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PUMP AND CONTROL THEREFOR

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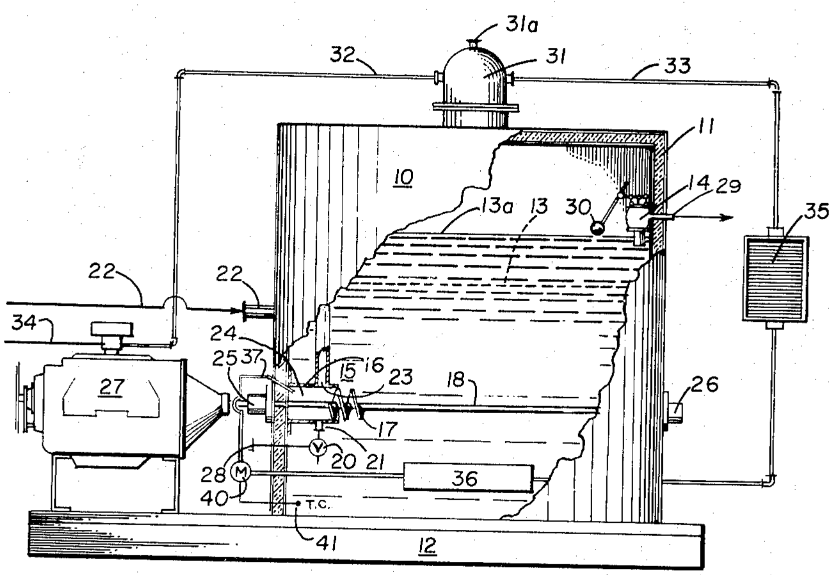

