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C. W. MILLAR

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PUMPING SYSTEM

Filed May 21, 1931

FIG. I.

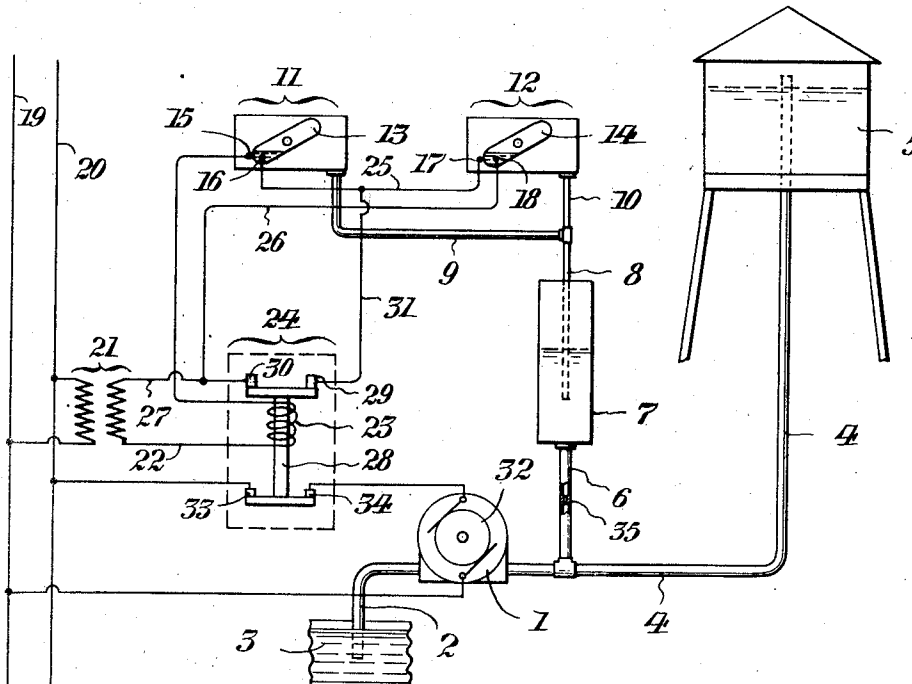


FIG. II.

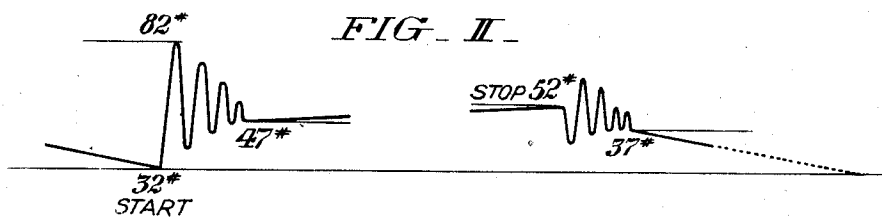
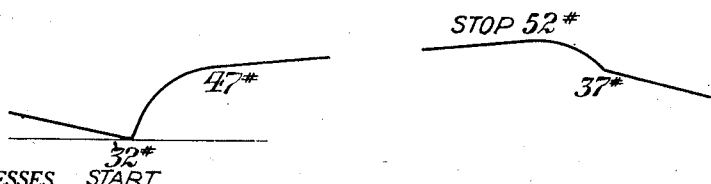


FIG. III.



WITNESSES

Hubert Fuchs
William Bell, Jr.

INVENTOR:

Charles W. Millar,
BY *Fraser & Paul*
ATTORNEYS.

UNITED STATES PATENT OFFICE

CHARLES W. MILLAR, OF CARNEGIE, PENNSYLVANIA

PUMPING SYSTEM

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This invention relates to pumping systems, and more particularly to systems in which a pumping station is located at a distance from an elevated storage tank and in which it is desired to automatically control the operation of the pump to maintain the fluid level in the storage tank between certain upper and lower limits.

With the use of a centrifugal pump in such a system, the pump in starting movement of a column of water through the discharge line builds up a relatively high pressure. Where the discharge line leading to the storage tank is relatively long, or is of small diameter with relation to the rate of flow, the pressure so built up upon the starting of the motor with an empty tank may exceed the total dynamic head after the flow has been established and the tank has been filled. Accordingly, the use of a single pump controlling device responsive to the pressure in the discharge line of the pump to both start and stop its motor is inadequate, for, when the motor has started, as the result of the static head having fallen to a predetermined value, the motor will at once stop if the pressure in establishing the flow is greater than the total dynamic pressure with a full tank. This condition of continual starting and stopping of the pump motor incident to the dynamic surge of the flow of liquid is known as "telegraphing."

