unit for cracking and catalyzing the production fluids. Downhole flow control devices such as chokes may be located in the branch well bores, the production of the different reservoirs being commingled in the main well bore.



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HYDROCARBON PRODUCTION USING MULTILATERAL WELLBORES

The invention relates to well bore construction. More particularly, but not by way of limitation, this invention relates to a method and apparatus of drilling, completing, and producing hydrocarbon reservoirs.

Generally, the exploitation of hydrocarbon reservoirs has been achieved by the drilling of a bore hole to a subterranean reservoir. Once drilled, the reservoir may be completed and the reservoir may be produced until the well is plugged and abandoned for economic reasons. In the case where the well bore intersected numerous hydrocarbon reservoirs, the operator may chose to complete to a reservoir with the option to complete to the upper horizons at a later time.

Also, when the well bore intersects at least two different reservoirs, a dual completion is utilized by some operators. In such a case, the two reservoirs are produced with separate production strings.

Advances in drilling and completion techniques have led to the completion of highly deviated wells. This allows a driller to reach reservoirs that are a significant distance from the surface location (known as the throw). Many offshore wells drilled from platforms are drilled utilizing this technique. One prior art technique involves sidetracking from the production casing; however, sidetracking necessarily involves the abandonment of the lower zone in order to reach the upper horizon.

Another prior art technique is the use of extended reach wells. As the throw of wells increases, they are referred to as extended reach wells. The deviation of the well bores may approach 90 degrees in which case the well will have a horizontal portion. The productivity of a well is increased when the length of the completion actually intersecting a productive interval increases. Thus, many wells being drilled utilize the horizontal drilling technique in order to increase productivity.

In order to produce the well, certain surface facilities are required. For instance, separation of the oil, gas and water is crucial. Many times, the wells will be required to have compressor facilities or pressure boosting equipment to aid in production. Process equipment is also needed. Government regulations many times affect the discharges from the well bore, as well as the placement of the well bore. Many fields are now located in exotic regions so that the type, placement and performance of the production equipment is a major obstacle to economic development.

More recently, the use of multilateral wells have been used such as those disclosed in U. S. Patents 5,325,924; 5,322,127; 5,318,122; 5,311,936; 5,318,121; and 5,353,876, all assigned to applicant. The multilateral wells include having a first and second lateral (branch) well bore that extends to a single productive interval. The prior art purposes of the multilateral wells has been to have multiple completions that extend laterally through a single subterranean reservoir thereby increasing the productive length of the completion.

Despite these advances, there is a need for a method to construct a well bore that will efficiently and effectively deplete multiple reservoirs.

Summary of the Invention

The invention includes a method of drilling a plurality of well bores with a drill string containing sensing means for sensing subterranean properties of reservoirs, the method comprising the steps of drilling a primary access well bore and measuring physical parameters of the subterranean reservoirs from the primary access well bore. Next, the operator generates a subterranean model of the reservoirs and develops target reservoirs for placement of branch completions.

A casing string may serve as a primary access conduit for multiple branch wells extending therefrom. The placement of the primary access well bore is important so that the entry and placement of the multiple branch wells achieves maximum production and drainage from the multiple reservoirs. The positioning of the branch well bore path will depend on the specific geology of the field as well as certain requirements of the various production equipment that will be contained within the branch wells.

The method may further comprise the steps of placing a primary access casing in the primary access well bore and thereafter generating window sections from the primary access casing. The windows are not necessarily in the immediate proximity of the reservoirs (as is the case with prior art wells being generated). Instead, the branch well bore paths will be a function of field geology, drilling concerns and completion concerns.

The method may further comprise the steps of drilling, utilizing the windows, a bore hole to a first target reservoir; then, drilling, utilizing a second window, a bore hole to the second target reservoir. The steps further include completing the first target reservoir with means for completing to the first target reservoir, and completing the second target reservoir with means for completing to the second target reservoir. Some of the possible completion means include sand control screens, slotted liners, and consolidated packs such as resin coated sand, all well known by those of ordinary skill in the art.

In one embodiment, the operator may position a first and second valve means for variably controlling the flow from the first and second branch. Also included may be sensor means for sensing the production parameters of the reservoir and produced fluids. Under this scenario, the method further comprises the steps of producing a hydrocarbon from the first branch completion and monitoring the production parameters of the first branch completion. Next, the first valve means is positioned in the closed position once production of the hydrocarbons drops below a predetermined level while the second valve means is positioned in the open position so that a hydrocarbon is produced from the second branch completion.

The invention also allows for cycling amongst the multiple reservoirs. In determining the cycling between the multiple branches, once the estimated productivity of the first branch rises to a predetermined level, various cycling of the multiple branches may occur. One of the measurable parameters will be reservoir pressure. The pressure of the first branch completion is monitored and once the reservoir pressure of the first branch completion rises to a predetermined level, the second valve means is placed in the closed position. Other types of sensor means are available, such as: flow rate sensor, and/or a fluid composition sensor.

In another embodiment, the invention discloses generating a first window section from the primary access casing then drilling a partial first branch well bore from the first window section, with the first branch well bore extending partially to the first target reservoir. Next, a second window is generated from the primary access casing and thereafter a second branch well bore is drilled from the second window section, with the second branch well bore extending partially to the second target reservoir. Next, the operator would then mobilize a remedial work over rig and reenter the first branch well bore and drill an extended well bore intersecting the first target reservoir and thereafter completing the first branch with means for completing to the reservoir. Next, the second branch is drilled (with the remedial rig) and completed with means for completing to the reservoir similar to the first branch well bore.

Various branch well bores may have disposed therein means for separating gas/oil/water. Alternatively, the branch well bore may contain process equipment means for compressing or pumping fluids and gas to the surface. The branch may contain means for treating the reservoir fluids and gas with treatment chemicals. Alternatively, the branch may contain processing equipment that would treat the fluids and gas for hydration or catalytic transformation of hydrocarbon molecules. Still further, the branch may contain means that will sense production parameters such as pressure, temperature, fluid composition, and/or water percentage.

A system for depleting a plurality of reservoirs is also disclosed. The system comprises a primary access passage with a first branch well extending from the primary access passage and intersecting a first subterranean reservoir. The system also contains a second branch well extending from the primary access passage, with the second branch well intersecting a second subterranean reservoir.

In one embodiment, the first and second branch well extends from the primary access passage at an optimum trajectory angle for intersection with the first and second subterranean reservoir. The placement of the windows is not dependent on the proximity of target horizons; rather, the criteria is based on a branch well bore path that can be drilled quickly, efficiently, and with minimal tortuosity. Of course, the ultimate paths chosen are based on data known at the time that have been generated in order to model the fields under consideration. As more and more data is generated due to drilling and production quantitative information, the model of the field may change.

The first and second branch well may contain valve means for variably constricting the first and second branch well from communication with the primary access passage. The first branch well contains completion means for completing to the reservoir. In order to produce the reservoir, the first branch well includes production means for allowing the production of reservoir fluids and gas and controlling the production of a reservoir. The second branch well may have contained therein separator means for separating the hydrocarbon phase and in-situ water phase produced from the first branch well. Also, diverter means are included for diverting the reservoir fluids and gas production from the first branch to the separator means.

The system further comprises first and second sensor means, operatively associated with the first and second production means, for sensing physical parameters of the first and second target reservoirs respectively.

A feature of the present invention includes use of a primary access conduit. Another feature includes the use of multiple branches that extend from the primary access conduit. Another feature includes use of separator means for separating the oil, gas and water, with the separator being located within one of the branch well bores.

Another feature includes use of a valve means placed within the branch well bores that will constrict the flow path so that the reservoir fluids and gas may be restricted or terminated.

the reservoir fluids and gas may be restricted or terminated. Yet another feature includes using sensor means in individual branches that will determine important characteristics of the flow, pressure and temperature of the reservoir. A control means, with a pre-programmed logical command sequence, may be included for receiving information from the sensor means, comparing and analyzing the information thus received, and causing an output signal to maneuver the valve means to an open, closed or partially opened position.

Another feature includes use of a compressor or pump in one or more of the multiple branches. Yet another feature is the ability to have multiple branches extending into a single reservoir. Alternatively, multiple branches may extend into multiple reservoirs. Yet another feature allows the placement of chemical treating means in one or more of the branch well bores to treat the produced reservoir fluids and gas.

An advantage of the present invention includes having multiple well bores intersecting multiple reservoirs and maintaining the ability to selective manage these individual productive intervals. Another advantage includes the capability of partially or fully commingling the production from the multiple reservoirs. Still yet another advantage is the ability of cycling the multiple reservoirs based on production and/or pressure considerations.

Another advantage includes use of a single main access well bore that can reach numerous targets. Another advantage includes placement of down hole equipment in the subterranean branches rather than at the surface. Yet another advantage includes use of less surface equipment in exotic locations which ultimately reduces cost. Still yet another advantage is the ability to deplete an entire field with fewer surface facilities.

Another advantage consist of pressure supporting producing reservoirs with the down hole re-injection of gas or water. Still yet another advantage involves modifying the produced fluid composition to achieve desirable physical properties (i.e. change viscosity, wax or paraffin content) which enhances the value of fluids and/or simplify transportation or other production problems.

Another advantage is the main access well bore serves an analogous role as the prior art surface production headers and manifold in that the main access well bore may serve as the placement point of the headers and manifold with the unique advantage of being downhole rather than at the surface. Thus, the equivalent of a sub-sea template or cluster well development is possible subsurface, for instance, within the main access well bore with the teachings of the present invention.

Brief Description of the Drawings

FIGURE 1 is a schematic illustration of a main access well bore.

FIGURE 2 is the schematic illustration of Fig. 1 with windows generated for placement of branch well bores.

FIGURE 3 is the schematic illustration of Fig. 2 a first and second branch well bores.

FIGURE 4A is the schematic illustration of Fig. 3 showing the utilization of valve means.

FIGURE 4B is an enlargement of the valve means from Fig. 4A.

FIGURE 5 is a schematic illustration depicting a first and second branch well bores utilizing separator and water injecting means.

FIGURE 6 is a schematic illustration depicting a first and second branch well bore utilizing another separator and water injecting embodiment.

FIGURE 7 is a schematic illustration depicting a first and second branch well bore utilizing yet another separator and water injecting embodiment.

FIGURE 8 is a schematic illustration depicting a first branch well bore and second branch well bore with gas recycling means.

FIGURE 9A is a schematic illustration depicting a first and second branch well bore with flow control means in the second branch.

FIGURE 9B is an enlargement view of the commingling device of Fig. 9A.

FIGURE 10 is a schematic illustration depicting a first branch well bore for production and a second branch well bore for treatment means.

FIGURE 11 is a schematic illustration depicting a first branch well bore for production, a second branch well bore for treatment means and a third branch well bore for treatment means.

FIGURE 12 is schematic illustration of the sealing means for sealing a branch well from the main access well bore.

FIGURE 13 depicts the embodiment of Fig. 12 showing regulation means disposed therein.

FIGURE 14 is a schematic illustration of another embodiment of a branch well bore with regulation means disposed therein.

Detailed Description of the Preferred Embodiments

Referring now to Fig. 1, a schematic illustration of a main access well bore 2 is shown. The main access well bore 2 is drilled from a platform 4 that is set on the sea floor 6. While Fig. 1 depicts a platform, the invention is applicable to land uses as well as drill ships, semi-submersible drilling platforms, jack-up rigs, etc. The placement of the main access well bore 2 is dependent on the interpretation of the reservoirs sought to be produced via the novel system disclosed herein. Therefore, the main access well bore 2 does not necessarily intersect any one productive interval. Rather, the main access well bore 2 is placed so that the paths of the branches, to be described later in the application, maximize well bore trajectory and entry angle into the productive zone, which is defined as optimum placement of the branch pathway. In fact, the lower end of the main access well bore may act as a completion without the need of a separate branch.

The platform 4 will have positioned thereon a drilling rig 8 that will serve to drill the main access well bore 2. As is well appreciated by those of ordinary skill in the art, the drill bit will be connected to a drill string (not shown). The drill string will have operatively associated therewith logging means for sensing the physical parameters of the subterranean reservoirs. In accordance with the teachings of the present invention, the main access well bore 2 will be drilled while continuously monitoring the physical parameters of the subterranean reservoirs. Thus, the operator will be able to use this data, as well as other data such as seismic data, drill stem testing data and other offset well data in which to model the subterranean structure. Of course, the operator has some indication as to location and hydrocarbon potential of reservoirs before drilling. However, the drilling of the main access well bore will further delineate and significantly improve the understanding of the subterranean field leading to a superior model. Also, the drilling of each branch well bore will further delineate and significantly improve the understanding of the subterranean field.

After drilling the main access well bore 2, a development model may be generated. The development model may indicate a plurality of reservoirs. As seen in Fig. 1, the model thus generated based on the seismic data, offset wells, and the drilling of the main access bore depicts a first reservoir 10, a second reservoir 12 and a third reservoir 14. An aquifer 16 has also been identified.

After developing a representative model, the operator may then develop target reservoirs for production, placement of production equipment, all in accordance with the teachings of the present invention. As seen in Fig. 2, after the bore hole has been drilled and the casing string run to the necessary depth, the windows 20, 22, 24, and 26 may be generated from the primary access well bore 2. It should be noted that the drilling rig may be demobilized (taken off) from the platform 4 and a smaller, less expensive, rig may be utilized in order to generate the windows.

The placement of the windows 20, 22, 24 and 26 is dictated by optimum trajectory path of the branch well bores. Thus, the placement of some branch wells is dependent on the location of the reservoirs containing commercial quantities of hydrocarbons, while placement of other branches may be selected for placement of production and process equipment, which will be discussed hereinafter. It should be noted that placement of the path takes into account not only the longitudinal position but also the deviation desired (or lack of deviation desired) for the specific branch. For instance, a production branch with a high deviation may be selected for a horizontal completion and a branch with a substantially vertical inclination is selected for placement of phase separation equipment.

In an alternate embodiment, the windows may be pre-installed in the casing string at the surface. The location of the window segment would be dependent on the same considerations as the placement and generation of the downhole windows--the ultimate targets and optimum placement of the well bore path to the target. In this embodiment, the casing string (with window segment pre-installed) is run into the bore hole, and thus, milling and generation is not necessary.

Referring now to Fig. 3, a first branch well bore 30 and a second branch well bore 32 is depicted. Hence, the steps would include generating from the window 22 a branch well bore 30 that ultimately intersects the second reservoir. As depicted in Fig. 3, the branches 30 and 32 are completed to the reservoirs 12 and 10 at optimum trajectories. The actual productive intervals 34 and 36 of the well branches 30 and 32, respectively, are maximized since they are essentially horizontal. However, the path as generated from the windows 20 and 22 allowed for optimum entry and a proper curvature for leading to the horizontal section.

