United States Patent

Engel

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[54] **WELL PRODUCTION METHOD AND APPARATUS**

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[52] **U.S. Cl.** **55/43**, 55/172

[51] **Int. Cl.** **B01d 19/00**

[58] **Field of Search** 55/23, 174, 175, 36, 24, 43, 55/45, 46, 49, 159, 171, 172

[56] **References Cited**

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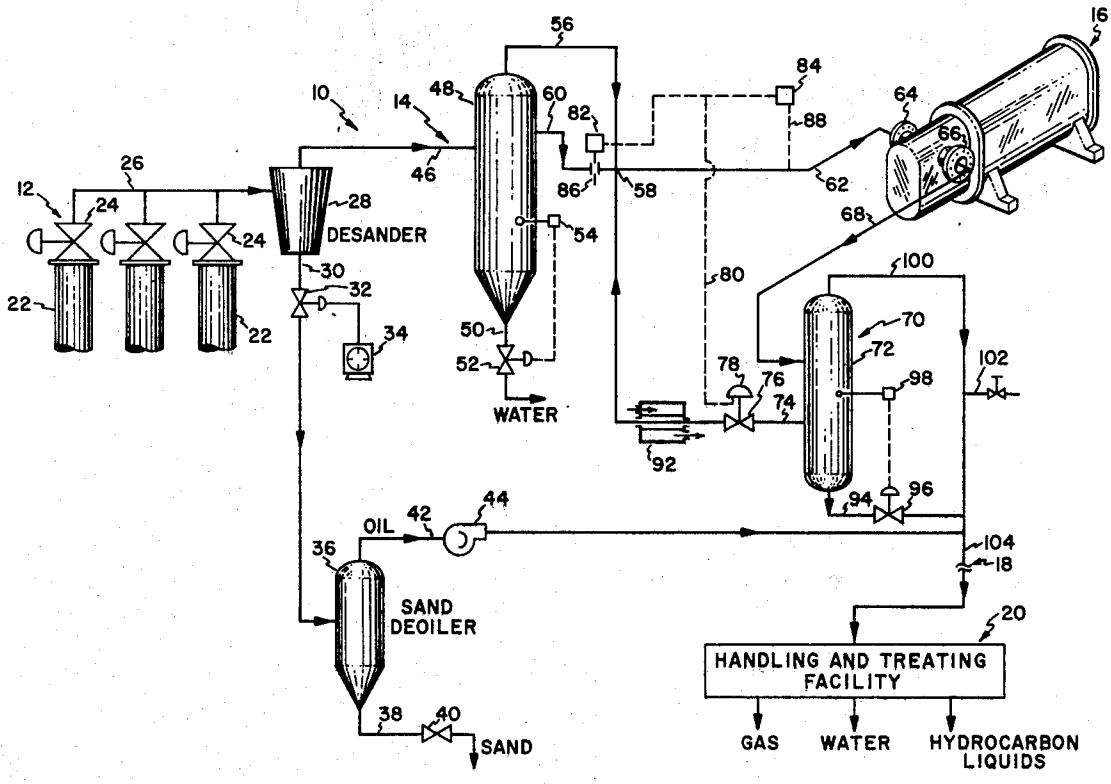
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[57] **ABSTRACT**

A multiphase hydrocarbon mixture is produced from each of a plurality of wells. The multiphase mixture is pressurized by a single machine without separating the gas and liquid components. The multiphase mixture is then transported through a conduit to a treating facility where the gas and liquid components are separated for ultimate sale or use.