Fig 1

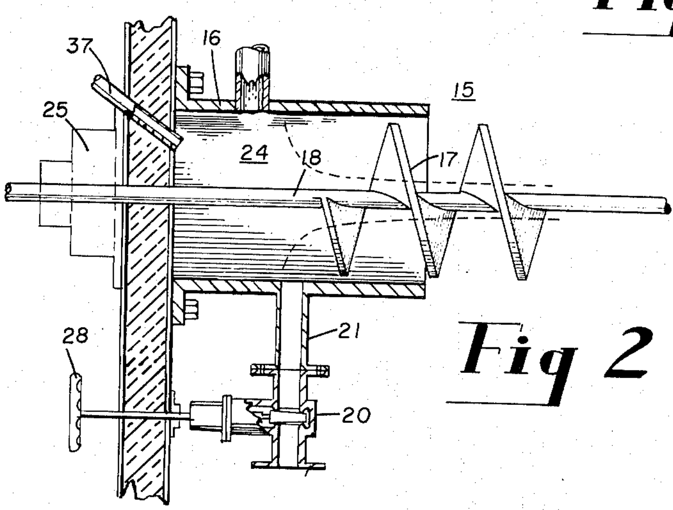

Fig 2

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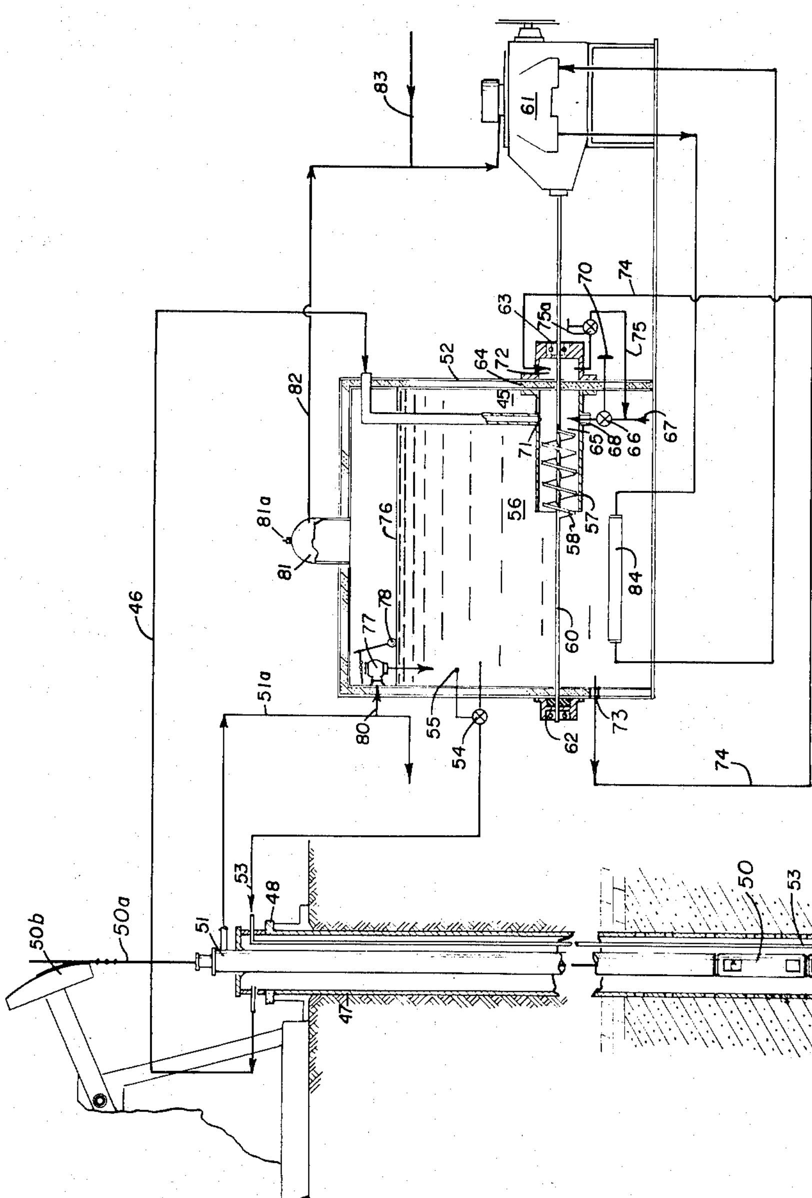

Fig. 3

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PUMP AND CONTROL THEREFOR

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4 Claims. (Cl. 103—1)

This application is a division of my copending application Serial No. 168,675, filed January 25, 1962.

This invention relates to vacuum pumps and to systems employing such pumps and particularly to an improved pump and control system for pumping large volumes of gas and for facilitating the production of viscous fluids from oil wells and the like.

Many industrial processes require large volumes of gas to be pumped continuously and various types of pumps and blowers have been proposed or employed for this purpose. Certain of these applications require that relatively low pressures be maintained and conventional expansible chamber, displacement and centrifugal pumps have not proved entirely satisfactory for these applications. By way of example, it has been proposed to maintain relatively low pressures in oil wells to facilitate the production of oil but conventional equipment has proved to be uneconomical and difficult to maintain in operation for this purpose.

It is an object of this invention to provide an improved apparatus for maintaining low pressures in oil wells and the like.

It is another object of this invention to provide an improved pumping apparatus and control system for facilitating the production of viscous petroleum for oil wells and the like.

Briefly, in carrying out the objects of this invention in on embodiment thereof, a vacuum pump is provided which comprises a tank containing a body of liquid in which is immersed a pump having a rotor of the screw or helical type arranged in a cylinder or shroud closed at one end and opening into the tank at the other. The pump is provided with a gas inlet and a liquid inlet adjacent its closed end, the liquid inlet being arranged to admit liquid from the tank. The pump during operation produces a vortex in the shroud and the vortex is controlled by adjusting the liquid inlet opening. It has been found that by proper adjustment of the rate of recirculation of the liquid a highly effective pumping action is secured which is capable of maintaining a high vacuum (low gas intake pressure) when the liquid intake supply is regulated and will pump a high volume of gas. The pump operates effectively as a vacuum pump and will maintain a vacuum in an oil well where it maintains a continuous and steady pressure and greatly facilitates the production of oil. The pump during operation generates heat and this heat is employed with the vacuum in another embodiment of the invention to heat viscous petroleum in a well and facilitate its production from the well.

The features of novelty which characterize this invention are set forth in the claims annexed to and forming a part of this specification. The invention itself, however, both as to its organization and method of operation will be better understood upon reference to the following description taken in connection with the accompanying drawings, in which:

FIG. 1 is an elevation view partly in section to show the interior illustrating a vacuum pump used in systems embodying the invention;

FIG. 2 is an enlarged sectional view of the shroud and rotor of the pump of FIG. 1; and

FIG. 3 is a somewhat diagrammatic view partly in

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section illustrating an oil well heating system embodying the invention.

