# United States Patent

[11] 3,556,218


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[73] Assignee **Mobil Oil Corporation**
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[54] **UNDERWATER PRODUCTION SATELLITE**
**33 Claims, 8 Drawing Figs.**


[52] **U.S. Cl.** ..... **166/265,** 166/.5
[51] **Int. Cl.** ..... **E21b 39/00,** E21b 33/035
[50] **Field of Search** ..... 166/265, 267, 5.6, 265, 315, 154



[56] **References Cited**

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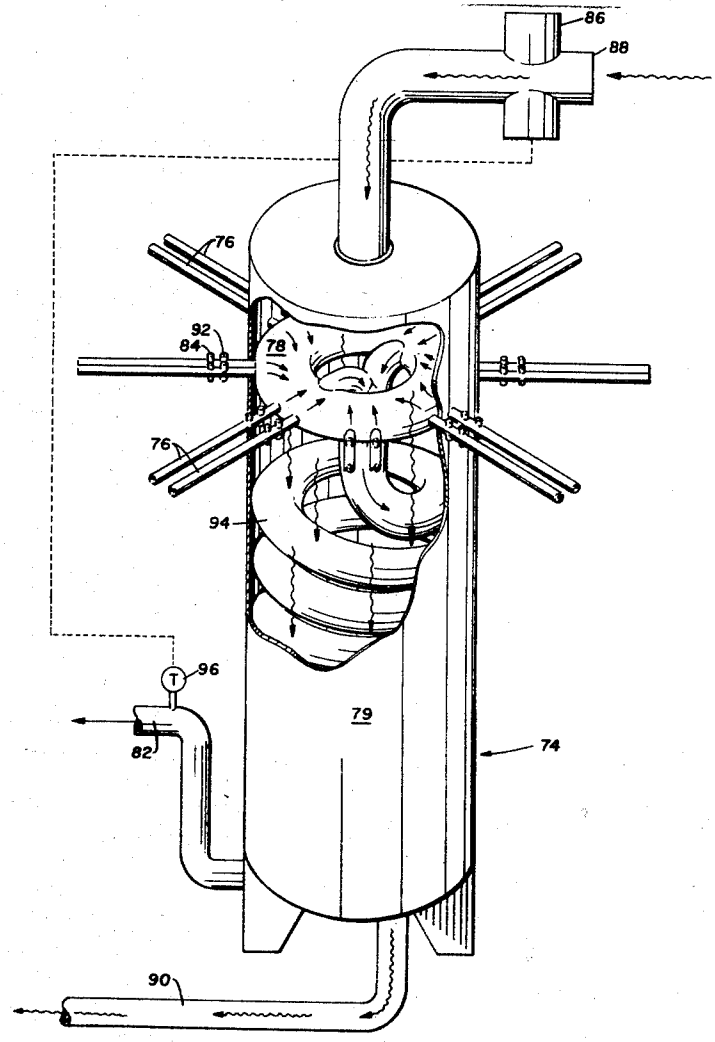
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**ABSTRACT:** This specification discloses a method and apparatus for the production of subaqueous deposits of fluid minerals through a subsea satellite system. The wells are drilled in a circular pattern through a template on the marine bottom serving also as base upon which the satellite body is installed. The production and control passages of each of the wells are connected to production equipment within the satellite body by separate connector units, independently lowered into place from a surface vessel, to form portions of fluid paths between the passages within the subsea wellheads and the production equipment within the shell of the satellite. Such an installation permits production through the satellite, installed on the template base, after only one of the wells has been drilled and completed. The produced fluids are separated and/or metered within the satellite prior to being transported to storage. Flowline tools are programmed to enter the various subaqueous wells through the connector units. Hydraulic circuitry and controls are provided for pumping the tools and chemicals down through the various wells and for retrieving the tools. Also disclosed is a hot water well utilized in conjunction with the heat exchanger within the satellite for warming the separated-off gases to prevent the formation of hydrates.