12 Claims, 2 Drawing Figures



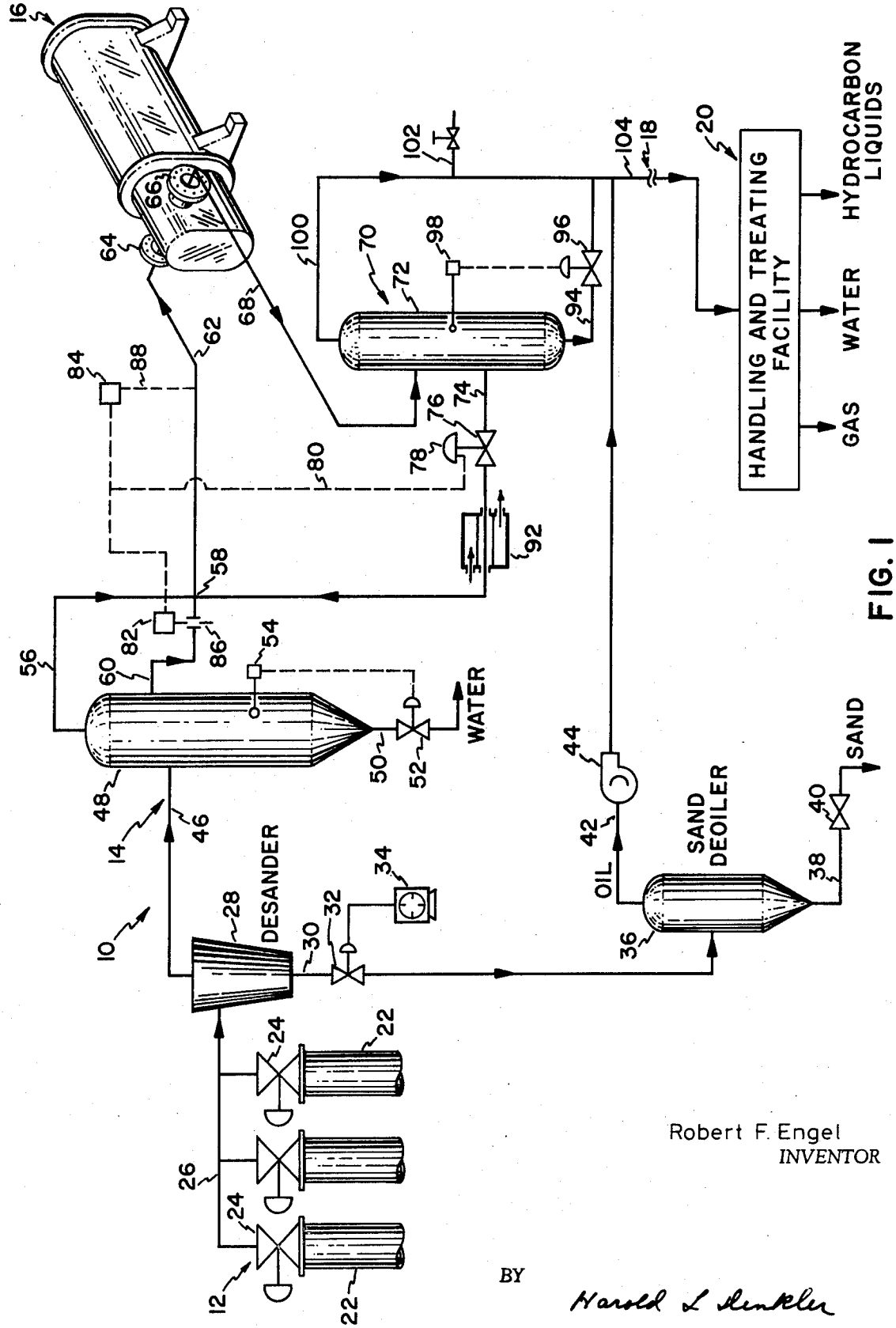


FIG. 1

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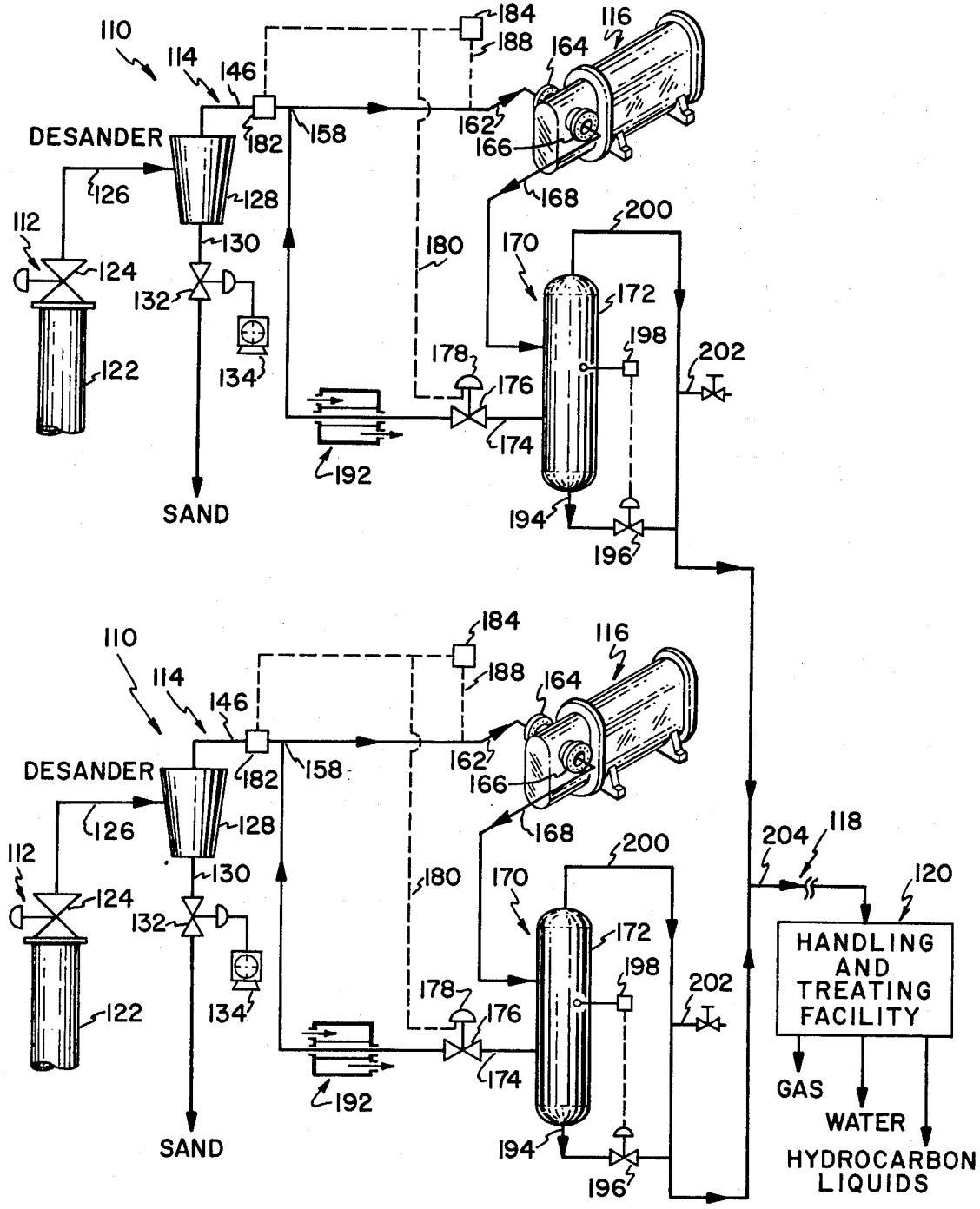


FIG. 2

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WELL PRODUCTION METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

The term "oil well" is used in the industry to connote a well producing predominantly liquid hydrocarbons. This term is somewhat misleading since almost all oil wells produce some gaseous hydrocarbons and, conversely, most gas wells produce some quantity of liquid hydrocarbons. It is a characteristic of oil wells that the tubing string or other production conduit is more or less filled with liquid. Even though the formation pressure may be substantial, the wellhead pressure of an oil well is characteristically low to moderate. Conversely, gas wells do not characteristically have a column of liquid in the production conduit and the wellhead pressure is accordingly a substantial fraction of the formation pressure.

It is desirable in many instances to transport produced fluids to a relatively remote facility for treating and/or separating the produced fluids. Since gas wells typically exhibit a substantial wellhead pressure, such wells may be produced into a conduit for transmitting all produced fluids to a treating facility without having to compress the well fluids. Since oil wells do not typically exhibit a substantial wellhead pressure and since they produce a large proportion of liquid, the wellhead pressure is often insufficient to move the produced fluids through a single conduit to a remote treating facility. Consequently, oil wells produced in this manner are typically provided with a gas-oil separator adjacent the wellhead with separate conduits being provided for the oil and gas respectively. Pump and/or compressor facilities are provided adjacent the wellhead to move the produced fluids separately to a treating facility and/or to points of sale or use.

