

Sept. 17, 1968

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3,401,746

SUBSEA PRODUCTION SATELLITE SYSTEM

Filed Dec. 10, 1965

3 Sheets-Sheet 1

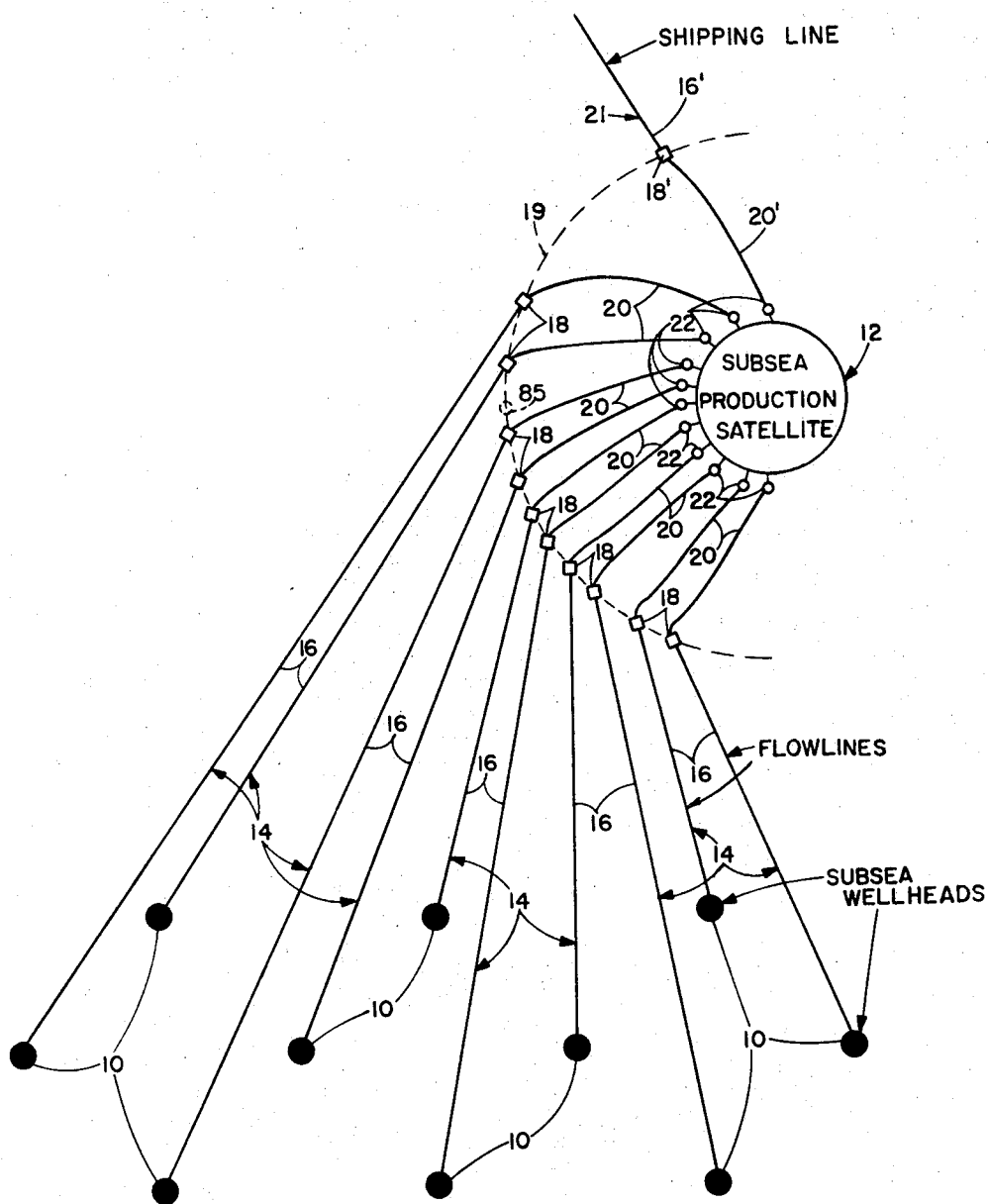


FIG I

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3 Sheets-Sheet 2