The method of completing the productive intervals 34 and 36 will consist of normal completion methods such as perforating the branch well casing strings 30 and 32. After the perforating, the well bores 34 and 36 may have placed therein sand control means for preventing the migration of sand into the inner bores of branches 30, 32 as is well known in the art.

As illustrated in Figs. 4A and 4B, the branches 30 and 32 will also contain flow control device means 38 and 40 for controlling the flow of the reservoir fluids and gas into the main access well bore 2. The flow control device means 38, 40 will be placed into a landing profile or landing receptacle 42, 44 respectively. As used in this application, the flow control device means could be a choke means that would allow for a variably reduced flow area, or a valve means having an open position and a closed position, or a check valve means that would be pressure sensitive and allow for flow in one direction but would prohibit flow in the opposite direction. The mechanism and method of placing the flow control valve means 38, 40 into the landing receptacles 42, 44 will described in greater detail later in the application. Fig. 4B depicts the flow control device means 38, 40 within the landing profile 42, 44.

The flow control device means 38, 40 could also have a microprocessor and sensor means operatively associated therewith. The sensor means would sense certain production parameters such as pressure, resistivity, fluid composition, etc. Based on a pre-determined criteria, once the information has been processed and interpreted with the downhole microprocessor control means, the microprocessor would then generate an output signal to the flow control device means which could be to open, close and/or constrict the flow control device means. Moreover, the actual microprocessor could be disposed within the downhole flow control device means, or within a central unit located within one of the branches or even within the main access well bore. The sending of signals downhole to the microprocessor in order to manipulate the control flow devices is also possible. The microprocessor control means may receive and transmit through hard wired connection, acoustically linked, optically linked, etc.

Other types of well branching is certainly possible. For instance, a scenario is illustrated in Fig. 5 wherein the branch well bore 30A has been completed to the hydrocarbon reservoir 12. A second branch well bore 50 has been drilled and completed to the aquifer 16. In the embodiment depicted in Fig. 5, the location of the window has been selected based on the optimum trajectory angles of the branch well bores 30A and 50 in conjunction with the entry and physical placement within the subterranean reservoir 12 and aquifer 16. The branch well bore 30A will be completed 52 to the reservoir 12 as previously described so that the well bore 30A is capable of producing the reservoir's 12 fluids and gas. Further, the branch well bore 50 is similarly completed to the aquifer 16, except that the completion 54 is such that the fluids may be injected via the completion 54 into the aquifer 16.

The branch well bore 30A will have disposed therein a separator means 56 for the separation of the hydrocarbon phase and water phase of the reservoir fluid. Examples of such separators are found in U. S. Patent Nos 4,241,787 and 4,296,810 to Mr. E. Price. Another type of separator is disclosed in "Downhole Oil/Water Separator Development", The Journal Of Canadian Petroleum Technology, Vol. 33, No. 7 (1994) by Peachey and Matthews. Still yet another separator is seen in U. S. Patent 4,766,957 to Mr. McIntyre. Thus, flow from the reservoir enters into the internal diameter of the branch well bore 30A and enters the separator means 56 as shown in Fig. 5. The separator means 56 will separate the water and hydrocarbon phase.

The diverter tubing 58 leads from the separator means 56 to a waste water pump 60 that is sealingly engaged within the branch well bore 50. The waste water pump 60 will be capable of receiving the water which has been separated from the separator means 56 and injecting the water into the aquifer via the completion means 54. An example of a waste water pump 60 is found in the previously mentioned "Downhole Oil/Water Separator

Development", The Journal Of Canadian Petroleum Technology, Vol. 33, No. 7 (1994) by Peachey and Matthews.

The separator means 56 will have extended therefrom the production tubing 62 which will deliver the fluid and natural gas to the main access well bore 2 after separation. Hence, the fluid entering the main access well bore from the production tubing 62 will not contain large amounts of produced water from reservoir 12.

Referring now to Fig. 6, an alternate embodiment depicting a separator means 64 for separating the hydrocarbon phase and water phase of the produced reservoir fluid. The separator means 64 will be sealingly engaged within the main access well bore 2. In the embodiment shown in Fig. 6, the produced reservoir fluids and gas will be produced via the branch well bore 30A from the completion 52. The produced fluids and gas will then be delivered to the main access well bore 2 and will enter the water separator 64 and will be separated into an oil/natural gas phase and a water phase. An example of such a separator was mentioned earlier.

The separator means 64 will have operatively associated therewith a waste water pump 66 that will take the separated water and pump the water via the injection conduit 68 for ultimate injection into the aquifer 16. An example of such a separator and pump was mentioned earlier. It should be noted that a packer 70 is set within the main access well bore 2 so that the flow from the separator is diverted to the branch well bore 50 for ultimate delivery to the completion means 54 and injection into the aquifer 16.

In operation, the reservoir 12 is allowed to produce the reservoir fluids and gas via the branch well bore 30A. The flow from the reservoir will enter the main access well bore 2 and be collected within the separator means 64. The liquid hydrocarbons and natural gas will be delivered to the main access well bore 2 for production to the surface. The water separated therefrom will be pumped down to the completion 54 for injection into the aquifer 16.

A third embodiment of use of separator means is seen in Fig. 7. In this embodiment, the branch well bore 32B extends to the reservoir 10. The reservoir 10 will be an oil reservoir having an oil-water contact represented at 72. The branch well bore 30B will extend into the same reservoir 10, and in particular, will be completed with completion means 74 in the water zone. A separator means 76 for separating the hydrocarbon phase from the in-situ water phase is sealingly engaged within the branch well bore 32B. The separator may be similar to the separator 56.

The separated in-situ water phase is diverted via the diverter tubing 78 to be delivered to the lower annulus 80 of the main access casing 2. The diverter tubing 78 will be disposed within a packer means 82 for sealingly engaging the main access well bore 2. The separated oil and natural gas will be delivered to the production tubing 84 for ultimate production to the surface. Thus, the in-situ water will be disposed of within the reservoir 10, and more particularly, within the water zone. This will have the beneficial effect of maintaining pressure within the reservoir 10 as well as initiating secondary recovery via this modified water flood.

With reference to Fig. 8, another embodiment of the present invention depicts the branch well bore 32C being completed 86 to the reservoir 10. In this particular embodiment, the reservoir 10 has a gas cap with the gas-oil contact represented at 88. The branch well bore 30C extends into the same reservoir 10, and in particular into the oil zone, with the completion means 90 allowing the hydrocarbon fluids and gas to flow into the branch well bore 30C. Ultimately, the flow proceeds into the main access well bore's lower annulus 92. The lower annulus will have disposed therein a packer means 94 for sealingly engaging the main access well bore 2. Extending from the packer means 94 will be the diverter tubing 96 that is operatively connected to a separator means 98 for separating the fluids and gas. The separator means 98 will have connected thereto a pump means 100 that will pump the separated gas via the branch 32C and completion 86 into the gas cap so that the produced gas is recycled into the reservoir 10. Pressure maintenance may be important for several reasons including maintaining the reservoir pressure above the bubble point pressure. Leading from the separator means 98 will be a production tubing 102 for delivery to the surface. The pump may also be used to assist in delivery of oil to surface.

Fig. 9A shows another embodiment possible with the disclosure of the present invention in order to produce hydrocarbons. In this embodiment, the main access well bore 2 has two branch wells extending therefrom with the branch 32D being completed with completion means 104 to the reservoir 10 which in this embodiment will be an oil reservoir. The branch well bore 106 will be completed with the completion means 108 to the reservoir 14 which in this case is a gas reservoir. A diverter tubing 110 will extend to the commingling assembly 112.

The branch well bore 106 will contain flow control device means 114 for regulating the flow of natural gas from the reservoir 14. The flow control means 114 will be seated within the branch well bore 106 and will have disposed therein a valve means 115. A diverter tubing 116 will lead to the commingling assembly 112.

The flow control device means 114, 115 may be a pressure sensitive device that would allow natural gas to enter into the diverter tubing and ultimately into the commingling assembly 112. It may also be controlled utilizing the previously discussed microprocessor control means. The intermittent flow of natural gas will allow for the lifting of reservoir fluids into the production tubing 118. This is particularly useful when the pressure of reservoir 10 becomes sufficiently depleted that the reservoir pressure is no longer capable of supplying sufficient lifting capacity of the reservoir fluids.

Referring now to Fig. 9B, an enlargement of the commingling assembly 112 is shown. It should be noted that the commingling assembly used herein was described in Figs. 9A-9C of U. S. Patent 5,322,127, assigned to applicant, and is incorporated herein by reference. Referring to Fig. 9B, the main access well bore 2 has been placed within the bore hole 120 and thereafter set into a cement annulus 122 as is well understood by those of ordinary skill in the art. The commingling assembly 112 generally consist of an enlarged section having a first input 124 and a second input 126 that is disposed within an extendable completion 86 into the gas cap so that the produced gas is recycled into the reservoir 10. Pressure maintenance may be important for several reasons including maintaining the reservoir pressure above the bubble point pressure. Leading from the separator means 98 will be a production tubing 102 for delivery to the surface. The pump may also be used to assist in delivery of oil to surface.

Fig. 9A shows another embodiment possible with the disclosure of the present invention in order to produce hydrocarbons. In this embodiment, the main access well bore 2 has two branch wells extending therefrom with the branch 32D being completed with completion means 104 to the reservoir 10 which in this embodiment will be an oil reservoir. The branch well bore 106 will be completed with the completion means 108 to the reservoir 14 which in this case is a gas reservoir. A diverter tubing 110 will extend to the commingling assembly 112.

The branch well bore 106 will contain flow control device means 114 for regulating the flow of natural gas from the reservoir 14. The flow control means 114 will be seated within the branch well bore 106 and will have disposed therein a valve means 115. A diverter tubing 116 will lead to the commingling assembly 112.

The flow control device means 114, 115 may be a pressure sensitive device that would allow natural gas to enter into the diverter tubing and ultimately into the commingling assembly 112. It may also be controlled utilizing the previously discussed microprocessor control means. The intermittent flow of natural gas will allow for the lifting of reservoir fluids into the production tubing 118. This is particularly useful when the pressure of reservoir 10 becomes sufficiently depleted that the reservoir pressure is no longer capable of supplying sufficient lifting capacity of the reservoir fluids.

Referring now to Fig. 9B, an enlargement of the commingling assembly 112 is shown. It should be noted that the commingling assembly used herein was described in Figs. 9A-9C of U. S. Patent 5,322,127, assigned to applicant, and is incorporated herein by reference. Referring to Fig. 9B, the main access well bore 2 has been placed within the bore hole 120 and thereafter set into a cement annulus 122 as is well understood by those of ordinary skill in the art. The commingling assembly 112 generally consist of an enlarged section having a first input 124 and a second input 126 that is disposed within an extendable key and gauge ring member 128 of the commingling assembly 112. The commingling assembly also includes a swivel assembly 129 that is operatively associated with the production tubing 118.

The first input section 124 is connected to the diverter tubing 116 and the second input 126 is connected to an intermediate tube 130 that has at one end a set of seal members 132 that will sealingly engage with a polished bore receptacle 134. The polished bore receptacle is contained on one end of the diverter tubing 110. Also contained on the diverter tubing 110 is the centralizers 136.

A packer 138, which may be a hydraulic or mechanical type of packer, for sealingly engaging the main access well bore 2 is provided. As contained within the main access well bore 2 is the whip stock diverter 140 that is used for generation of the window 20. Thus, the completion 104 is isolated from the completion 108.

Another embodiment of the present invention is depicted in Fig. 10. In this embodiment, the branch well bore 106A will extend to the reservoir 14 which will be a hydrocarbon bearing reservoir. The branch well bore 106A will be completed via the completion means 108A for allowing the flow of hydrocarbon fluids and gas to flow from the reservoir 14 through the completion means 108A and into the well bore 106A for ultimate production to the surface.

A second branch well bore 32E has also been provided, but unlike the previous branch well bores 32-32D, the branch well bore 32E will not necessarily intersect a reservoir. Thus, as shown in Fig. 10, the branch well bore 32E extends from the main access well bore 2 at an optimum angle so that chemical treatment facilities means 160 for treating the reservoir fluids and gas produced from the reservoir 14.

In this embodiment, the main access well bore 2 will have contained therein a production tubing 162 with the production tubing string being operatively associated therewith a production packer 164 which will form a lower annulus 166 and an upper annulus 168. Hence, as the reservoir fluids and gas enter into the lower annulus 166, production to the surface will be via the route of the production tubing 162.

The chemical treatment facilities means could have different types of chemicals, with the necessary injector capacity in order to introduce the specific chemical (or chemicals) into the lower annulus 166 for ultimate mixing and exposure to the reservoir fluids and gas production. A metering device may also be included in order to introduce a precise amount of chemical. In one type of chemical treatment, the treatment may be to prevent the formation of hydrates within the lower annulus 166 and within the production string 162 and into the surface facilities (not shown). Some other types of chemicals that may be placed within the treatment branch well bore 32E include corrosion inhibitors for the prevention of corrosion in the down hole and surface tubular. Also, a paraffin inhibitor may be placed within branch 32E for the deterrence of paraffin precipitation within the tubing 162 and surface facilities. By mixing the treatment chemical with the reservoir fluids and gas downhole, certain benefits are obtained such as introduction of hydration inhibition chemicals prior to reaching uphole pressure and temperature which would promote formation of hydrate plugging. Another benefit is that intermittent down hole injection correlated to shut-downs of the system will permit loading of flow lines and other deposition prone areas with the treated (inhibited) produced fluids.

The method and apparatus of landing the treatment means within the branch well bore 32E may essentially consist of landing a packer 170 within the well bore 32E, with the packer having extending therefrom a tail pipe section 172 with the tail pipe section having attached thereto the treatment means 160. It should be noted that the quantity of chemical actually stored may be a finite amount; however, since the branch well bore 32E may extend for several thousand feet from the main access well bore, the quantity held within this chemical facilities means can be quite significant.

Referring now to Fig. 11, another embodiment is disclosed that shows the use of multiple process/treatment branches. The branch well bore 30D will be completed to the hydrocarbon reservoir 12 via the completion means 174 for producing the reservoir's 12 fluids and gas. Also extending from the main access well bore 2 will be the branch well bore 176 that will have contained therein process equipment 178 such as water separation means and injection means as previously described.

