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Waters

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[54] **HYDROGAS LIFT SYSTEM**

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[52] **U.S. Cl.** **417/90**, 417/92, 417/109

[51] **Int. Cl.** **F04f 11/00**, F04f 1/20

[58] **Field of Search** 417/92, 101, 54, 55, 99, 417/103, 108, 109, 111, 90

[56] **References Cited**

UNITED STATES PATENTS

3,215,087	11/1965	McLeod	417/92
3,653,717	4/1972	Rich et al.	417/55 X

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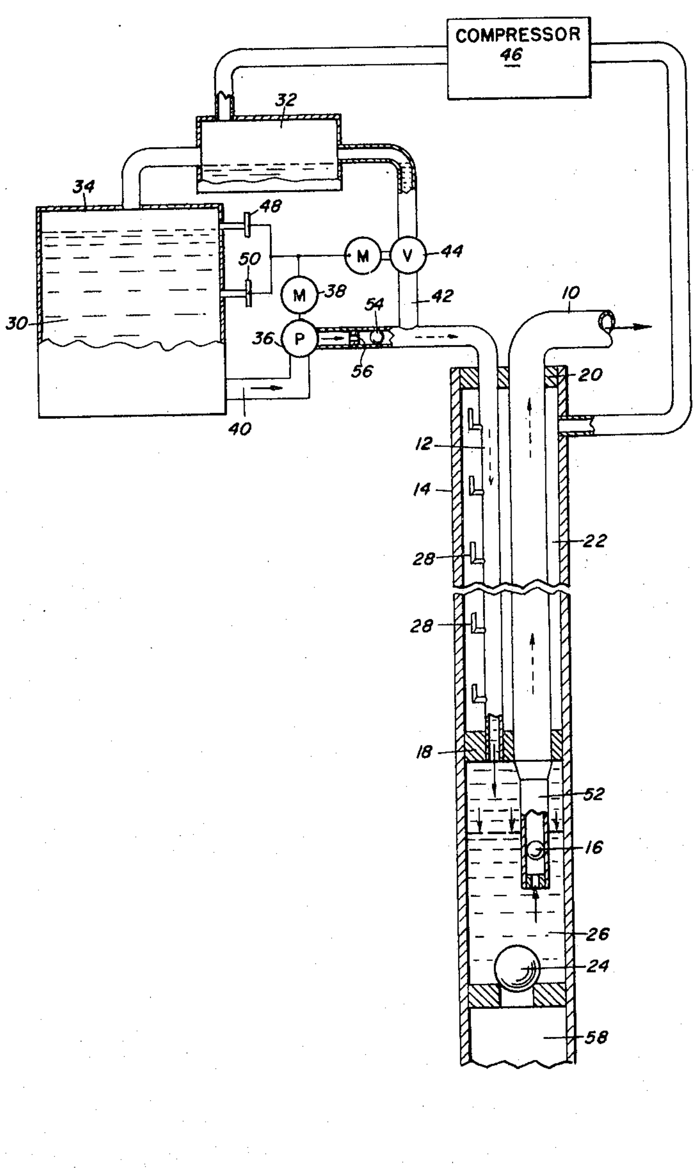
Assistant Examiner—Richard E. Gluck
Attorney, Agent, or Firm—John J. Byrne

[57] **ABSTRACT**

A power fluid is pumped downwardly through a power fluid tube toward the bottom of a well. The power fluid, due to pressure placed on the power oil fluid by a surface pump, forces the production fluid through a check valve and upwardly through a production fluid tube to the surface of the wall. Compressed gas is used to withdraw the power fluid from the power fluid tube so that the production fluid may again rise to the level of the production fluid tube and the pumping cycle is thereafter repeated. The power oil may also be removed by swabbing, rod pump, rotary pump, or any other form of artificial lift which may be applicable to the well.