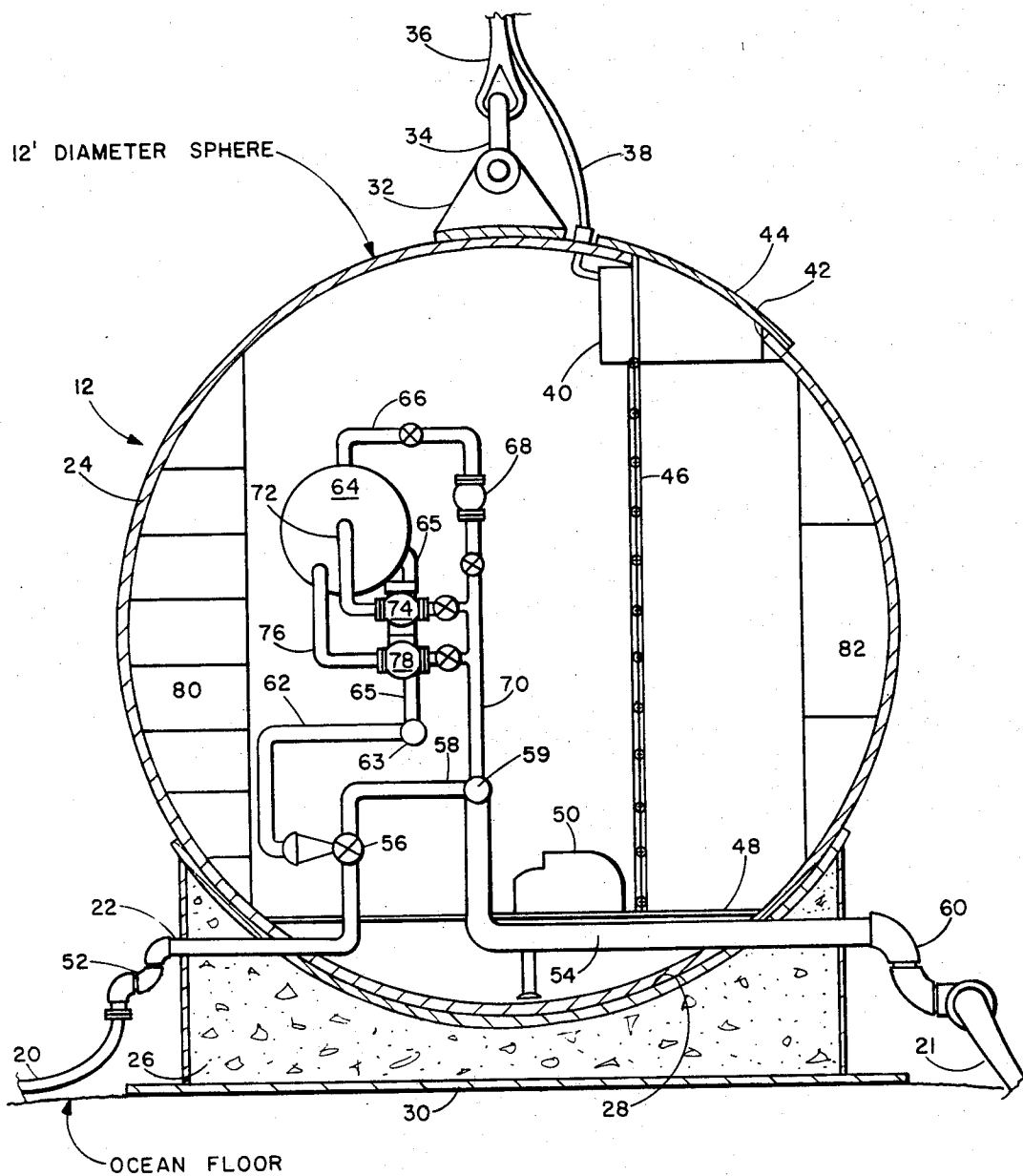


FIG III

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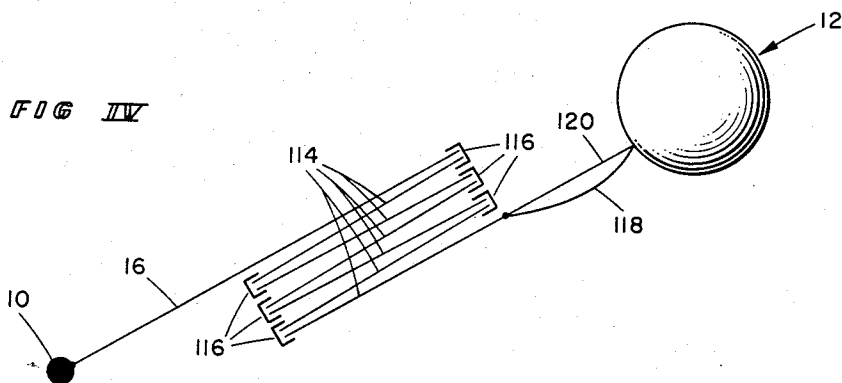
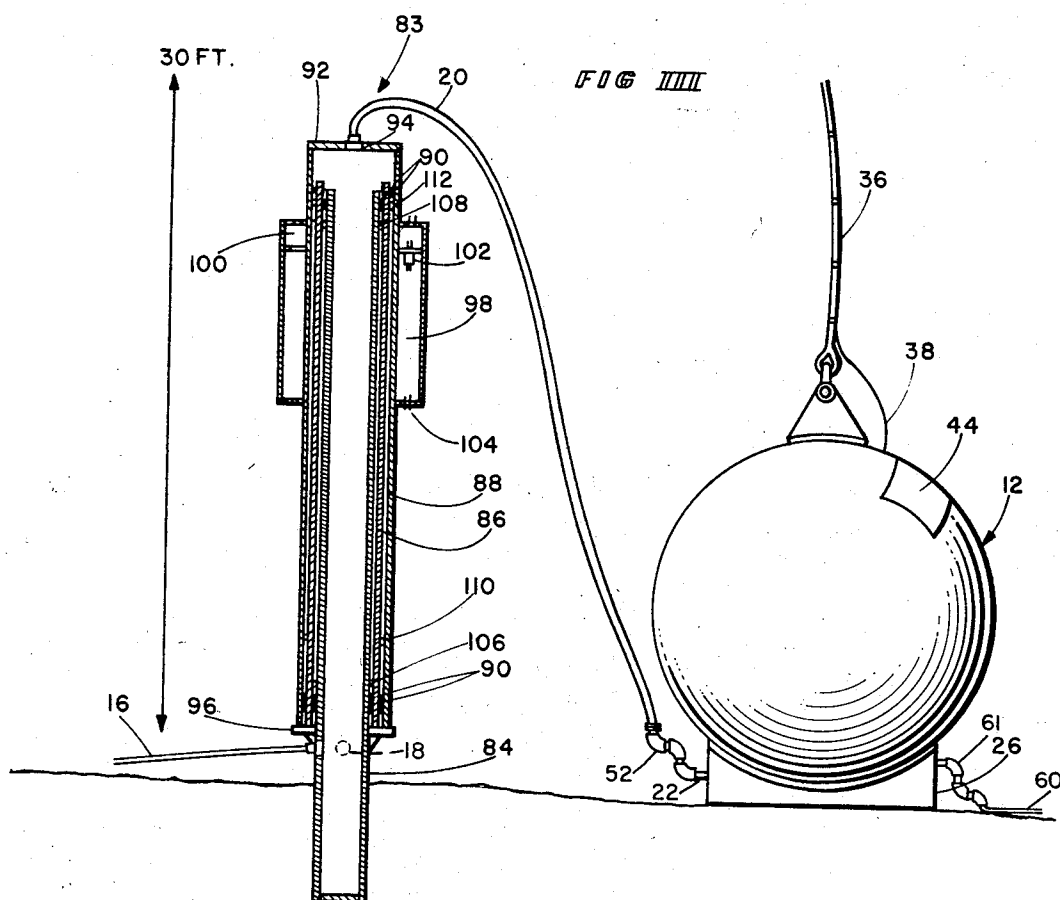
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3 Sheets-Sheet 3