A third branch well bore 180 may also extend from the main access well bore 2. The well bore 176 may contain process equipment 182 which in one embodiment may be a catalyst bed to crack the hydrocarbon fluids produced from the reservoir 12 via the completion means 171. The benefit of such a treatment process is that the modified hydrocarbon molecular composition may be less likely to wax or build up paraffin deposit in the down hole tubular as well as the surface facilities.

Thus, the branch 30D will contain a packer 184 for sealingly engaging the branch 30D. Extending from the packer will be the diverter tubing 186 which will extend to the branch well bore 176 and in particular for the separation with the separation means 178 of the reservoir fluids and gas as previously set out in Figs. 5, 6, and 7. The hydrocarbon fluid and gas will then be transferred via the diverter tubing 188 to the process equipment 182 for catalyzing and cracking the hydrocarbon molecular structure. After appropriate treatment, the fluid and gas stream will be delivered via the diverter tubing 190.

The main access well bore 2 will have disposed therein a packer 192 which will create a lower annulus 194 and an upper annulus 196. The packer 192 will have extending therefrom the production tubing 198. The diverter tubing will deliver the hydrocarbon stream to the production tubing 198 for transporting to the surface as is well known in the art.

Referring now to Fig. 12, a schematic illustration of a type of sealing means for sealing a branch well bore from the main access well bore with a tail pipe extension is shown. In the embodiment shown, the branch well bore may be the branch well bore 32 depicted in Fig. 4 that extends from the main access well bore 2. The packer means 202 for sealingly engaging the branch well bore 32 is commercially available from Baker Hughes Incorporated and sold under the packer model number "SC-1". The packer means 202 has internal bore 204 that will have disposed therein a tail pipe 206. The tail pipe 206 will extend below the packer 202 as least partially to the productive interval. The tail pipe 206 will have contained therein a landing profile 208 for landing an apparatus, such as a plug, orifice, plug, pressure probe, or other production monitoring sensor. Another apparatus that is possible to land into the landing profile 208 is latch placement of operatively associated production equipment such as the three-phase separator, chemical injection or catalytic/reactor devices.

Fig. 13 depicts the packer means 202 of Fig. 12 with the tail pipe 206 extending therefrom. The embodiment of Fig. 13 has a control means 210 for controlling the production into the main access well bore 2. In the embodiment shown, a choke is provided which is a variably controlled valve that will cause a pressure drop at the point of orifice restriction that is well known in the art. The purpose of having the down hole choke is that production from the reservoir is restricted to a limited extent because of the pressure drop created at the restriction. The pressure drop may be used to balance production from several of the open zones, i.e. assist in commingling. Also, the choke may be used for regulating the amount of lift gas from a zone as in Fig. 9A so as to optimize oil production while not unnecessarily depleting the hydrocarbons and pressure available from the reservoir.

Yet another embodiment is shown in Fig. 14. A branch well bore 214 extends from a window section 216 of the main access well bore 218. This particular branch well bore 214 will have a series of perforations 220 that communicate the internal diameter of the branch well bore 214 with the reservoir 222. The branch well bore will also contain landing profiles 224 and 226. As depicted in Fig. 14, a control valve means 228 for opening and closing the branch well bore 214 from communication with the main access well bore 218 is provided. The control valve means is operable between an open position and a closed position. The control valve 228 is retrievable and resettable. The landing profile 226 is generally a back-up profile landing receptacle for a plug. These type of landing profiles 224, 226 are generally incorporated into the casing strings 214.

Changes and modifications in the specifically described embodiments can be carried out without departing from the scope of the invention which is intended to be limited only by the scope of the appended claims.

CLAIMS:

1. A method for recovering hydrocarbons from subterranean formations, having at least one producing zone and one disposal zone, through a multilateral well bore having at least one branch well bore, wherein the method comprises:

extending a primary access well bore from a surface location to a downhole location, the primary access well bore having a first flow passage to a subterranean reservoir;

intersecting the primary access well bore with a branch well bore having a second flow passage to a subterranean reservoir with one of the flow passages being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;

delivering production fluids from the producing zone to a subterranean processing unit located within the multilateral wellbore;

processing the production fluids in the subterranean processing unit which comprises a fluids separator for separating the production fluids into a hydrocarbon production phase and a in-situ disposal phase;

delivering the hydrocarbon production phase from the subterranean processing unit to the surface through the primary access wellbore; and

delivering and re-injecting the in-situ disposal phase from the subterranean processing unit into the disposal zone through the flow passage in fluid communication with the disposal zone.

2. The method as set forth in claim 1, wherein the production fluids are separated with a fluids separator selected from the group consisting of a centrifugal-type separator, a cyclone-type separator and a rotating-bowl separator.

3. The method as set forth in claim 1, wherein

the production fluids are separated with a two-phase fluids separator selected from the group consisting of a liquid-gas separator and a liquid-liquid separator.

4. The method as set forth in claim 3 wherein the production fluids are selected from the group consisting of:

a liquid hydrocarbon production phase and a gas hydrocarbon production phase;

a liquid hydrocarbon production phase and a in-situ water disposal phase; and

a gas hydrocarbon production phase and a in-situ water disposal phase.

5. The method as set forth in claim 1 further comprises: locating the subterranean processing unit in the primary access well bore.

6. The method as set forth in claim 1 further comprises: locating the subterranean processing unit in a branch well bore.

7. The method as set forth in claim 1 further comprises: providing a flow control apparatus in at least one of the flow passages.

8. The method as set forth in claim 1 further comprises: providing a subterranean processing unit which further comprises a submersible pump assembly for delivering the hydrocarbon production phase to the surface and for re-injecting the in-situ disposal phase in the disposal zone.

9. The method as set forth in claim 1 further comprises: intersecting the primary access well bore with a further branch well bore having a flow passage in fluid communication between the subterranean processing unit and a subterranean reservoir with a second disposal zone

for delivering at least a portion of the in-situ disposal phase therein.

10. The method as set forth in claim 9, wherein

separating the production fluids in a three-phase fluids separator into a liquid hydrocarbon production phase, a gas hydrocarbon production phase and an in-situ water disposal phase.

11. The method as set forth in claim 10, further comprises:

delivering the liquid hydrocarbon and the gas hydrocarbon production phases, separately, to the surface through the primary access well bore from subterranean processing unit; and

delivering and re-injecting the in-situ water disposal phase into a second disposal zone from subterranean processing unit.

12. The method as set forth in claim 11 further comprises:

pumping each separated phase of the production fluids with a pump assembly to maintain sufficient reservoir pressure above a bubble point in the producing and disposal zones.

13. The method as set forth in claim 1 further comprises:

intersecting the primary access well bore with a further branch well bore having a flow passage for delivery of a treating chemical that is in fluid communication between a chemical storage zone within a multilateral well bore and the subterranean processing unit;

delivering the treating chemical from the surface location to the chemical storage zone and storing the treating chemical;

delivering production fluids from the producing zones to the subterranean processing unit;

delivering the treating chemical to the subterranean processing unit for treating the hydrocarbon production phase;

treating the hydrocarbon production phase from the subterranean processing unit with a treating chemical; and

delivering the treated hydrocarbon production phase to the surface through the primary access well bore from the subterranean processing unit.

14. A well bore system for recovering hydrocarbons from subterranean formations, having at least one producing zone and at least one disposal zone, through a multilateral well bore having at least one branch well bore comprising:

a primary access well bore extending from a surface location to a downhole location, the primary access well bore having a first flow passage to a subterranean reservoir;

a first branch well bore intersecting the primary access well bore having a second flow passage to a subterranean reservoir with one of the flow passages being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;

a subterranean processing unit located within the well bore system which comprises a fluids separator for separating the production fluids received from a producing zone into a hydrocarbon production phase which is delivered to the surface and a in-situ disposal phase which is re-injected into a disposal zone; and

whereby the primary access well bore, the branch wellbore and the subterranean processing unit together form the well bore system for producing, separating and delivering production fluids in a multilateral well bore.

15. The fluids separator as set forth in claim 14 is selected from the group consisting of a centrifugal-type separator, a cyclone-type separator and a rotating-bowl

separator.

16. The well bore system as set forth in claim 14 further comprises:
a flow control apparatus located in a flow passage.

17. The well bore system as set forth in claim 14 wherein:
the subterranean processing unit is located in the primary access wellbore.

18. The well bore system as set forth in claim 14 wherein:
the subterranean processing unit is located in a branch wellbore.

19. The subterranean processing unit in the well bore system as set forth in claim 14 further comprises:
a submersible pump assembly for delivering the hydrocarbon production phase to the surface while reinjecting the in-situ disposal phase to the disposal zone.

20. The well bore system as set forth in claim 14 further comprises:
a further branch well bore intersecting the primary access well bore having a third flow passage to a subterranean reservoir with two of the flow passages each being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;
a commingling assembly located within the multilateral well bore and operatively associated with the flow passages for commingling the hydrocarbon production phases from each producing zone to thus deplete a hydrocarbon field more efficiently; and
whereby the primary access well bore, the branch wellbores and the subterranean processing unit together form the well bore system for

producing, separating and delivering production fluids multiple producing zones in a multilateral well bore.

21. The separator of the well bore system as set forth in claim 14 further comprises:

A) a housing with an inlet for receiving the production fluids and at least two outlets for discharging the production fluids after separation;

a) a shaft axially mounted with the housing;

b) a plurality of disk stages operatively associated with the shaft for separating the production fluids;

c) a motor operatively associated with the shaft.

22. The disk stages in the separator as set forth in claim 21 comprise:

disks having a generally conical shape to impart varying centrifugal forces to the production fluids along its radial diameter to thereby effect separation of the production fluids into the hydrocarbon production phase and the in-situ disposal phase .

23. The separator as set forth in claim 22 further comprising:

a rotating inner bowl within the housing operatively associated with the disk stages to thereby impart varying centrifugal forces to the production fluids to effect further separation of the production fluids into the hydrocarbon production phase and the in-situ disposal phase.

24. A method for recovering hydrocarbons from subterranean formations, having at least one producing zone and one disposal zone, through a multilateral well bore having at least one branch well bore, wherein the method comprises:

extending a primary access well bore from a surface location to a downhole location;

intersecting the primary access well bore with a first branch well bore having a first flow passage to a subterranean reservoir;

intersecting the primary access well bore with a second branch well bore having a second flow passage to a subterranean reservoir with one of the flow passages being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;

delivering production fluids from the producing zone to a subterranean processing unit located within the multilateral wellbore;

processing the production fluids in the subterranean processing unit comprising a fluids separator for separating the production fluids into a hydrocarbon production phase and a in-situ disposal phase;

delivering the hydrocarbon production phase from the subterranean processing unit to the surface through the primary access wellbore; and

delivering and re-injecting the in-situ disposal phase from the subterranean processing unit into the disposal zone through the flow passage in fluid communication with the disposal zone.

25. A method for treating recovered hydrocarbons from subterranean formations through a well bore, wherein the method comprises:

providing a primary access well bore which extends from a surface location to a downhole location and which is in fluid communication with a producing zone;

intersecting the primary access well bore with a first branch well bore extending outwardly;

delivering and storing a treating chemical from the surface location to a chemical storage zone in the first branch well bore;

delivering production fluids from the producing zone to a subterranean processing unit;

delivering treating chemicals to the subterranean processing unit for treating the production fluids;

processing the production fluids in the subterranean processing unit which comprises a chemical treating apparatus; and

delivering the treated production fluids to the surface through the primary access well bore from the subterranean processing unit.

26. The method as set forth in claim 25 further comprises:

inserting an impermeable liner in the first branch well bore for storing the treating chemicals.

27. The method as set forth in claim 25 further comprises:

treating the production fluids with treating chemicals selected from a group consisting of a hydrate inhibitor, a corrosion inhibitor, a paraffin wax inhibitor, a scale inhibitor, a hydrogen sulfide scavenger and an emulsion breaker.

28. The method as set forth in claim 25 further comprises:

treating production fluids in a multilateral well bore with more than one producing zone.

29. The method as set forth in claim 28 further comprises:

providing a second branch well bore in a multilateral well bore for storing a processing apparatus comprising a catalyst bed for cracking the production fluids so as to prevent paraffin wax build-up in a production string located in the primary access well bore;

delivering the production fluids to the second branch well bore to the processing apparatus for cracking and catalyzing the production fluids; and

delivering the treated production fluids to the surface through the production string in the primary access well bore.

30. A well bore system for recovering treated hydrocarbons from a subterranean formation comprising:

a primary access well bore extending from a surface location to a downhole location, the primary access well bore having fluid communication with a producing zone in a subterranean reservoir;

a first branch well bore intersecting the primary access well bore and being in fluid communication with primary access well bore;

a subterranean processing unit located within the first branch well bore comprising a chemical treating apparatus for treating production fluids received from the producing zone and which is then delivered to the surface after being treated; and

whereby the primary access well bore, the branch wellbore and the subterranean processing unit together form the well bore system for producing, treating and delivering production fluids.

31. A method of drilling a multilateral well bore system for producing hydrocarbons, the method comprising the steps of:

a) drilling a primary access well bore from a surface location to a downhole location;

b) measuring at least one subterranean reservoir property relative to the primary access well bore with a sensing device in the primary access well bore;

c) determining a juncture location between a branch well bore and the primary access well bore with the property measured by the sensing device whereby an optimum branch well bore trajectory to a producing zone is attained for enhanced hydrocarbon production;

d) forming a juncture in the primary access well bore for the branch well bore at a depth, azimuth and dip in alignment with the optimum branch well bore trajectory; and

e) drilling the branch well bore through the juncture to extend outwardly to the producing zone along the optimum branch well bore trajectory.

32. The method of claim 31 further comprising:

a) perforating the branch well bore to thereby be in fluid communication with the producing zone;

b) inserting a slotted liner in the branch wellbore;

c) inserting a flow control device in the branch wellbore;

d) delivering production fluids from the producing zone;

e) monitoring the production of production fluids in the branch wellbore;

f) controlling the flow control device in the branch well bore to vary flow of the production fluids; and

g) controlling the flow of production fluids by manipulating the flow control device as determined by a sensor located in the branch wellbore.

AMENDED CLAIMS

[received by the International Bureau on 09 September 1996 (09.09.96); original claims 1-32 amended new claims 33-44 added; remaining claims unchanged (12 pages)].