Situations commonly exist where it would be desirable to transmit produced fluids from a plurality of oil wells to a common treatment facility. One common situation is where a number of oil wells are located in inland waters or near shore where a large onshore treating facility having the capacity of treating production from a large number of wells is substantially cheaper than separate treating facilities located in the water for each of the wells. Another common situation is where a plurality of oil wells are located offshore producing onto a platform having no treatment facility where a platform and treating facility is located nearby. Another situation is where a plurality of oil wells are completed underwater or on shore which do not separately produce enough gaseous hydrocarbons to justify separate gas handling facilities.

The prior art has avoided laying separate gas and liquid gathering systems to a plurality of oil wells only by separating the produced fluids at each wellhead, elevating the pressure of the separate phases and then commingling the separate phases for delivery into a single conduit. While this approach avoids laying separate conduits, it is still quite expensive because of the cost of individual gas compressing and oil pumping equipment.

It will be appreciated by those skilled in the art that the ability to transport low pressure multiphase fluids from a plurality of oil wells through a single conduit without having to separate and then separately pressurize the fluid phases can have many applications.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a method of producing a low pressure multiphase mixture from a plurality of wells and transporting the mixtures through a single conduit for treatment at a common facility without having to separate and separately pressurize the fluid phases.

Another object of the invention is to provide a method and apparatus for producing a two phase fluid from a plurality of wells and pressurizing the two phase fluid adjacent the wells where some of the liquid phase material is recycled through the compressor to provide sufficient fluid to lubricate and cool the heat of compression.

The method of this invention comprises producing from each of a plurality of wells a multiphase mixture including liquid and gaseous hydrocarbons; pressurizing the multiphase mixture adjacent the wells; transporting the multiphase mixture through a conduit to a treating facility; and separating the liquid and gaseous components at the treating facility.

The combination of this invention comprises a plurality of wells for producing a low pressure multiphase mixture including liquid and gaseous hydrocarbons; multiphase machine means for receiving the low pressure mixture and elevating the pressure thereof; a treating facility common to the plurality of wells; and conduit means receiving the low pressure multiphase mixture from the wells and delivering the same through the multiphase machine means to the common facility.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of one production arrangement of the invention illustrating a plurality of wells connected to a single machine for delivery to a common handling and treating facility; and

FIG. 2 is a schematic view of another arrangement of the invention illustrating a plurality of wells delivering a low pressure multiphase mixture to separate multiphase machines means for delivery to a common handling and treating facility.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is illustrated a production system **10** comprising as major components a plurality of wells **12** producing a low pressure multiphase mixture including liquid and gaseous hydrocarbons, means **14** for receiving, initially treating and initially transporting the multiphase mixture, machine means **16** for elevating the pressure of the multiphase mixture, means **18** for transporting the high pressure multiphase mixture and a handling and treating facility **20** for separating the mixture into salable or usable components. It will be seen that the general plan of operation is to pressurize the low pressure multiphase mixture for transport through a conduit to a common treatment facility rather than separating the phases of the mixture, separately compressing the phases and then recombining the phases for transportation purposes.

Each of the wells **12** comprises a production conduit or tubing string **22** having a suitable valve **24** thereon. The wells **12** produce a low pressure multiphase mixture including liquid and gaseous hydrocarbons. The

wells 12 may also produce substantial quantities of salt water and/or sand. As will be apparent, the components of the initial treating and transporting means 14 depend in large part on the relative quantity of sand and salt water produced from the wells 12.

