May 6, 1941. W. G. HELTZEL ET AL 2,240,775

CONTROL SYSTEM FOR PIPE LINES

Filed April 4, 1938 2 Sheets-Sheet 1

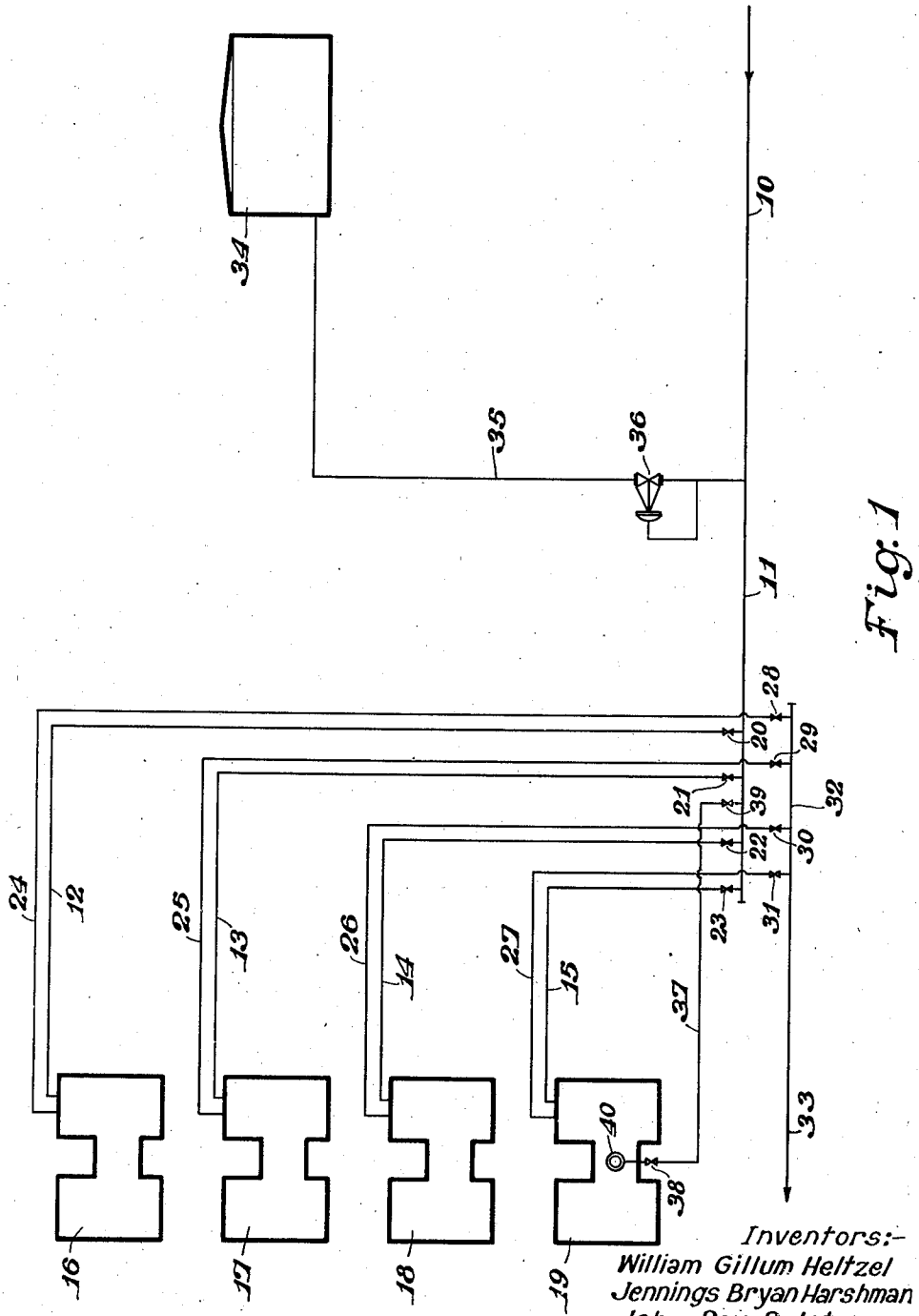


Fig. 1

Inventors:-
William Gillum Heltzel
Jennings Bryan Harshman
John Ray Polston

BY Geo. L. Parkhurst

ATTORNEY

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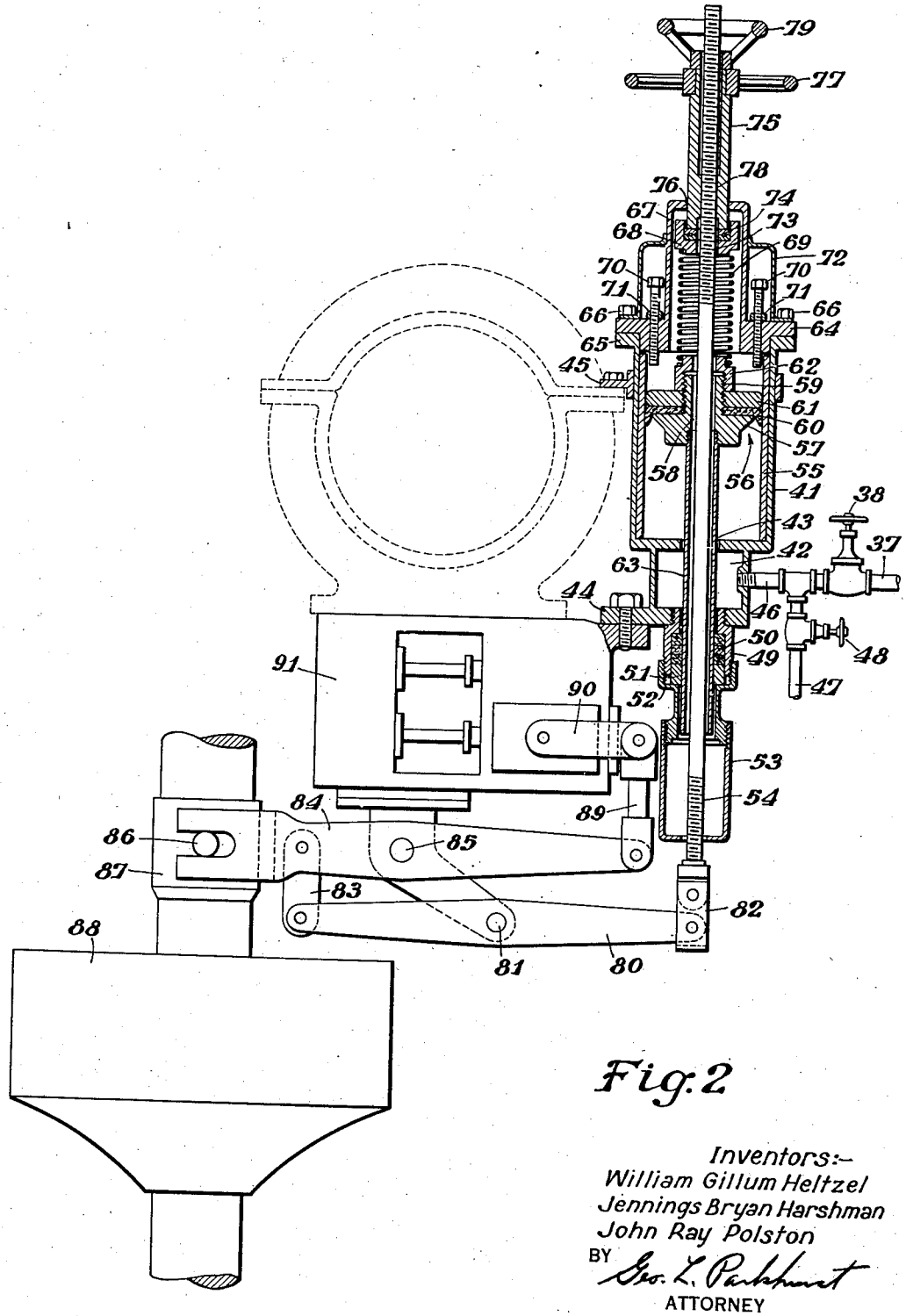


Fig. 2

Inventors:-
William Gillum Heltzel
Jennings Bryan Harshman
John Ray Polston
BY Geo. L. Parkhurst
ATTORNEY

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CONTROL SYSTEM FOR PIPE LINES

William Gillum Heltzel, Jennings Bryan Harshman, and John Ray Polston, Tulsa, Okla., assignors to Stanolind Pipe Line Company, Tulsa, Okla., a corporation of Maine

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4 Claims. (Cl. 103—16)

This invention relates to pipe lines, and more particularly to pipe lines for the transportation of fluids for long distances. Still more specifically it relates to a method and apparatus for automatically controlling the pumping rate of a pumping station in such a pipe line.