1. A method of drilling a plurality of wellbores with a drill string containing a sensor device for sensing subterranean properties of hydrocarbon reservoirs, the method comprising:
   -drilling a primary access wellbore;
   -measuring at least one subterranean property of the hydrocarbon reservoirs from said primary access wellbore with the sensor device;
   -developing a subterranean model of the hydrocarbon reservoirs;
   -developing, using the subterranean model, an optimum trajectory path from the primary access wellbore to a first target reservoir and a second target reservoir for placement of a first branch completion equipment and a second branch completion equipment.

2. The method of claim 1 further comprising:
   -placing a primary access casing in said primary access well bore;
   -cutting a first window section in said primary access casing leading to the first target reservoir;
   -cutting a second window section in said primary access casing leading to the second target reservoir.

3. The method of claim 2 wherein a remedial work over unit is mobilized, and the method further comprises:
   -drilling, utilizing said first window, a branch wellbore to said first target reservoir;
   -drilling, utilizing said second window, a branch wellbore to said second target reservoir.

4. The method of claim 3 further comprising:
   -completing construction of the branch wellbore to said first target reservoir with completion equipment;

-completing construction of the branch wellbore to said second target reservoir with completion equipment.

5. The method of claim 4 further comprising [the steps of]:

-placing a first valve device in the branch wellbore to the first target reservoir for variably controlling the flow from said branch wellbore;

-placing a second valve device in the branch wellbore to the second target reservoir for variably controlling the flow from said branch wellbore.

6. The method of claim 5 wherein each of said first and second valve devices further comprises a sensor device for sensing a production parameter of the target reservoirs, and wherein the method further comprises:

-producing a hydrocarbon from said branch wellbore to the first target reservoir;

-monitoring the production parameter of said branch wellbore to said first target reservoir;

-positioning said first valve device in a closed position from an open position when the production of hydrocarbon drops below a predetermined parameter level;

-positioning said second valve device in an open position from a closed position so that a hydrocarbon is produced from said branch wellbore to said second target reservoir;

-monitoring the production parameter of said branch wellbore to said first target reservoir;

-positioning said second valve device in the closed position when the production parameter of said branch wellbore to the first target reservoir rises to a predetermined level;

-positioning said first valve device in the open position when the production parameter of said branch wellbore to the first target reservoir rises to a predetermined level.

7. The method of claim 6 wherein each of said first and second valve devices have operatively associated therewith a control device for receiving an output signal from said sensor device in each of the valve devices and wherein the control device generates a transmission signal in order to control the position of said first and second valves, and wherein the method of positioning said valve devices comprises:

-receiving the data signal from said sensor in each of the first and second valve devices;

-processing the data signal received from each of the first and second valve devices with said control device;

-transmitting an output signal to each of said first and second valve devices in response to the data signal so that each of said first and second valve devices are appropriately positioned.

8. The method of claim 3 wherein drilling said first and second branch well bores is completed by a drilling rig, and wherein the method further comprises:

-demobilizing said rotary rig;

-mobilizing a remedial work over unit;

-reentering said first branch well bore;

-drilling, with said remedial work over unit, an extended well bore intersecting said first target reservoir.

9. The method of claim 8 further comprises:

-reentering said second branch well bore;

-drilling, with said remedial work over unit, an extended well bore intersecting said second target reservoir.

10. A method for recovering hydrocarbons from subterranean formations, having at least one producing zone and one disposal zone, through a multilateral well bore having at least one branch well bore, wherein the method comprises:

-extending a primary access well bore from a surface location to a downhole location, the primary access well bore having a first flow passage to a subterranean reservoir;

-intersecting the primary access well bore with a branch well bore having a second flow passage to a subterranean reservoir with one of the flow passages being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;

-delivering production fluids from the producing zone to a subterranean processing unit located within a branch wellbore;

-processing the production fluids in the subterranean processing unit which comprises a fluids separator for separating the production fluids into a hydrocarbon production phase and a in-situ disposal phase;

-delivering the hydrocarbon production phase from the subterranean processing unit to the surface through the primary access wellbore; and

-delivering and re-injecting the in-situ disposal phase from the subterranean processing unit into the disposal zone through the flow passage in fluid communication with the disposal zone.

11. The method as set forth in claim 10, wherein

-the production fluids are separated with a two-phase fluids separator selected from the group consisting of a liquid-gas separator and a liquid-liquid separator.

12. The method as set forth in claim 11 wherein

-the production fluids are selected from the group consisting of:

-a liquid hydrocarbon production phase and a gas hydro-carbon production phase;

-a liquid hydrocarbon production phase and a in-situ water disposal phase; and

-a gas hydrocarbon production phase and a in-situ water disposal phase.

13. The method as set forth in claim 10 further comprises:

-locating the subterranean processing unit in the branch well bore in - fluid communication with a producing zone or a disposal zone.

14. The method as set forth in claim 10 further comprises:

-providing a flow control apparatus in at least one of the flow passages.

15. The method as set forth in claim 10 further comprises:

-providing a subterranean processing unit which further comprises a submersible pump assembly for delivering the hydrocarbon production phase to the surface and for re-injecting the in-situ disposal phase in the disposal zone.

16. The method as set forth in claim 10 further comprises:

-intersecting the primary access well bore with a further branch well bore having a flow passage in fluid communication between the subterranean processing unit and a subterranean reservoir with a second disposal zone for delivering at least a portion of the in-situ disposal phase therein.

17. The method as set forth in claim 16, wherein

-separating the production fluids in a three-phase fluids separator into a liquid hydrocarbon production phase, a gas hydrocarbon production phase and an in-situ water disposal phase.

18. The method as set forth in claim 17, further comprises:

-delivering the liquid hydrocarbon and the gas hydrocarbon production phases, separately, to the surface through the primary access well bore from subterranean processing unit; and

-delivering and re-injecting the in-situ water disposal phase into a second disposal zone from subterranean processing unit.

19. The method as set forth in claim 18 further comprises:

-pumping each separated phase of the production fluids with a pump assembly to maintain sufficient reservoir pressure above a bubble point in the producing and disposal zones.

20. The method as set forth in claim 10 further comprises:

-intersecting the primary access well bore with a further branch well bore having a flow passage for delivery of a treating chemical that is in fluid communication between a chemical storage zone within a multilateral well bore and the subterranean processing unit;

-delivering the treating chemical from the surface location to the chemical storage zone and storing the treating chemical;

-delivering production fluids from the producing zones to the subterranean processing unit;

-delivering the treating chemical to the subterranean processing unit for treating the hydrocarbon production phase;

-treating the hydrocarbon production phase from the subterranean processing unit with a treating chemical; and

-delivering the treated hydrocarbon production phase to the surface through the primary access well bore from the subterranean processing unit.

21. A well bore system for recovering hydrocarbons from subterranean

AMENDED SHEET (ARTICLE 19)

formations, having at least one producing zone and at least one disposal zone, through a multilateral well bore having at least one branch well bore comprising:

-a primary access well bore extending from a surface location to a downhole location, the primary access well bore having a first flow passage to a subterranean reservoir;

-a first branch well bore intersecting the primary access well bore having a second flow passage to a subterranean reservoir with one of the flow passages being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;

-a subterranean processing unit located within a branch well bore which comprises a fluids separator for separating the production fluids received from a producing zone into a hydrocarbon production phase which is delivered to the surface and a in-situ disposal phase which is re-injected into a disposal zone; and

-whereby the primary access well bore, the branch wellbore and the subterranean processing unit together form the well bore system for producing, separating and delivering production fluids in a multilateral well bore.

22. The well bore system as set forth in claim 21 further comprises:

-a flow control apparatus located in a flow passage.

23. The well bore system as set forth in claim 21 wherein:

-the subterranean processing unit is located in the branch wellbore in fluid communication with a producing zone or a disposal zone.

24. The subterranean processing unit in the well bore system as set forth in claim 21 further comprises:

-a submersible pump assembly for delivering the hydrocarbon production phase to the surface while reinjecting the in-situ disposal phase to the disposal zone.

25. The well bore system as set forth in claim 21 further comprises:

-a further branch well bore intersecting the primary access well bore having a third flow passage to a subterranean reservoir with two of the flow passages each being in fluid communication with a producing zone and the other passage being in fluid communication with a disposal zone;

-a commingling assembly located within the multilateral well bore and operatively associated with the flow passages for commingling the hydrocarbon production phases from each producing zone to thus deplete a hydrocarbon field more efficiently; and

-whereby the primary access well bore, the branch wellbores and the subterranean processing unit together form the well bore system for producing, separating and delivering production fluids multiple producing zones in a multilateral well bore.

26. A method for treating recovered hydrocarbons from subterranean formations through a well bore, wherein the method comprises:

-providing a primary access well bore which extends from a surface location to a downhole location and which is in fluid communication with a producing zone;

-intersecting the primary access well bore with a first branch well bore extending outwardly;

-delivering and storing a treating chemical from the surface location to a chemical storage zone in the first branch well bore;

delivering production fluids from the producing zone to a subterranean processing unit;

-delivering treating chemicals to the subterranean processing unit

for treating the production fluids;
-processing the production fluids in the subterranean processing unit which comprises a chemical treating apparatus; and delivering the treated production fluids to the surface through the primary access well bore from the subterranean processing unit.

27. The method as set forth in claim 26 further comprises:
-inserting an impermeable liner in the first branch well bore for storing the treating chemicals.

28. The method as set forth in claim 26 further comprises:
-treating the production fluids with treating chemicals selected from a group consisting of a hydrate inhibitor, a corrosion inhibitor, a paraffin wax inhibitor, a scale inhibitor, a hydrogen sulfide scavenger and an emulsion breaker.

29. The method as set forth in claim 26 further comprises:
-treating production fluids in a multilateral well bore with more than one producing zone.

30. The method as set forth in claim 29 further comprises:
-providing a second branch well bore in a multilateral well bore for storing a processing apparatus comprising a catalyst bed for cracking the production fluids so as to prevent paraffin wax build-up in a production string located in the primary access well bore;
-delivering the production fluids to the second branch well bore to the processing apparatus for cracking and catalyzing the production fluids; and
-delivering the treated production fluids to the surface through the production string in the primary access well bore.

31. A method for producing hydrocarbons from a producing zone, comprising:

(a) forming a primary wellbore substantially in a non-producing formation;

(b) drilling a branch wellbore into the producing zone for producing hydrocarbons therefrom, said branch wellbore intersecting the primary wellbore;

(c) forming a sealed junction at the intersection of the primary wellbore and the branch wellbore, said junction formed entirely within the non-producing zone; and

(d) producing the hydrocarbons from the producing zone by flowing such hydrocarbons through the primary wellbore.

32. The method of claim 31 further comprising placing a flow control device in the branch wellbore for controlling the flow of the hydrocarbons from the producing zone into the primary wellbore.

33. The method of claim 31, wherein the primary wellbore is substantially free of equipment which is not utilized for flowing hydrocarbons through the primary wellbore.

34. A method for producing hydrocarbons from a producing zone, comprising:

(a) forming a primary wellbore;

(b) forming a first branch wellbore into the producing zone for producing a fluid therefrom, said first branch wellbore intersecting the primary wellbore; and

(c) forming a second branch wellbore from the primary wellbore for treating the fluid from the producing zone to alter a property of the fluid produced from the producing zone.

35. A method for producing hydrocarbons from a producing zone, comprising:

(a) forming a primary wellbore;

(b) forming a first branch wellbore into the producing zone for producing the hydrocarbons;

(c) forming a second branch wellbore from the primary wellbore for treating the hydrocarbons to initiate a change in a property of the hydrocarbons; and

(d) passing the hydrocarbons from the first branch wellbore into the second branch wellbore to initiate the change in a property of the fluid passed into the second branch wellbore.

36. The method of claim 35, wherein the second branch wellbore contains equipment for initiating the change in the property of the hydrocarbons.

37. The method of claim 36, wherein the property of the hydrocarbons changed is a physical property.

38. The method of claim 36, wherein the property of the hydrocarbons changed is a chemical property.

39. The method of claim 35, wherein the second branch wellbore contains a chemical for initiating the change in the property of the hydrocarbons.

40. A method for producing a hydrocarbon from a sub-surface reservoir, comprising:

(a) forming a primary wellbore;

(b) forming a first branch wellbore into the reservoir for producing the hydrocarbon therefrom; and

(c) converting the hydrocarbon produced from first branch wellbore downhole into a refined material having chemical structure that is different from the hydrocarbon produced from the reservoir.

41. The method as specified in claim 40, wherein the conversion of the hydrocarbon is done in a second branch wellbore formed from the primary wellbore.

42. The method as specified in claim 41, wherein the primary wellbore is formed substantially in a non-hydrocarbon bearing formation.

43. The method as specified in claim 41, wherein the conversion is done by processing the hydrocarbon with a chemical stored in the second branch wellbore.

44. A method for producing hydrocarbons from a producing zone, comprising:

(a) forming a primary wellbore;

(b) forming a branch wellbore into the producing zone for producing the hydrocarbons;

(c) producing hydrocarbons from the producing zone via the branch wellbore; and

(d) compressing vapors present in the hydrocarbons produced from the producing zone by a compressor placed downhole.