The initial treating and transporting means 14 comprises a gathering system 26 collecting the produced mixture from each of the wells 12 and delivering it to a desander 28. The desander 28 is particularly desirable to protect the machine 16 if the wells 12 produce a substantial amount of sand. It may be desirable to include the desander 28 as a preventive measure even if the wells 12 do not produce sand at the time the system 10 is installed. The desander 28 includes an outlet conduit 30 having a valve 32 therein controlled by a timer 34 or other suitable mechanism. A sand deoiler 36 may be provided to remove oil absorbed on the sand, particularly if a large quantity of sand is produced by the wells 12. The deoiler 36 includes an outlet conduit 38 having a suitable valve 40 therein for discharging sand from the system 10. The deoiler 36 also includes an oil outlet 42 having a pump 44 therein for delivering oil to the transporting means 18 as will be more fully apparent hereinafter.

The initial treating and transporting means 14 also includes a conduit 46 connecting the desander 28 to a free water knockout 48 which may desirably be provided if the wells 12 produce a substantial amount of water. As will be apparent to those skilled in the art, the horsepower expended by the machine 16 to move liquid through the transporting means 18 is relatively small. Consequently, the decision to incorporate the free water knockout 48 in the system 10 depends not only on the total amount of water produced by the wells 12 but also the capacity of the machine 16, the transporting means 18 and the handling facility 20. The free water knockout 48 is basically a gas-liquid separator having a water outlet conduit 50 and a valve 52 therein controlled by a water level sensor 54 for discharging water from the system 10.

A gas outlet conduit 56 connects the upper end of the free water knockout 48 to a connection 58. An oil outlet conduit 60 extends from intermediate the free water knockout 48 to the connection 58 to commingle the oil and gas emitting from the free water knockout 48. A conduit 62 extends from the connection 58 to an inlet 64 of the machine 16 for carrying the commingled fluids thereto.

The machine 16 may be any suitable type multiphase helical-rotor type machine including that shown in U.S. Pat. No. 2,381,695 but is preferably of the type presently available from Ingersoll-Rand Corporation under the tradename H–AXI Compressor. Compressors of this latter type comprise single or multiple compression stages and utilize the liquid phase passing therethrough as a coolant, sealant and lubricant for the internal moving parts. In the normal mode of operation, compressors of this type are used to compress gasses only with the necessary liquid being injected into the compressor inlet, passed through the compressor to perform the desired functions and separated in the outlet stream for reuse. Compressors of this type may be driven by any suitable means, e.g. electric motors, turbines, internal combustion engines, diesel engines and the like.

The machine 16 includes an outlet 66 which is connected to a conduit 68. If the gas-oil ratio of the wells 12 is below about 1500 cubic feet per barrel, there is sufficient liquid passing through the machine 16 to perform the cooling, sealing and lubricating functions. In this event, the conduit 68 may be directly connected to the transporting means 18 for delivering the multiphase mixture to the handling facility 20. In the event the gas-oil ratio of the wells 12 is higher, means 70 may be provided for recirculating part of the liquids through the machine 16 to provide a sufficient quantity of liquid therefor.

The recirculating means 70 comprises a separator 72 for extracting liquid from the multiphase mixture passing therethrough and includes an oil outlet 74 leading to the connection 58 for delivering liquid into the conduit 62. A suitable control valve 76 is positioned in the oil outlet 74 and includes a valve operator 78 controlled through a control line 80 leading to a flow meter 82 in the oil line 60, and a pressure controller 84 associated with the conduit 62. The flow meter 82 includes an orifice plate 86 or other suitable measuring device to ascertain the quantity of liquid flowing through the oil line 60. The pressure controller 84 includes a control line 88 in communication with the conduit 62. The pressure controller 84 ascertains if there is sufficient fluid passing through the machine 16 and if there is an adequate input to prevent the machine 16 from operating without suction fluid.

The recirculating means 70 alleviates two distinct problems. If the wells 12 do not produce sufficient liquid to cool, seal and lubricate the machine 16, the recirculating means 70 provides additional liquid for these functions. When insufficient liquid is flowing through the oil outlet 60 to cool, seal and lubricate the machine means 16, a signal is generated by the flow meter 82 which is transmitted to the valve operator 78 through the control line 80. The valve 76 is thereupon opened to deliver additional liquid to the conduit 62. The other function of the recirculating means 70 is to keep the machine 16 loaded. When the pressure at the machine inlet 64 falls below a predetermined value, the machine 16 is starved and will not function properly. The pressure controller 84 senses the pressure at the machine inlet and provides a signal when the inlet pressure falls below the predetermined value. The pressure controller 84 thereupon transmits a signal through the control line 80 to manipulate the valve operator 78 to deliver oil and gas, if required, through the oil outlet 74 into the conduit 62. While the oil outlet 74 is normally below the liquid level in the recirculating means 70, under some load conditions the machine 16 will draw the liquid level down and gas will be circulated through the machine.