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SUBSEA PRODUCTION SATELLITE SYSTEM
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Filed Dec. 10, 1965, Ser. No. 522,805
5 Claims. (Cl. 166—5)

ABSTRACT OF THE DISCLOSURE

This specification and drawings disclose a subsea production satellite system having gathering and monitoring equipment, within an enclosed satellite, operatively connected to a plurality of subaqueous wells through subsea wellheads thereof by means of flexible flowline sections permitting the satellite to be raised from its normal resting place on the marine bottom, to the surface of the body of water, to allow maintenance and repair operations to be conducted within the satellite at the surface without interrupting any connections between the satellite and the subsea wellheads.

This invention relates to a subsea production satellite system having a satellite removably situated on the bottom of a body of water, adjacent the site or in the midst of subsea wellheads of a plurality of subaqueous wells. More particularly, the invention relates to a subsea or submerged production satellite system in which the satellite is adapted to be lifted to the surface without using a diver or without breaking any subsea connections.

Since its inception, the offshore oil and gas industry has has used bottom-supported above-surface platforms as the principal mechanism for the installation and support of the equipment and services necessary for the operation of offshore oil and gas fields. As the industry has developed over the years, it has extended its search for offshore fluid mineral deposits from its birthplaces in the shallow coastal waters of California and the Gulf of Mexico into areas where, because of excessive water depth or other local conditions, the bottom-supported platform is neither as economically nor technologically feasible. For purposes of this disclosure, the term "fluid minerals" is to be construed broadly to include minerals such as gas and/or oil and also minerals adaptable to be mined as slurries, solvents, or any other similar states that may be transported through a production passage of a well and/or flowlines.

While, theoretically, there is no limit to the depth for which a bottom-supported platform can be designed and installed, experience to date indicates that platform costs increase almost exponentially with increase in water depth. Thus, the presently estimated costs of a platform to carry the production facilities for the exploitation of fluid mineral deposits located in formations underlying the marine bottom in three to four hundred feet of water or more are so high as to indicate that such an installation cannot be justified economically for any but a very productive and prolific field. Furthermore, the few bottom-supported above-surface platforms that have been designed and built for use in three hundred feet or more of water depth have almost invariably suffered leg failures of one type or another.

A possible solution is to install the production facilities on a floating platform, which could be maintained in position in the field by either a fixed multipoint mooring system of anchors and anchor lines, or by a dynamic positioning system. Either of the above solutions involves the expense of continuous maintenance and surveillance of the locating system as well as the associated problems and expense of maintaining the multiple flexible hoses connecting the wells on the sea bottom with the continuously

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moving floating production platform, and the potential hazard, of this system, to the hoses, in the event of a failure of either the fixed mooring or dynamic positioning systems.