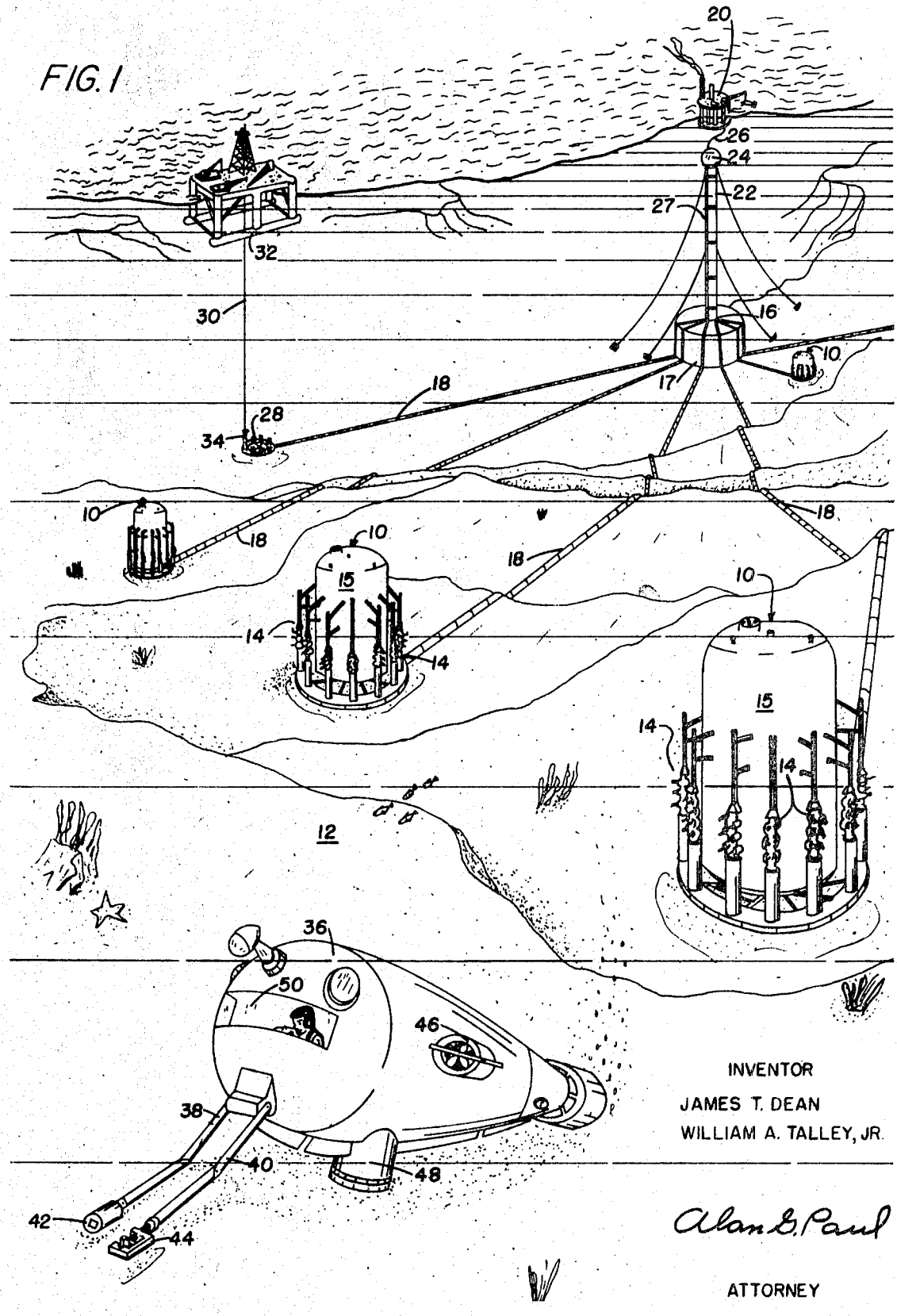



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SHEET 1 OF 6

FIG. 1




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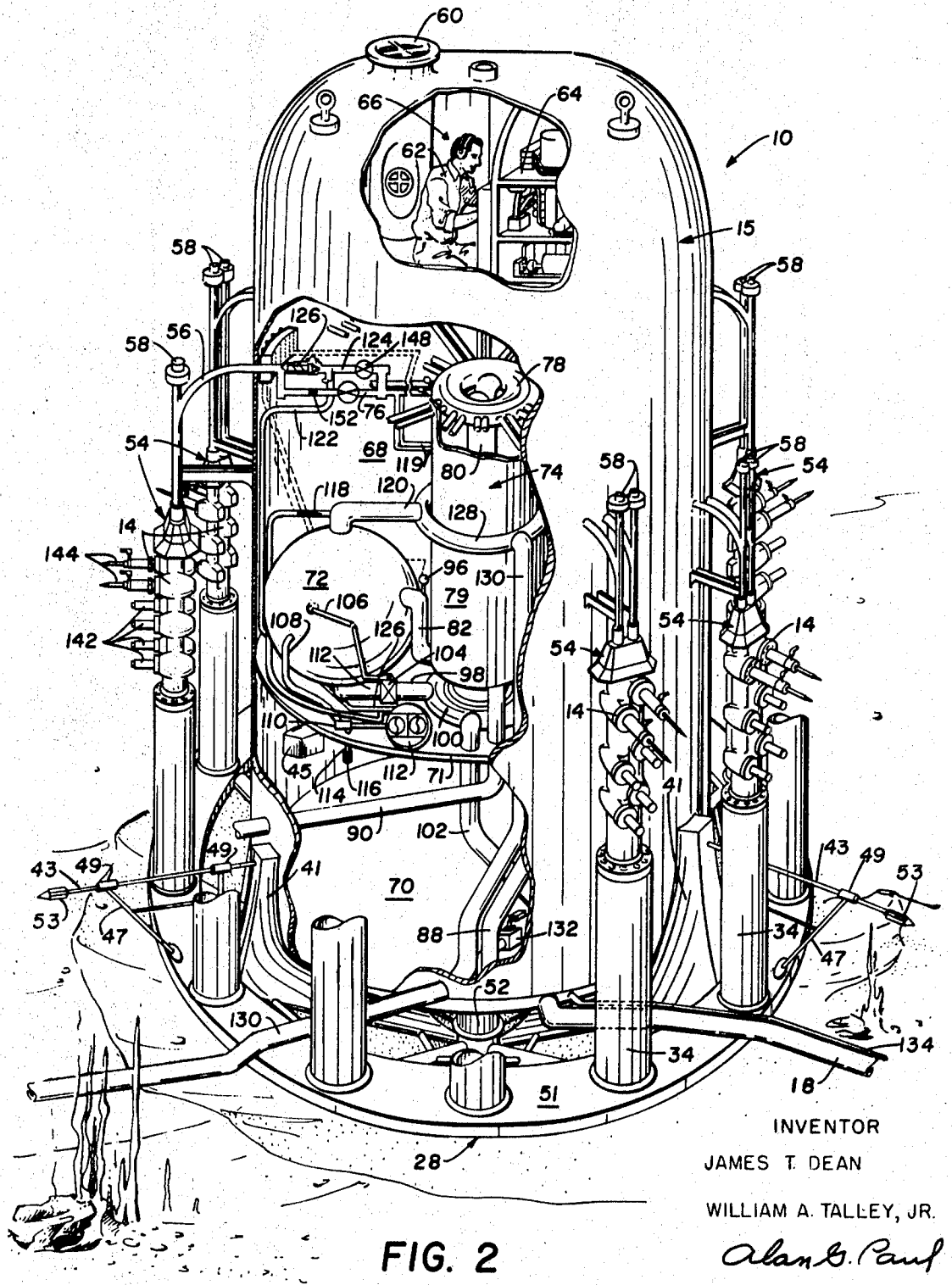
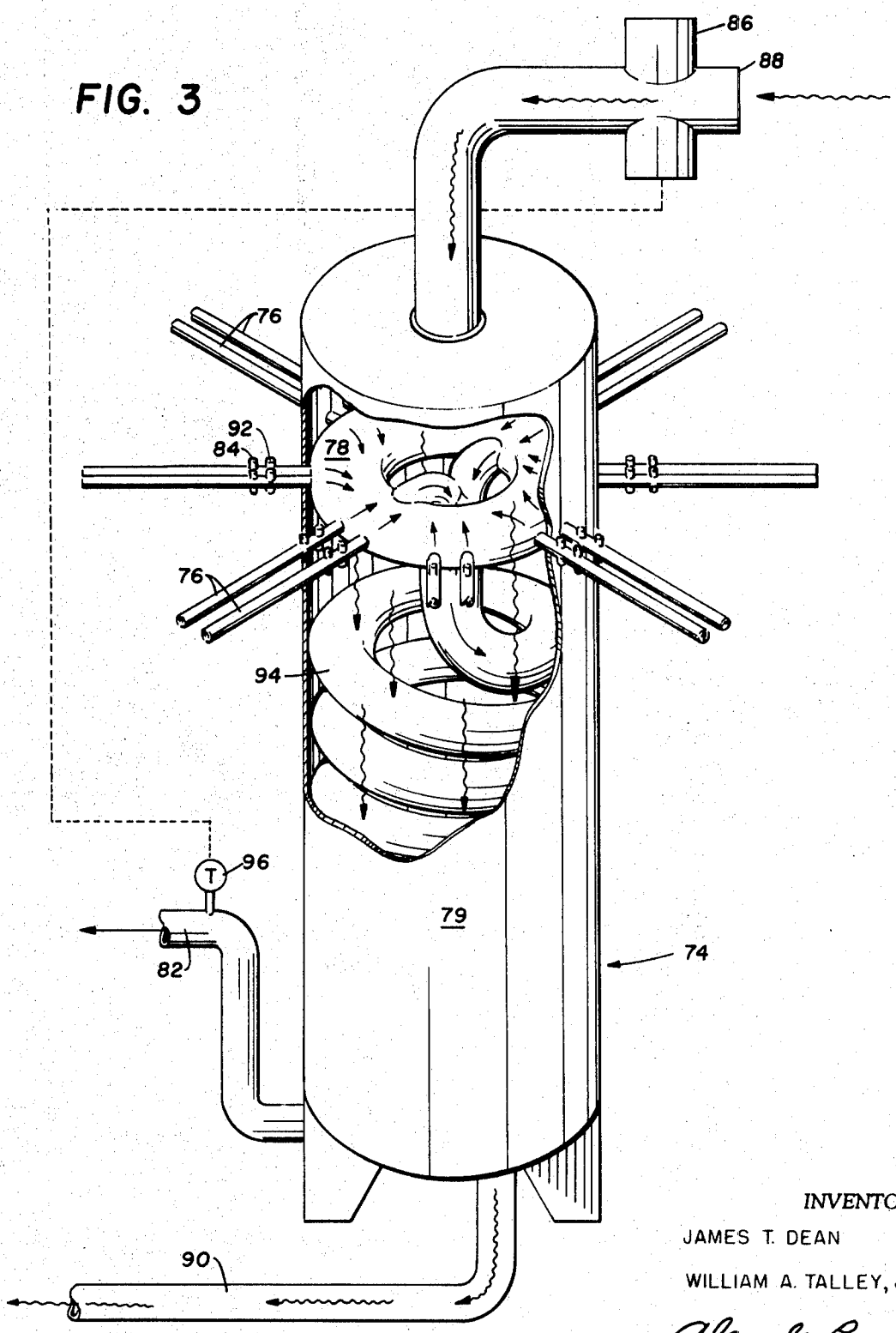

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FIG. 2

FIG. 3




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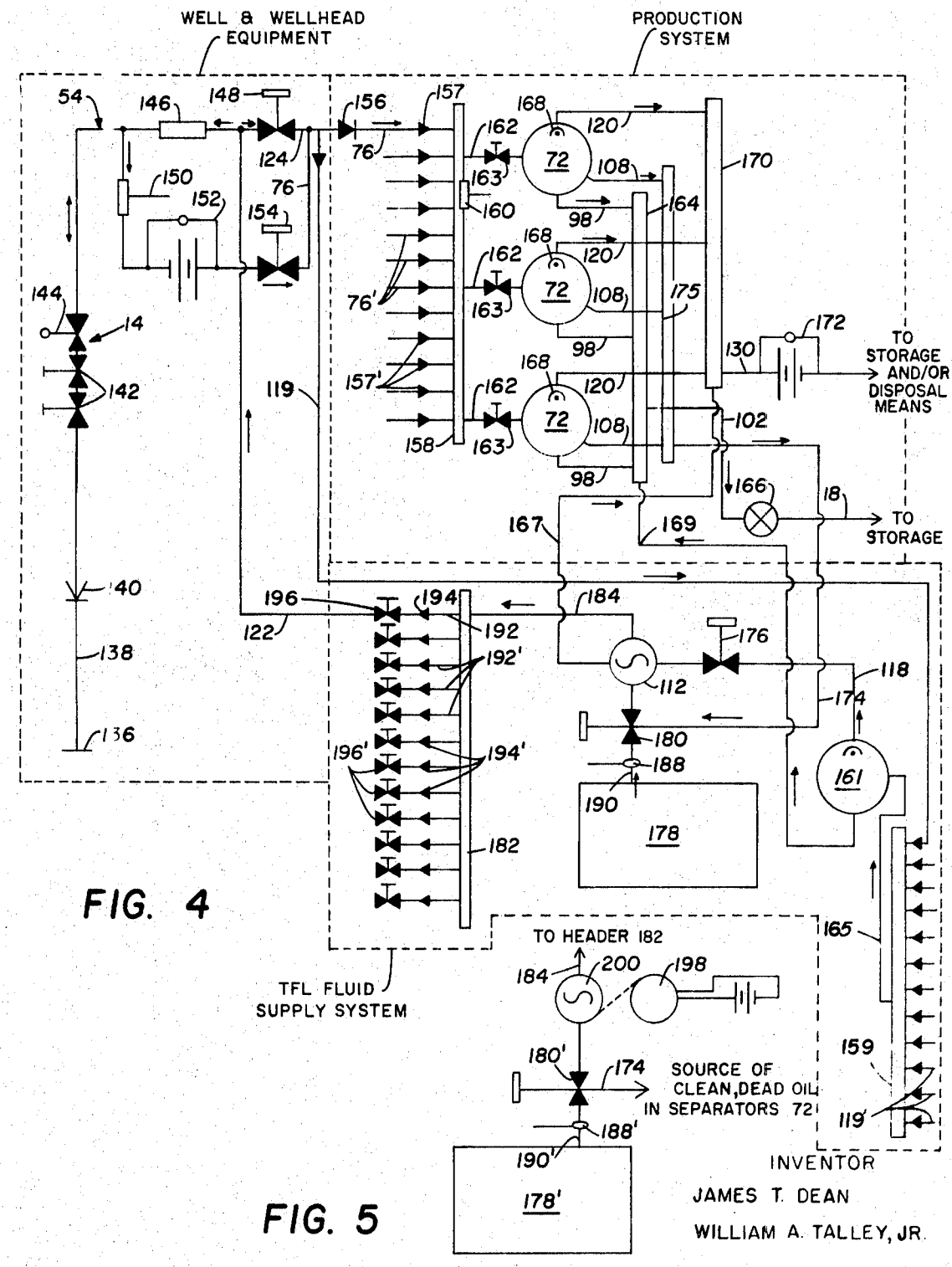



FIG. 4

FIG. 5

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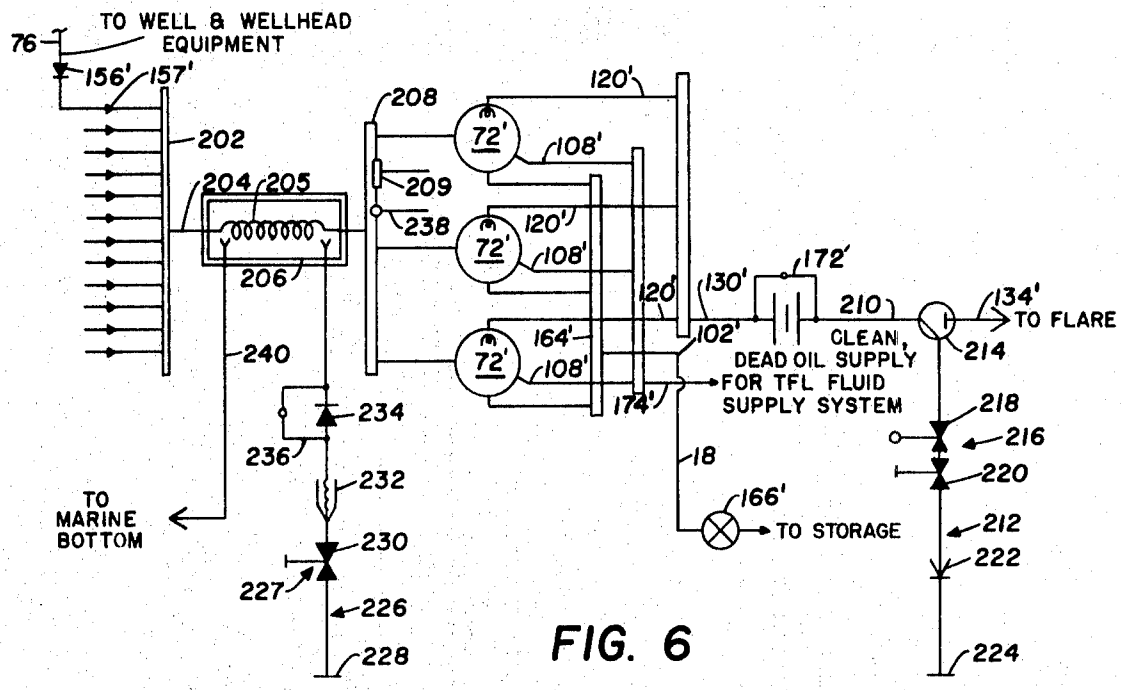



