

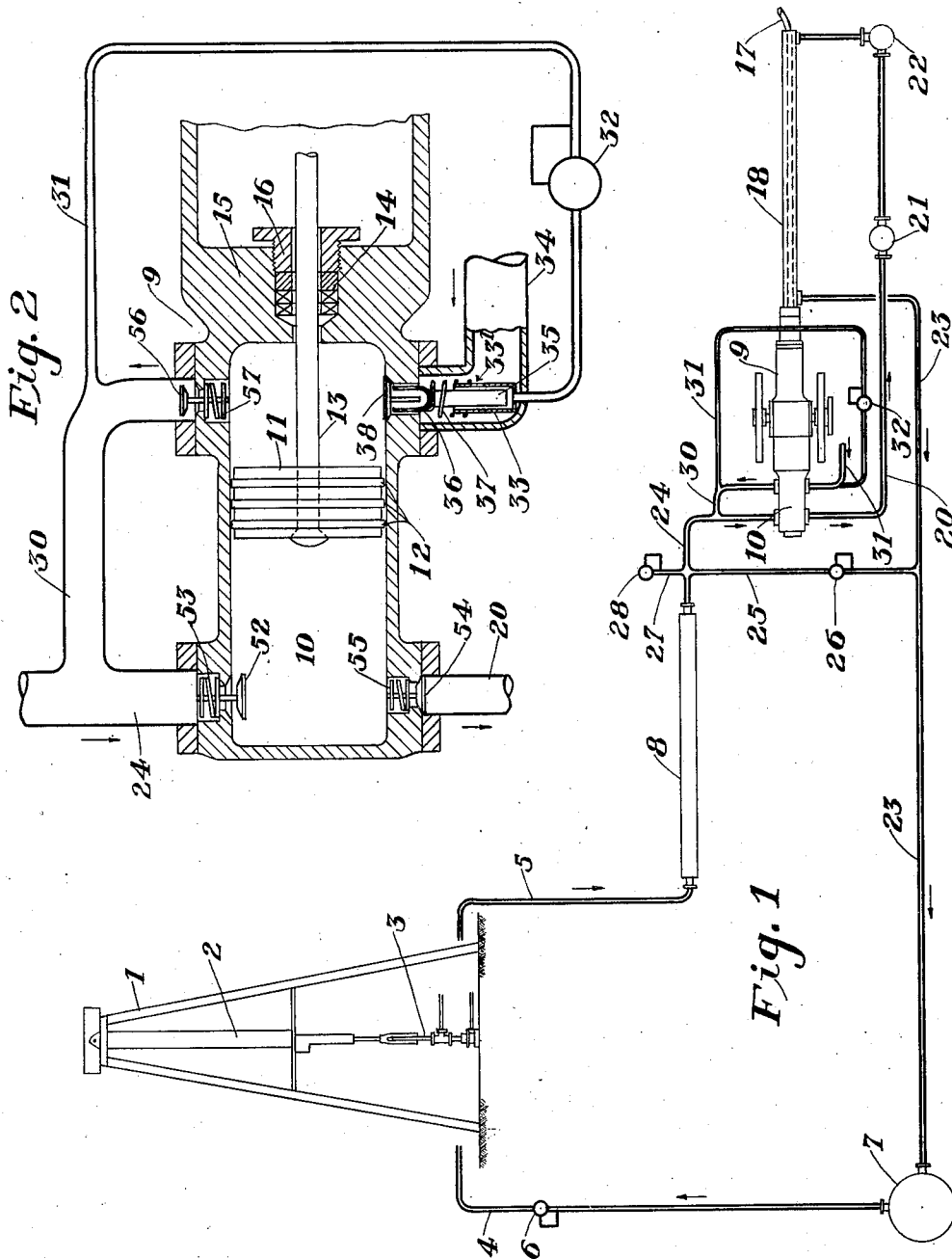
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PUMPING SYSTEM AND METHOD OF OPERATING SAME

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PUMPING SYSTEM AND METHOD OF
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8 Claims. (Cl. 60—59)

This invention relates to a pumping system and to the method of operating same, and is more particularly concerned with automatic means for maintaining the volumes and pressures of the gas in the system substantially uniform.

In Patent No. 1,860,137 I have disclosed and claimed a method and apparatus for pumping wells wherein a closed gas system under pressure is used to operate a motor cylinder from which well pumping mechanism was suspended.

The present invention is an improvement over the system disclosed in the above mentioned patent and includes features which provide for more efficient and economical operation and automatic control.

One of the objects of the present invention is to utilize the waste heat of the exhaust gases of a gas or other combustion engine to heat the gases in the pumping circuit.

Another object of the invention is to provide automatic means for making up gas losses in the gas circuit.