In the operation of pipe line systems, and especially of such systems for the transportation of crude oil, it is the general practice to maintain a number of pumping stations along the line a considerable distance apart, in each of which the pumping rate is manually controlled. It has been found necessary in using this system to have tanks located at each station connected to the incoming line to receive the excess oil when the up-stream station is pumping at a faster rate than the down-stream station, and conversely to supply oil to the down-stream station when its pumping rate is greater than that of the up-stream station. One undesirable feature of this arrangement is the necessity of constantly adjusting the pumping rates at all of the stations, and another is that the amount of oil in the station tanks fluctuates widely and often, thus resulting in high losses of volatile fractions from the oil in the tanks by evaporation.

It is an object of our invention to provide a method of automatically controlling the pumping rate at a pipe line pumping station so that it is substantially synchronized with that of the adjacent up-stream station. Another object is to provide means for controlling the pumping rate at a pipe line pumping station in accordance with the pressure of the incoming fluid. Still another object is to provide an improved apparatus for controlling the speed of an engine by hydrostatic pressure. Further objects will be apparent from the following detailed description read in conjunction with the drawings, in which:

Figure 1 shows diagrammatically a pipe line pumping station equipped with our improved control system; and

Figure 2 shows a view in elevation and partly in cross-section of a preferred form of our improved control system.

Our invention in its broadest aspects can best be understood by reference to Figure 1, in which 10 represents a pipe line carrying a fluid from the adjacent up-stream pumping station to the pumping station which is represented by the figure. Since our invention is particularly applicable to oil pipe lines, although not limited thereto, we will hereafter refer to oil as the fluid being pumped. The oil arriving through line 10 enters suction header 11, and then passes through suction lines 12, 13, 14 and 15 to pump units 16, 17, 18 and 19, respectively. Valves 20, 21, 22 and 23 are provided in lines 12, 13, 14 and 15, respectively, so that one or more of the pump units may be shut down when the amount of oil to be pumped can be handled by less than all of the units.

Each pump unit consists of a prime mover, such as a Diesel, gasoline or steam engine, or an electric motor, and a pump, which may be of the reciprocating or centrifugal type. The oil which has had its pressure increased by pump units 16, 17, 18 and 19 is discharged through discharge lines 24, 25, 26 and 27, and valves 28, 29, 30 and 31, respectively, into discharge manifold 32, from which it is further discharged through line 33 to the next down-stream pumping station on the pipe line.

Incoming line 10 is also connected to tank 34 by means of line 35, which is controlled by valve 36. Valve 36 is of a type which does not allow oil to flow into tank 34 unless the pressure in line 10 exceeds a predetermined value but allows oil to flow from tank 34 into line 10, when the head of oil in the former exceeds the pressure in the latter. A suitable valve for this purpose is that described in U. S. Patent 2,098,014, granted on November 2, 1937, to J. R. Polston.

A small pipe line 37 equipped with valves 38 and 39 connects suction header 11 and our improved control device 40, which is shown installed on pump unit 19. By means of this device, one embodiment of which will hereinafter be described in detail, the speed of the engine driving the pump in this unit is increased as the pressure in suction header 11 increases, and vice versa, so that the amount of oil discharged from the station is equal to that arriving from the next up-stream station. It is apparent, therefore, that when a series of pipe line pumping stations is equipped with our control system, variations in rate of discharge from the up-stream station will automatically vary that of the successive down-stream stations so that no oil need be introduced into or withdrawn from the station tanks.

In order for the control system to function properly, it is essential that the pressure at which valve 36 allows oil to flow into tank 34 be greater than that which exists in suction header 11. The actual pressures used may vary considerably depending upon local conditions, but in general satisfactory operation is obtained when valve 36 is set to operate at about 20 pounds per square

inch and control 40 is set to operate when the pressure in suction header 11 ranges from about 3 to about 15 pounds per square inch, with maximum engine speed and therefore maximum pumping rate at the higher value. If the oil is arriving at the station at a rate which exceeds its capacity, control 40 increases the pumping rate to capacity, and the pressure in suction header 11 increases to 20 pounds per square inch, so that valve 36 opens and the excess oil flows into tank 34. If the incoming oil rate then decreases to a value within the capacity of the station, the pressure in suction header 11 falls below 20 pounds per square inch, thus causing valve 36 to close, and then below 15 pounds per square inch, thus causing control 40 to become operative and adjust the pumping rate to the incoming oil rate. If the incoming oil rate falls so low that the head of oil in tank 34 exceeds the pressure in suction header 11, oil from the tank flows through line 35 and valve 36 into the suction header.