FIG. 6

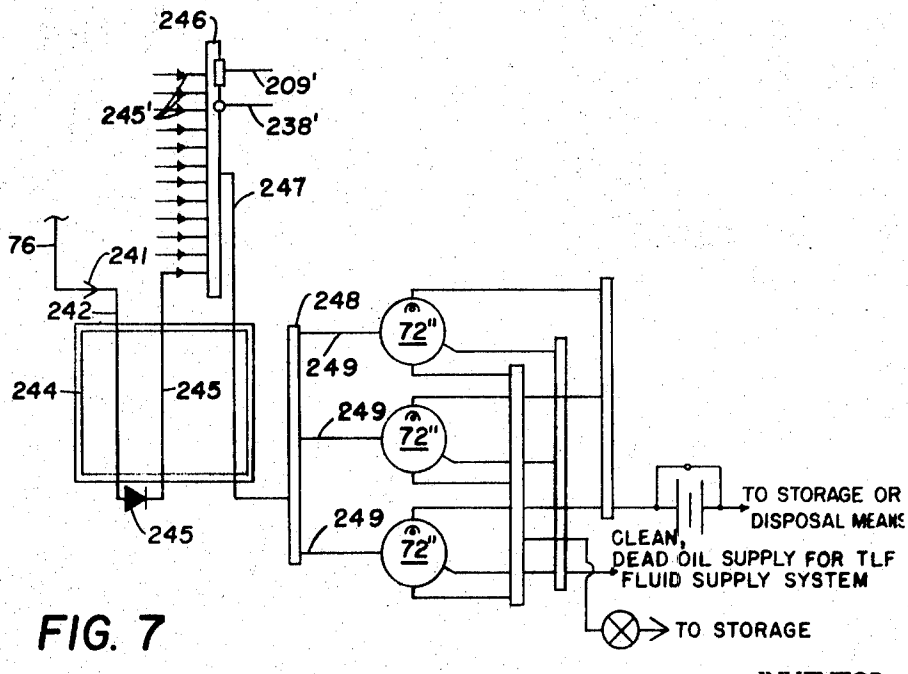



FIG. 7

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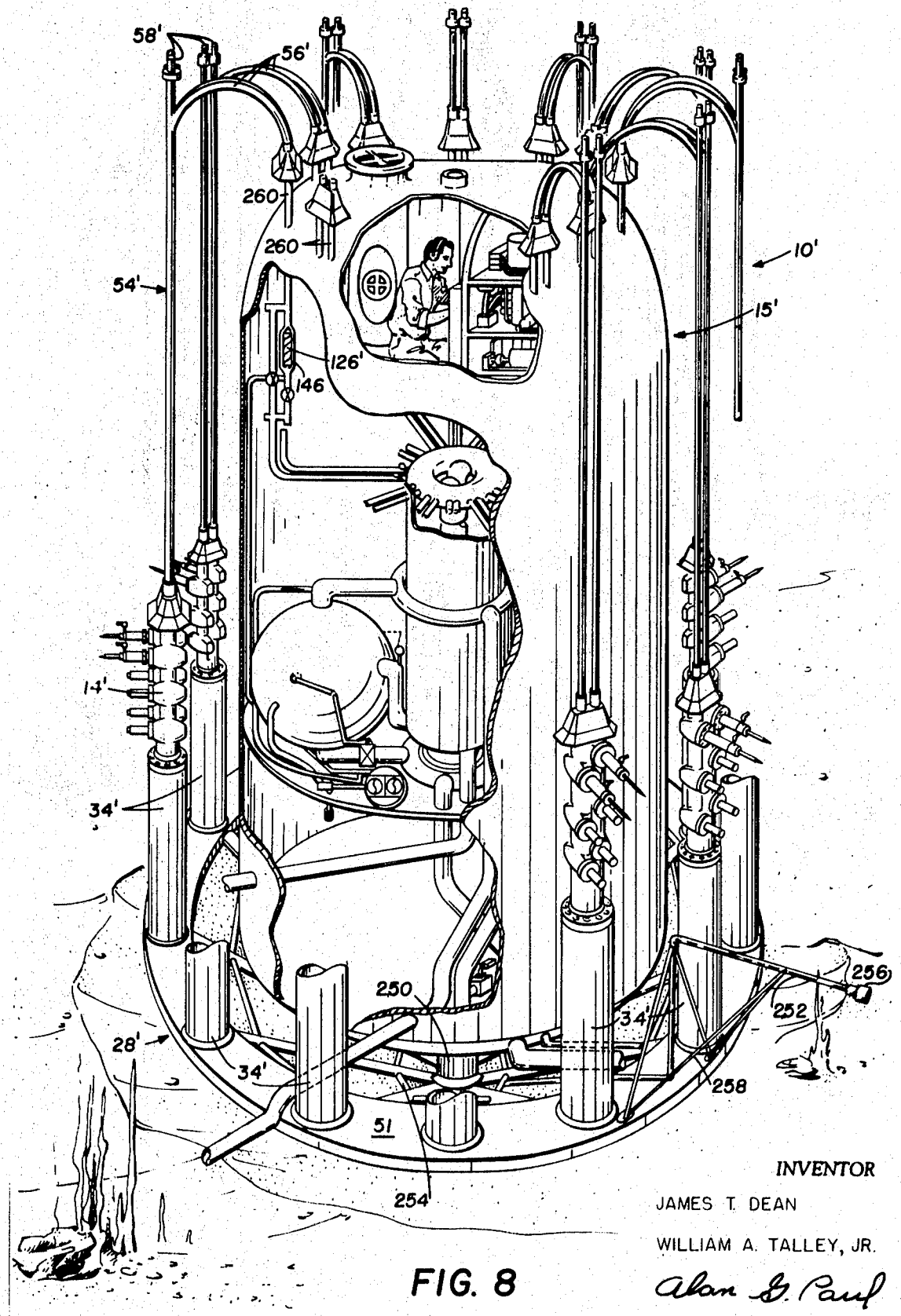



FIG. 8

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# UNDERWATER PRODUCTION SATELLITE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a subsea satellite designed to be interconnected with a group of subaqueous wells having subsea wellheads so as to control the production therefrom and to provide ordinary maintenance therefor. More particularly, the invention relates to a system for inserting one or more types of tools, and/or chemicals, down through selected wells and for retrieving the tools upon the completion of the respective function.

2. Description of the Prior Art

Since its inception, the offshore oil and gas industry has used bottom-supported above-surface platforms as the principal mechanism for the installation and support of the equipment and services necessary for the production of the subaqueous mineral deposits. As the industry has developed over the years, it has extended its search for offshore minerals from its birthplace, producing oil and gas in the shallow coastal waters off California and the Gulf of Mexico into areas where, because of excessive water depth and/or other local conditions, the bottom-supported platform is not as economically or technologically feasible.

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 the increase in water depth. Thus, the presently estimated costs of a platform to carry the production facilities for a field in 400 feet of water or more are so high as to indicate that such an installation cannot be justified economically for any but the most productive fields. Furthermore, the few bottom-supported above-surface platforms that have been designed and built for use in 300 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, as is described in the H. D. Cox Pat. No. 3,111,692, issued Nov. 26, 1963, which can be maintained in position in a field by either a fixed multipoint mooring system of anchors and anchor lines, or by a dynamic positioning system. The above solution 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 lines connecting wellheads on the marine bottom with the continuously moving floating production platform, and the potential hazard, of this system to the hoses, in the event of a failure of the fixed mooring or dynamic positioning systems.

Another consideration is that, in many areas of the world, local conditions other than water depth impose critical limitations on the use of bottom-supported production platforms. In arctic areas, a bottom-supported platform must be built to withstand the forces imposed by ice that forms on the water surface during the winter months of the year, and in many such areas all year long. Furthermore, 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 storms can be exceeded by the forces exerted against the platform by movement of the thick ice layers that freeze on the surface of the water. For example, in Cook Inlet, Alaska, the local extremely high tidal movements on the order of 30 feet or more cause very fast tidal currents in the Inlet, with velocities of up to 8 to 10 miles an hour or more. These very rapid currents carry with them the heavy pack ice that forms on the surface of the Inlet, so that it 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, but manmade, conditions that restrict the use of bottom-supported above-surface production platforms. Among such conditions could be listed official and/or public objection to oil production facilities near public recreational or residential areas, and the presence of heavy marine traffic as in harbors, channels, rivers, and other navigatable bodies of water which make it necessarily advantageous to install as much of the production equipment beneath the water surface as possible. For example, the first known use of subsea wellheads is in Lake Erie where gas is produced from subaqueous formations beneath the heavily traveled lake.



Therefore, it would appear that where there is extremely deep water and/or adverse surface conditions, a fully subsea installation would be the most advisable solution. One method, as is shown by the J. A. Haeber Pat. No. 3,261,398, issued Jul. 19, 1966, is to locate the individual pieces of production equipment on the marine bottom. Such an installation almost necessitates the use of robots such as shown in the G. D. Johnson Pat. No. 3,099,316, issued Jul. 30, 1963. However, such instrumentalities are expensive and not without their own limitations and maintenance problems. Another solution is suggested by the H. L. Shatto, Jr. et al. Pat. No. 3,221,816, issued Dec. 7, 1965, wherein the production equipment for a plurality of wells is grouped within a satellite chamber adapted to be raised to the surface for repair and/or maintenance.

To economically package production equipment used for scheduling, measuring, separating, and otherwise performing the usual manipulations on producing oil and gas wells, it is believed to be necessary to enclose the equipment within a pressure-resistant satellite shell within which can be maintained a breathable atmosphere permitting the equipment inside to be serviced and/or maintained by personnel, not encumbered with diving suits. Single well chambers, most being removable, have been proposed and are exemplified by the J. D. Watts et al. Pat. No. 3,202,216, issued Aug. 24, 1965. The most feasible system should include a subsea satellite having therewithin production equipment servicing a number of wells and capable of maintaining life sustaining conditions therewithin.