Referring now to the drawings, the vacuum pump shown in FIG. 1 includes a generally cylindrical closed tank **10** having its walls insulated as indicated at **11** and mounted on a supporting base **12**. The tank is arranged to be filled with a liquid such as water to be a predetermined level indicated at **13** and with a condensed petroleum liquid to a level **13***a* maintained by operation of a float valve **14** in a manner to be described below. In the lower portion of the tank and mounted on the left-hand wall as shown there is provided a pump **15** comprising a cylindrical sleeve or shroud **16** and a screw or helical rotor **17** mounted on a horizontal shaft **18** for rotation partly within the shroud. The diameter of the rotor is enough smaller than the internal diameter of the sleeve **16** to leave a substantial annular clearance space. The left end of the shroud adjacent the tank wall is closed while the right end opens into the tank. The rotor **17** extends a short distance into the shroud, the major portion of the screw lying outside the shroud.

Liquid is circulated from the tank through the pump **15** under control of a valve **20** for varying the water admitted to the shroud through an inlet **21** in the bottom wall thereof. Gas or vapor from a supply line **22**, which may, for example, be connected to an oil well (not shown) is admitted to the pump through a vapor inlet **23** in the top wall thereof. Both the liquid inlet **21** and the gas inlet **23** communicate with the pump **15** within a chamber **24** formed between the closed end of the shroud and the rotor **17**. The shaft is journaled in bearings **25** and **26** and is driven by a suitable prime mover illustrated as an internal combustion engine **27**.

When the rotor **17** is driven at suitable speed, say 900 revolutions per minute, gas is drawn into the pump through the inlet **23** and a vortex forms about the shaft **18** decreasing in diameter toward the right as indicated by dotted lines in FIG. 2. The water or other liquid is forced outwardly by centrifugal force and forms an effective seal around the rotor. Condensible vapors are liquefied in the vortex and in the water in the tank, noncondensibles being released into and rising through the main body of liquid in the tank. In order to secure effective and efficient operation of the pump it is necessary to adjust the liquid return through the inlet port **21** to secure its optimum setting for the conditions of operation. In the illustration the valve **20** is of the gate type and is controlled manually by a wheel **28**. When the optimum valve setting has been attained, large volumes of gas are drawn into the pump and condensed. The pump at this setting is capable of maintaining a relatively high vacuum while pumping large volumes of gas.

The rapid condensation of vapor by operation of the rotor **17** raises the level **13***a* of the petroleum liquid in the tank and a float **30** which operates the valve **14** rises and opens the valve to discharge liquid until the level is restored. The discharged liquid is supplied to a production line or pipe **29** for use or transportation.

When the pump is operated to pump a petroleum gas well, for example, the heavier hydrocarbons are condensed in the liquid in the tank while the lighter hydrocarbons, non-condensible under the conditions of operation of the pump, are collected in the tank above the level of liquid therein. These gases rise into a dome **31** and are removed through pipes **32** and **33** or through a suitable pop-off valve **31***a*. The pipe **32** may be employed to supply gas to the engine **27** to supplement or replace the usual fuel supply through a supply line **34**. The line **33** is employed to supply cooling gas to the pump; this gas passes through a heat transfer unit **35**, cooled by air or other suitable fluid, and is then returned to the pump through a heat exchanger 36 in the liquid in the lower portion of the tank and thence through a nozzle 37 into the chamber 24. The operation of this heat transfer arrangement may be controlled by a valve 40 actuated automatically in response to the temperature of the liquid in the tank as determined by a temperature sensing element 41 located therein.

In this application of the vacuum pump it is desirable to maintain a relatively low temperature of the water in the tank and it is for this reason that the rotor 17 is confined only at the entrance of the shroud. As will be pointed out below, the enclosure of a substantial length of the rotor in the shroud results in the generation of a very substantial quantity of heat which is desirable for many applications of the invention. The cooler temperatures realized in the pump of FIG. 1 facilitate the the condensation of the heavier hydrocarbons and the return of cooled gas through the line 33 further effects cooling of the liquid.