The temperature in the outlet stream from the machine means 16 is quite hot and is typically on the order of about 200° F. Without some cooling, it will be apparent that liquids of this temperature do not efficiently cool the machine 16 when circulated therethrough. Accordingly, a heat exchanger 92 is provided in heat exchanging relation with the oil outlet 74 to depress the temperature of the oil stream passing into the connection 58.

The separator 72 is equipped with a liquid outlet 94 having a valve 96 therein controlled by a liquid level

sensor **98**. It will be noted that the liquid level sensor **98** is above the oil outlet **74** to provide a liquid reservoir for recirculation at any time. It will also be seen that oil is recirculated through the machine **16** rather than water which will tend to collect in the bottom of the separator **72**.

The separator **72** also includes a gas outlet **100** joining the liquid outlet **94** for commingling the fluid phases emitting from the separator **72**. The oil outlet **42** from the sand deoiler **36** also merges with the conduits **94, 100** for delivery to the transporting means **18**. A gas line **102** may be connected to the gas outlet **100** to deliver high pressure gas for gas lift purposes and the like to the wells **12**.

The transporting means **18** comprises a conduit **104** in fluid receiving relation with the conduits **42, 94, 100** for delivering a multiphase high pressure mixture to the handling facility **20**. The conduit **104** is of whatever length necessary to reach the handling facility **20**. The handling and treating facility **20** may be of any desired type to separate and/or treat the multiphase mixture for ultimate sale, use or disposition of the fluid components.

In the operation of the production system **10**, a low pressure multiphase fluid mixture is produced from the wells **12** and typically includes oil, gas, water, and sand. The desander **28** removes sand above a predetermined size from the mixture. The mixture then passes into the free water knockout **48** where a large proportion of salt water produced from the wells **12** is discharged from the system **10**. Gas and liquid hydrocarbons separately emitting from the free water knockout **48** are recombined at the connection **58** and pass through the conduit **62** into the machine **16**. The machine inlet pressure and temperature are typically on the order of about 25 to 200 psig and 50° to 100° F. The mixed fluid stream emitting from the machine outlet **66** is typically at about 400 to 1,400 psig and 100° to 300° F.

If insufficient liquid is passing through the oil outlet **60** or if the machine inlet pressure falls below a predetermined value, the valve **76** is opened allowing some of the oil accumulating in the separator **70** to flow past the heat exchanger **92** and into the conduit **62** for recirculation. When the liquid level in the separator **72** rises above the sensor **98**, the valve **96** is opened allowing liquid to flow into the conduit **104** for transport to the handling facility **20**. Gas from the separator **72** passes through the outlet **100** and is commingled with the liquid stream in the conduit **104**.

A comparison of this invention with the typical oil well production plan where the oil and gas are separated, separately pressurized and then commingled for transport through a common conduit to a treating facility reveals that the production system of this invention is substantially cheaper than the prior art approach. The most expensive single item of the prior art approach is the gas compressor which has been omitted entirely. For offshore installations, the construction cost of a production system of this invention is about two-thirds that of the conventional approach.

Referring to FIG. **2**, there is illustrated a production system **110** comprising another embodiment of this invention and including as major components a plurality of wells **112** producing a low pressure multiphase mixture including liquid and gaseous hydrocarbons, means **114** for receiving, initially treating and initially transporting the multiphase mixture, machine **116** for elevating the pressure of the multiphase mixture, means **118** for transporting the high pressure multiphase mixture and a handling and treating facility **120** for separating the mixture into salable or usable components. It will be seen that the general plan of operation is to pressurize the low pressure multiphase mixture for transport through a conduit to a common treatment facility rather than separating the phases of the mixture, separately pressurizing the phases and then recombining the phases for transportation purposes.