No feasible system has been presented to date for economically maintaining the several serviced wells in operating condition during production. This would require the periodic passing through of tools for cutting paraffin, setting chokes, removing sand, and other operations normally done with wirelines in a land or platform-supported well. A necessary part of such a maintenance system is means for detecting a malfunction in a well or in simpler installations, for instance, where frequent paraffin cutting is necessary, a timed sequence can be used. Apparatus must be provided for moving a single tool selectively through one of a number of wells and for storing one tool when one performing a different function is to be directed into a well.

While wireline tools have been used for many years to maintain wells and through-the-flowline (TFL) tools are known and have been used at least experimentally, a complete automatic system for maintaining several wells as a group is not available. The P. R. McStravick et al. Pat. No. 3,022,822 discloses a system for pumping a wireline tool down through a single subsea wellhead from a nearby above-surface location, but is not concerned with the selection of a particular tool, the timing of the operation, or the storage of the tool for a second operation. The F. H. Culver et al. Pat. No. 3,101,118 discloses a subsea wellhead to be utilized in conjunction with a wireline tool which is guided in and out of the wellhead through wide branch conduits thereof. The S. A. Bergman et al. Pat. Nos. 3,063,079 and 3,063,080 disclose launching devices for inserting pipe scraping tools or pigs into a pipeline while the K. D. Savage Pat. No. 2,856,884 discloses a system for storing a pig in an adjacent pipe when it is not being used in the pipeline.

## SUMMARY OF THE INVENTION

In accordance with this invention, fluid produced from a plurality of wells, through subsea wellheads, is processed

within a satellite station prior to being transported to storage. The produced fluid from the plurality of wells is combined into a single stream within the satellite station. The fluid stream is choked to reduce the wellhead pressure to that necessary to drive the fluid up to a surface installation. The fluid is then directed into a plurality of gravity separators connected in parallel. The gas taken off from the plurality separators is recombined and the main portion thereof directed to storage, utilized in a gas lift operation, or disposed of by flowing or being injected into shallow sand formations. A minor portion of the gas may be utilized to drive a turbine of a turbine-pump for pressuring up a TFL (through-the-flowline) system. The liquids, including oil and gas and sediment, are directed through the lower ends of each of the separators, the liquids being recombined and transmitted to storage. A clean oil pickup from within at least one of the separators directed oil from a point above the sediment level of the respective separator to the pump portion of the TFL system. In a storage tank forming a lower portion of the satellite body, open to the sea at the lower end thereof, a well treating fluid may be stored. Alternatively, the well treating fluid can be stored in and supplied from a surface vessel moored over the site. Wherever the source of treating fluid, it is in fluid communication with a first inlet of the turbine-pump through a three-way two-position valve, the second inlet thereof being connected to the clean oil source whereby a prescribed amount of treating fluid followed by clean oil can be pumped into the TFL circuitry behind a tool whereby the TFL tool is forced through the subsea wellhead and down into the respective well to perform a desired function. In place of the turbine-pump, an electrically driven pump may be used. In this case, the clean oil pickup line is dispensed with. Where a medium or high GOR (gas-to-oil ratio) is encountered, a heat exchanger unit is necessary to prevent hydrate formation, minimize excessive paraffin deposition, and restrict emulsion formation. For a medium GOR, the unit may consist of only passing the fluid prior to expansion in close conjunction with the fluid after expansion within an insulated area. Where there is a high GOR, an outside heat source is necessary.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a pictorial view of a subsea production system in accordance with the present invention;

FIG. **2** is a partially broken away enlarged view of one of the satellite stations shown in FIG. **1**, illustrating the arrangement of the equipment therewithin;

FIG. **3** is a schematic representation of a heat exchange system to be utilized within the satellite station also, but shown in less detail in FIG. **2**;

FIG. **4** is a schematic diagram of the basic circuitry required to produce a plurality of oil and gas wells within a satellite station;

FIG. **5** is a schematic diagram of a modified TFL Fluid Supply System;

FIG. **6** is a schematic diagram of a modified production system for producing a field having a high gas-oil ratio;

FIG. **7** is a schematic diagram of a modified production system for producing a field having a medium gas-oil ratio; and

FIG. **8** is a schematic diagram of a modified satellite station configuration for allowing the satellite body to be installed on a base template of a satellite station prior to the completion of any of the wells through the base template.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now looking to FIG. **1**, a subsea system for producing fluid minerals, in particular gas and oil, from a subaqueous field by a plurality of subsea wellheads is illustrated. A plurality of subsea production satellite stations, generally designated **10**, are spaced across a marine bottom **12**, each satellite station **10** comprising a satellite body **15** centrally positioned within a circular group of closely spaced subsea wellheads **14**. The produced fluids from the subaqueous wells are directed through encircling subsea wellheads **14** into the satellite body **15** of the respective satellite station **10**. The fluids being produced from the subsea wellheads **14** of each circular group are combined within the respective enclosed satellite body **15** and a first stage of separation (gravity) takes place. At least the liquid portion is then directed to a circular manifold **16** atop a central bottom-mounted storage tank **17** through a shipping line **18**, one shipping line **18** extending from each satellite station **10**.

A floating master station **20**, having power generating and final stage separation equipment thereon, as well as being fitted out with off-loading apparatus, is in fluid and electrical communication with the bottom-supported storage tank **17** through a tensioned tether pipe **22** extending from the storage tank **17** to a point just beneath the turbulent surface zone of the body of water and fixed at this point to a large subsurface buoy **24**. A flexible conduit **26**, containing a plurality of electrical and fluid flow paths, extends from the upper end of the tensioned tether pipe **22** to the floating master station **20**. The produced liquid, collected in the circular manifold **16**, is directed to the master station through a main shipping line **27** supported along the length of the tether pipe **22**, and a fluid line forming a portion of the flexible conduit **26**. The produced liquid passes through the final stage separation equipment on the master station **20** where the pressure is normalized and dissolved gases are removed. The dead liquid is then transported to storage within the storage tank **17** through a line of the flexible conduit **26** connected to an axial passage in the interior of the tether pipe **22**.

In the upper left-hand corner of FIG. **1** is illustrated the drilling of a well through a satellite base template, generally designated **28**, which has been previously installed on a marine bottom along with a shipping line **18'** for connecting a satellite station, when completed in conjunction with the template **28**, with the storage tank **17**. A drill string **30** is suspended from above the surface from a semisubmersible drilling vessel **32** and extends through a blowout preventer stack **33** mounted on one of a plurality of upstanding well conductor pipes **34** forming a portion of the template **28**. Illustrated in the lower portion of FIG. **1** is a manned submersible work vehicle, generally designated **36**, of a type to be employed at assist in the subsea operations and for the dry transfer of personnel to the satellite station **10**. The submersible work vehicle **36** has a pair of articulated arms **38** and **40** carrying a socket wrench **42** and a vise grip tool **44**, respectively. The submersible work vehicle **36** is further equipped with a pivotable positioning motor **46** on each side (one shown) to assist in locating the submersible work vehicle **36** adjacent a satellite station **10** firstly when subsea operations are to be performed during the drilling operations and the installation of the satellite body **15** therewithin, and at later times during maintenance and workover operations. A lower port **48** of the submersible work vehicle **36** is connected with a rear compartment (not shown) within the shell thereof to permit a diver to be released at an installation site if one should be needed. The rear compartment is isolated from the pilot's compartment, seen through the front view plate **50**, so that a diver after exposure to deep water can be kept in compression in the rear compartment while the front compartment is maintained at atmospheric conditions. This general type of submersible work vehicle is well known in the art and specific vehicles of this type are more fully described in the application Ser. No. 649,959, filed Jun. 29, 1967, of Warren B. Brooks, Charles Ovid Baker, and Eugene L. Jones, and the references cited therein.

Now looking at FIG. **2**, the interior of the satellite body **15**, as well as the satellite base template **28**, are illustrated in more detail. The internal equipment comprises that necessary for a high gas-oil ratio, high pressure field. The base template **28** comprises an outer ring **51** to which are rigidly connected the plurality of upstanding vertical well conductor pipes **34** through which subaqueous wells have been drilled. As shown,

a dual completion wellhead **14** is mounted on the upper end of each of the well conductor pipes **34** in completing each of the respective subaqueous wells. The satellite body **15** is installed after the completion of all of the wells drilled through the respective base template **28**. The satellite body **15** is shown to be cradled in a plurality of radially extending spaced arms **41** fixed to the base template **28**. Threaded detent rods **43** extend through each of the arms **41** and through the shell of the satellite body **15** into receivers **45** fixed to the inner wall of the shell. The detent rods can be screwed into and out of engagement with the receivers by means of the socket wrench **42** of the submersible work vehicle **36**. A hex nut **53**, terminating in a conical guide, is affixed to the outer end of each detent rod **43**. Support frames **47**, having pillow boxes **49** in which the detent rods **43** are journaled, allow the use of long detent rods **43** extending radially out beyond the well conductor pipes **34**.

A water well **52** is shown as having been drilled through the center of the base template **28** and is necessarily completed prior to the installation of the satellite body **15**. After all of the wells, including the water well **52**, have been completed, the satellite body **15** is lowered into place and is leveled and locked into the base template **28** in any suitable manner. There would be no reason why one water well could not be drilled through one of the well conductor pipes **34** on the ring **51** of the base template **28**, if this should prove more convenient. The only disadvantage would be the elimination of one possible producing well. The W. F. Manning patent applications Ser. Nos. 663,799 and 663,798 entitled Subsea Satellite Foundation Unit and Method for Installing a Satellite Body Within said Foundation Unit, and Subsea Satellite Foundation Unit and Method for Installing a Satellite Body Therewithin, respectively, disclose alternate leveling and locking means as well as means for registering the installed satellite with respect to encircling wellheads.

The water well **52** is designed to provide a heat source for a heat exchanger unit (to be discussed below) to warm the produced fluids after a pressure cut has been taken. The well water may also be directed through radiators in the portions of the satellite body **15** in which personnel are present to raise the interior temperature of that portion of the satellite body **15** above the ambient temperature at the marine bottom. In deep water the temperature at the marine bottom is in the range of 35° F. to 45° F., too cold for a man to work for long periods unless he is heavily clothed.