A further object of the invention is to provide means for automatically controlling the pressure in the gas circuit and to provide automatic shutoff means when a break occurs in the high pressure line or the pumping mechanism ceases to function properly.

Further objects of the invention will be evident from the following description in conjunction with the accompanying drawing of which Fig. 1 is a diagrammatic view of the pumping system;

Fig. 2 is an enlarged cross-sectional view of the compressor forming part of the system.

Referring to the drawing, the numeral 1 indicates a derrick from which is suspended the motor cylinder 2 and rods 3 in a manner similar to that disclosed in Patent No. 1,860,137. The motor cylinder forms no part of the present invention except insofar as it enters into the general combination and is not shown in detail. The line 4 is connected to the admission valve of the motor cylinder, and the line 5 is connected to the exhaust valve of the motor cylinder. An automatic valve 6 operating by pressure differential such as shown and described in the application of Wade H. Wineman, Serial No. 619,658, and a surge tank 7 are connected in the line 4, and an atmospheric cooler 8 is connected in the line 5.

The numeral 9 represents a gas-driven compressor having a compression cylinder 10. Slidably mounted in the compression cylinder is a piston 11 having rings 12. The piston 11 is rigidly mounted on the rod 13 which extends through a packing gland or stuffing box 14 placed in a recess of the wall 15 and held in place by the member 16 which is threaded to screw into

the recess in the wall 15. The opposite end of the piston rod 13 is connected to a piston, not shown, slidably mounted in the cylinder of the gas engine.

The hot combustion gases from the gas engine exhaust through the pipe 17 which is enclosed in a casing 18. A pipe 20 is connected from the exhaust outlet of the compression cylinder to the rear end of the casing 18. Traps 21 and 22 are connected in the line 20. A line 23 connects the front of the casing 18 to the surge tank 7. A line 24 connects the cooler 8 to the intake of the compressor 10. A line 25 having automatically controlled valve 26 connects the lines 23 and 24. A line 27 having an automatically controlled valve 28 connects the line 24 to the atmosphere. A line 30 connects the line 24 to the rear end of the compression cylinder 10 at a point behind the piston 11. A line 31 having an automatically controlled pilot valve 32 therein is connected between the line 30 and an open ended cylinder 33 forming part of an unloading valve 33'. A pipe 34 connects the compression cylinder 10 at a point behind the piston 11 to the atmosphere. The pipe 31 which is of smaller diameter than the pipe 34, passes through the wall of the pipe 34 and is connected to the cylinder 33 which is located inside the pipe 34. Inserted in the cylinder 33 is a piston 35, on the upper end of which is rigidly mounted a three-prong fork 36. A coil spring 37 is placed in such a manner as to normally hold the piston 35 in the lower position. The upper ends of the fork 36 are adjacent to the lower surface of a suitable valve plate 38 which normally remains in the closed position. The plate 38 may be integrally united to the fork 36 so as to operate as a unitary structure therewith. It will be understood that any well known type of unloading valve may be substituted for the valve 33'.

The intake to the front of the compression cylinder 10 is controlled by a poppet or plate valve 52 normally held in closed position by a coil spring 53. The discharge opening at the forward end of the cylinder is controlled by the poppet or plate valve 54 normally held in closed position by the coil spring 55, and the opening connecting the rear end of the cylinder to the line 30 is controlled by the poppet or plate valve 56 normally held in closed position by the coil spring 57. The springs are only of sufficient tension to normally hold the valves in closed position and to permit them to open by pressure or suction created by the operation of the piston.

The system functions in the following manner:

The gas engine is started causing the compressor to build up the pressures in the lines 23 and 24 to operating pressures. When the pressure has been built up to a sufficient degree,

throttle valves in the lines 4 and 5 (not shown) are opened to permit the air to enter the motor cylinder and exhaust therefrom, whereupon it begins functioning to lift and lower the well pump and rods. The operating pressure on the high pressure side in the gas circuit may be between 100 to 350 pounds per square inch, but may vary from these figures depending upon the load that is placed upon the system and upon the size of the compression cylinder. It will be apparent that with a larger compression cylinder, lower pressures may be used, while higher pressures than those mentioned may be used with small compression cylinders. The gases leaving the compression cylinder 10 pass through the casing 18 where they pass counter-current to the exhaust gases from the combustion engine, and are heated to an elevated temperature which will vary depending chiefly upon the speed at which the compressor is driven. With a compressor having a rated speed of 300 R. P. M., it has been found that the compressed air may be heated to as high as 700° F. by passing it counter-current to the exhaust gases from the gas engine. When the compressor is run at 150 R. P. M., the compressed air may be heated to 325° F. From the heat exchanger or casing 18 the gases pass into the surge tank 7 which acts as a reservoir for the compressed and heated gases, and then through line 4 and the admission valve of the motor cylinder which operates the pumping mechanism and thereby lifts the rods and well pump which are connected to the piston in the motor cylinder. At the end of the power or the up stroke of the motor cylinder piston the exhaust valve opens allowing the gases to exhaust from the motor cylinder under pressure by means of the weight of the well pump and rods through the line 5. The air is exhausted under pressure sufficient to balance the pumping mechanism and passes through the atmospheric cooler 8 where the gases are cooled down by virtue of the large radiating surface to substantially atmospheric temperature. Other cooling media may be used instead of the atmosphere for cooling the gases at this stage.