3 Claims, 2 Drawing Figures



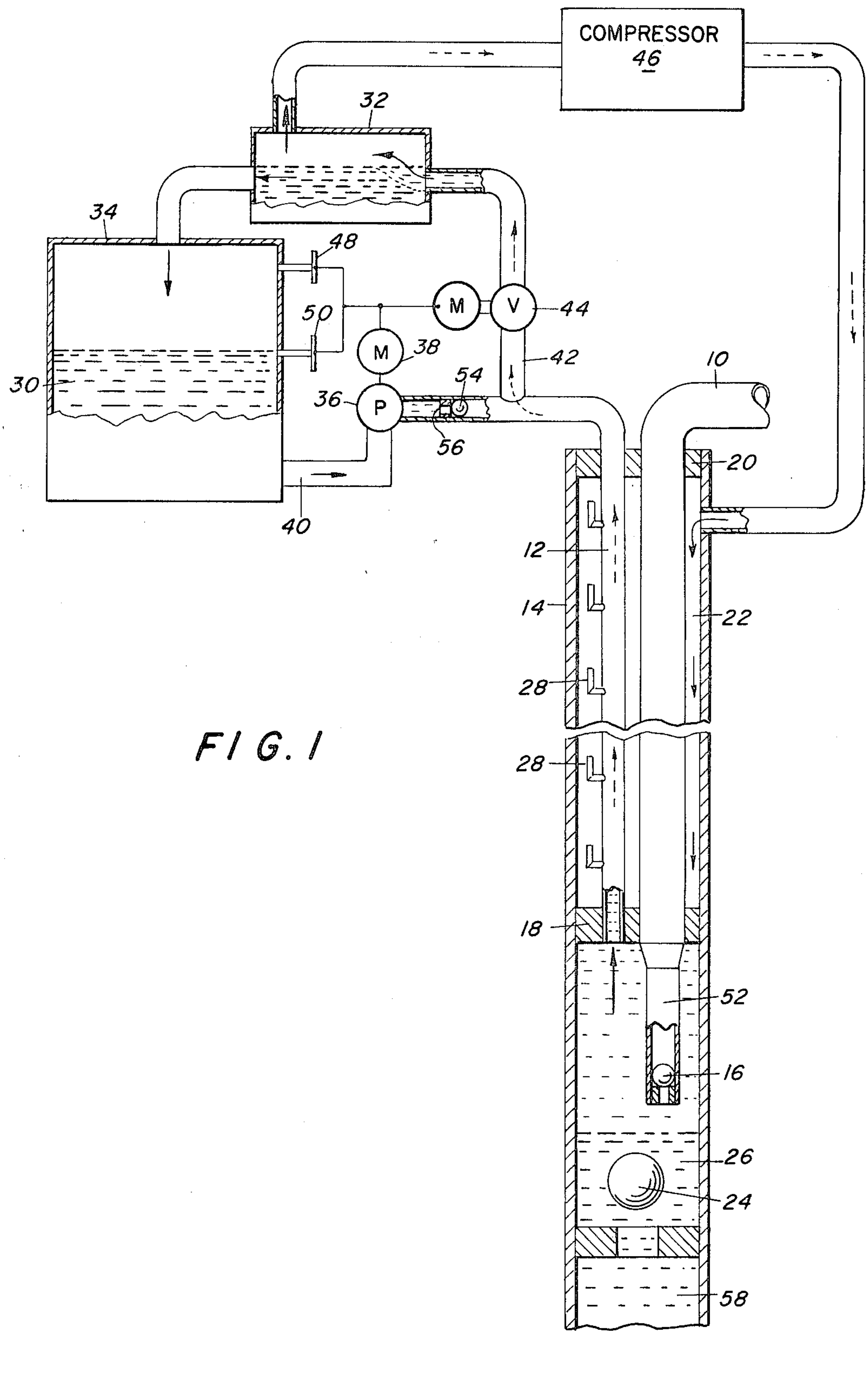

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FIG. 1

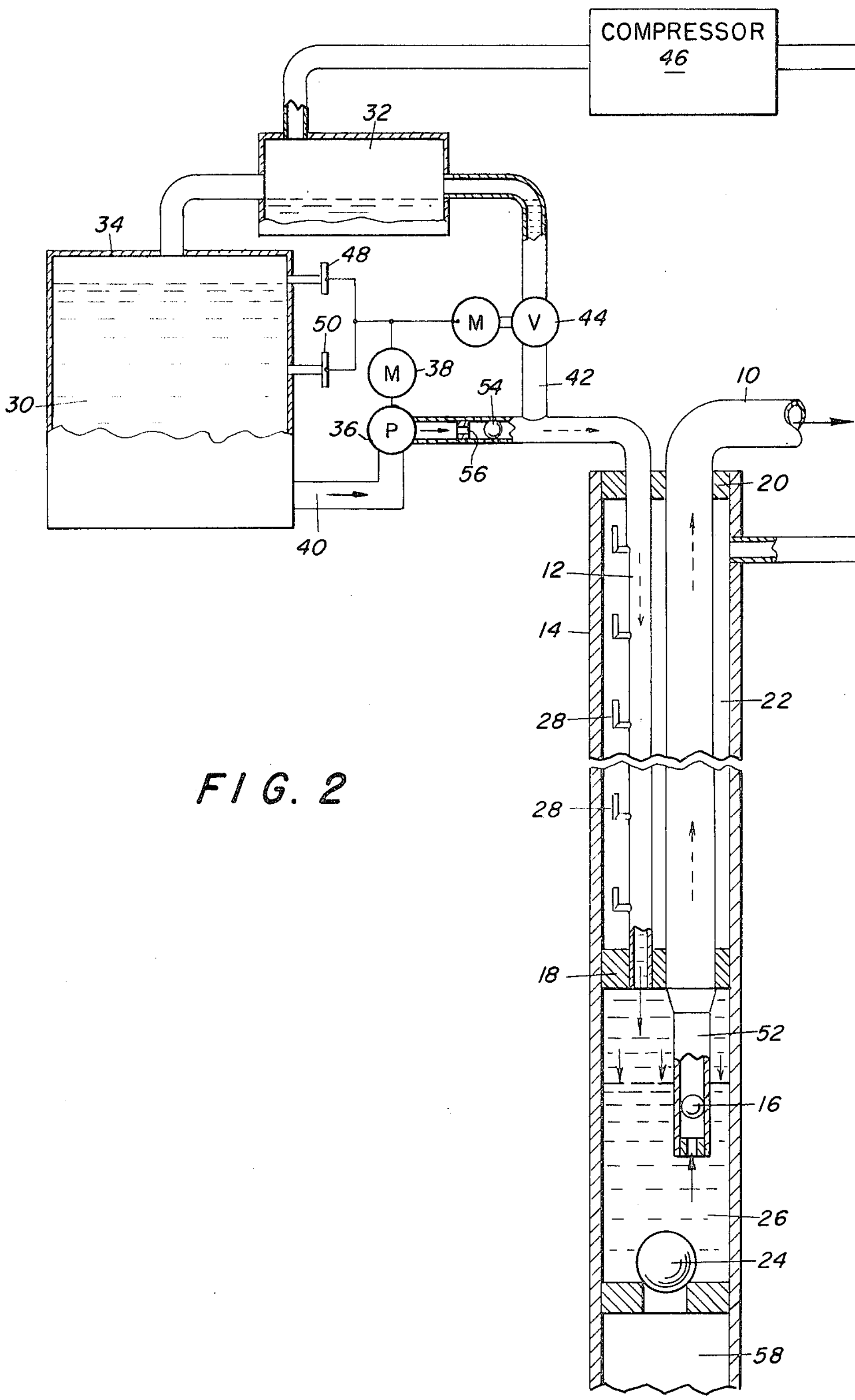
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FIG. 2

HYDROGAS LIFT SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the pumping or lifting of a subsurface liquid by a liquid of a lower density. The lower density liquid is drawn toward the surface again by means of compressed gas. The compressed gas and the liquid are then separated at the surface and recycled in subsequent pumping operations. If another form of artificial lift is used, then the separator and gas compression system may be eliminated.