In many areas of the world, local conditions other than water depth impose critical limitations on the use of bottom-supported production platforms. One such area is the Arctic, as exemplified by the Cook Inlet, in Alaska, where a bottom-supported platform must be built to withstand the forces imposed by thick ice layers that form on the water surface during the winter months of the year. While any above-water production platform is subject to the mercy of the wind and waves, especially those occurring during hurricanes and other violent storms, in the Arctic areas, these forces can be exceeded by the forces exerted against the platform by the movement of the thick ice layers on the surface of the water. This is particularly true of an area such as the Cook Inlet, in which local, extremely high, tidal movements, of the order of thirty feet or more, cause very fast tidal currents in the Inlet, with velocities up to eight miles per hour or more. These very rapid currents carry with them broken up sections of the thick ice layers that form on the surface of the Inlet, so that the ice bears with tremendous force against any fixed structure, such as a production platform, that should be installed in its path.

In still other areas, it is not adverse natural conditions but man-made prohibitions which restrict the use of bottom-supported above-surface production platforms. Among such conditions could be listed official and/or public objections to oil production facilities near public recreational or residential areas, and the presence of heavy marine traffic, as in harbors, channels, rivers, or other navigable bodies of water, which may make it necessary or advantageous to install as much of the production equipment below the water surface as possible. Although the term "sea" is used hereafter to denote the body of water in which the satellite system is used, it is meant to encompass any open ocean, coastal, inland, or offshore area. If economically feasible, such a design would be used even in sheltered bays and large lakes, such as Lake Maracaibo in Venezuela.

It is, of course, technically possible to so modify and package the typical production equipment used for scheduling, measuring, testing, and otherwise performing the usual manipulations on producing wells, so that it could be installed below the water surface and on the ocean bottom. Such packaging and modifications have already been accomplished, to a very limited extent for the much simpler problem of enclosing a single wellhead for the subsea producing of a gas or oil well. However, the cost to accomplish such modifications and packaging have been quite high, usually doubling or tripling the cost of the subsea wellhead over its comparable above-water counterpart, because of the need to protect against the inimical undersea environment. Further, the problems of performing the necessary, if limited, service and maintenance on this submerged equipment are substantial. Men cannot work as efficiently underwater, where they are subject to the encumbrances of diving gear and the physiological problems of working under, and breathing in, the much higher than normal atmospheric pressures. Attempts have been made to replace man in this hostile environment by use of robotics, but these devices, at the present stage of their development, can only perform simple chores, and the cost of maintenance of the devices, themselves, is high. Further, they depend, for their efficiency of operation, on the effective use of underwater television, so that, in turbid or muddy waters, where television is not effective, the robotic devices become almost useless. Thus, when all of the above disadvantages are considered with respect to the

installation of complicated well testing and production equipment on the ocean floor, it can be seen that, while, perhaps such is technically feasible, it is only just barely so, and most certainly falls beyond the bounds of being economically feasible for all save a few very special situations.

Accordingly, it is an object of this invention to provide a subsea satellite for handling the production of a number of submerged wells at an offshore site.

It is another object of this invention to provide a subsea satellite which may be lifted to the surface of the water without interrupting any subsea connections.

It is a further object of this invention to provide a normally submerged satellite which may be serviced without the need for a diver.

Other objects and advantages of this invention will be readily apparent from the following description, when read in conjunction with the accompanying drawings that illustrate useful embodiments in accordance with this invention.

In the drawings:

FIGURE 1 is a schematic plan view of a subsea production satellite system showing the grouping of a number of subsea wellheads and the interconnection between the wellheads and the subsea production satellite;

FIGURE 2 is a cross-sectional elevational view of the subsea satellite shown in FIGURE 1;

FIGURE 3 is an elevational view of a portion of the submerged production satellite system of FIGURE 1, partially in cross section, illustrating a modified structure for interconnecting flowlines to the satellite to permit the satellite to be raised to the surface from a greater depth; and

FIGURE 4 is a schematic plan view of a further modification for connecting a submerged well to the subsea satellite without using a long flexible flowline.

In accordance with the present invention, the proposed subsea production satellite is designed as a watertight pressure resistant vessel which normally rests on the sea bottom and is connected by flowlines to a group of subaqueous wells in a field or block. The satellite may be directly in the center of a group of subsea wellheads or may be located to one side of the wellheads for reasons to be explained later. Where a number of shallow wells are required and deviation would not be adequate to achieve the desired spacing, the wells could be spaced directly over their subsurface locations. The wells would be operatively connected to the satellite by flowlines, each comprising a rigid pipeline extending from the respective wellhead and to the area adjacent which the satellite is to be located, each of the flowlines having a section adjacent the satellite consisting of a flexible hose or leadline of sufficient length to permit the satellite to be lifted to the water's surface for service and repair without disturbing the rigid pipelines to which the other ends of the flexible hoses or leadlines are attached. While, in all probability, flexible hoses would be used to connect the rigid pipelines with the satellite, there might be an occasional instance of use of a so-called "steel-hose", i.e., a line made up of short (ten to twenty feet long) sections of steel pipe connected by swivel joint connections, such as the common Chiksan joints.

The proposed satellite itself consists of a fabricated shell of shape and design adequate to withstand the hydrostatic head of the water depth in which it is intended to operate. A sphere, spheroid, or a cylinder with spheroidal heads, would meet the requirements depending on the design depth.