The diameter of the rotor determines the size of the vortex formed during the operation of the pump. For a given shaft speed the larger the diameter of rotor the larger the vortex and the greater the peripheral speed of the turns of the helix. The volumetric capacity of the pump is determined by the speed of the shaft and the length of pitch of the helix. It will thus be apparent that a wide range of design is available. The spacing of the rotor from the shroud or cylinder wall may also be varied within a relatively wide range dependent upon the application for which the pump is intended. In all cases the control of the admission of liquid to the pump cylinder is relatively critical and is adjusted to effect the optimum performance in each application and condition of operation.

For many applications of the pump of this invention it is desired to generate substantial quantities of heat, and FIG. 3 illustrates a system wherein such heat is employed to facilitate the production of relatively viscous petroleum. In this embodiment a pump assembly indicated generally at 45 and which is similar to that shown in FIG. 1 is connected by a vacuum or suction line 46 to remove gas from a well casing 47, the suction line being connected in communication with the interior of the casing through a well head fitting 48. Liquid petroleum is removed from the well by operation of a pump 50 connected by a sucker rod 50*a* to be driven by a horsehead 50*b*; the pump receives liquid from the formation and delivers it to a production stream or tube 51.

In order to heat the well fluids in the well, high temperature liquid is supplied from the tank 52 of the pump assembly 45 through a line 53 under control of an automatic valve 54 having a temperature sensing element 55 immersed in the liquid in the tank. The line 53 extends downwardly into the well between the casing and the tubing 51 so that the hot liquid flows downwardly alongside the production tube and heats the liquid petroleum flowing upwardly therethrough; the hot liquid thus flows down into the well and over the producing surface of the formation where it counteracts the refrigerating effect of the liquid vaporized under the low pressure; the liquid then flows upwardly with the well fluids through the tube 51. The vacuum pipe 46 maintains the well at low pressure during the operation of the pump 45 and greatly facilitates the production of the well fluids. The pump 45 maintains a steady suction line pressure and has been found very effective in increasing the rate of production from petroleum formations which have been relatively low rate producers.

The pump assembly 45 includes a pump 56 comprising a sleeve or shroud 57 and a helical rotor 58 mounted on a shaft 60 for rotation in the shroud by operation of an internal combustion engine 61. The shaft 60 is journaled in bearings 62 and 63 and the rotor 58 is positioned within the sleeve 57 substantially throughout its length, the rotor diameter being smaller than the internal diameter of the sleeve and providing an appreciable spacing therebetween. The shroud is closed at its right-hand end by a plate 64 and a suction chamber 65 is formed between the end plate and the rotor 58. This arrangement which provides a longer portion of the rotor in the shroud results in the generation of larger amounts of heat in the liquid which is thereby maintained at higher temperatures than in the embodiment of FIG. 1.

Liquid is admitted to the pump under control of a valve 66 which controls a passage from valve inlet 67 in the tank to a pump intake port 68. The valve has been illustrated as manually controlled by a hand wheel 70. Gas or vapor from the well flows through the suction line 46 to a vapor inlet or port 71 entering the chamber 65. It will be noted that both intake ports 68 and 71 enter the chamber 65 behind the last turn or blade of the rotor 58; this arrangement of the rotor and ports assures effective operation of the pump.

The bearing 63 adjacent the suction side of the pump is sealed by liquid circulated from the tank through a compartment 72 in the bearing assembly and thence to the pump intake. For this purpose liquid is drawn from an outlet 73 in the side of the tank through a pipe 74 to the compartment 72 and thence to the chamber 65 under control of a valve 75*a* through a conduit 75 opening adjacent the inlet of the valve 66. This prevents leakage of air into the suction side of the pump through the bearing 63.

In this application the liquid in the tank 52 is petroleum and other well fluids and is maintained at a level 76 by operation of a float valve 77 actuated by a float 78; whenever the liquid level falls sufficiently the float opens the valve and admits petroleum from the production line indicated at 51*a* through a connection 80.

Volatile petroleum components collect above the level of the liquid in the tank and fill a dome 81; these gases are removed from the dome through a line 82 and are supplied as fuel for the engine 61, excess gases being removed by a pop-off valve 81*a*.

Additional heat may be supplied to the liquid in the tank 52 from the hot exhaust gases of the engine or from its cylinder jacket cooling system; by way of example, a heat exchange device 84 has been shown immersed in the liquid in the tank and connected to receive the hot fluid from the engine 61 and to return the fluid to the engine after it has been cooled by this heat exchanger.