2. Description of the Prior Art

Prior art oil pumping systems oftentimes depend on natural oil pressure, artificial suction, or the injection of a gas or liquid to drive or draw petroleum to the surface. Typical of such systems is that disclosed in the Rich et al. U.S. Pat. No. 3,653,717 which depicts a system for lifting enriched solvents in solution mining wells by means of a liquid immiscible with, and lighter than, the solvent which is extracted.

There are several drawbacks to the prior art methods of operation. For instance, at great well depths, the efficiency and capacity decrease. Also, prior art systems often require the use of means to cope with high pressures at the surface. This often requires the installation of expensive, low-capacity equipment which renders such systems uneconomical. Moreover, many prior art systems cannot control the large drops in pressure that may occur in an oil well. A further problem with prior art systems is that when gas lift valves are used in cooperation with compressed gas to lift crude petroleum from a well, the crude will frequently emulsify and become a foam. Typically, the foam is of very light density and little crude is brought to the surface in this manner. It is difficult to separate compressed gas from the crude petroleum once the foam reaches the surface. The present invention provides an improved solution to these problems.

SUMMARY OF THE INVENTION

The present invention is designed to overcome the deficiencies of the prior art as described above. Also, a system has been provided that is rugged and simple and contains few moving parts. A principal advantage of the gas-hydraulic system described herein is that maintenance costs are kept to a minimum. The working environment of an oil field demands that all equipment have the capability to withstand rough daily punishment.

With this in mind, a system has been developed using both gas and a power fluid in an artificial lift system. A power fluid is pumped down a power fluid tube into an enclosed chamber at the bottom of the pipe string. The bottom of the chamber includes a check valve permitting the production fluid to enter the chamber when the pressure above the valve is lower than the pressure below the valve. As the power fluid is pumped into the chamber, production fluid is forced upwardly via a dip tube and through a discharge type check valve into a production tube. Compressed gas may be used to withdraw the power fluid or other conventional forms of artifical lift may be employed to evacuate the power oil from the power oil string.

A principal object of this system is to accomplish pumping from very deep wells with a high pumping efficiency.

Another object of this invention is to be able to control the well from the surface, thus eliminating the high cost of a work-over rig if one is necessary.

A further object is to develop a hydraulic pump with a relatively low surface pressure requirement and which is rugged and requires few moving parts.

A still further object of this invention is to increase the rate of production of an oil well while maintaining the pressure at the bottom of the well relatively constant.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference is made to the following description of representative embodiments thereof and to the accompanying drawings wherein:

FIG. 1 is a schematic depicting the hydrogas lift system at the end of the power fluid pump cycle when the power fluid in the power oil storage reservoir has reached the level of the low level control. The power fluid in the power fluid tubing is returned back to the power fluid reservoir via a separator by means of compressed gas introduced into the power fluid tubing; and

FIG. 2 shows the hydrogas lift system of FIG. 1 wherein the power fluid is in contact with the high level control on the power fluid reservoir. The pumping cycle is about to begin.

DESCRIPTION OF AN EMBODIMENT

In describing this invention, reference is made to both FIG. 1 and FIG. 2 wherein like elements are similarly numbered. FIG. 1 and FIG. 2 show the hydrogas lift system at different points in the lift. The system includes a production tube **10** and a power fluid tube **12** which fits inside and extends the entire length of a power string casing **14.** At the bottom end of the production tube **10** there is a one-way discharge valve **16.** The discharge valve **16** allows production fluid **58** to flow upwardly through the valve into the production tube **10** but does not allow production fluid **58** to flow back through the production tube.