The satellite has a concrete base, providing sufficient ballast for resting on the bottom in a reasonably stable condition, and a lifting eye, at the top, for hoisting the satellite to the surface of the water for servicing. A pressure-tight hatch, also near the top of the satellite, provides access to the inside thereof, when it has been hoisted out of the water. Stub-outs, for the various flowlines to

which the satellite is to be connected, extend through the satellite shell to terminate around the base thereof. One of the flexible hoses or leadlines is connected to each of the stub-outs by a three-way swivel joint to prevent binding or excessive bending at the connection when the satellite, when utilized to exploit a subaqueous oil field, is raised or lowered.

The satellite can be fitted with a variety of equipment to perform such normal oil field production functions as: gauging total production and check testing of the individual wells periodically, separating the produced oil and gas, boosting produced oil and gas from the satellite to a central production facility, distributing gas for artificial lifting from the central production facility to the individual wells, automatic or supervisory control over the individual wells, etc. Most of the equipment installed to perform these various functions is similar to that used for the same functions in conventional onshore operations, with necessary modifications, miniaturization, and automation to adapt it to the limited confines and substantially unattended operation in a subsea satellite.

Referring to the drawings, FIGURE 1 illustrates, in a plan view, a group of subsea wellheads 10, connected to a single submerged production satellite, generally designated 12, by means of flowlines, generally designated 14. Each flowline 14 consists of a rigid leadline 16 extending from the respective wellhead 10 to a point 18 on an imaginary circular line 19, and a flexible hose 20 coupled between the rigid leadline 16 by a first end at the point 18, and the satellite 12 at the second end of the hose 20. The satellite 10 is located on the concave side of the arc, and as is illustrated, is concentric therewith. A shipping line 20, comprising a rigid leadline 16' and a flexible hose 20' coupled at a point 18' on the imaginary circular line 19, operatively connects the satellite 12 with a central facility (not shown). The portion of the circular line 19 over which the points 18 and 18' extend is an arc of a circle of one hundred eighty degrees or less. A series of radial stub-outs 22 (FIGURE 2) extend from the submerged satellite 12 a short distance. Each stub-out 22 is connected to the second end of one of the flexible hoses 20. Although only ten wellheads 10 are shown as connected to the satellite 12 there may be either more or less than this number depending, at least in part, on the convenience of the well locations and/or the production capacity of the satellite 12.

FIGURE 2 illustrates the general configuration of a satellite 12 having a spherical vessel shell 24 constructed of steel plate, or the like, by one of the various methods known in the prior art for constructing bathyspheres and other large pressure vessels designed for subsea use. A weighted base 26, of concrete, or the like, is rigidly fixed to the under portion of the satellite 12. The base 26 is designed with a concave upper face 28, to match the spherical shape of the pressure vessel 24, and a planar lower face 30, for resting firmly in a stable condition without becoming mired in an unconsolidated sea bottom. Welded to the uppermost portion of the spherical shell 24 is an ear 32 carrying a pivotable ring 34 for securing a hoisting cable 36 to the satellite 12. The hoisting cable 36 extends to the surface where it may be held by a floating buoy (not shown) when the satellite 12 is resting on the bottom. If it is not feasible for a floating buoy to be used, such as when heavy ice on the surface might destroy it, the end of the hoisting cable 36 may instead be connected to a remotely controlled buoy which lies on the bottom until activated. (This type of buoy, which is no part of the present invention, consists of a remotely actuated device for releasing compressed gas into a hollow body to provide buoyancy.) A communication cable 38 is connected to the hoisting cable 36 along the length thereof so that electrical communication may be had between a point on the surface and the inside of the satellite.

The lower end of the communication cable 38 extends through the pressure vessel 24 and is connected therewithin to a control and alarm box 40 adjacent an access hatch 42.

The access hatch 42 is covered with a hatch cover 44 which is clamped down, in the usual manner, to provide a watertight seal. A ladder 46, within the pressure vessel 24, extends from a point adjacent the hatch 42, to an inner working deck 48, beneath which are carried the majority of the pipes used to bring the produced fluid into and out of the satellite 12. An automatic sump pump 50 pumps out any water or other fluids that accumulate beneath the deck 48 of the pressure vessel 24, above a maximum allowable level. If the satellite is near shore, the liquid wastes can be pumped by a second shipping line (not shown) to a permanent central processing station, or if further out at sea, the wastes can be periodically collected by a vessel through an outlet line (not shown) extending to the surface.

Only one of the stub-outs 22 is shown, in FIGURE 2, extending through the pressure vessel 24 and the concrete base 26, out into the water near the bottom of the satellite 12. A three-way swivel 52 interconnects the outer end of the stub-out 22 with the inner end of one of the flexible hoses or leadlines 20. The inner end of the stub-out 22 is connected to a main production outlet line 54 through a three-way two-position valve 56, a bypass line 58, and an outlet manifold 59 when the valve 56 is in a first position. The main outlet line 54 extends through the pressure vessel hull 24 and the base 26 into the water where it is connected to the flexible section of the shipping line 21 through another three-way swivel 60. The other end of the shipping line 21 is connected to a production storage facility (not shown) which can be either a floating tank, anchored to the bottom, or a conventional land based unit.