Although we have used a pumping station having four pumping units of which one is equipped with our improved control for purposes of illustration, it is apparent that more or fewer pumping units may be employed, and that a plurality of these pumping units may be equipped with our control. For most purposes, however, automatic control of one pumping unit is sufficient to take care of the usual variation in oil flow through a pipe line.

We will now describe in detail our improved control apparatus. Referring therefore to Figure 2, cylinder 41 is provided with a chamber 42 at its lower end with an axial opening 43 between the latter and the interior of cylinder 41. The lower portion of chamber 42 has a horizontally extending bracket 44 and cylinder 41 has a bracket 45 attached thereto so that the control mechanism may be supported in operable relation to the engine of a pumping unit.

A pipe connection 46 communicating with chamber 42 is provided with a drain pipe 47, controlled by a valve 48, and a valve 38 which is connected to pipe line 37 leading from suction header 11 (Fig. 1). A stuffing box 49 is provided at the bottom of chamber 42 which contains packing material 50 held in place and compressed by packing ring 51 and packing gland nut 52. A housing 53 is attached to nut 52 to prevent injury to rod 54 which will be described in subsequent paragraphs. Cylinder 41 is fitted with a replaceable liner 55, preferably of brass or other metal not readily attacked by crude oil, in which a piston assembly 56 is adapted to move vertically. Piston assembly 56 is composed of a member 57 having a vertical bore 58 therethrough and an outwardly threaded raised portion 59 for the reception of leather cup 60, disc 61 and lower spring seat 62. Member 57 also supports a depending vertical tube 63, preferably of brass, which passes through opening 43 with considerable clearance and through stuffing box 49 in which the packing 50 is such that tube 63 may slide vertically without substantial loss of liquid.

Housing 64 is attached to flange 65, which is formed at the upper end of cylinder 41 by means of cap screws 66, and has upwardly extending cylindrical portion 67 adapted to provide a sliding fit with upper spring seat 68. A compression spring 69 is supported by spring seat 62 and in turn supports spring 69. Housing 64 is also provided with a plurality of long stop bolts 70 having lock nuts 71 adapted to limit the upward travel of piston assembly 56, and a shield 72 secured by cap screws 66 to prevent inadvertent interference with stop bolts 70.

Upper spring seat 68 has an axial bore 73 and an upwardly-facing depression adapted to receive ball-bearing 74. A shank 75, which rests upon ball-bearing 74 and extends through an opening 76 in housing 64, has affixed to its upper end an adjusting wheel 77 and adjacent its lower end is provided with a threaded bore 78. Rod 54, which is adapted to pass without friction through housing 53, tube 63 and bores 58 and 73, is threaded at its upper end and is operably mounted in threaded bore 78. Locking wheel 79 is provided on rod 54 to cooperate with shank 75 to maintain rod 54 in a desired position with respect to shank 75.

The lower portion of rod 54 is also threaded and may be connected by any suitable means to the usual mechanism for changing the speed of a prime mover. For instance, it may be connected to the throttle of a steam, gasoline or gas engine, a resistance in an electric motor circuit, or to the fuel pump of a Diesel engine. In any case, there must be a force tending to move rod 54 downward so that spring 69 is compressed and this may suitably be accomplished by means of a spring in the system.

For purposes of illustration, however, we have shown in Figure 2 an arrangement for controlling the speed of a Diesel engine. A lever 80 pivoted at 81 is attached at one end to the lower end of rod 54 by means of link connection 82, and at the other to a link 83 which is in turn attached to a forked lever 84 pivoted at 85. Adjacent link 83, lever 84 engages pins 86 on governor slip collar 87 so that changes in the position of the governor, which is of a conventional type enclosed by governor bowl 88, moves slip collar 87 and forked lever 84. Adjustable link 89 is attached to the other end of forked lever 84 and to ball crank 90 of the fuel pump 91, which regulates the effective length of stroke of the pump plunger, and consequently the speed of the engine and the pumping rate of the unit.