A dual packing **18** is provided at the bottom of the power fluid tube **12** in order to contain the compressed gas stored within the power string casing **14** and to support the power fluid tube **12** and the production tube **10.** A similar packing is shown at the top of the well as element **20.** The packings **18** and **20** are designed to prevent the compressed gas **22** from leaking from the well casing **14.**

A one-way standing check valve **24** is shown at a location below discharge valve **16.** The packing is provided about the standing valve **24** to form a pressure-tight chamber **26** between the packing **18** and the standing valve **24.** A series of gas lift valves **28** are placed at intervals along the power fluid tubing **12.** Conventional gas lift valves such as the CM2FS-RC type made by the MACCO Oil Tool Company, Inc. are satisfactory for this type of operation. Gas lift valves are valves which permit a compressed gas to enter a pipe string when the differential pressure between the fluid in the pipe string and the compressed gas reaches a predetermined point. In this particular application, compressed gas may enter the pipe string at the end of the pumping cycle when triplex pump **36** shuts off. The gas lift valves allow the compressed gas **22** inside the casing **14** to flow into the power fluid tubing **12** at the end of the pump cycle thereby returning power fluid **30** to a separator **32** and then to a power fluid reservoir **34.**

The power fluid reservoir stores the power fluid **30** and the now decompressed gas **22** is returned to the compressor **46** for recompression. A triplex type pump **36,** driven by an electric motor **38,** is connected to the bottom discharge line **40** from the power fluid reservoir **34.** The pump **36** powers the fluid **30** downwardly through the power fluid tubing **12.**

Mounted within the power fluid reservoir **34** is a high level control **48** and a low level control **50.** Controls **48** and **50** are sensitive to the fluid level in the power fluid reservoir. They, in turn, control the opening and closing of motor valve **44** and the operation of electric motor **38** which drives triplex pump **36.**

A dip tube **52** extends from the bottom of production tube **10** into production fluid **58.** Discharge valve **16** is located at the lower end of dip tube **52.** Another one-way check valve **54** is mounted on the discharge port **56** of the triplex pump **36.** Valve **21** prevents compressed gas **22** and power fluid mixture from returning to the pump **36.**

DESCRIPTION OF OPERATION

FIG. **2** shows a hydrogas lift system immediately after to the beginning of the power fluid pump cycle. Prior to this stage, power fluid **30** is entering reservoir **34.** When the level of power fluid reaches the high level control **48,** motor valve **44** is caused to close and motor **38** is energized and pump **36** is operated. By action of pump **36,** the power fluid **30** from reservoir **34** is driven through check valve **54** and downwardly through power fluid tube **12.** It is, of course, understood that power fluid **30** is of a lower density than that of production fluid **58.** Typically, power fluid **30** is an oil rated about **55** gravity crude. As a result of the pumping action, power fluid **18** will fill the chamber **26** between packing **18** and standing valve **24.** As chamber **26** is filled with power fluid **18,** production fluid **58** trapped within the chamber is displaced and forced to flow through discharge valve **16** of production tube **1** and towards the surface. At this time, standing valve **24** is closed because the pressure above the valve is higher than the pressure below it. Similarly, discharge valve **16** is caused to open because the pressure below it is higher than the pressure above it.

After a predetermined amount of power fluid **38** is pumped out of reservoir **34,** the low level control **50** is tripped. The low level control **50,** in turn, de-energizes electric motor **38,** pump **36** stops, and the motor valve **44** is opened. This stage of the operation is shown at FIG. **1.**

At this point, gas lift valves **28** open and the compressed gas **22** within the casing **14** flows into the power fluid tube **12** causing the power fluid **30** within the tube to rise through motor valve **44** and the by-pass line into separator **32.** In operation, the gas lift valves would not all operate simultaneously but rather would be operated in sequence with the valve or valves closest to the surface opening first and with the lower valve sequentially opening as the differential pressure between the power fluid and the compressed gas reaches the predetermined point at which the particular selected gas lift valve will operate. The gas lift valves do not have to be located equidistant from one another along the power fluid string. In fact, it is preferred that the gas lift valves be located closer to one another the deeper those valves are located on the power fluid string. The purpose of placing the gas lift valves closer to each other at deeper depths is to give added boosting power where it is needed. The deeper valves have to provide more power because they must lift not only the increment between themselves and the nearest valve up the string, but they must also lift all of the foam and residue in the power string located between the next uppermost valve and the surface of the well. The compressed gas and power fluid mixture does not flow back into pump **36** because check valve **54** is closed. The compressed gas **22** displaces power fluid **30** and causes its withdrawal from chamber **26.** As power fluid **30** is withdrawn from chamber **26** an equal volume of production fluid **58** is drawn through one-way standing check valve **24** to replace the power fluid that has been withdrawn. The pressure within chamber **26** at this time is lower than during the pump cycle and discharge valve **16** is closed due to the higher pressure of the production fluid **58** within tube **10.** The compressed gas and power fluid mixture flows into separator **32** where it is segregated. The compressed gas **22** is returned to casing **14** by means of compressor **46,** and power fluid **30** is returned to power fluid reservoir **34.** As the power fluid **30** is returned to the power fluid reservoir, the level of the power fluid **30** rises. When a sufficient amount of the power fluid **30** is withdrawn from chamber **26,** the level of the power fluid in power fluid reservoir **34** will again reach the high level control **48.** At this point, the pump cycle as shown in FIG. **2** begins again. Each operation of the pump cycle causes a pre-determined increment of production fluid **58** to flow up production tube **10.** Repeated pumping eventually causes this increment to reach ground level.