When the three-way valve 56 is in the second position, any fluid flowing therethrough is diverted into a line 62 leading into an inlet manifold 63 and from there, by a vertical pipe 65, into test separator 64. The gas is taken off through the upper line 66 and flows down through a gas meter 68 into a line 70 operatively connected to the outlet manifold 59. The crude oil flows out of the separator 64 through pipe 72 and a positive displacement oil meter 74 into line 70 to remix with the gas from the upper line 66. The separated water flows out of the bottom of the separator through a pipe 76 and a positive displacement water meter 78 before remixing with the oil and gas in the line 70. The gas-oil-water mixture, recombined as a three-phase fluid, flows from the line 70 through the outlet manifold 59 into the main outlet 54.

Although there is only one stub-out 22 shown as connected to the separator 64, in actuality, all of the stub-outs 22, spaced around the periphery of the satellite 12, would be operatively connected to the test separator 64 through the inlet and outlet manifolds 63 and 59, respectively. The test separator 64 is sequentially connected to each one of the stub-outs 22, while the remainder of the production flows directly into the main outlet line 54. The three-way valve 56, controlling the flow from one of the wellheads 10, will be automatically turned into its second position to allow testing of the contents thereof while the three-way valves 56 controlling the flow from the other wells will be held in the first position to direct the production from these wellheads 10 directly into the main production outlet line 54.

If an external electrical power source is available, power would be brought in, by means of a power cable (not shown) attached to the hoisting cable 36, from a generator station on an offshore platform or by a cable laid on the marine bottom, from a power station ashore. A bank of storage batteries 80, stored within the satellite 12, would be either the prime source of electrical power or an auxiliary power supply to be held in reserve for the contingency of a power failure. If the batteries 80 are to be the prime power source, the electrical power cable would be used to periodically recharge them. Electric power is needed for operating a programming and data storage unit 82, as well as for positioning the various valves in the

satellite including the three-way two-position valves 56 under the control of the programming and data storage unit 82. Alternatively the gas pressure from the separator 64 can be bled off to actuate the various valves under the control of electric pilot valves. The timing of the well production testing, controlled by the programming and data storage unit 82, will depend upon the requirements of the government involved and/or the most efficient procedure. Recorded data, such as the gas-oil-water ratio of each well, may be read out over the communication cable 38 upon a signal from the surface. Such remote readout signals may also be used to check out various functions of the satellite 12 and the wellheads 10.

If there is an indication that repairs or maintenance may be necessary, as for example the cleaning out of the separator 64, the satellite 12 is pulled to the surface by the hoisting cable 36 and a workman enters through the hatch 42 to make the repairs. Meanwhile, the flexible hoses 20 and the flexible portion 16' of the shipping line 21 would merely be drawn up behind the satellite 12 and production would continue or could be shut in by the automatic valve at each wellhead prior to hoisting.

The apparatus within the satellite 12, as described above and shown in FIGURE 2, is merely illustrative, the particular functions being accomplished within this satellite 12 not being a part of this invention. In an actual device many types of testing equipment, as well as equipment for performing various well maintenance functions, could be incorporated. One useful device would be a capacitance product analyzer and computer system to determine the net oil produced from the measured volume and the cut of the oil/emulsion. A group oil and gas separator could also be included to permit the use of single phase shipping lines, one carrying oil while the other carries gas. Booster pumps may be included for pumping the produced liquids to the production facilities. Booster compressors can be used for shipping low pressure produced gas to the production facilities and an automatic or remote controlled distribution manifold may be used to distribute, regulate, and meter high pressure gas for gas lifting or sea water for water injection wells. Some emergency equipment would also be included to shut down malfunctioning wells and equipment either upon direction through the communication cable 38 or automatically. Equipment could also be included to produce a nitrogen atmosphere in the satellite and sustain the nitrogen content sufficiently high to avoid all possibility of spontaneous ignition or explosion, except when the satellite is at the surface for inspection and maintenance and a breathable atmosphere is desirable.

The satellite system as designed, with a central satellite 12 ringed by a number of wellheads 10, requires that the flexible sections 20 of the flowlines 14, between the satellite and each one of the wells, be longer than necessary to stretch therebetween to permit the satellite to be raised to the surface. With the system described above, in which the wellheads 10 surround the satellite 12, the length of the free flexible hoses 20 that could be permitted without the danger of tangling would probably not allow the satellite to be set on the bottom and brought back to the surface in relatively deep water.

The alternate method for situating the satellite, to one side of the field of wells, is more adaptable for deep water and for aligning and preventing tangling of the flexible hoses during the lifting and lowering of the production satellite from and to the ocean bottom. It is envisaged that a servicing vessel with a center well, similar to the usual drilling vessel, would be used, although the satellite could be hoisted by an over-the-side rig just as well. The service vessel would be positioned over the satellite in its on-bottom position at the start of the lift, and, as the production satellite is lifted to the service vessel, the latter would be moved gradually to a location over the portion of the middle point of the imaginary circular line 19 over which the points 18 and 18' are distributed. The approxi-

mate middle point is illustrated in FIGURE 1 by numerical designation 85. The service vessel is moved across the subsea system by winching in and out on its various anchor lines. The procedure would be reversed when lowering the production satellite to the bottom. To prevent overstressing the flexible hoses during either operation, with attendant possibility of parting them, it might be desirable to tether the production satellite to one or more anchor points placed on the circle 19, and with the length of each wire cable tether line just slightly shorter than the length of each flexible hose or leadline 20.