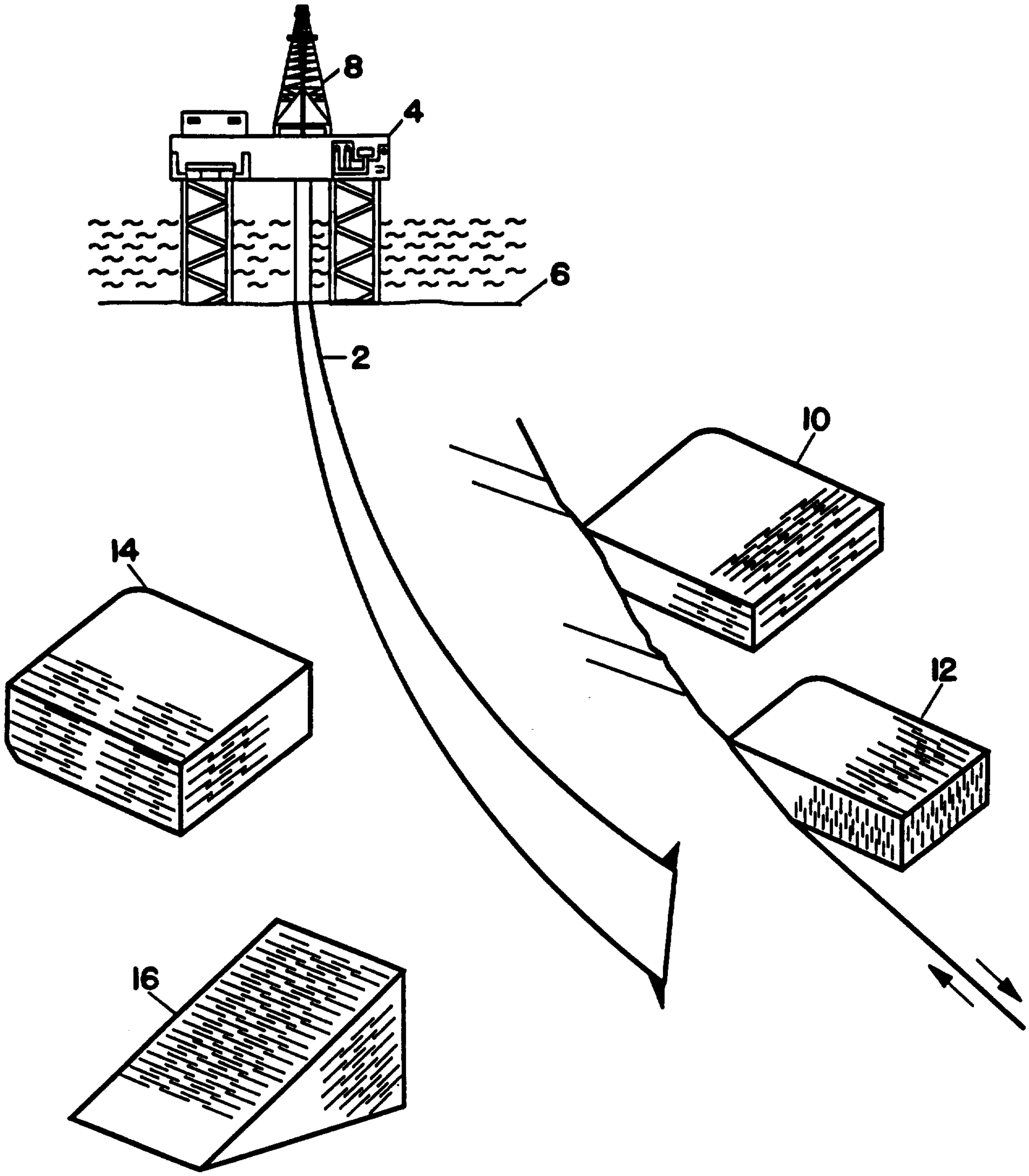


FIG. 1

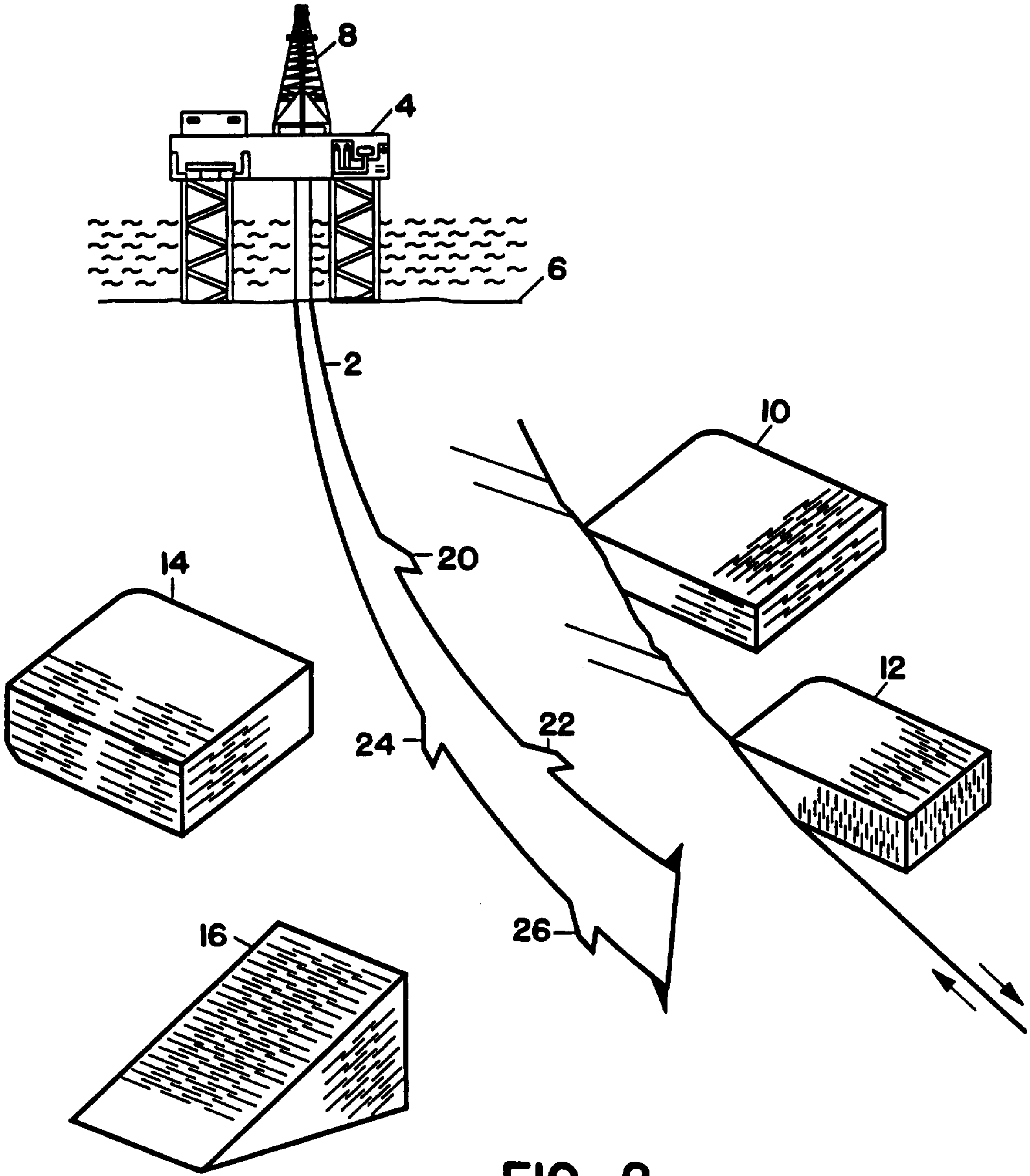


FIG. 2

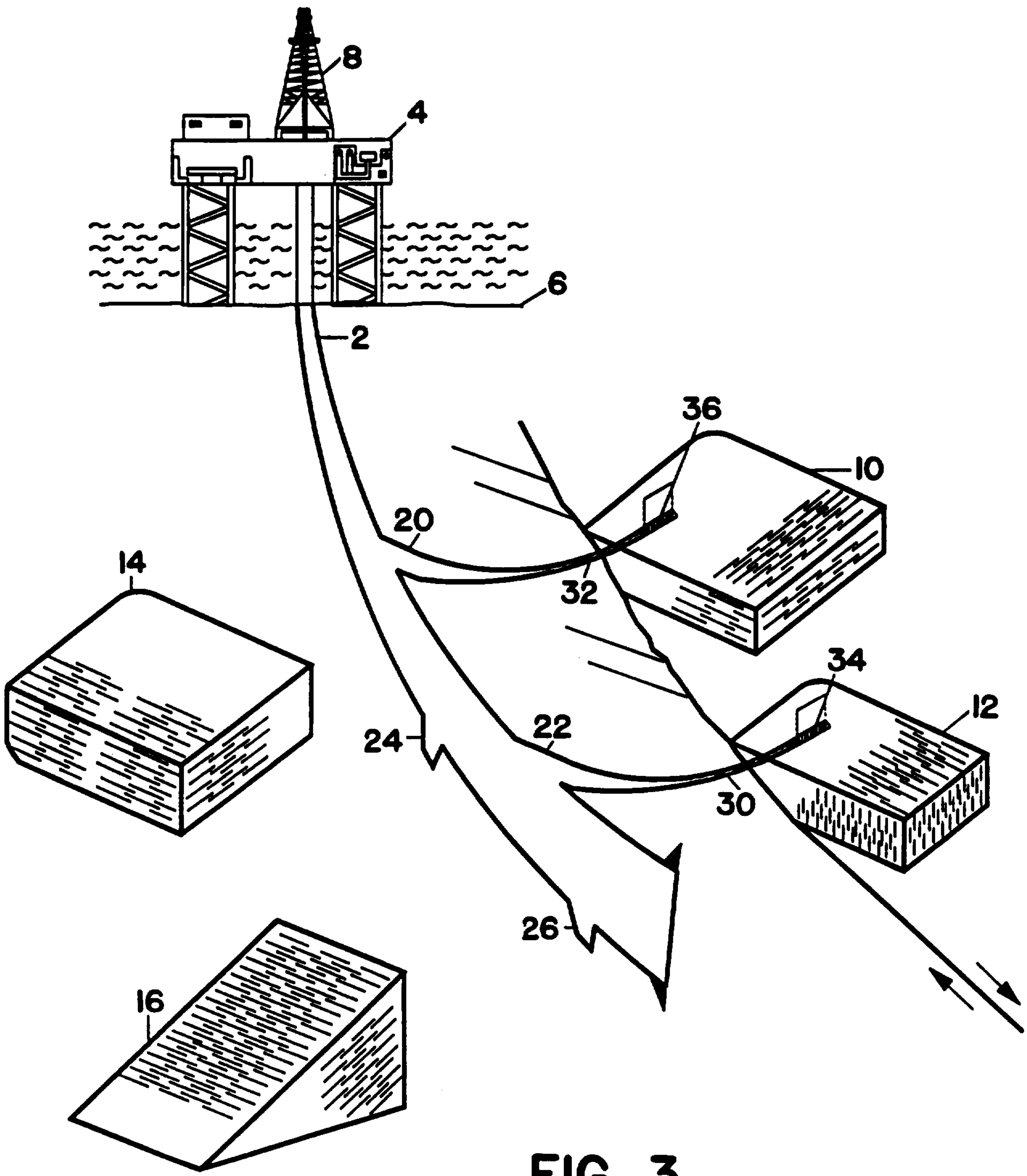


FIG. 3

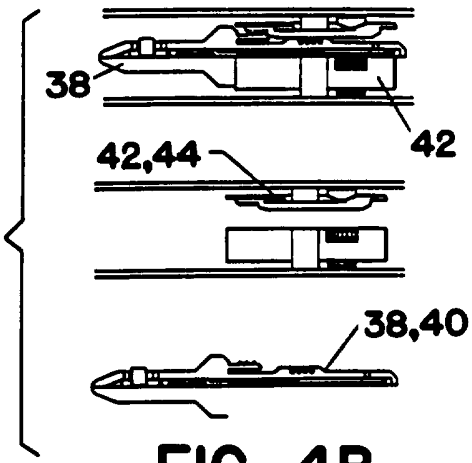


FIG. 4B