While gas lift valves have been shown as a preferred means of removing the power oil from the power oil string, it is clear that there are many other ways of performing the same function. For instance, it would be further possible to withdraw the power oil by means of a swab which is drawn up the power oil string at predetermined intervals. Also, a rod pump or a rotary pump or any other form of artificial lift may be used to withdraw the power oil.

Other modifications of the described embodiment may be obvious to one of ordinary skill in the art. For instance, separator **32** which has been shown in FIGS. **1** and **2** to be of the conventional, horizontal variety, may be vertical instead. Also, it is clear that this application is not intended to be limited to the production of petroleum. This method instead may be employed to lift any type of suitable production fluid by means of a lighter power fluid.

In a general manner, while there has been described an effective and efficient embodiment of the invention, it should be well understood that the invention is not limited to such an embodiment, as there might be changes made in the arrangement, disposition, and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

I claim:

1. A system for lifting a production fluid comprising, a well casing,

a power fluid tube and a production tube within said well casing,

said production tube including a first one-way valve for allowing the production fluid to pass only in the upward direction through the production tube,

a second one-way valve located in said well casing below said first one-way valve for allowing said production fluid to pass only in the upward direction,

a compressor for forcing a gas through said well casing,

a reservoir for storing a power fluid,

a pump disposed between said reservoir and said power fluid tube for driving said power fluid from said reservoir through said power fluid tube, said power fluid causing said production fluid to be forced upwardly through said production tube,

first means for displacing said power fluid with said gas after a predetermined amount of power fluid has been pumped from said reservoir, and

wherein said first means includes a gas lift valve means for passing said gas from said well casing to said power fluid tube, said gas forcing said power fluid back through said power fluid tube.

2. A system for lifting a production fluid comprising,

a well casing,

a power fluid tube and a production tube within said well casing,

said production, tube including a first one-way valve for allowing the production fluid to pass only in the upward direction through the production tube,

a second one-way valve located in said well casing below said first one-way valve for allowing said production fluid to pass only in the upward direction,

a compressor for forcing a gas through said well casing,

a reservoir for storing a power fluid,

a pump disposed between said reservoir and said power fluid tube for driving said power fluid from said reservoir through said power fluid tube, said power fluid causing said production fluid to be forced upwardly through said production tube,

first means for displacing said power fluid with said gas from said compressor after a predetermined amount of power fluid has been pumped from said reservoir,

a second means for separating said gas and power fluid,

a bypass line connecting said second means to said power fluid tube,

a control means for selectively operating said pump, said control means being responsive to the level of power fluid in said reservoir,

a bypass valve in said bypass line selectively opened and closed by said control means, and

wherein said control means is responsive to a predetermined high level and a predetermined low level of said power fluid in said reservoir, said control means causing said pump to energize and said bypass valve to close upon said power fluid attaining said predetermined high level and said control means causing said pump to de-energize and said bypass valve to open upon said fluid attaining said predetermined low level.

3. A system for lifting said production fluid of claim **2** wherein said power fluid is introduced into said well casing above said second one-way valve by said pump at a pressure sufficient to close said second one-way valve.

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