Each of the submerged dual completion wellheads **14** has a pair of upstanding tubing nipples (not shown), each being in fluid communication with a producing zone. Each of the pairs of tubing nipples is adapted to telescope into complementary passages of stabover connector unit, generally designated **54**, comprising a pair of downwardly curving tubing sections **56** extending radially outward from within the shell of satellite body **15** and terminating in vertical lubricator sections **58**. By means of the stabover connector units **54**, the production and control passages extending through the subaqueous wells are connected to manifolds within the satellite body **15** for the combining of the produced fluids through the satellite body **15** and/or for the injection of lift gas, or other fluids utilized in secondary recovery procedures, from the satellite body **15**, to all or selected ones of the subaqueous wells. As shown in the embodiment of FIG. **2**, the stabover connector units **54** are permanently fixed with respect to the satellite body **15**. Therefore, the satellite body **15** must be radially positioned quite precisely so that the stabover connector units **54** can register with and telescope over the upstanding tubing nipples of the respective wellheads **14**.

An escape hatch **60** is formed within the upper end of the satellite body **15** to permit the entry of an operator **62** from a diving bell or travel chamber, as shown in the Townsend application Ser. No. 521,745, filed Jan. 19, 1966, or a submersible work vehicle **38**. The upper portion of the interior of the satellite body **15**, within which the operator **62** is shown sitting at a panel **64**, comprises a control section, generally designated **66**, from which various operations, not normally programmed, may be controlled and from which stored information can be retrieved. Below the control section **66** is a production section, generally designated **68**, containing the various equipment necessary to separate and meter the produced fluids as well as to pump treating fluids and tools through the various wells.

Beneath the floor of the production section **68** is a treating fluid storage section, generally designated **70**. The treating fluid storage section **70** generally comprises an open-bottomed tank defined by the floor **71** of the production section **68** and the outer, generally cylindrical shell of the satellite body **15**. The storage section **70** can be partitioned to permit the storage of two or more discrete well treating fluids needed in one or more operations. Although some plumbing extends through the storage section **70**, it is substantially uncluttered to permit the storage of a large quantity of well treating fluid.

Centrally located, within the production section **68**, is a cylindrical heat exchanger unit **74**. Equiangularly spaced around the heat exchanger unit **74** are a plurality of spherical separators **72**. The produced fluids normally flow through the shell of the satellite body **15** by way of the tubing section **56** of the connector units **54**. From a tubing section **56** the fluid is directed by a branch conduit **76** through an expansion valve (shown in FIG. **3** and to be discussed with respect thereto) into an upper heat exchanger manifold **78** located within the upper end of an insulated jacket **79** of the heat exchanger unit **74**. Fluids, exiting from the manifold **78**, flow down through a central pipe **80**, leaving the heat exchanger unit **74** near the lower end thereof by means of conduits **82** (one shown) which lead the produced fluids into the individual separators **72**.

The separators **72** in the satellite station **10** are of the gravity type to permit the separation of the gas from the oil without a substantial temperature drop in the separators, avoiding hydrate and paraffin deposition problems therewithin. A loss of 7° F. to 8° F. would be normal with such equipment. With a one-minute retention time within the separator, all of the free gas will be removed, only the gas, dissolved in the liquid at the separator pressure, remaining for the secondary, or final, separation stage. While the separators planned for this installation have no water knockout feature, provision for removal of water from the oil could be provided if it was desirable at this stage of production. The pressure at which the separators **72** are designed to function may be governed by the depth at which the satellite station **10** is located since it is desirable to have sufficient pressure to lift the oil from the marine bottom to the master station **20** on the surface. In very deep water the produced oil may have to be lifted, at least in part, by power-driven pumps. Where the satellite is connected into a truck pipeline, rather than being transported away by tanker, the output pressure of the separators would be governed by the line pressure in the pipeline. Where the wells are producing with a wellhead pressure of, for example, 1,500 p.s.i. and the satellite station **10** is located in 2,000 feet of water, a 900-pound pressure drop will be taken, prior to introducing the produced fluid into the separators **72**, to obtain a pressure of approximately 600 p.s.i., which would be that necessary to drive the oil from the marine bottom to the surface. Taking a pressure drop of 900 p.s.i. lowers the temperature of the produced fluids by more than 50° F. When considering a 10,000-foot well in which the produced fluids at the wellhead would be at from 150° F. to 170° F., at 50° F. the resultant temperature would be well within the formation temperature of hydrates and paraffins.

The heat exchanger unit **74**, as shown more fully in FIG. **3**, is located in the process fluid circuitry between expansion chokes **84**, one located in each of the branch conduits **76**, and the separators **72**, providing a regulated flow of warm water as a heat source to increase the temperature of the mixed oil and gas on the downstream side of the choke **84** where a pressure cut has been taken, to prevent hydrate formation, minimize excessive paraffin deposition in the equipment, and restrict emulsion formation. The heat exchanger unit **74** depends upon well water obtained from the previously mentioned

water well **52** (shown only in FIG. **2**). The water is produced through a normal type of oil well completion and then flows through a variable choke **86** that regulates the flow and downstream pressure. In an example, using a 10,000-foot water well, the water at the upper end of the heat exchanger will also be in the range of 150° F. to 170° F. The water from the well **52** is directed upward through a conduit **88**, entering the insulated cylindrical jacket at **79** of the heat exchanger unit **74**, through the upper end thereof. The water travels down through the interior of the heat exchanger jacket **79**, emerging from the lower end thereof in outlet line **90** from which the water is dumped into the sea. As the cold produced fluid passes into the manifold **78** within the upper end of the heat exchanger unit **74**, after passing through the expansion choke **84** and a one-way valve **92**, the fluid comes into indirect contact with the warmer water flowing around the manifold **78**. From the manifold **78**, the produced fluid flows through a helical coil **94** extending axially through the heat exchanger unit **74** and into a heat exchanger manifold (not shown) in the lower end thereof, and then out of the jacket **79** through conduits **82**, each connected between one of the separators **72** and the lower heat exchanger manifold. A temperature sensor **96** is installed in at least one of the outlet lines **82** to act as a flow indicator and monitor mechanism to control the increase or decrease of the water flowing into the heat exchanger unit **74**. By increasing or decreasing the size of the choke **80**, the water flow is regulated to maintain the required temperature of the produced fluids entering the separators **72** (FIG. **2**). Such a system also acts as a resource conservation in that large use of produced oil and/or gas to fire such heater equipment as would be otherwise needed is not required.

Looking back to FIG. **2**, the liquids leave the separators **72** through respective liquid outlet lines **98**, connecting the separators **72** with liquid output manifold **100** centrally positioned around the lower end of the heat exchanger unit **74**. The combined produced liquid from the plurality of separators **72** is directed from the manifold **100** through a main oil outlet line **102** which is connected to the input end of a respective shipping line **18**.

The liquid is removed, at the lower end of each of the separators **72**, by the respective line **98** so as to also drain off all the water, entrained sand, and other impurities with the oil. These impurities might otherwise impede the action of the separator **72** and cause a premature malfunction thereof. A shutoff valve **104** in each of the liquid outlet lines **98** is controlled in conjunction with a float (not shown) within each of the separators **72**, to regulate the levels of the liquid within the separators **72**. As shown, a mechanical linkage is utilized between the float and the valve **104**. One of the electromechanical systems, well known in the art, could be substituted for the mechanical linkage. A clean oil line **108** is connected at a first end thereof into at least one of the separators **72**, above the lower end thereof, to pick up oil from above the sediment level and below the low level of the liquid to provide substantially clean oil (with dissolved gas) for pumping a tool into and down through a selected well. Line **108**, at the other end thereof, is connected to a first inlet of three-way two-position valve **110**, the outlet of which is connected to the inlet of a gas-driven turbine-pump **112** to provide the clean oil under pressure to the TFL system. A second inlet of the three-way two-position valve **110** is also connected to a line **114** having a pickup head **116** in the fluid storage section **70** of the satellite body **15** to provide a source of treating fluid for the turbine-pump **112**. Gas under pressure, for driving the turbine portion of the turbine-pump **112**, is provided through a turbine gas supply line **118** extending from an auxiliary turbine (not shown in this view) which is supplied with produced fluid tapped off, through lines **119**, upstream of the chokes **84**. The clean oil under pressure from the pump portion of the turbine-pump **112** is fed into a manifold (not shown in this view). From this last-mentioned manifold, the oil is pumped out, being selectively directed into one or more pressure lines **122**, each pressure line **122** being connected into a bypass conduit section **124** just behind a TFL tool **126** stored therein. Each bypass conduit **124** is directly connected to a curved tubing portion **56** of a connector unit **54** for pumping the TFL tool **126** therein into the connected wellhead **14** and down a passage of the respective well. The separated-out gas, leaving a separator **72** through an upper pipe or gas outlet line **120**, is combined with the separated-out gas from the other separators **72** in a ring manifold unit **128** encircling the insulated jacket **79** of the heat exchanger unit **74**.

The separated-out gas can be, in various instances, utilized in production procedures, stored for eventual transportation to shore, or disposed of at the site of the offshore production field. A main outlet line **130**, from the ring manifold **128**, is shown directing the gas out of the satellite station **10** for disposal through one or more distant gas disposal wells (not shown) where the gas will be injected into shallow sands underlying the marine bottom. A safety regulator valve **132** is connected in the main outlet line **130** to allow gas to be bled off through a flare line **134** to the master floating station **20**, if the pressure in the main outlet line **130** should rise above a predetermined value. If the gas obtained in the primary stage of separation is to be either disposed of by flaring or is to be stored for future transportion-to-shore facilities, it is conducted to the master station **20** by shipping line (not shown), as described with respect to the produced oil. At the master station **20**, the gas obtained from the primary stage of separation is combined with the gas obtained from the secondary or final stage of separation on the master station **20**. If the gas is to be flared, a flare stack is erected above the master station **20**. If the gas is to be stored, it is first compressed at the master station **20** and then is pumped down to a portion of the storage tank **17** or to a separate storage tank (not shown) nearby. As noted above, the gas from the primary separation stage may also be utilized in production procedures, the most common of these procedures being the utilization of the gas under pressure to provide lift pressure in the producing formations. A gas injection well for this purpose may be one of the wells drilled through the ring **51** of the template **28**, in which case a separated-out gas is fed into the wellhead **14** through a respective one of the curved tubing sections **56** of a stabover connector unit **54**, or the injection well may be located at a distance from the satellite station **10**, in which case an interconnecting flowline having a pressure regulator valve and a flare line, as described above with respect to injecting the gas into shallow sand formations, will be utilized.