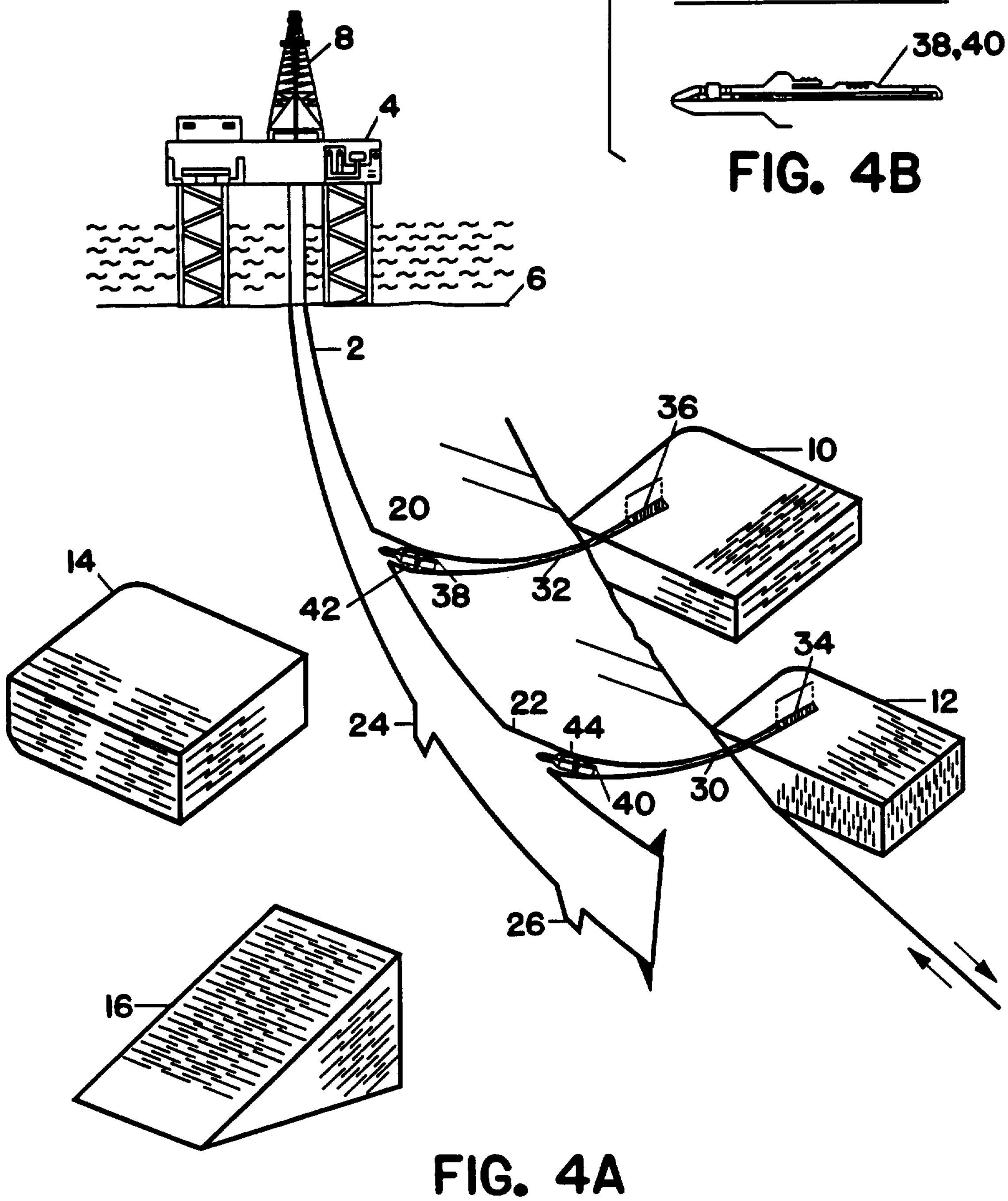


FIG. 4A

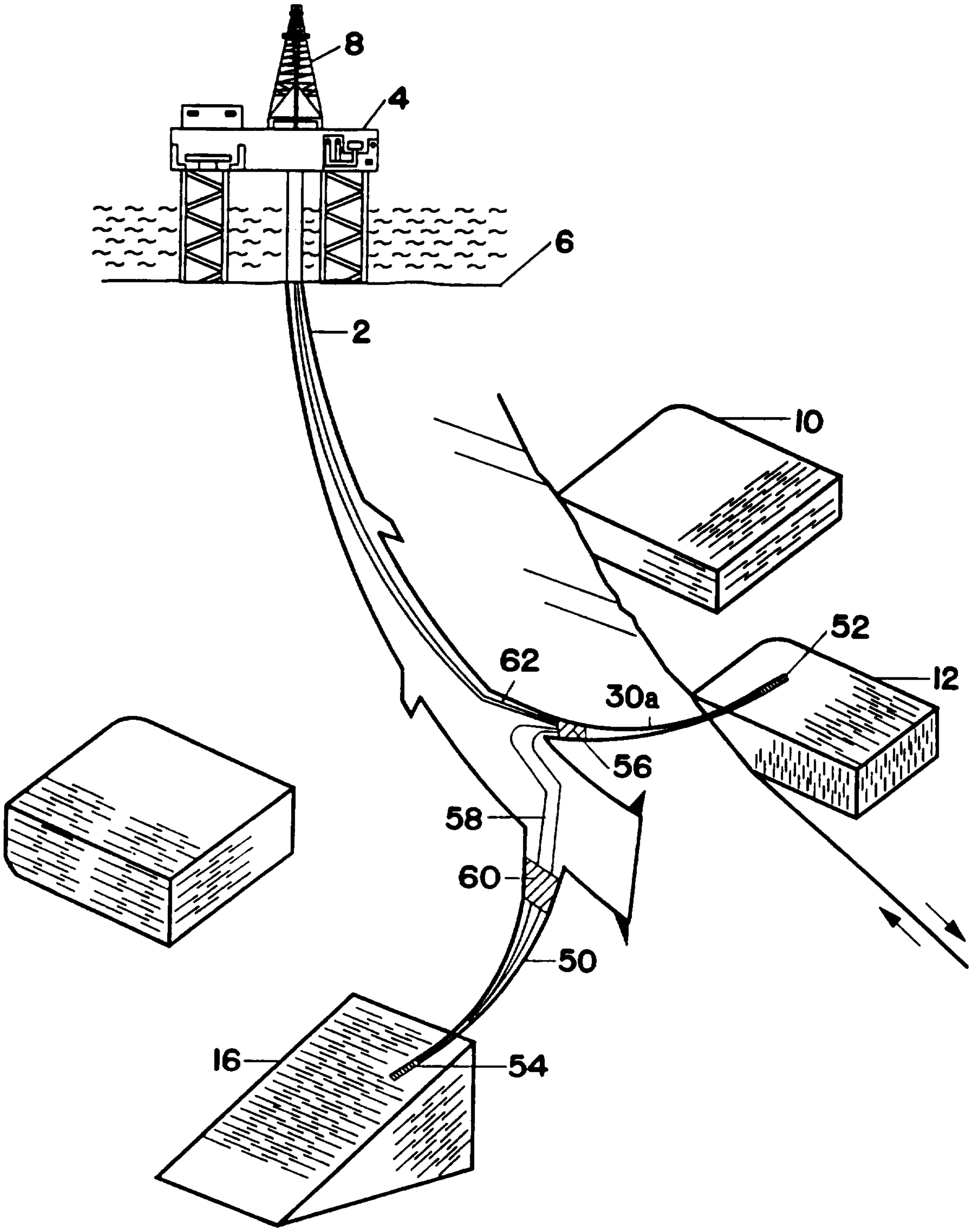
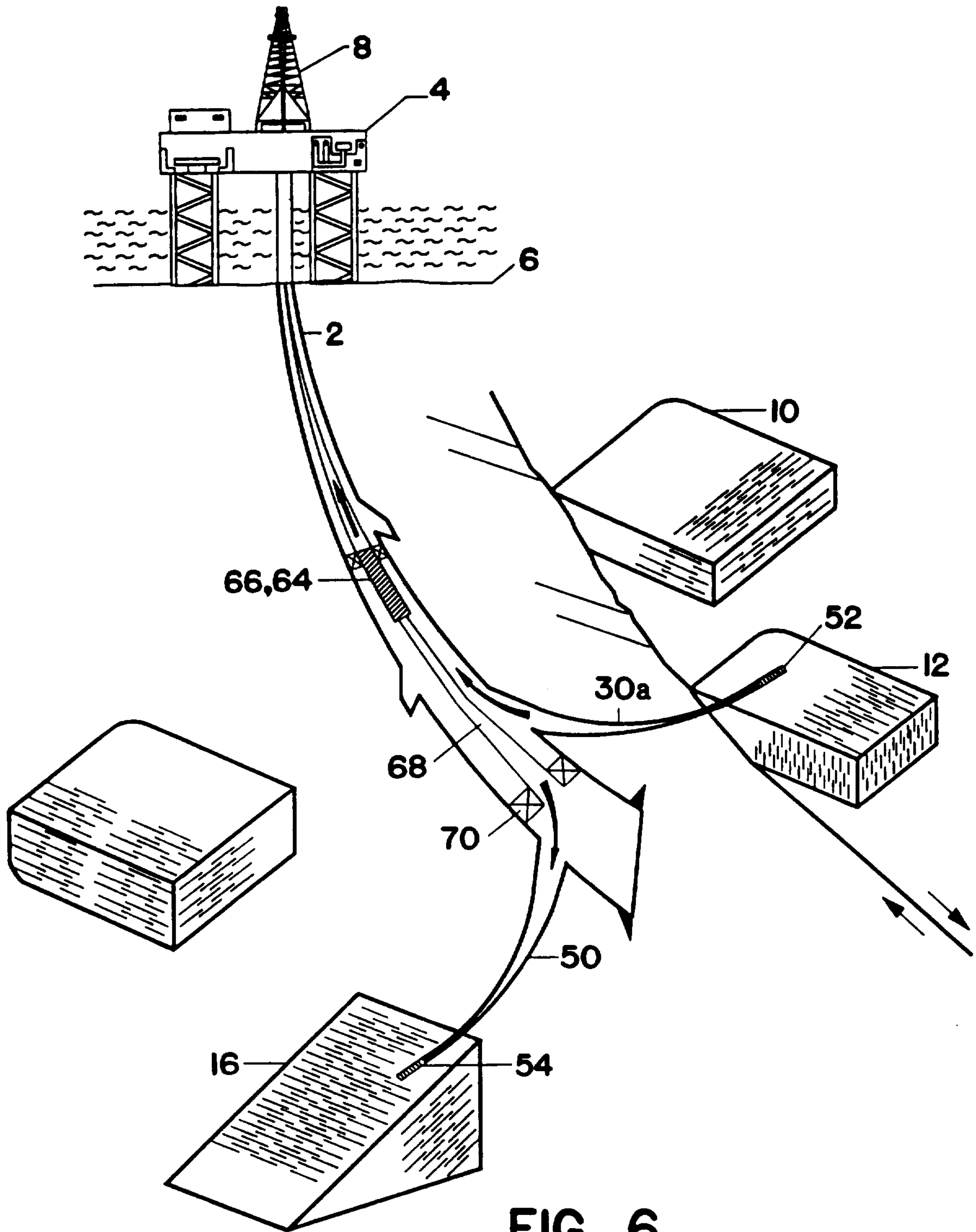


FIG. 5



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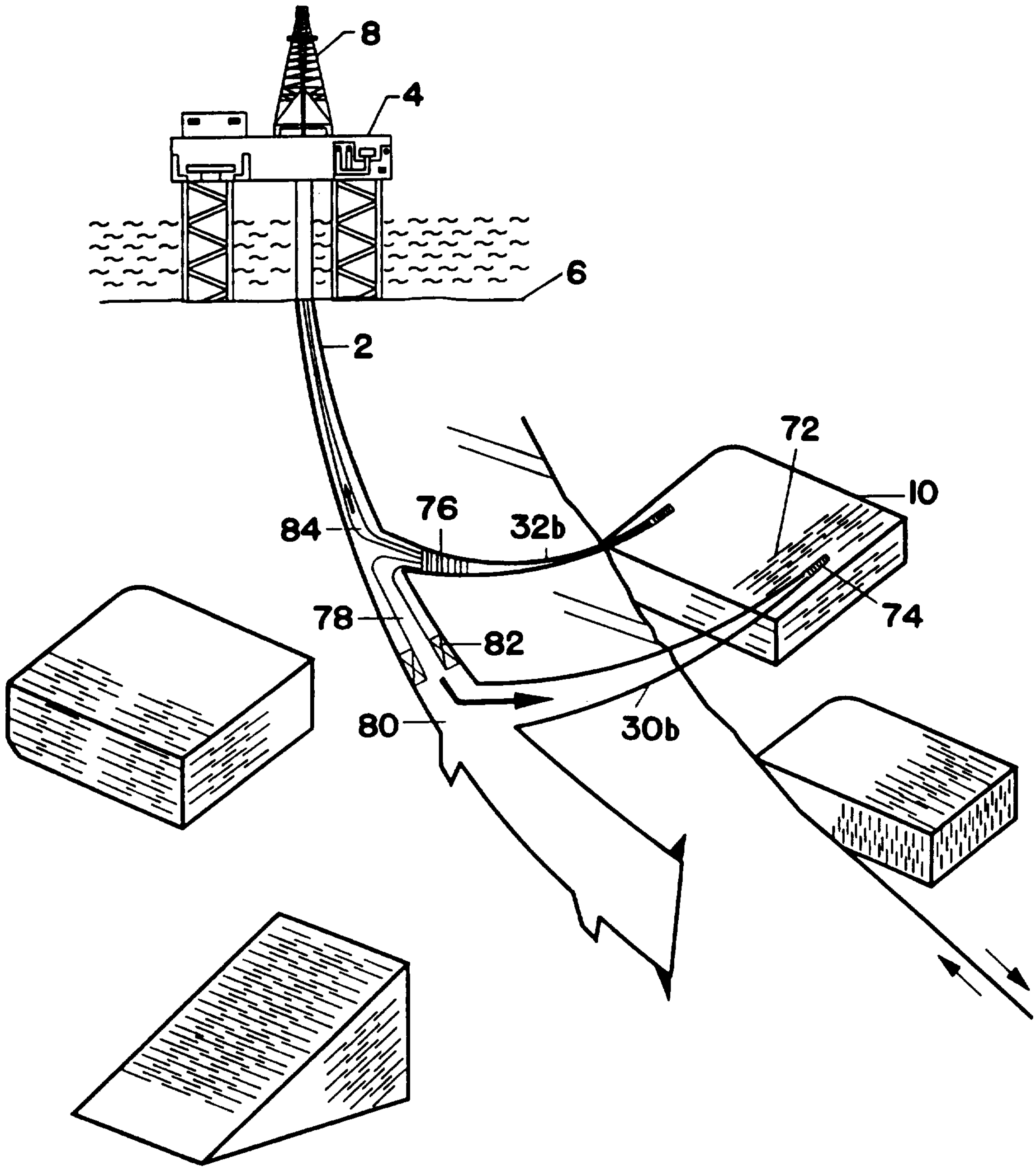