It will be seen that the production system **110** differs from the system **10** in that each of the wells **112** is provided with machine **16** for elevating the pressure of the multiphase mixture produced thereby. For purposes of brevity, analogous reference characters are used to indicate analogous components of the system **110** and only the differences between the system **10, 110** are described with specificity.

Since individual machines **116** are provided for each of the wells **112**, the initial transporting means **114** includes a gathering system **126** leading to only one well. The initial transporting and treating means **114** is not illustrated as including a sand deoiler since the quantity of sand produced by each of the wells **112** is probably insufficient to justify a deoiler. Such devices may be included, of course, if desired.

The liquid carrying capacity of the compressors of the type envisioned for use as the machine **116** is quite high. Consequently, it is unlikely that the wells **112** will each produce more liquid than can be handled by the machine **116**. Consequently, the low pressure free water knockout is omitted from the system **110** although such devices may be incorporated if desired.

Since the system **110** is not equipped with a low pressure free water knockout and since it is desirable to measure the liquid flowing toward the machine, the flow meter **182** is a meter to determine the quantity of liquid flowing in the conduit **146**. The flow meter **182** is equipped with means for actuating the valve operator **178** when the liquid passing therethrough falls below a predetermined value. In this manner liquid may be recirculated from the separator **172** to ensure adequate sealing, cooling and lubricating of the machine **116**.

Where the wells being produced are closely spaced, e.g., offshore wells producing on a platform, the production system **10** is preferred because of the cost savings over the system **110**. With widely spaced wells, e.g., underwater completions, the production system **110** is preferred.

It will be seen that there is provided a well production method and apparatus having many applications for present and contemplated situations.

I claim as my invention:

1. The method of producing a plurality of wells comprising the steps of

producing from each of the plurality of wells a low pressure multiphase mixture including liquid and gaseous hydrocarbons;

pressurizing the multiphase mixture adjacent the plurality of wells;

transporting the multiphase mixture through a conduit to a treating facility; and

separating the liquid and gaseous hydrocarbons at the treating facility.

2. The method of claim 1 wherein the producing step comprises commingling the multiphase mixture from the plurality of wells before the pressurizing step.

3. The method of claim 1 comprising the steps of extracting liquid from the high pressure mixture; and delivering the extracted liquid into the low pressure multiphase mixture for repressuring.

4. The method of claim 3 further comprising sensing the pressure of the low pressure multiphase mixture; and wherein the delivering step is conducted in response to the pressure of the low pressure multiphase mixture below a predetermined value.

5. The method claim 3 further comprising measuring the liquid in the low pressure multiphase mixture before the pressurizing step; and wherein the delivering step is conducted in response to the flow rate of the liquid below a predetermined value.

6. In combination,
a plurality of wells for producing a low pressure multiphase mixture including liquid and gaseous hydrocarbons;
a machine for receiving the low pressure mixture and elevating the pressure thereof;
a treating facility common to the plurality of wells; and
conduit means receiving the low pressure multiphase mixture from the wells and delivering the same through the machine to the common facility.

7. The combination of claim 6 further comprising means upstream of the machine for desanding the low pressure multiphase mixture.

8. The combination of claim 6 further comprising a free water knockout upstream of the machine.

9. The combination of claim 6 wherein the machine is of the type circulating liquid therethrough for sealing the moving parts and for cooling the machine and further comprising
means downstream of the machine for extracting high pressure liquid from the high pressure mixture and delivering the extracted liquid into the suction inlet.

10. The combination of claim 9 wherein the extracting and delivering means includes
normally closed valve means for controlling delivery of extracted liquid into the suction inlet; and
means responsive to suction inlet pressure below a predetermined value for opening the valve means.

11. The combination of claim 10 further comprising
a separator in the conduit means upstream of the machine for separating gas and liquid phases in the mixture, the separator having a gas outlet and a liquid outlet; and wherein
the extracting and delivering means includes means responsive to liquid flow through the liquid outlet below a predetermined value for opening the valve means.

12. The combination of claim 10 wherein the delivering and extracting means includes
means responsive to the amount of liquid flowing toward the machine below a predetermined value for opening the valve means.

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