FIG. **4** illustrates, in schematic form, a complete system, with the exception of a storage means, for the production of a low gas-oil ratio low pressure field. The fluid is produced in the portion of the system designated as Well and Wellhead Equipment at the TD (total depth) **136** of a representative well, generally designated **138**. In the well **138** is a storm choke **140** placed at approximately a 3,000-foot depth, below the normal lower limit of paraffin deposition, for safety purposes. Quarter-turned manually operated valves **142** are mounted on the wellhead **14** outside the satellite body **15** where they are easily accessible for operation by a man, robot, or a manned craft such as the underwater submersible work vehicle **36** illustrated in FIG. **1**. In some instances, it may be desirable to utilize remotely actuatable valves in place of the manually operated valves **142**. A high-low safety valve **144**, also mounted on the wellhead **14** outside the satellite body **15**, will automatically close should the pressure in the well **138** exceed a specified high pressure or drop below a specified low pressure.

From the upper end of the wellhead **14**, the fluid is directed through connector unit **54** to the portion of the wellhead equipment within the satellite body **15** where one or more TFL tools are stored in a storage chamber, designated by block **146**. (A TFL storage device and a paraffin cutting tool, designed to be stored therewithin, are fully described in the patent application Ser. No. 579,571 of James T. Dean, entitled Storage System for TFL Tools, filed Sept. 15, 1966, now U.S. Pat. No. 3,396,789. In FIG. **3** of the Dean patent, the in-

corporation of the described storage device in a fluid circuit for automatically maintaining a subsea well is shown.) The TFL storage chamber **146** is located in the previously described bypass conduit section **124**, as is a TFL tool control valve **148**, which remains closed except during TFL maintenance and/or testing. The branch conduit **76** contains a pressure indicator **150**, an orifice meter **152**, and a production wing valve **154**. The production wing valve **154** is normally open while the well **138** is producing and closed during TFL operations. The branch conduit **76**, through which the produced fluid generally flows, provides a path around the TFL storage chamber **146** and the closed control valve **148**. When the well **138** is producing, the fluids flow from TD point **136**, up through the storm choke **140**, and the series of valves **142** and **144**, of the wellhead **14**, into the branch conduit **76**. The pressure and flow rate of the fluid at the wellhead **14** are monitored at all times by the pressure indicator **150** and the orifice meter **152**, respectively, and representative signals are transmitted to, and recorded within, the control section **66** of the satellite station **10**.

The produced fluid flowing through the branch conduit **76**, past the interconnection with the bypass conduit section **124**, leaves the portion of the system designated in the schematic diagram as Wellhead and Wellhead Equipment and enters the portion designated Production System through a rotary variable choke **156**. As the fluid passes through the variable choke **156**, the pressure is lowered from that at the wellhead **14** to a pressure just above that necessary to drive the fluid from the marine bottom to the surface. From the rotary choke **156**, the produced fluid is directed through a check valve **157** into a collector manifold **158**. Branch conduits **76'**, each having a check valve **157'**, also shown as leading into the collector manifold **158**, are connected to the wellhead equipment of the various wells encircling the satellite station **10**. A pressure sensor **160** is mounted in the collector manifold **158** to monitor the pressure therewithin, a signal representative of which is transmitted to and recorded within the control portion of the satellite station **10**. The rotary variable choke **156** is controlled in response to the pressures indicated by the pressure sensors **150** and **160**. Three gravity separators **72** are connected, in parallel, to the collector manifold **158** through inlet lines **162**, each having a shutoff valve **163** therewithin. The liquids, including oil and water, exit for the most part through lines **98** which empty into a liquid collector manifold **164**. This manifold corresponds to the circular manifold **100** shown in FIG. **3**. From the liquid collector manifold **164**, the oil exits through the outlet line **102** and is transferred to storage through shipping line **18** after passing through a flow meter **166**. A clean oil outlet line **108**, as previously discussed, extends from a point within each of the separators **72**, from where substantially clean pure oil can be obtained, to a manifold **175**, which empties in turn into the upstream end of a line **174** connected at its downstream end to an inlet port of a three-way two-position valve **180** in the TFL Fluid Supply System. The gas accumulating in the separators **72** passes out through a high liquid shutoff valve **168** located in the upper end of each of the separators **72**, into a gas outlet line **120**, which empties into a gas collector manifold **170**. The major portion of the gas leaves the manifold **170** through the main gas outlet line **130**, passing through an orifice meter **172**, and is transferred to storage or disposal means. By disposal means is meant "flaring" or "shallow sand injecting" as previously discussed. The fluid pressure supply line **119** is connected between the bypass conduit **124**, at one end thereof, and a manifold **159** at the other end. Lines **119'** connect the bypass conduits of the other wells, which flow through the satellite station **10**, with the manifold **159**. The inlet of an auxiliary separator **161**, where only a small pressure cut is taken, is in fluid connection with the manifold **159** through a high pressure line **165**. The turbine gas supply line **118** is connected between the gas outlet of the auxiliary separator **161** and the inlet of the turbine of the turbine-pump **112** of the TFL Fluid Supply System to supply high pressure gas to the pump portion of the turbine-pump **112**. The pressure-reduced gas, from the gas discharge, or outlet, of the pump portion of the turbine-pump **112**, is directed through a line **167** into the gas collector manifold **170**. The liquids separated out in the auxiliary separator **161** are directed through line **169** into the liquid collector manifold **164**. The purpose of the turbine-pump **112** is discussed below. If one of the separators **72** becomes plugged, the liquid will fill that separator and force the respective valve **168** to close. With this possibility in mind, the separators **72** are designed so that any two are all that are required to process the total amount of fluid passing through the satellite station **10**. With the same rate of flow of gas through the orifice meter **172**, and liquid through the flow meter **166**, a signal warning of an increase in pressure will be transmitted to the control portion **66** of the satellite station **10** from the sensor **160** in the manifold **158**, indicating that there is a problem. Furthermore, the closing of a valve **168** can be made to actuate an electric switch, which in turn will provide a signal indicating which separator is malfunctioning. The production stream through the plugged separator **72** would then be cut off by closing the respective shutoff valve **163** so that the respective separator **72** can be serviced by personnel within the satellite station **10**.

The portion of the schematic diagram designated as the TFL Fluid Supply System contains a fluid storage means **178**, which corresponds to the open-bottomed fluid storage section **70** of the satellite station **10** as shown in FIG. **2**. The storage means **178** is connected to a first inlet port of the three-way two-position valve **180** through a line **190** having a salt water sensor **188** therein to provide a signal in the control section of the satellite station **10** indicating that the storage means **178** is empty of treating fluid and now contains only salt water. The other inlet port of the three-way two-position valve **180**, as previously discussed, is connected to a source of clean oil through the line **174** extending from the manifold **175** in the Production System portion of the schematic diagram. The outlet of the three-way two-position valve **180** is operatively connected to the inlet of the pump portion of the turbine-pump **112**, the outlet of the pump portion of the turbine-pump **112** being connected to an inlet of a manifold **182** through a conduit **184**. The power for driving the pump portion of the turbine-pump **112** is provided by gas under pressure obtained through the line **118** from the auxiliary separator **161**, which is fed with produced fluid at wellhead pressure from the Well and Wellhead Equipment portion of the system as previously outlined. By opening and closing a valve **176** in the line **118**, the operation of the turbine-pump **112** may be controlled. From the manifold **182** the clean oil and/or the treating fluid, under pressure, is pumped through one or more of the outlet lines **192** at a time, each of the outlet lines **192** having a check valve **194** and a selectively actuated cutoff valve **196** therein from which the fluid is directed through the respective line **122** into the Well and Wellhead Equipment portion of the schematic diagram where it is directed into the bypass conduit **124** between the TFL tool storage chamber **146** and the shutoff valve **148**. Outlet lines **192'**, each having a one-way check valve **194'** and a shutoff valve **196'** therein, are connected to the bypass conduits of the Well and Wellhead Equipment portions of the other wells (not shown) producing through the respective satellite station **10**.

To commence a TFL maintenance and/or testing procedure, valves **148** and **154** in the Well and Wellhead Equipment portion would both be closed. The shutoff valve **176**, in the TFL Fluid Supply System, connected to the input of the turbine-pump **112** would be open to activate the turbine portion. For paraffin removal, for instance, a paraffin solvent and corrosion inhibitor stored in the storage means **178** would first be drawn into the input of the pump section of the turbine-pump **112** by the proper positioning of the valve **180**. After pumping approximately one barrel of treating fluid through the valve **180**, the position of the valve would be changed so that the oil from line **174** would then be supplied to the pump portion of the turbine-pump **112**. One or more of

the valves 196, 196' would be open to permit the fluid driven by the turbine-pump 112 to exit from the header 182 through a line 122 to apply fluid pressure in the section of the bypass conduit 124, of the Well and Wellhead Equipment portion, between the valve 148 and the storage means 146. With the valve 148 closed, the fluid driven through line 122 into the bypass conduit 124, behind the storage means 146, will cause a paraffin cutting tool 126 positioned within the storage means 146 to be propelled down through the curved tubing section 56 of the connector unit 54 and down through the wellhead 14 of the respective well 138. The piston section of the tool 126 is not completely sealed within the tubing of the well 138 in which it moves so that by the time the tool is down in the well, at the lower end of the paraffin deposition zone, all of the treating fluid is in the well ahead of the tool. When the tool 126 reaches the end of its travel, above the storm choke 140, the valve 176, in the TFL Fluid Supply System portion, controlling the turbine-pump 112, would be shut causing the turbine-pump 112 to cease operation. The shutoff valve 148 in the bypass conduit 124 is then opened causing the TFL tool 126 to be returned up the well 138 by the fluid being produced, which now is directed into the downstream portion of the branch conduit 76 through the bypass conduit 124. When the TFL tool 126 has reentered the storage chamber 146, an indication of this condition will be given in the control section 66. A switching means for providing this function is shown in the Dean patent U.S. Pat. No. 3,396,789 discussed above. At this time, the valve 148, in the bypass conduit 124, will be shut and the valve 154, in the branch conduit 76, will be reopened, returning the well to production through the branch conduit 76. All of the previously described steps can be sequentially performed by an operator in the control section 66 of the satellite station 10, by remote control from the floating master station 20, or by a programmed computer, or by a combination of the aforementioned methods.