FIG. 7

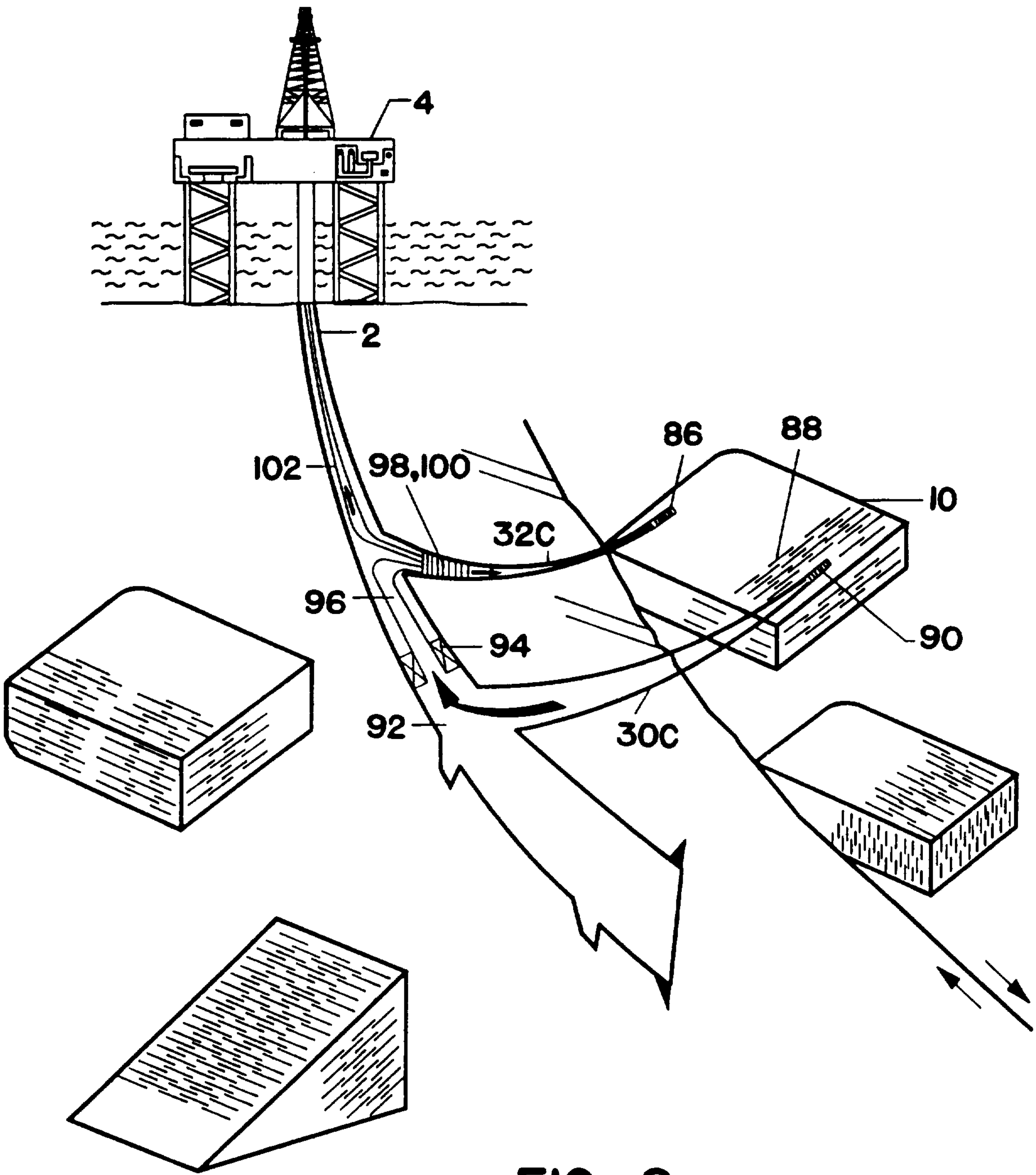

FIG. 8

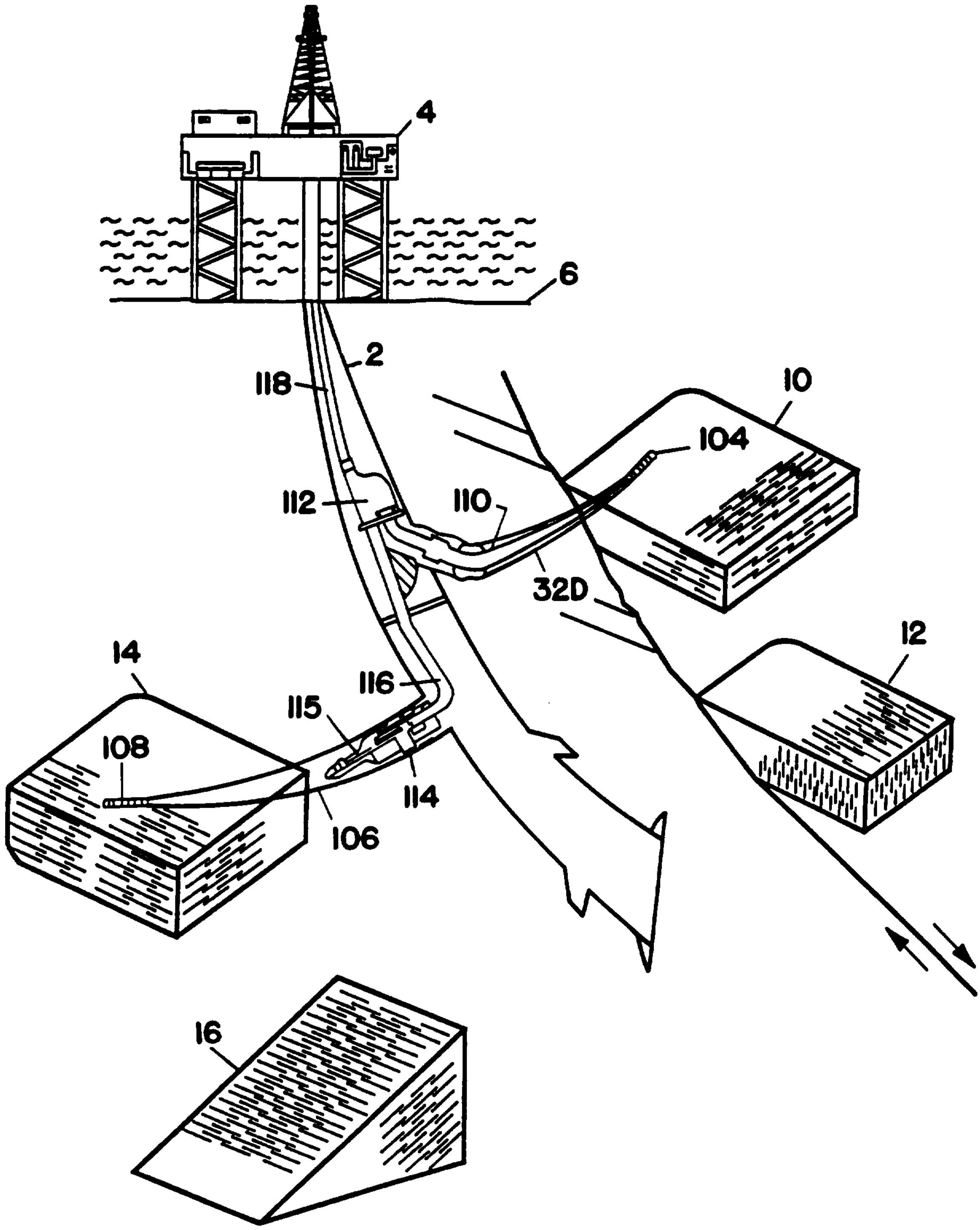

FIG. 9A

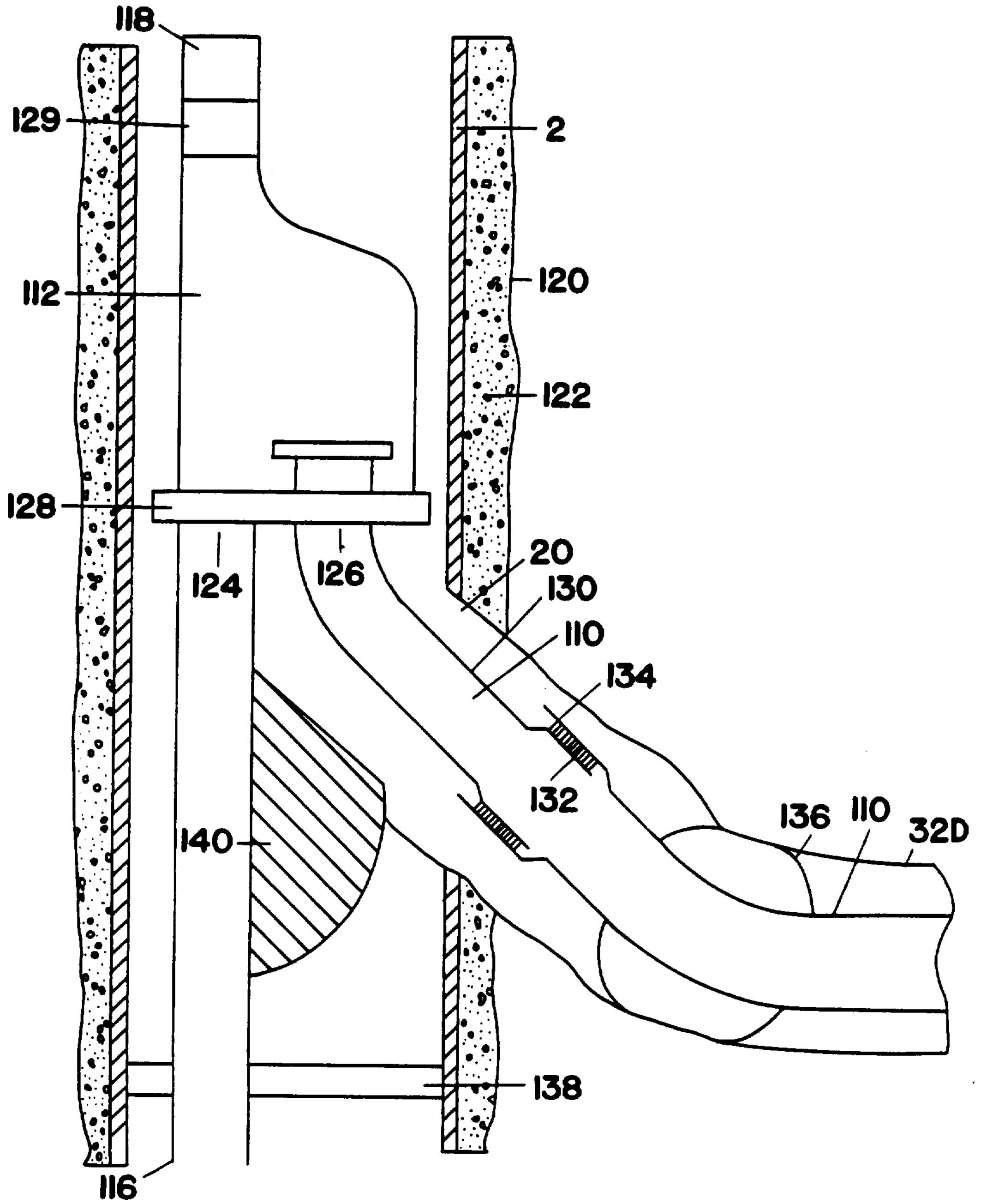
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FIG. 9B

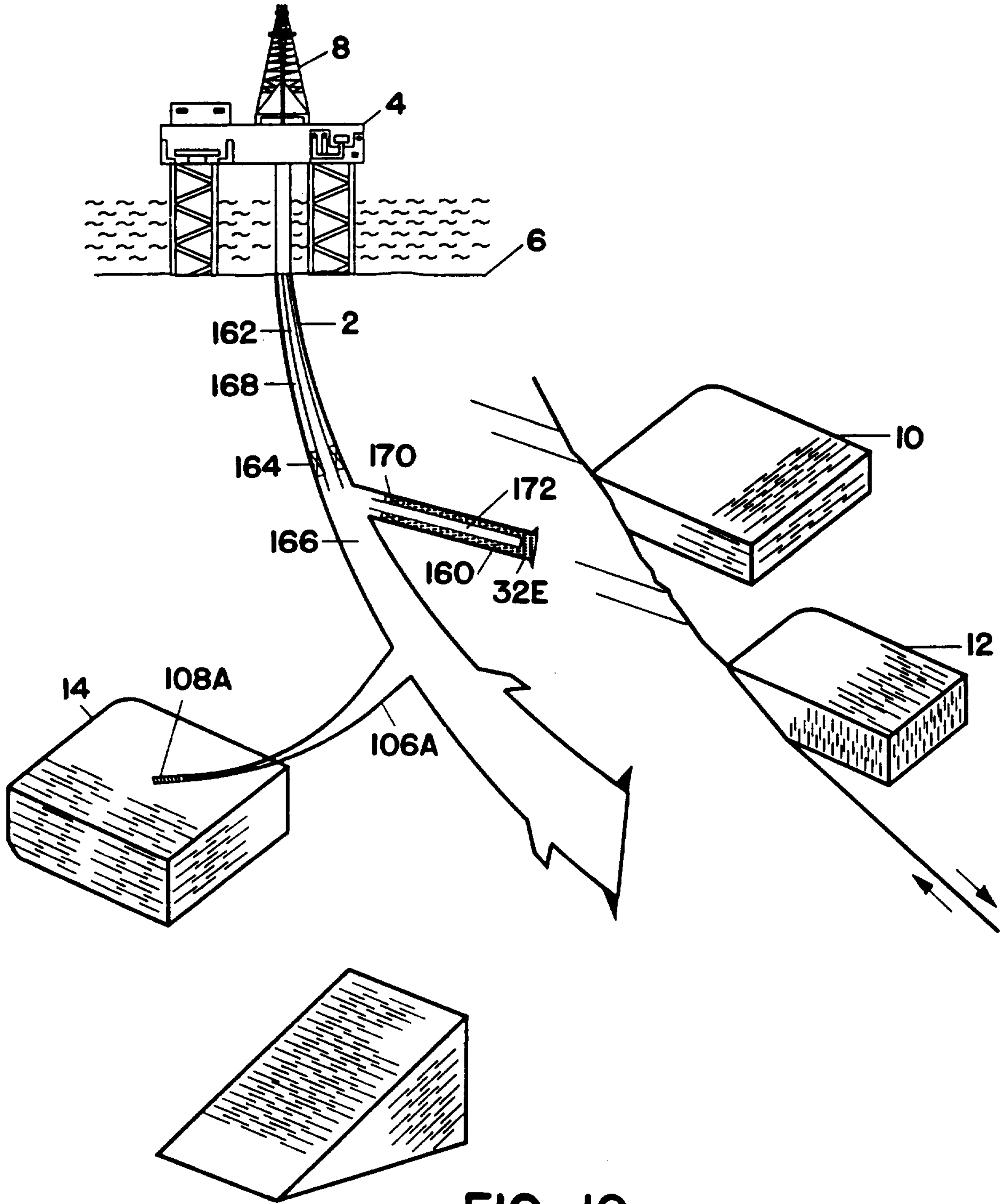

FIG. 10

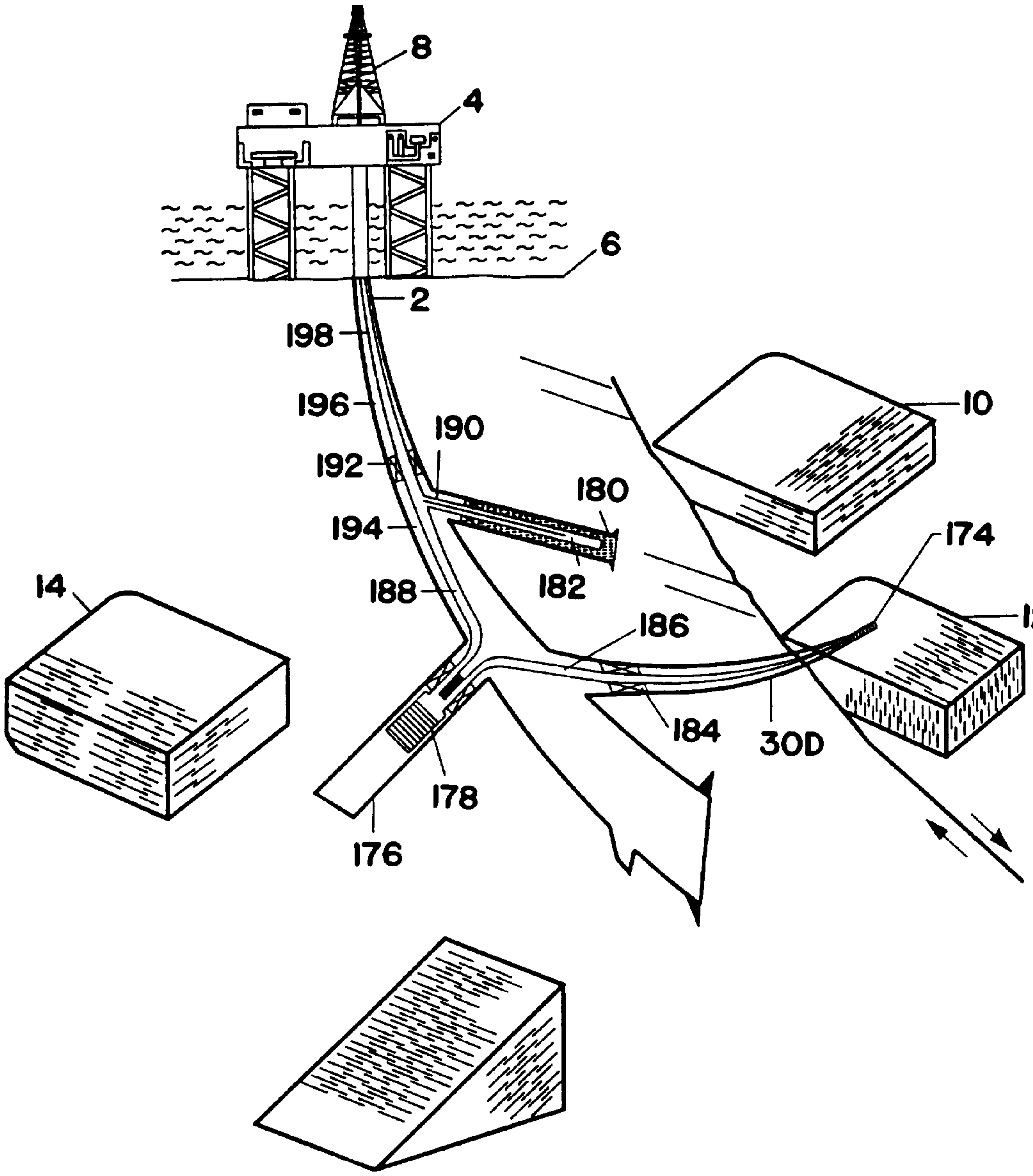
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FIG. 11