We will now describe the operation of our control system in connection with the embodiment shown in Figure 2. Valve 38 is opened and valve 48 closed so that the pressure in suction header 11 is transmitted through line 37, valve 38, chamber 42 and opening 43 into cylinder 41, in which it is exerted against piston assembly 56, causing the latter to move upward and compress spring 69. Upper spring seat 68 and therefore rod 54 consequently tend to move upward, but this motion is opposed by a force acting downward on rod 54, which may be that exerted by a spring in an obvious manner, but which in the embodiment shown is the force exerted by the governor in bowl 88 when it is displaced from its normal position for a particular engine speed acting through slip collar 87, pins 86, lever 84, link 83, lever 80 and link 82. This force increases with the displacement of rod 54, so that a given displacement of piston assembly 56 causes a much smaller displacement of rod 54. It is seen therefore that an increase in pressure in suction header 11 causes rod 54 to be raised a small amount, and that this movement is transmitted to the bell crank 90 through link 82, lever 80, link 83, lever 84 and link 89, thereby increasing the effective stroke of fuel pump 91, the speed of the engine, and the pumping rate of the unit so as to compensate for the increased flow of oil to the station.

The characteristics of spring 69 depend upon the particular conditions under which the control is to operate. In one installation of the type shown on a pumping unit equipped with a Diesel engine having a minimum speed of 186 R. P. M. and a maximum speed of 257 R. P. M. at full load, this variation in speed is obtained when rod 54 moves three-eighths of an inch, and the force which must be overcome to cause this movement is 285 pounds. The area of piston assembly 56 is 23.8 square inches, so that the entire movement is obtained when the pressure in cylinder 41 varies from 0 to about 12 pounds per square inch. Spring 69 compresses about one inch for each 69 pounds exerted on it, and consequently is compressed about 4⅛ inches as the pressure in cylinder 41 is varied over this range. The total travel of piston assembly 56 is therefore about 4½ inches, and the stop bolts 70 are adjusted so as to limit the piston travel to this value and avoid overworking the engine. In this installation the height of cylinder 41 is such that the pressure therein is 3 pounds per square inch less than in suction header 11, so that when the pressure in suction header 11 varies from 3 to 15 pounds per square inch, the pressure in cylinder 41 varies from zero to 12 pounds per square inch.

Another feature of our improved control device is the ease with which it may be changed over to manual adjustment. To accomplish this, it is only necessary to close valve 38, open valve 48 so as to relieve the pressure in cylinder 41 and allow piston assembly 56 to rest upon the lower end thereof, turn adjusting wheel 77 until the engine speed and pumping rate are at the desired value, and lock wheel 77 in place with locking wheel 79.

While we have described our invention in connection with a specific embodiment thereof, we do not desire to be limited thereto, but only by the scope of the following claims.

We claim:

1. In a control system for pipe line pumping stations including a prime mover, a pump driven by said prime mover and a fluid inlet to said pump, the combination which comprises a cylinder, a piston adapted to reciprocate within said cylinder, means for subjecting one face of said piston to the pressure in said fluid inlet, whereby said piston moves in accordance with said pressure, a control member, means actuated by said piston for moving said control member a fraction of the distance moved by said piston, and means actuated by said control member for regulating the speed of said prime mover.

2. In a control system for pipe line pumping stations including a prime mover, a pump driven by said prime mover and a fluid inlet to said pump, the combination which comprises a cylinder, a piston adapted to reciprocate within said cylinder, means for subjecting one face of said piston to the pressure in said fluid inlet, whereby said piston moves in accordance with said pressure, a control member, resilient means actuated by said piston for moving said control member, means for urging said control member against said resilient means, and means actuated by said control member for regulating the speed of said prime mover.

3. In a control system for pipe line pumping stations including a prime mover having a governor, a pump driven by said prime mover and a fluid inlet to said pump, the combination which comprises a cylinder, a piston adapted to reciprocate within said cylinder, means for subjecting one face of said piston to the pressure in said fluid inlet, whereby said piston moves in accordance with said pressure, a control member, a spring actuated by said piston adapted to move said control member, means actuated by said governor for urging said control member against said spring, and means actuated by said control member for regulating the speed of said prime mover.

4. In a control system for pipe line pumping stations including a prime mover, a pump driven by said prime mover and a fluid inlet to said pump, the combination which comprises a cylindrical chamber, a piston adapted to reciprocate within said chamber having an axial opening therethrough and a depending axial tube of a length such that its lower end extends below the bottom of said chamber, means for subjecting the lower side of said piston to the pressure in said fluid inlet, an elongated control member extending through said tube and said axial opening in said piston, a spring actuated by said piston tending to raise said control member, means for urging said control member against said spring, and means actuated by the lower portion of said control member for regulating the speed of said prime mover.

WILLIAM GILLUM HELTZEL.
JENNINGS BRYAN HARSHMAN.
JOHN RAY POLSTON.