FIG. 5 illustrates a modification in which an electric motor 198 is utilized for driving a pump 200. With the substitution of the electric motor 198 and the pump 200 for the turbine-pump 112 (shown in FIG. 4), the gas line 118 is eliminated and the only exit line from the manifold 170 is the line 130. The remainder of the TFL Fluid Supply System (shown in FIG. 5) is identical to that shown in FIG. 4, therefore being a storage means 178' connected to one inlet of a three-way two-position valve 180' through a line 190' having a salt water sensor 188' therein. The other inlet of the three-way two-position valve 180' is connected to the line 174 as shown in FIG. 4 which is connected at the other end thereof to a clean oil source in the separators 72. The outlet of the three-way two-position valve 180' is operatively connected to the inlet of the pump 200. The outlet of the pump 200 is in turn connected, through the line 184, to the header 182, as shown in FIG. 4. The identical procedure would be followed with the exception that electrical power would be used to operate the electric motor 198 to drive the pump 200.

FIG. 6 shows the modified Production System to be used with the typical high gas-oil ratio high pressure well. This modified Production System is utilized with the Well and Wellhead Equipment portion and TFL Fluid Supply System portion of the schematic diagram of FIG. 4. As the produced fluid is directed from the branch conduit 76 through a variable choke 156' and a check valve 157', it is collected in a primary manifold 202 (generally similar to the manifold 78 shown in FIG. 2). The produced fluid in the manifold 202, having a high gas content, is now quite cold due to expansion in the choke 156'. This cold fluid passes out of the manifold 202 through a line 204 extending through a heat exchanger unit 206 (corresponding to the heat exchanger unit 74 of FIG. 2). The fluid, warmed up in the heat exchanger unit 206, enters a secondary manifold 208 from which it is directed into three separators 72'. A pressure sensor 209 and a temperature probe 238 are located in the secondary manifold 208. From the separators 72' the major part of the produced liquid is collected in the manifold 164' after which it is removed through a line 102' having a flow meter 166' therein, the outlet of the flow meter 166' being connected to the inlet of a shipping line 18 connecting the satellite station 10 with a distant storage facility. Again, clean oil is picked up by lines 108' and is directed through line 174' to the clean oil supply inlet of the three-way two-position valve, as shown in FIG. 4. The gas exiting from the separators 72', through lines 120', is collected in the manifold 170' from which it is, in the main, transmitted through a line 210 from the orifice meter 172, through a safety popoff valve 214, to a gas injection well 212, for disposal in shallow sand formations. The gas enters the injection well 212 through the wellhead 216 thereof having a high-low fail-safe valve 218 and a manually operated valve 220. There is also a storm choke 222 beneath the marine bottom in the injection well 212. If the back pressure in the shallow sand formations being used for disposal should rise above a preset limit of the popoff safety valve 214, the gas will be directed instead through a line 134' to the surface where it will be flared. To heat the cold fluids within the heat exchanger unit 206, warm water, at 150° F. to 170° F., is obtained from the TD 228 of a water injection well 226 producing through a wellhead 227 comprising a manual valve 230 and an automatic setting valve 232, and a rotary choke 234 having a pressure differential indicating device 236 located thereacross. The warm water flows through the heat exchanger unit 206, past a series of coils 205, in the line 204. From the heat exchanger unit 206, the then cooled water is directed out through line 240 into the surrounding water near the marine bottom. The rotary choke 234 is operated automatically in response to a temperature signal obtained from the temperature probe 238 previously described as located in the primary manifold 208 downstream of the heat exchanger unit 206. As the temperature sensed by the temperature probe 238 decreases, the choke 234 is opened further. If the temperature indicated reaches a specified low level, the satellite station 10 is completely shut in.

FIG. 7 is a schematic diagram of another modification of the Production System of FIG. 4, for a typical medium gas-oil ratio, medium pressure well. A well is produced in the same manner as in the previous two examples utilizing the same type of well and wellhead equipment. In this modification the fluid, entering the Production System portion through a branch conduit 76, is directed through a one-way valve 241 into a heat exchanger conduit 242 which traverses a heat exchanger unit 244. The produced fluid having been produced from a TD of 10,000 feet makes its first pass through the heat exchanger unit 244 at a temperature of 150° F. to 170° F. Upon exiting from the heat exchanger unit 244, a pressure cut is taken through a variable choke 245. The now cold fluids are passed back through the heat exchanger unit 244 by the traversing heat exchanger conduit 245 to raise the temperature in the expanded fluid to a prescribed minimum to prevent hydrate formation and wax deposition. From the conduit 245 the fluid passes into a collector manifold 246 containing a pressure sensor 238' and temperature probe 209'. In collector manifold 246, the fluid from the heat exchanger conduit is combined with the pressure cut fluid from the other wells of the satellite stations through heat exchanger lines 245'. The fluid from each well has previously been directed through the heat exchanger unit 244, had a pressure cut taken and then been passed back through the heat exchanger unit 244 through separate conduits. The combined fluid in the collector manifold 246 is directed out through a conduit 247, making a final pass across the heat exchanger unit 244 into another collector manifold 248. From the manifold 248, the fluid is divided into separate streams and directed into separators 72' through lines 249. The remainder of the fluid system is identical to that already discussed with respect to FIG. 4. If the temperature indicated by the temperature probe 209' decreases below a specified value, all the wells of the satellite station 10 are shut in.

The schematic diagrams of FIGS. 4—7 illustrate examples of systems to be used in specific cases. However, the features

of the various figures can be combined in different arrangements to suit various conditions. For instance, the electric-motor-drivepump **200** of FIG. 5 could be used with the modifications of FIGS. **6** and **7**.

FIG. **8** illustrates a modified satellite station **10'**, similar to the satellite station **10** of FIGS. **1** and **2**, having the added advantage of being able to be installed prior to completing any of the production wells through the ring **51'** of the base template **28'**. In this embodiment, instead of using cradling arms as illustrated in FIG. **2**, the satellite body is held in the satellite base **28'** by a central sleeve **250** depending from the lower end of the satellite body **15'** and automatic spring-loaded latches (not shown) over the upper end of the well conductor pipe of the water well **52**. The latches can be disabled by a hydraulic pressure applied through the conduit **252** extending between a manifold **254**, forming a portion of the framing of the base template **28'**, at the inner end, and a quick-disconnect coupling section **256**, at the outer end. The outer end of the conduit is supported by a skeletal frame **258** to displace the coupling section **256** outward of the well conductor pipes **34'**. The arrangement of the equipment within the satellite body **15'** is substantially the same as the arrangement within the satellite body **15** of the earlier discussed embodiment with the exception of the orientation of the TFL tool **126** and the associated hydraulic circuitry. In this instance, the connector units **54'** are not permanently attached to the satellite body **15'** but instead are stabbed-over tubing nipples **260** extending vertically out of the upper end of the satellite body **15'**. When a well is to be completed through one of the upstanding well conductor pipes **34'**, a wellhead **14'** is first mounted on the respective well conductor pipe **34'**. A connector unit **54'** is later lowered from the surface to make the connection between the well head **14'** and the satellite body **15'**. The connector unit **54'** consists of a curved tubing section **56'** and a vertical lubricator section **58'**. The lower end of the lubricator section **58'** is stabbed over the tubing (not shown) extending vertically out of the upper end of the wellhead **14'**, while the outer vertical free ends of the curved tubing section **54'** stabs over the respective ones of the upstanding tubing nipples **260** extending out of the upper end of the satellite body **15'**. In this manner, with each connector section **54'** being individually engaged between the wellhead **14'** and the respective upstanding tubing nipples **260**, greater tolerances can be allowed in installing the satellite body **15'**. Furthermore, an individual well can be produced through the satellite station **10'** while the remaining wells are still being drilled and completed. The vertical orientation of the tubing nipples **260** extending vertically into the satellite body **15'** presents no problem, each of the TFL storage chambers **146'** is reoriented into a vertical position so as to be coaxial with the respective tubing nipples **260**. The vertical position of the storage chamber **146'** permits the TFL tool **126'** stored therewithin to move easily into respective tubing nipples **260** so that it can be pumped, under fluid pressure, through a full 180° bend in the tubing sections **56'** of the connector unit **54'** . Such a bend, of 180°, will not present any insurmountable problems requiring only that the wells be spaced out far enough from the satellite body **15'** to obtain a 5-foot radius bend in the conduit. Stabover connections, as discussed in this application, are more fully described in the Manning application Ser. No. 663,799.

Although the present invention has been described in connection with details of the 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.

We claim:

**1.** A system for maintaining a plurality of submerged wells from a central station comprising: a central station comprising a submergible, watertight shell and having a first manifold therewithin; first conduit means providing separate fluid connections between production passages of each of said plurality of wells and said first manifold, each of said first conduit means having parallel fluid flow paths including a first flow path for production flow and a second flow path for inserting well maintenance tools into a respective production passage of the respective well; a first shutoff valve in said first flow path; means within said shell for inserting a tool into said respective production passage being connected in series in said second flow path; and a second shutoff valve in said second flow path, said second shutoff valve being located between said tool-inserting means and said first manifold.

**2.** A system for maintaining a plurality of wells from a central station, as recited in claim **1**, comprising: a source of fluid under pressure for pumping a well maintenance tool from said tool-inserting means into said respective production passage against well pressure; and second conduit means fluidly connecting said source of fluid under pressure with said second flow path between said tool-inserting means and said second shutoff valve.

**3.** A system for maintaining a plurality of wells from a central station comprising: a central station having a first manifold therewithin; first conduit means providing separate fluid connections between production passages of each of said plurality of wells and said first manifold, each of said first conduit means having parallel fluid flow paths including a first flow path for production flow and a second flow path for inserting well maintenance tools into a respective production passage of the respective well; a first shutoff valve in said first flow path; means for inserting a tool into said respective production passage being connected in series in said second flow path; a second shutoff valve in said second flow path, said second shutoff valve being located between said tool-inserting means and said first manifold; a source of fluid under pressure for pumping a well maintenance tool from said tool-inserting means into said respective production passage against well pressure; second conduit means fluidly connecting said source of fluid under pressure with said second flow path between said tool-inserting means and said second shutoff valve; and a pressure-reducing means located in each first conduit just upstream of said first manifold.

**4.** A system for maintaining a plurality of wells from a central station, as recited in claim **3**, comprising: a source of fluid under pressure for pumping a tool from said tool-inserting means into said respective production passage against well pressure; second conduit means for connecting said source of fluid under pressure with said second flow path between said tool-inserting means and said second shutoff valve; said source of fluid under pressure being a turbine-pump; a third conduit connected into said first conduit upstream of said pressure-reducing means in at least one of said second flow paths for supplying gas under pressure from said at least one second flow path to the turbine portion of said turbine-pump; and means for exhausting waste gas from said turbine portion of said turbine-pump.