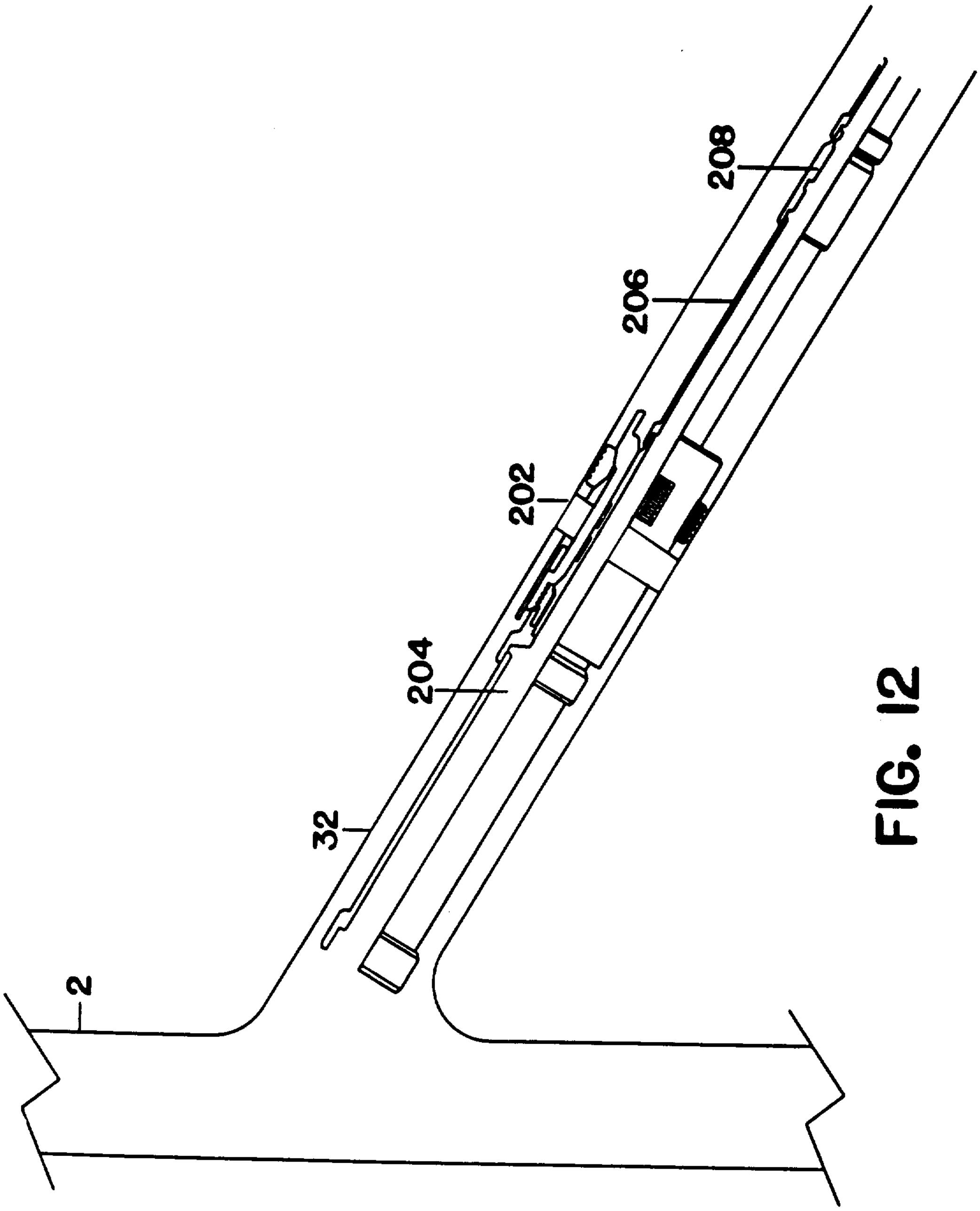

FIG. 12

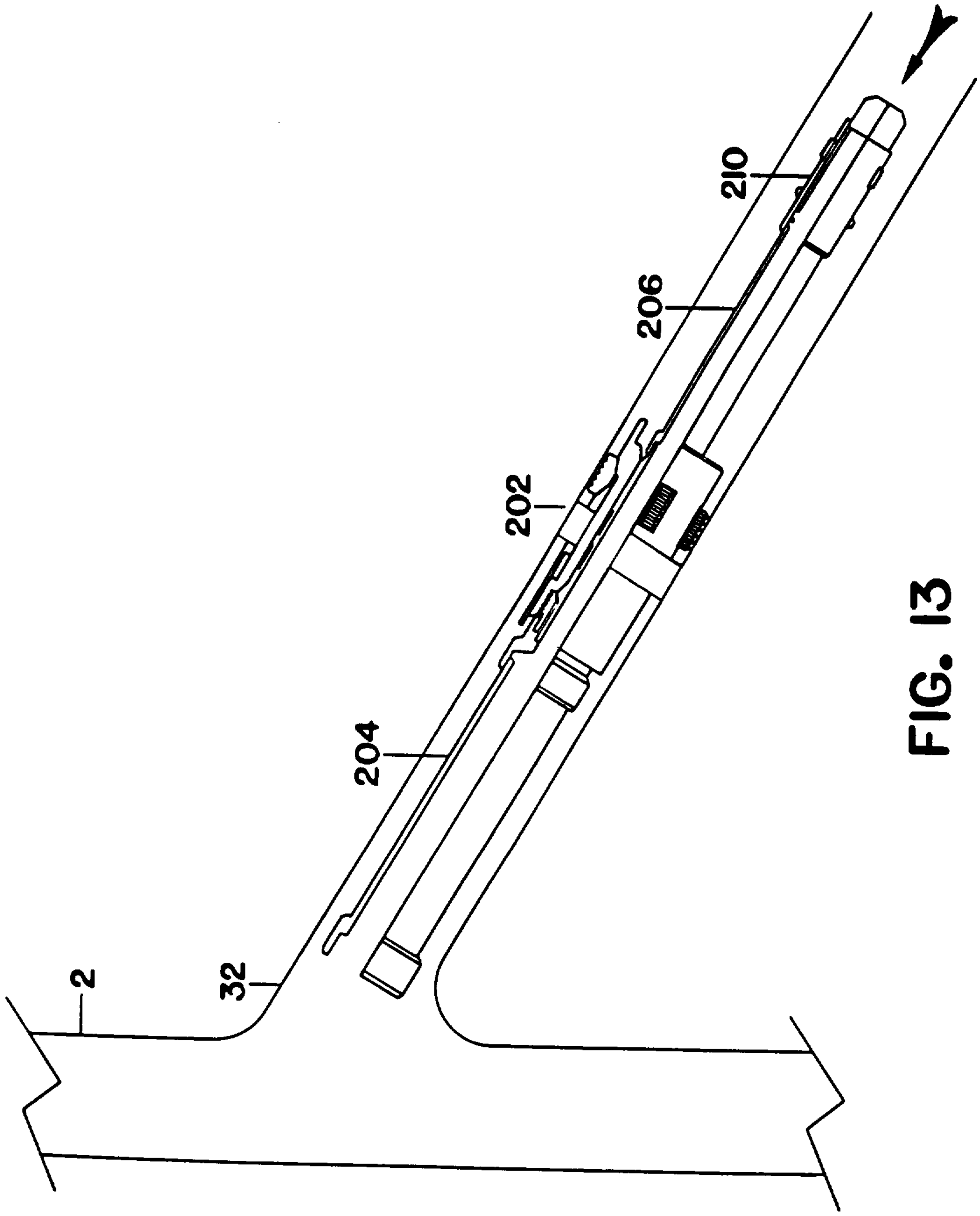

FIG. 13

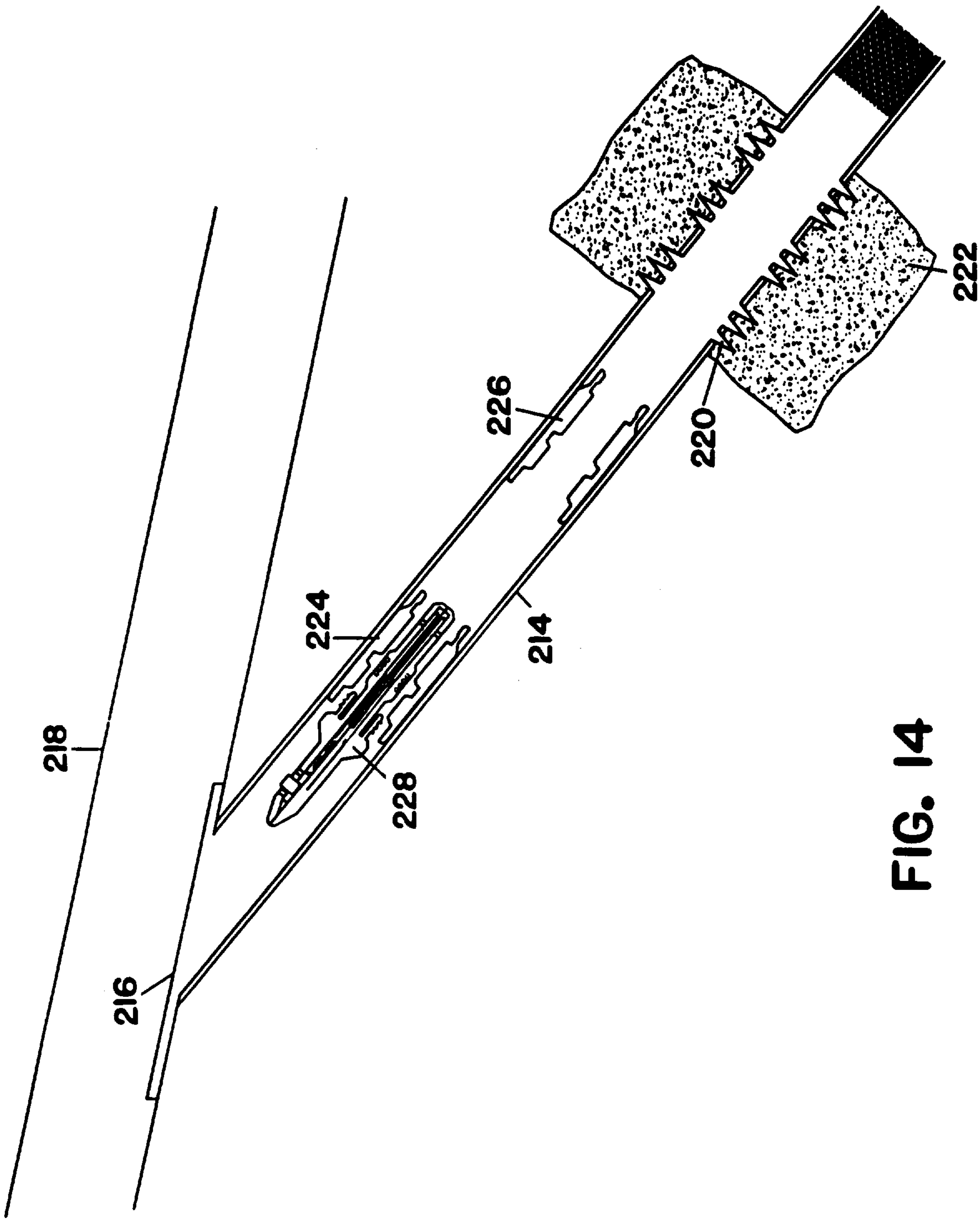

FIG. 14

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/04040

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B43/14 E21B43/30 E21B41/02 E21B37/06 E21B43/12
E21B43/40 E21B34/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI, Tulsa, Full-text english EP, WO, US, GB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB,A,2 194 572 (SOCIETE NATIONALE ELF AQUITAINE) 9 March 1988	1,3-5,8, 10,14, 17,19,24
Y	see page 4, line 95 - page 6, line 20	7,16, 21-23
Y	WO,A,92 08875 (FRAMO DEVELOPMENTS LTD) 29 May 1992 see page 1, paragraph 3	7,16
Y	US,A,2 752 090 (KYSELKA ET AL.) 26 June 1956 see the whole document	21-23

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
2 July 1996	-9.07.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rampelmann, K

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INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 96/04040

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 779 679 (SNAVELY ET AL.) 25 October 1988 see abstract see column 5, line 62 - column 6, line 3 ---	13,25,30
A	US,A,5 337 808 (GRAHAM) 16 August 1994 see column 7, line 11 - line 13 ---	20,31
A	US,A,5 301 760 (GRAHAM) 12 April 1994 see claim 17 ---	20,31
P,A	GB,A,2 284 223 (UK ATOMIC ENERGY AUTHORITY) 31 May 1995 see page 4, line 36 - page 5, line 15 -----	13,25,30

1

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Information on patent family members

Inte. onal Application No
PCT/US 96/04040

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		FR-A- 2603206	04-03-88
		NO-B- 178775	19-02-96
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		DE-T- 558534	03-03-94
		EP-A- 0558534	08-09-93
		ES-T- 2048696	01-04-94
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US-A-4779679	25-10-88	NONE	
US-A-5337808	16-08-94	NONE	
US-A-5301760	12-04-94	NONE	
GB-A-2284223	31-05-95	EP-A- 0656459	07-06-95
		JP-A- 7197764	01-08-95
		NO-A- 944512	29-05-95