The pressure at which the gases are returned to the compression cylinder 10 will depend upon the load of the pumping mechanism. For example, if a well 2000 feet deep is being pumped and we assume that $\frac{3}{4}$ inch rods weighing 166 pounds per hundred feet of length are used, the rod load will be approximately 3,320 pounds. Assuming that the area of the piston in the motor cylinder is 40.3 square inches, the pressure then necessary in the exhaust line from the motor cylinder would have to be less than

$$\frac{3320}{40.3}$$

or 83 pounds per square inch to permit the rods to fall. In actual practice a pressure of about 65 pounds per square inch would be carried in the exhaust line 5. With a well of this size, using equipment as above specified, the pressure in the high pressure line would be approximately 145 to 160 pounds per square inch.

On the suction stroke of the piston 11 in the compression cylinder, the valve 52 opens and permits the air exhausted from the motor cylinder to enter. At the end of the suction stroke, the valve 52 closes and the valve 54 opens and the gases are compressed and pass through the line 20, heater 18, line 23 to the surge tank 7 from whence they are drawn for operation of the motor cylinder. On the passage of the compressed

gases to the heater 18 any moisture or other sediment is removed by the traps 21 and 22. In order to make up any losses of air or other fluid used in the gas circuit, a line 34 is provided connecting the rear end of the compression cylinder 10 to the atmosphere or other fluid source. The passageway from the cylinder 10 to the line is automatically controlled so as to permit makeup air to enter the gas circuit only if the pressure in the gas circuit has fallen below a predetermined figure. For example, if gas is to be returned to the suction side of the cylinder at 75 pounds per square inch, the valve 32 in the line 31 will be set so as to open only if the pressure exceeds this figure. In that event the air enters the cylinder 33 through the line 31 and forces the piston 35 upwardly which in turn holds the valve 38 open. The air then sucked in through the pipe 34 will exhaust back to the atmosphere and will not enter the line 30. It is not desirable to add makeup air to the gas circuit so long as the pressure of the gas in the return line is above 75 pounds since this pressure indicates that the gas in the system is of sufficient volume so that makeup air is not required. However, if the pressure drops below 75 pounds, the valve 32 closes and the air in the cylinder 33 is exhausted therefrom permitting the piston 35 to return to its lowered position thereby permitting valve 38 to assume its normal operation of opening and closing with the stroke of the piston, sucking in air from the atmosphere on the compression stroke of the piston 11 and closing during the return stroke thereby forcing the air in the cylinder 10 behind the piston 11 through the line 30 to join the air returning to the front of the cylinder 10 through the line 24.

The system can be operated without the automatic unloading valve 33¹. When so operated, makeup air will be sucked in on each forward stroke of the piston 11 and added to the air returning through line 24 to the cylinder 10, on each return stroke of the piston. Any excess pressure that builds up in the system may be bled out through valves 26 and 28.

The line 25 with its automatic valve 26, automatically regulates the pressure in the line 23 so that if the pressure in the line 23 exceeds a predetermined amount, the valve 26 opens and permits the excess pressure to bleed into the line 24. If the pressure in the line 24 exceeds a certain predetermined amount, the automatic valve 28 permits the excess air to escape to the atmosphere and thereby bring the pressure in the line 24 back to normal operating pressure.

In the event that the line breaks between the valve 6 and the motor cylinder, or when the exhaust and admission valves of the motor cylinder remain open, or the pump rod breaks, the valve 6 automatically closes. The valve 6 operates by pressure differential so that if the pressure in the line between the valve and the motor cylinder is materially lowered, the valve will close. This prevents waste and also injury to the pumping mechanism. For example, if the pumping rods broke at a low point close to the well pump, the weight of the rods might be sufficient to return the piston in the motor cylinder to its lower position, but upon admission of compressed air to the motor cylinder there would be no load to lift since the well pump had become detached and serious breakage might occur by reason of the speed at which the motor cylinder would operate. The automatic valve 6 would immediately

shut off the air supply to the motor cylinder thereby preventing this from happening.

The desirability of returning air to the compressor at superatmospheric pressure will be evident when it is considered that the amount of work necessary to compress 1 cu. ft. of gas from 0 to 75 pounds per square inch is about 3400 foot pounds, whereas the amount of work required to compress 1 cu. ft. of gas from 75 to 200 pounds per square inch is approximately 2000 foot pounds. A large saving in operating expense results from admitting the exhaust gas to the compressor at high pressure, and a further economy results from utilizing the exhaust heat of the gases from the engine to counter-currently heat the compressed air. It will be evident that by heating the air the volume is increased and the amount of work that can be done is necessarily increased.

With a system operating in the manner described it will be found that the leakage of air in the gas circuit is almost negligible, amounting to only about 1 to 3% or less when operating under a compression pressure of 225 pounds per square inch.

It will be evident from the foregoing description that I have provided an automatic system for pumping which requires little or no attention and functions in a highly efficient manner.

What is claimed is:

1. Apparatus of the character described comprising a cylinder, a piston slidably mounted therein, fluid admission and exhaust means at one end of said cylinder, an intake line connected to said admission means, means at the opposite end of said cylinder for exhausting fluid from said cylinder, a line directly connecting said last mentioned exhausting means to said intake line, automatic valve means controlling an inlet at said opposite end, and means to maintain said valve in open position when the pressure in said intake line exceeds a predetermined value.

2. A closed system for operating a fluid motor mechanism comprising a compressor having admission and exhaust means, intake and exhaust lines connected at one end to said admission and exhaust means respectively and connected at the other end to the outlet and inlet respectively of said motor mechanism, a shunt connecting said lines, automatic means for bleeding fluid from the exhaust to said intake line when the pressure exceeds a predetermined value, automatic means for bleeding fluid from said intake line to a source of lower pressure when the pressure in said line exceeds a predetermined value, and automatic means in said exhaust line for closing the line upon abnormal release of pressure beyond said means.

3. Apparatus of the character described comprising a cylinder, a piston slidably mounted therein, means for admitting air to one end of said cylinder, means for exhausting compressed air from the same end of said cylinder, means for sucking makeup air into the opposite end of the cylinder during the forward stroke of said piston, means for uniting said makeup air directly with the air admitted to the first mentioned end of the cylinder during the return stroke of said piston, and means for exhausting said makeup air to the atmosphere when the pressure of the air admitted to the first mentioned end of the cylinder exceeds a predetermined value.

4. A gas pump comprising a cylinder, a piston slidably mounted therein, means for admitting

and exhausting fluid from one end of said cylinder, and means for admitting and exhausting fluid from the opposite end of said cylinder, means directly connecting said first mentioned admission means and said last mentioned exhausting means, and automatic means for controlling said last mentioned admission means by means of the pressure in the line connected to said first mentioned admission means.

5. A gas pump comprising a cylinder, a piston slidably mounted therein, fluid admission and exhaust means at one end of said cylinder, an intake line connected to said admission means, means at the opposite end of said cylinder for exhausting fluid from said cylinder, a line directly connecting said last mentioned exhausting means to said intake line, automatic valve means controlling an inlet at said opposite end, and means to maintain said valve in open position when the pressure in said intake line exceeds a predetermined value.

6. A gas pump comprising a cylinder, a piston slidably mounted therein, means for admitting air to one end of said cylinder, means for exhausting compressed air from the same end of said cylinder, means for sucking makeup air into the opposite end of the cylinder during the forward stroke of said piston, means for uniting substantially all of said makeup air with the air admitted to the first mentioned end of the cylinder during the return stroke of said piston, and means for exhausting said makeup air to the atmosphere when the pressure of the air admitted to the first mentioned end of the cylinder exceeds a predetermined value.

7. In the method of operating a motor cylinder, the piston of which is loaded with a gravity load, comprising compressing fluid, feeding the compressed fluid to said cylinder whereby to actuate said piston, heating the compressed fluid prior to its delivery to said cylinder, expanding the fluid in said cylinder against said piston by shutting off the fluid supply thereto prior to the end of the working stroke, forcing the fluid from said cylinder back to the compressor under super-atmospheric pressure by means of the weight of the gravity load, and cooling the fluid prior to its return to said compressor, the improvement which consists in accumulating a predetermined amount of makeup fluid equal in volume to the volumetric displacement of the compressor piston less the volume of the piston rod, during the compression stroke of the compressor piston, and adding said makeup fluid to the return fluid from the motor cylinder during the suction stroke of the compressor piston only when the pressure of the return fluid falls below a predetermined value.

8. In a closed system for operating a well pump by means of a gas actuated motor cylinder, a compressor, means for feeding fluid from said compressor to said cylinder under super-atmospheric pressure, means for returning fluid from said cylinder to said compressor under a lower super-atmospheric pressure than that at which it is fed, means to draw makeup fluid into the rear end of the compressor cylinder during the pressure stroke of the compressor piston, and automatically controlled means for feeding said makeup directly from the rear end of the compressor into the forward end of the compressor cylinder during the suction stroke of the compressor piston when the pressure in said return means falls below a predetermined amount.

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