**5.** A system for maintaining a plurality of wells from a central station, as recited in claim **4**, wherein there is means for disposing of waste gas that has been used to drive said turbine portion of said turbine-pump; said waste gas disposal means including a fourth conduit fluidly connecting the outlet of said turbine portion of said turbine-pump with a gas manifold downstream of said pressure-reducing means downstream of said first manifold, inlets of a plurality of separators connected in parallel to outlets of said first manifold; gas outlets of said plurality of separators connected in parallel to said gas manifold; and a gas outlet line connected to an outlet of said gas manifold for directing the separated-out produced gas from said central station.

**6.** A system for maintaining a plurality of wells from a central station, as recited in claim **4**, wherein said third conduit means includes first and second fluid lines and an auxiliary separator, an inlet of said auxiliary separator being operatively fluidly connected to an outlet of said first fluid line of said

third conduit means; and said second fluid line of said third conduit means being connected between a gas outlet of said auxiliary separator and an inlet to said turbine portion of said turbine-pump.

7. A system for maintaining a plurality of wells from a central station, as recited in claim 6, wherein said inlet of said auxiliary separator is fluidly connected to an outlet of a third manifold by a third fluid line of said third conduit means; and a first portion of said second fluid line of said third conduit means is fluidly connected to each of said second flow paths of said plurality of wells of said central station to inlets of said second manifold.

8. A system for maintaining a plurality of wells from a central station, as recited in claim 3, comprising: a power-driven pump for supplying fluid under pressure for pumping a tool from said tool-inserting means into said respective production passage against well pressure; and second conduit means for operatively connecting an outlet of said pump with said second flow path between said tool-inserting means and said second shutoff valve, said pressure-reducing means being located between said second shutoff valve and said first manifold.

9. A system for maintaining a plurality of wells from a central station, as recited in claim 8, wherein a means for driving said power-driven pump is an electric motor.

10. A system for maintaining a plurality of wells from a central station, as recited in claim 8, wherein there is means for selectively connecting the inlet of said power-driven pump to either a source of well treating fluid or a source of substantially clean, dead oil.

11. A system for maintaining a plurality of wells from a central station, as recited in claim 8, wherein there is a three-way two-position valve, the outlet port of said three-way two-position valve being connected to the inlet of said power-driven pump; a first inlet port of said three-way two-position valve being connected to a source of well treating fluid; and a second inlet port of said three-way two-position valve being connected to a source of substantially clean, dead oil.

12. A system for maintaining a plurality of wells from a central station, as recited in claim 8, wherein said second conduit means comprises: first and second fluid lines and a second manifold; said first fluid line of said second conduit means being connected between the outlet of said power-driven pump and an inlet of said second manifold, a plurality of second fluid lines of said second conduit means being connected between outlets of said second manifold and each of said plurality of second flow paths.

13. A system for maintaining a plurality of wells from a central station, as recited in claim 12 , wherein there is a shutoff valve in each of said second fluid lines of said second conduit means.

14. A system for maintaining a plurality of wells from a central station, as recited in claim 8, wherein there is a source of substantially clean, dead oil; fifth conduit means for fluidly connecting said source of substantially clean, dead oil to an inlet of said power-driven pump.

15. A system for maintaining a plurality of wells from a central station, as recited in claim 14, wherein said source of substantially clean, dead oil is at least one separator means for fluidly connecting an inlet of said at least one separator with an outlet of said first manifold, said separator comprising: a first outlet for separated-out gas; a second outlet, at the lower end of said separator, for a separated-out mixture of fluids and solids in suspension therein; and a third outlet, above said second outlet, for separated-out substantially clean, dead oil.

16. A system for maintaining a plurality of wells from a central station, as recited in claim 3, wherein there are a plurality of separators fluidly connected in parallel with said first manifold; a fourth manifold for collecting produced gas; means for fluidly connecting gas outlets of said plurality of separators in parallel with said fourth manifold; a gas outlet line for directing produced gas from said fourth manifold and out of said central station; a fifth manifold for collecting produced liquids; means for fluidly connecting liquids outlets of said plurality of separators in parallel with said fifth manifold; and a liquids outlet line for direction produced liquids from said fifth manifold and out of central station.

17. A system for maintaining a plurality of wells from a central station, as recited in claim 16, wherein there is a sixth manifold for collection clean, dead oil; means for fluidly connecting clean, dead oil outlets of said plurality of separators, above said liquids outlets of said respective separators, in parallel with said sixth manifold for supplying clean, dead oil for pumping well maintenance tools into the production passages of said respective wells.

18. A system for maintaining a plurality of wells from a central station, as recited in claim 16, wherein said gas outlet line, downstream of said fourth manifold, is in fluid connection with a means for injecting gas into at least one underground formation.

19. A system for maintaining a plurality of wells from a central station, as recited in claim 18, wherein said at least one underground formation is an underground formation from which fluids are being produced through at least one of said wells whereby said underground formation can be repressurized.

20. A system for maintaining a plurality of wells from a central station, as recited in claim 18, wherein said at least one underground formation is a shallow, low pressure porous formation, not being produced, whereby waste gas can be disposed of.

21. A system for maintaining a plurality of wells from a central station, as recited in claim 3, wherein each of said pressure-reducing means is a choke whereby the produced fluid is expanded downstream of each of said chokes; and means for heating the expanded fluid just downstream of said chokes to hinder the formation of hydrates and emulsions and to prevent the deposition of paraffin in the equipment.

22. A system for maintaining a plurality of wells from a central station, as recited in claim 21, wherein the source of heat for said heating means is outside of said produced fluid.

23. A system for maintaining a plurality of wells from a central station, as recited in claim 22, wherein said heating means is an indirect heat exchanger unit; a first fluid line portion of each of said first conduit means, upstream of said chokes, for directing the produced fluid, under pressure, in a first pass through said indirect heat exchanger unit; and a second fluid line portion of each of said first conduit means, between the respective choke, and said first manifold, for directing the produced fluid, now expanded, in a second pass through said heat exchanger unit whereby heat is exchanged between said first and said second passes to warm the expanded fluids downstream of said chokes.

24. A system for maintaining a plurality of wells from a central station, as recited in claim 23, wherein there is a third pass through said heat exchanger unit fluidly connected at the upstream end to the single outlet of said first manifold.

25. A system for maintaining a plurality of wells from a central station, as recited in claim 24, wherein the downstream end of said third pass through said heat exchanger is in fluid connection with a seventh manifold; and means for fluidly connecting each of a plurality of separators in parallel with said seventh manifold.

26. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of said well, said production passage of said well being a fluid connection with equipment in a distant production facility through a first conduit means; said first conduit means having parallel fluid paths including a first path connected to a first manifold for production flow and a second path for inserting said well maintenance tool into a respective production passage of a respective well; a first shutoff valve in said first flow path; a tool storage means being connected in series in said second flow path; a second shutoff valve in said second flow path, said second shutoff valve being located between said tool storage means and said first manifold; a source of

clean, dead oil for pumping said well maintenance tool down said respective well production passage against well pressure; a source of well treating fluid; and means for selectively fluidly connecting a second conduit means between said source of clean, dead oil and said second flow path between said tool storage means and said second shutoff valve, said selective connecting means is operable to selectively alternately connect said second conduit to said source of clean, dead oil or to said source of well treating fluid, including the following steps:

a. shutting said first shutoff valve while leaving said second shutoff valve closed as it is positioned during production of fluid from said respective production passage;
b. selectively fluidly connecting said source of well treating fluid with said second conduit means;
c. pumping a prescribed amount of well treating fluid behind said well maintenance tool;
d. selectively fluidly connecting said source of clean, dead oil with said second flow path through said second conduit means; and
e. pumping clean, dead oil from said source through said second conduit means whereby a well maintenance tool in said storage means is pumped out of said storage means and down through said production passage of said respective well.

**27**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of a well, as recited in claim **26**, wherein said well treating fluid is a paraffin dissolving agent and said well maintenance tool is a paraffin scraping tool.

**28**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of a well, as recited in claim **26**, including the following additional steps to be performed for the retrieval of said well maintenance tool from said production passage by the pressure of fluids being produced through said well:

f. shutting off the supply of fluid under pressure through said second conduit;
g. opening said second shutoff valve so that well fluids are produced through said second flow path;
h. closing said second shutoff valve when said well maintenance tool has been driven up said production passage and into said storage means by the produced fluids; and
i. opening said first shutoff valve after said well maintenance tool is again within said storage means whereby well production continues thereafter through said first flow path of said first conduit into said production facility.

**29**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of a well, as recited in claim **26**, including the following additional steps:

j. separating the produced fluids into liquid and gaseous components;
k. drawing off clean, dead oil from the upper portion of said liquid component which could include oil, water, and/or solids; and
l. directing said clean, dead oil to the inlet of a power-driven pump, the outlet of said power-driven pump being connected to said second conduit means.

**30**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of a well, as recited in claim **26**, wherein the means for pumping said oil is a gas-driven turbine-pump, including the following additional steps:

m. separating the produced fluid into liquid and gaseous components;
n. drawing off at least a portion of the gaseous component; and
o. directing said gaseous component, drawn off, into the inlet of the turbine portion of said turbine-pump to drive the turbine.

**31**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of a well, as recited in claim **26**, wherein there are a plurality of wells spaced from said production facility, said production facility being a satellite station located in the field being exploited, including the following additional step:

p. collecting the produced fluids from said plurality of wells in a first manifold.

**32**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into production passage of a well, as recited in claim **31**, including the following additional step:

q. choking the flow of produced fluid in the first conduit means just prior to the collecting of said produced fluids in said first manifold whereby the pressure in said produced fluids is reduced in said first manifold.

**33**. A method for maintaining a well in conjunction with a well maintenance tool that can be pumped into a production passage of a well, as recited in claim **32**, including the following additional step:

r. heating said produced fluids subsequent to reducing the pressure thereof by choking the flow of said produced fluids.

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# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,556,218 Dated January 19, 1971

Inventor(s) William A. Talley, Jr. and James T. Dean

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

Column 5, line 51, --a--has been omitted before "stabover".

Column 16, Claim 16, line 3, "direction" should be --directin
line 4, --said-- has been omitted before "central".

Claim 17, line 7, "collection" should be --collect

Claim 26, line 66, before "fluid" "a" should be ca
and --in--inserted.

Column 18, Claim 32, line 33, --a-- has been omitted before "production".

Signed and sealed this 25th day of May 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents