PRESSURE GENERATING MEANS FOR DEEP WELL PUMPS

Inventors:
John E. Dube, Roger W. Schoen
By: Kingston, Roger & Bill
Attorneys
The present invention relates to the pressure generating components of deep well pump apparatus of the type wherein the operation of a pump at the bottom of a well is caused by the controlled application of fluid pressure in a column of power fluid leading down from the surface to the pump.

In such apparatus there is a prime mover such as a gasoline or gas engine, a pump such as a vane pump which delivers primary oil under pressure, a hydraulic piston motor reciprocated by the primary oil pressure, and a hydraulic piston pump having a piston reciprocated in a hydraulic cylinder connected to the power oil tubing leading to the bottom of the well and the pump thereat. Reciprocation of the piston produces the pressure in the power oil required to operate the pump. Sometimes this pressure alternates high and low; other times, such as in the following explanation, a substantially constant pressure is maintained in the power oil tubing.

The so-called primary oil normally is circulated from the vane pump through a four-way valve alternately to the opposite ends of the power cylinder, whence it is exhausted back to the vane pump, in a closed system. The power oil tubing leads from a suitable supply tank at the surface through the power oil cylinder of the pump and down to the bottom of the well. Finally, there is a production oil line to conduct production oil (combined with exhaust power oil) back up to the surface and into appropriate separators and storage tanks.

Heretofore there has been a problem in this type of pumping operation because of the heat of the primary oil in the closed circularly hydraulic motor system. Such oil tends to heat, and if it has any vaporizable fractions in it which do vaporize, a vapor lock can occur in the pumping system.

It is an object of the present invention to overcome the heating problem in the primary oil. It is a more specific object to overcome the heating problem by the use of cooling mediums that are immediately available at the point of use so as to minimize the expense of building and operating the heat exchange arrangement.

Specifically, it is an object of the present invention to arrange a heat exchange device in the primary oil system which has one pass to receive the primary oil and an other pass to receive some other cooling medium which is either the production fluid coming up from the well or is the power oil that is going down to the well. In the preferred construction, the cooling fluid is the production oil coming up from the well.

In the description to follow, reference will be made to deep well pumping of oil. It will be understood that the invention is applicable to other fluids than oil.

In the drawings:

Figure 1 is a schematic view of the surface components of an oil well pump involving the present invention and wherein the cooling medium consists of the production oil being pumped;

Figure 2 is a similar view wherein the cooling oil is the power oil;

Figure 3 is a vertical sectional view through the heat exchange device showing the two passes therein; and

Figure 4 is a horizontal section through the heat exchange device taken on the line 4—4 of Figure 3.

Referring first to Figure 1, a cased oil well is indicated at 10. It is here shown with the well tubing 11 bringing the production oil up for delivery through a surface pipe 12. There is also a power oil pipe 13 leading to a hydraulically operated pump at the bottom of the well.

The type of pump herein involved finds many different embodiments, but a typical embodiment is that shown in the MacDougall Patent No. 2,478,410, dated August 9, 1949. Other types are operated by a substantially constant pressure in the power oil line, and the present description will be such a pump system.

The surface apparatus includes a prime mover 15 which is here shown as a gas or gasoline engine. This motor operates a vane-type primary pump 16 which rotates to deliver liquid under pressure from an intake pipe 17 to an outlet pipe 18. The pipe 18 passes through a four-way valve 19, whence it branches by a pipe 20 or a pipe 21, the two pipes leading into opposite ends of a primary oil cylinder, hydraulic motor cylinder 22. The cylinder 22 contains a piston 23 on a piston rod 24. The piston rod passes through a packing gland and reciprocates in a power oil pump piston 25 in a power oil pumping cylinder 26. This power oil pump may be referred to as a secondary pump.

A piston rod 30 also projects oppositely from the piston 23, outside the cylinder 22, and has a head 31 at its end. This head operates trip mechanism 32 connected with a pilot valve 33 which is designed to reverse the four-way valve 19. Since the pilot valve is not part of the present invention, it is not necessary to explain in greater detail the operation of the four-way valve 19. A mechanism that may be used is that shown in the MacDougall patent. The head 31 operates the trip mechanism to reverse the pilot valve and cause reversal of the four-way valve, each time the pistons reach either end of their stroke.

In the un-employment of the pilot valve 33, and hence of the four-way valve 19, the pressure fluid from the pump through the line 18 passes through the line 20 to the left side of the piston 23, driving the piston to the right, which is made possible because the line 21 is ported to exhaust by the four-way valve. In the other position of the pilot valve 33, and of the four-way valve 19, the high pressure fluid from the pump 16 passes through the line 21 to the right side of the piston 23 while the line 20 is ported by the valve 19 to exhaust so that the piston then moves to the left.

It will be noted that the line 13 connects into the pumping cylinder 26 by two pipes 36 and 37. These two pipes contain check valves 38 and 39 that admit only outflow from the cylinder 26 into the line 13.

The cylinder 26 is also connected by two pipes 40 and 41 to a pipe 42 that leads from a power oil supply tank 43. The two branches 40 and 41 are controlled by check valves 44 and 45 that admit flow only from the line 42 into the cylinder 26.

A heat exchanger 50 contains two separate fluid flow passages. It has an outer casing 51 having a top 52, a bottom 53, and a pair of headers 54 and 55. A plurality of tubes 56 connect through the two headers, thereby connecting a top space 57 and a bottom space 58 and separating them from an intermediate space 59 surrounding the several tubes.

The pipe 12 enters the space 59 which constitutes one pass of the heat exchanger, and a pipe 60 leads from
the upper end of this pass 59. The pipe 60 leads to a separator 61 from whence another pipe 62 leads to an oil storage tank.

There is a low pressure primary oil pipe 63 leading from the four-way valve 19 and entering the heat exchanger 50 at the top. It passes centrally down through the heat exchanger and then opens below a baffle 64 in the bottom space 58 of the heat exchanger. The baffle 64 ensures a spreading of the fluid. The fluid may then rise through the tubes 56 to the top space 57, whence it may emit through the pipe 17 that constitutes the intake to the vane pump. The spaces 57 and 58 and the interior of the tubes 56 constitute the other pass of the exchanger.

Operation

In general, the operation of the prime mover 15 and the liquid pump 16 need hardly be described since they are well known in the art. See the patent to MacDougall, No. 2,475,410, dated August 9, 1949. Suffice it to say at this point that the engine 15 rotates the pump 16 and causes it to draw liquid through the pipe 17 and discharge it under pressure through the pipe 18 to the four-way valve 19. That valve is shifted by the pilot valve 33 which, in turn, is shifted each time the piston 32 reaches an extreme of its stroke, all as described in the MacDougall patent. The shifting of the pilot valve 33 alternately causes the four-way valve 19 to deliver high pressure oil from the pump 16 through the pipe 20, or to deliver such high pressure oil through the pipe 21 at the opposite side of the piston 23. Each time one of these two pipes 20 and 21 is connected to high pressure, the other will be connected by the four-way valve 19 to the return line 63.

The primary oil in each case returns from the four-way valve 19 to the pipe 63, whence it enters the heat exchanger 50, flowing axially therethrough to below the baffle 64. Spreading around the baffle, it rises through the tubes 56 and finally flows out the pipe 17 back to the pump 16 for recirculation to the four-way valve and hydraulic motor.

As shown, high pressure primary oil is being introduced from the four-way valve 19 through the line 20, and the piston 23 is moving to the right, approaching its rightward extreme, and causing corresponding movement of the pump piston 25 in the cylinder 26. Owing to the presence of the check valves 38 and 39, the rightward movement of the piston 25 in the cylinder 26 drives the oil through the line 37 past the check valve 39 into the power oil line or tube 13. Meanwhile, the check valve 45 prevents the egress of the aforesaid oil back into the supply line 42. Appropriate relief means against excess pressure in the pipe 13 may be provided.

Rightward movement of the piston 25 also draws oil in from the supply line 42 past the check valve 44, and by the pipe 48 to the left side of the piston 25. During this, the check valve 38 prevents the drawing of oil from the pipe 13 to the left side of the piston.

Rightward movement of the two pistons occurs in corresponding manner, upon shift of the valves 33 and 19. In other words, the piston 25 constitutes a two-way pump which maintains substantially continuous pressure on the oil in the pipe 13. It will be understood that a one-way alternate high pressure and low pressure pumping system may be used where that is the type of deep well pump involved. The present arrangement, however, is used where the deep well pump requires continuous high pressure on the power oil.

The deep well pump within the well 10 brings oil up and discharges it through the pipe 12. From this pipe it enters the intermediate pass 59 of the heat exchanger. Being cold, it withdraws heat from the primary oil that is circulating through the tubes 56. The production oil leaves the heat exchanger by the pipe 60, thence moves through a separator 61 from which it leaves by a pipe 62 to suitable storage.