To overcome this condition it has heretofore been proposed to position pump motor controlling devices at the storage tank and to run wires from these devices to the pump motor. However, when the storage tank is substantially remote from the pumping station, it is obviously an expensive matter to build a long control line of this nature.

The primary object, therefore, of the present invention is to provide at the pumping station means which are responsive to the modulated pressure in the discharge line from the pump for controlling the operation of the pump motor, but which are unaffected by the initial dynamic surge of the flow of liquid upon the starting of the pump motor.

A further object of the invention is to pro-

vide a choke or air cushion tank in the hydraulic pressure line leading to the pump controls which serves to decrease the amplitude of the initial surges in the flow of liquid upon the starting of the pump motor.

Other objects and advantages characterizing my invention will become more fully apparent from the description of one embodiment or example thereof which follows hereinafter, and which has reference to the accompanying drawing; whereof:

Fig. I is a diagrammatic representation of the complete pumping station.

Fig. II is a curve representing pressures at different stages of operation in the line of a similar pumping system in which no choke is used to smooth out surges; and,

Fig. III is a curve representing pressures at different stages of operation in the line of a pumping system in which a choke is used to smooth out surges and thus modulate the pressure in the discharge line.

With reference to Fig. I of the drawing, there is shown diagrammatically at 1 a centrifugal hydraulic pump. On the suction side of the pump 1 there is a pipe 2 through which water (assuming that water is the fluid medium of the system) is carried from a reservoir 3 to the pump. On the discharge side of the pump 1 there is a pressure line 4 leading to a remote storage tank or reservoir 5 which is elevated at a considerable distance above the level of the pumping station. From a point in the discharge line 4, a branch line 6, leads to an air cushion tank 7. The air cushion tank 7 serves as a choke for decreasing the amplitude of surges in the flow of water and for delaying the time period during which maximum pressure is built up; and to further assist the smoothing out of surges in the flow of water, I provide an orifice 35 in the branch line 6.

Within the water space of the air cushion tank 7 there is an additional pipe 8, which I prefer to designate a "hydraulic control pipe". One end of the hydraulic control pipe 8 is immersed in the liquid of the air cushion tank 7, and the other end comprises two branches 9 and 10 leading respectively

to the "stop control" switch 11 and the "start control" switch 12.

Each control switch 11 and 12 is preferably of the "mercoid" type comprising a tiltable tube 13, 14 partially filled with mercury and occupying alternate positions depending upon the pressure to which the tilting mechanism is subjected. When the tubes 13, 14 are in the position shown in the drawing, tilting downward to the left, the mercury effects contact between electrodes at 15 and 16 in the "stop control" switch and at 17 and 18 in the "start control" switch. When the tubes 13, 14 are in their opposite positions, tilting downward to the right, there is a gap between electrodes 15 and 16 and between electrodes 17 and 18.

The mechanism for tilting the mercury tube 13 of the stop control switch 11 is set to move from closed to open position when a predetermined high pressure has been reached, corresponding to the head of the water in the discharge line 4 and storage tank 5 when the water level in the tank has risen to a certain upper limit, say, at a pressure of 52 pounds per square inch. The mechanism for tilting the mercury tube 14 of the start control switch 12 is set to move from open to closed position when a predetermined low pressure has been reached, corresponding to the head of water in the discharge line 4 and storage tank 5 when the water level in the tank has fallen to a certain lower limit, say, at a pressure of 32 pounds per square inch. For simplicity of illustration the details of the mercoid control switches 11 and 12 have been omitted, this apparatus being of a well-known type and forming no part of the present invention which is directed to the system as a whole and not to any special instrumentalities used therein.