The valve 54 is controlled to open and admit hot liquid to the well casing when the temperature as sensed by the element 55 is above a predetermined value. The system thus operates to maintain a low pressure in the well formation and simultaneously supply hot well fluid or other liquid to heat the viscous petroleum fluids and facilitate their production from the formation and their flow through production pipes under operation of the pump 50.

The systems as described above employ the cylindrical shroud and helical rotor of applicant's invention. As has been mentioned above, the effect of this rotor may be varied by changing the portion of the rotor which is within the shroud, and greater cooling is accomplished by having a smaller portion of the rotor within the shroud so that the cooling effect of vapor drawn through the pump and expanded may be utilized and so that there is a minimum heating due to the compression or vortex forming characteristics of the helical rotor within the shroud. The adjustment of the valve for controlling the recirculation of water through the pump has been found to be critical, as mentioned above, and for this reason the adjustment is made in accordance with the particular conditions of operation for each application and condition of operation at the time. Furthermore, the spacing between the helical rotor and the shroud is also selected to secure optimum conditions for any one application of the invention.

To further facilitate an understanding of the invention and by way of example and not by way of limitation, one pump embodying the invention was constructed which had the following dimensions:

	Inches
Internal diameter of shroud **16**	25
Length of shroud **16**	27½
Diameter of shaft **18** (for length of rotor and through chamber **24**)	3⁷⁄₁₆
Distance from bottom of tank to shroud	17½
Diameter of rotor helix	24
Pitch of rotor helix (2 turns), each turn	5
Length of chamber **24** between wall and first rotor turn	12¾
Diameter of gas inlet **23**	10
Diameter of liquid inlet **21**	12
Gate valve **20**	12

The pump was mounted in a tank four feet five inches wide, six feet ten inches long and nine feet high filled with water to a height of seven feet and thus containing approximately 1300 gallons. The rotor was driven by a diesel engine at approximately 800 r.p.m. When the gas inlet supply conduit was closed the pump maintained a vacuum of 24 inches of mercury and the temperature of the water was observed to rise from 48° F. to 86° F. in eighteen minutes.

While the invention has been described in connection with specific constructions of the pumping unit and systems, various other applications and modifications will occur to those skilled in the art. Therefore it is not desired that the invention be limited to the specific constructions illustrated and described and it is intended by the appended claims to cover all modifications which fall within the spirit and scope of the invention.

I claim:

1. A fluid treating system for facilitating the production of relatively high viscosity liquids from oil wells and the like which comprises a closed tank having a body of liquid therein, means for supplying liquid from a well to said tank and for maintaining a predetermined level of the liquid therein, means for supplying liquid from said tank to the well, means including a combined liquid and vapor pump mounted in said tank below the level of liquid therein for heating the liquid in said tank and for pumping gas into said tank to maintain a low pressure of vapor in the well, said pump including means providing an intake chamber and a liquid inlet for conducting liquid from said tank to said chamber, means for driving said pump to force liquid from said chamber into said tank, means including a vapor inlet for connecting said chamber in a communication with the well, and means effective to control the flow of liquid through said liquid inlet for adjusting the vapor intake pressure of said chamber.

2. A fluid treating system as set forth in claim **1** including means dependent upon the temperature of the liquid in said tank for controlling the supply of liquid from said tank to the well.

3. A fluid treating system as set forth in claim **1** whereing said driving means comprises an internal combustion engine and including a heat exchange unit mounted in said tank below the level of liquid therein, a liquid cooling system for said internal combustion engine and liquid conduit means connecting said system and said unit for supplying heat from said engine to the liquid in said tank.

4. A fluid treating system for facilitating the production of relatively high viscosity liquids from oil wells and the like which comprises a closed tank having a body of liquid therein, means for supplying liquid from a well to said tank and for maintaining a predetermined level of the liquid therein, means for supplying liquid from said tank to the well, means including a vacuum pump mounted in said tank below the level of liquid therein for heating the liquid in said tank and for maintaining a low pressure of vapor in the well, said pump comprising a substantially cylindrical casing closed at one end and in open communication with said tank at its other end, a helical rotor in said casing spaced from the closed end thereof to provide an intake zone means for driving said rotor to force liquid through said casing and into said tank, means including a liquid inlet for supplying liquid from said tank to said zone for recirculation, means including a vapor inlet for connecting said zone in communication with the well, and means for controlling the flow of liquid through said liquid inlet.

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