It thus may be seen that the primary oil which is required to move the hydraulic motor piston 23 so as to operate the pump piston 24 is kept cool through the medium of the pump production oil brought up from the well.

Embodiment of Figure 2

As illustrated in Figure 2, the cooling of the primary oil may also be obtained by passing the power oil instead of the production oil through the heat exchanger. Figure 2 shows the prime mover 15 and the pump 16 as before. The pump delivers to the four-way reversing valve 19 just as before, and this valve controls the flow to the hydraulic motor piston motor 22, just as before. This motor operates the pump piston, not shown, but contained within the cylinder 26 just as before so as to maintain substantially constant high pressure on the power oil pipe 13. The production oil pipe 12 brings oil up and, in this case, delivers it directly to the separator.

The heat exchanger 50 is the same as before. However, the power oil pipe 142 delivers power oil into the intermediate pass of the heat exchanger, and it emits from that pass by the pipe 140 and flows into the opposite end of the cylinder 26. In other words, in the present case the intermediate pass of the heat exchanger 50 has been interposed into the pipe leading from the power oil supply tank to the opposite ends of the pump cylinder 26. The other pass of the heat exchanger receives primary oil from the pipe 63, that is the exhaust side of the four-way valve, and it delivers oil through the pipe 17 that leads to the intake side of the vane motor 16, all just as in Figure 1.

The only difference of Figure 2 over Figure 1, therefore, is that instead of passing the production oil through the intermediate pass of the heat exchanger 50, as in Figure 1, the power oil from the power oil tank is run through this intermediate pass in Figure 2. The operation of the system is the same as before, save only that the power oil does the cooling of the primary oil, and it is itself increased in temperature somewhat. This latter is immaterial because the power oil will be cooled when it descends into the earth through the well.

It will be seen that in both exemplifications of this invention the primary oil which is used to operate the hydraulic motor is kept from heating excessively and perhaps foaming or vaporizing, because of the presence of the heat exchanger. It also is apparent that the heat exchanger derives its source of cold from an immediately available supply of fluid such as the production oil delivered from the well or the power oil delivered to the well.

What is claimed is:

1. In a well pumping apparatus: a fluid circuit including a primary fluid pump, a fluid motor, connections between the pump and the fluid motor so that the fluid pressure produced by the pump operates the fluid motor, and connections from the fluid motor back to the pump whereby the fluid can be circulated in a closed system; a heat exchanger having two passes, one pass interposed in one of said connections; a secondary pump connected with and adapted to be operated by the fluid motor; power fluid piping connecting into the last named pump; power oil high pressure piping leading from the last named pump, a deep well pump connected to the power oil high pressure piping at the bottom of a well; a production fluid piping for conducting production fluid from the production well and connections introducing one of said last named fluid pipings through the other pass of the heat exchanger.

2. The combination of claim 1, in which the production fluid piping is the one of the pipings connected to the heat exchanger.
3. The combination of claim 1, in which the power fluid piping is the one of the pipings connected through the heat exchanger.

4. In a well pumping apparatus: a prime mover; a primary hydraulic pump operated by the prime mover; a hydraulic piston motor, a heat exchanger; connections from the heat exchanger to the primary pump; connections from the primary pump to the opposite sides of the hydraulic piston motor, with reversing valve means in said last-named connections alternately to connect one side of the piston to the high pressure side of the primary pump and correspondingly to connect the opposite side of the piston to the heat exchanger; a hydraulic secondary pump connected to and operated by the hydraulic piston motor; piping connecting power oil into the secondary pump and piping leading from the secondary pump; a pump for the well, into which the last-named piping connects; piping to conduct production oil from the pump in the well; and means connecting one of the pipings through the heat exchanger to provide cooling of the primary oil.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,860,137</td>
<td>Carr</td>
<td>May 24, 1932</td>
</tr>
<tr>
<td>2,033,210</td>
<td>Tennant et al.</td>
<td>Mar. 10, 1936</td>
</tr>
<tr>
<td>2,429,947</td>
<td>Rose</td>
<td>Oct. 28, 1947</td>
</tr>
<tr>
<td>2,432,079</td>
<td>Albert</td>
<td>Dec. 9, 1947</td>
</tr>
<tr>
<td>2,478,410</td>
<td>MacDougall</td>
<td>Aug. 9, 1949</td>
</tr>
</tbody>
</table>