The stop control switch 11 and start control switch 12 form part of an electrical circuit which receives its energy from wires 19 and 20. When the control switches 11 and 12 are closed, as shown in the drawing, current from the secondary coil of a transformer 21 is free to pass from wire 22 through the coil 23 of an electromagnet or "starting relay" 24 to electrode 15 of the stop control switch 11 and through the mercury tube 13 to electrode 16. From thence current passes through a wire 25 to electrode 17 of the start control switch 12 and through the mercury tube 14 to electrode 18. From thence current passes through wires 26 and 27 to the other side of the secondary coil of the transformer. Accordingly, the coil 23 (which I term the "starting coil") of the electromagnet 24 is energized in this situation and the armature 28 is brought to the position shown in the drawing. As soon, however, as the armature is brought to this position, that part of the circuit

which leads to the start control switch 12 is short circuited. A holding circuit is then formed through contacts 29 and 30 of the electromagnet 24, current passing from wire 22 through the starting coil 23 and electrodes 15 and 16 of the stop control switch 11 to a wire 31 and from thence through contacts 29 and 30 to wire 27.

With the armature 28 in the raised position, the circuit to the motor 32, which is shaft-connected to the pump 1, is closed through contacts 33 and 34. When the starting coil 23 of the electromagnet 24 is de-energized the armature 28 falls, causing the motor to stop, and at the same time opening the holding circuit through contacts 29 and 30.

In Fig. II there is illustrated diagrammatically a curve representing the variations in pressure in a system similar to that herein described, but in which no air cushion tank is used. It will be noted that the pressure resulting from the initial surges when the motor starts is at one point as high as 82 pounds, which exceeds the pressure (52 pounds) at which the control switches are adapted to function to stop the motor. The pressure on the discharge line finally settles down to 47 pounds and then rises gradually until it reaches the stop point of 52 pounds.

In Fig. III a similar curve is shown illustrating the effect of the air cushion tank which serves as a choke smoothing out the surges accompanying starting and stopping of the motor and delaying the time period for the building up of maximum pressure. In both of these curves, as shown at the left, the pressure at which the start control switch 11 is designed to close, is assumed to be 32 pounds; and the pressure at which the stop control switch 12 is designed to open, is assumed to be 52 pounds.

The operation of the pumping system is as follows: Let it be assumed that the pump 1 is stopped and that the storage tank 5 is filled with water, with the water level between the upper and lower limits. In this situation the stop control switch 11 will be in the "closed" position, while the start control switch 12 will be in the "open" position. When the water in the tank 5 has fallen to the predetermined low level corresponding to a pressure of 32 pounds at the hydraulic control pipe 8, the start control switch 12 will move from the "open" to the "closed" position. Both control switches now being in the "closed" position, the circuit through the coil 23 of the starting relay and the control switches connected in series will be energized, causing the motor 32 to start.

Shortly after the starting of the motor (when the pressure in the hydraulic control pipe has risen to the extent of about 5 pounds) the start control switch 12 will

move to "open" position without, however, affecting the operation of the motor, for the holding circuit through contacts 29 and 30 of the starting relay is still energized through the stop control switch 11. After the initial surge has subsided due to the flow of water having been established (the amplitude of the surge being decreased by the use of the choke or air cushion tank in the hydraulic pressure control line) the total dynamic head will be that due to the friction head in the pipe, plus the static head of the water in the discharge line 4 and in the storage tank 5.

When the storage tank 5 has been filled to the predetermined high level, corresponding to a pressure of 52 pounds at the hydraulic control pipe 8, the stop control switch 11 will move to "open" position, breaking the circuit through the starting relay 24 and causing the motor to stop.

Shortly after the stopping of the motor, the stop control switch will return to "closed" position by reason of the drop in pressure in the hydraulic control pipe 8. The state of the apparatus will then be the same as it was when the described operation began.

While I have described my invention with reference to a particular embodiment thereof, it will be apparent that various changes may be made in the form of the apparatus herein disclosed without departing from the spirit of my invention as set forth in the claim hereto annexed.

Having thus described my invention, I claim:

In a pumping system, including a hydraulic pump, a motor for driving said pump, a discharge line leading to a reservoir above the level of said pump and a control pipe having communication with said discharge line through an air cushion tank; an electric circuit for automatically starting and stopping said pump motor, said circuit having serially connected switches controlled by and responsive to the modulated pressure in said discharge line, one of said switches being designed to operate at a pressure corresponding to a predetermined high level of water in said tank, and another of said switches being designed to operate at a pressure corresponding to a predetermined low level of water in said tank, and said circuit having a starting relay energized through both said switches and having means whereby when the starting relay is energized one of said switches is short circuited and the starting relay maintains its energization through its own contacts and the other of said switches.

In testimony whereof, I have hereunto signed my name at Carnegie, Pennsylvania, this 9th day of May, 1931.

CHARLES W. MILLAR.