FIGURE 3 shows a modified satellite system, using telescoping units, generally designated 83, at each hose connecting point 18, to make it possible to submerge the satellite 12 in almost any depth of water in which submerged wells are being drilled and produced today. As shown, the system is designed for a water depth with a maximum of one hundred twenty feet. Each telescopic unit 83 includes a hollow pile 84, sealed at the lower end, driven into the sea bottom at each point 18 (in FIGURE 1) with a thirty-foot portion of the pile 84 extending above the sea bottom. The rigid pipeline 16 extending substantially to the respective point 18 is connected to the lower end of the pile 84 so that the pile 84 may be used to transport oil from its lower end to its open upper end. A pair of thirty-foot long hollow tubes 86 and 88 are mounted in telescopic arrangement over the pile 84 with packings 90 fixed within the ends thereof to provide fluid-tight seals. The upper end of the outer tube 88 is covered by a plate 92 having a port 94 therein connected to the outer end of its respective flexible hose 20, which is in turn connected at its inner end through the swivel 52 to its respective stub-out 22. A circumferential flange 96 is welded around the lower end of the pile 84, just above the connection with the hose 20, to support the lower ends of the tubes 86 and 88 to prevent them from dropping down to a point at which they would cut off or damage the pipeline 16. Surrounding and fixed to the outermost telescoping tube, tube 88, is a buoyant lift cylinder 98 having an inner compartment 100 adapted to hold a compressed gas. A remotely controlled valve 102 regulates the passage of the compressed gas from the inner compartment 100 into the lift cylinder 98. An open port 104 in the lower end of the lift cylinder 98 permits the gas, when released from the inner compartment 100, to expel water from the lift cylinder 98. The buoyancy of the lift cylinder 98, when the gas is released, should be enough to raise the telescoping tubes 86 and 88 into an extended position. The tube 86 is kept from completely separating from the pile 84 by a pair of cooperating stops, stop 106 welded within the lower end of the tube 86 and stop 108 on the upper end of the pile 84. Another pair of cooperating stops 110 and 112 are fixed within the lower end of the telescoping tube 88 and on the upper end of the tube 86, respectively, to insure that the two tubes 86 and 88 do not separate.

When starting to hoist the satellite 12 to the surface by means of the cable 36 the valve mechanism 102 on each of the telescoping devices is actuated to cause the compressed gas in the compartment 100 of each lift cylinder 98 to expand down into the lift cylinder 98 and expel the water therein. The actuating means may be a sonar-controlled actuator means connected to the valve 102. As water is expelled from the lift cylinder 98 it becomes buoyant, tending to lift up the outermost telescoping tube 88. When inner stop 110 fixed within the lower end of the outer tube 88 coacts with the stop 112 on the upper end of the inner tube 86, the inner tube 86 tends to move upward also. This movement continues until the stop 106 within the lower end of the inner tube 86 coacts with the stop 108 on the upper end of the hollow pile 84. At this point the telescoping unit 83 is completely extended. If the section of the pile 84, above the bottom, and each of the tubes 86 and 88, are each approximately thirty feet long, the satellite can be immersed in about one hundred twenty

feet of water, the first ninety feet being that of the extended telescopic units 83 and the other thirty feet being accounted for by the distance that the satellite 12 can be above the height thereof due to the length of the flexible hose 20.

Another modification of the basic satellite system, which can be utilized if the satellite is centrally located or situated at the side of the submerged wellheads, is shown in FIGURE 4 where a subsea wellhead 10 is interconnected with the satellite 12 by a foldable arrangement of rigid pipes consisting of a series of rigid "steel hose" lines 114 connected by pressure-tight swivel joint connections 116. The leadline from the wellhead 10 is connected by one of the swivels 116 to the first end of the folded arrangement while a flexible hose 118 bridges the short space between the other end and the satellite 12. A wire cable 120, slightly shorter than the flexible hose 118, also connects the arrangement of "steel hose" lines 114 with the satellite to take the weight off the hose 118 when lifting the satellite. Separate lifting cables can also be provided for each swivel connection.

Although the present invention has been described in connection with details of specific embodiments thereof, it is to be understood that such details are not intended to limit the scope of the invention. The terms and expressions employed are used in a descriptive and not a limiting sense and there is no intention of excluding such equivalents, in the invention described, as fall within the scope of the claims. Now having described the apparatus and methods herein disclosed, reference should be had to the claims which follow.

What is claimed is:

1. A subsea production satellite system for producing fluid minerals from a plurality of subaqueous wells whose subsea wellheads are located adjacent the bottom of a body of water comprising: a production satellite removably situated on said bottom of said body of water spaced from said subsea wellheads, means for raising said production satellite to the surface for maintenance or repair, first fluid flow means operatively connecting each of said subsea wellheads to said production satellite for conveying the fluids produced through said subsea wellheads to said production satellite, a second fluid flow means operatively connecting said production satellite to a production facility for conveying at least a portion of said produced fluids to said production facility, said first and second fluid flow means being operatively connected to said production satellite in an area not extending more than half way around said production satellite, and means comprising at least a portion of each of said first and second fluid flow means for allowing said production satellite to be hoisted to the surface from the bottom without disconnecting said first and second fluid flow means.

2. A subsea production satellite system for producing fluid minerals from a plurality of subaqueous wells whose subsea wellheads are located adjacent the bottom of a body of water comprising: a production satellite removably situated on said bottom of said body of water spaced from said subsea wellheads, means for raising said production satellite to the surface for maintenance or repair, first fluid flow means operatively connecting each of said subsea wellheads to said production satellite for conveying the fluids produced through said subsea wellheads to said production satellite, and a second fluid flow means operatively connecting said production satellite to a production facility for conveying at least a portion of said produced fluids to said production facility, said first fluid flow means operatively connecting each of said wells to said production satellite being provided with a rigid line extending from the respective wellhead to a point on an imaginary circular line having its center at the center of said satellite, and a flexible hose connected by a first end to said rigid line at said point on said circular line and by a second end to said production satellite for allowing said production satellite to be hoisted to the surface from the

bottom without disconnecting said first and second fluid flow means.

3. A subsea production satellite system for producing fluid minerals from a plurality of subaqueous wells whose subsea wellheads are located adjacent the bottom of a body of water comprising: a production satellite removably situated on said bottom of said body of water spaced from said subsea wellheads, means for raising said production satellite to the surface for maintenance or repair, a plurality of first fluid flow means, each of said first fluid flow means being operatively connected at its outer end to one of said subsea wellheads and at its inner end to said production satellite for conveying the fluids produced through said subsea wellheads to said production satellite, a second fluid flow means being operatively connected at its outer end to a production facility and at its inner end to said production satellite for conveying at least a portion of said produced fluids from said production satellite to said production facility, said first and second fluid flow means each comprising a first section and a second section, said first section being a rigid line extending from the outer end thereof to a point on an imaginary circular line, all of said points being on an arc of said imaginary circular line of one hundred eighty degrees or less, said second section being flexible hoses extending from said points on said imaginary circular line to said production satellite, said production satellite being situated on said bottom in a position substantially equally distant from the ends of said portion of said imaginary line and on the concave side of said line, said first and second fluid flow means being operatively connected to said production satellite in an area not extending more than half way around said production satellite.

4. A subsea satellite system as recited in claim 3 wherein said satellite is situated on said bottom, concentric with said imaginary circular line.

5. A method for raising, from the bottom to the surface of a body of water, a production satellite of a subsea production satellite system for producing fluid minerals from a plurality of subaqueous wells whose subsea wellheads are located adjacent the bottom of a body of water, wherein said production satellite is removably situated on said bottom of said body of water spaced from said subsea wellheads, means on said production satellite for connecting a hoisting cable thereto for raising said production satellite to the surface for maintenance or repair, a plurality of fluid flow means, each of said fluid flow means

being operatively connected at its outer end to one of said subsea wellheads and at its inner end to said production satellite for conveying the fluids produced through said subsea wellheads to said production satellite, each of said plurality of fluid flow means comprising a first section and a second section, said first section being a rigid line extending from the outer end thereof to a point on an imaginary circular line, all of said points being on an arc of said imaginary circular line of one hundred eighty degrees or less, said second section being flexible hoses extending from said points on said imaginary circular line to said production satellite, said production satellite being situated on said bottom in a position substantially equally distant from the ends of said portion of said imaginary line and on the concave side of said line, said fluid flow means being operatively connected to said production satellite in an area not extending more than half way around said production satellite; said method comprising the following steps:

- (a) positioning a surface vessel over said satellite situated on said bottom;
- (b) connecting a cable between said surface vessel and said satellite situated on said bottom; and
- (c) hoisting said satellite to the surface while at the same time moving said surface vessel over the middle point of the imaginary circular line.

References Cited

UNITED STATES PATENTS

2,079,689	5/1937	Gorton	179—170
2,294,296	8/1942	Hansen	114—0.5
2,594,105	4/1952	Watts	114—0.5 X
2,614,803	10/1952	Wiggins	166—.5
2,648,201	9/1953	Marancik et al.	114—0.5
2,937,006	5/1960	Thayer	175—6
2,990,796	7/1961	Cole et al.	114—0.5
3,045,750	7/1962	Peters	166—4 X
3,063,507	11/1962	O'Neill et al.	166—.5 X
3,099,316	7/1963	Johnson	166—.6
3,111,692	11/1963	Cox	166—.5 X
3,221,816	12/1965	Shatto et al.	166—.5
3,261,398	7/1966	Haeber	166—.5
3,301,322	1/1967	Newsome	166—.5

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Washington, D.C. 20231

**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,401,746

September 17, 1968

L. C. Stevens et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 6, cancel ", when utilized to exploit a subaqueous oil field," and insert the same after "equipment" in line 8, same column 4.

Signed and sealed this 3rd day of February 1970.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents