May 4, 1948. M. C. SMITH 2,440,981

PUMPING SYSTEM

Filed Dec. 29, 1944

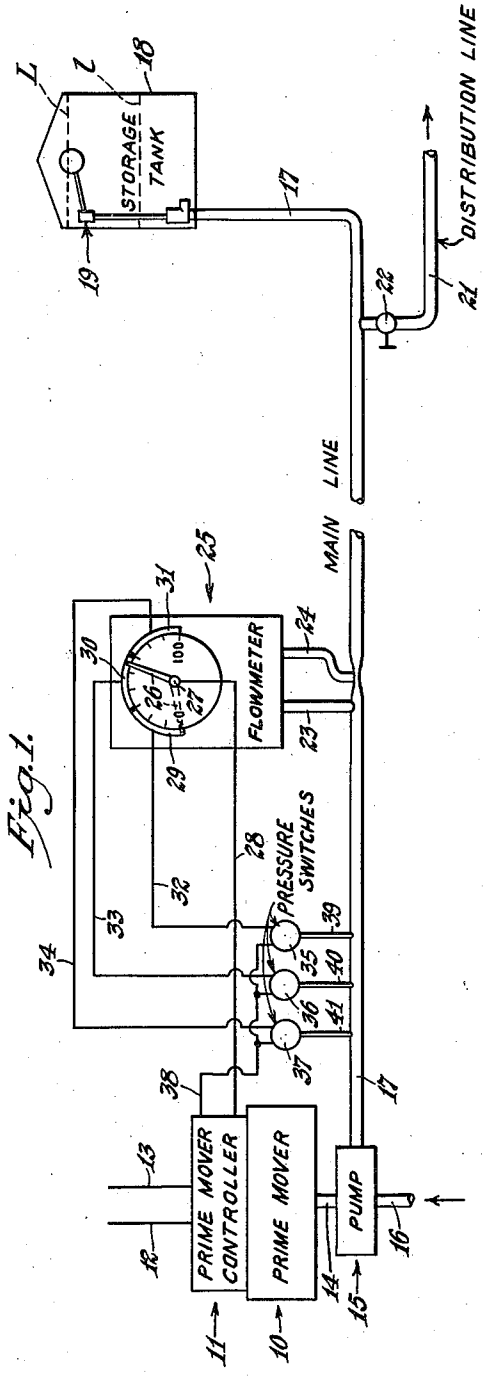


Fig. 1.

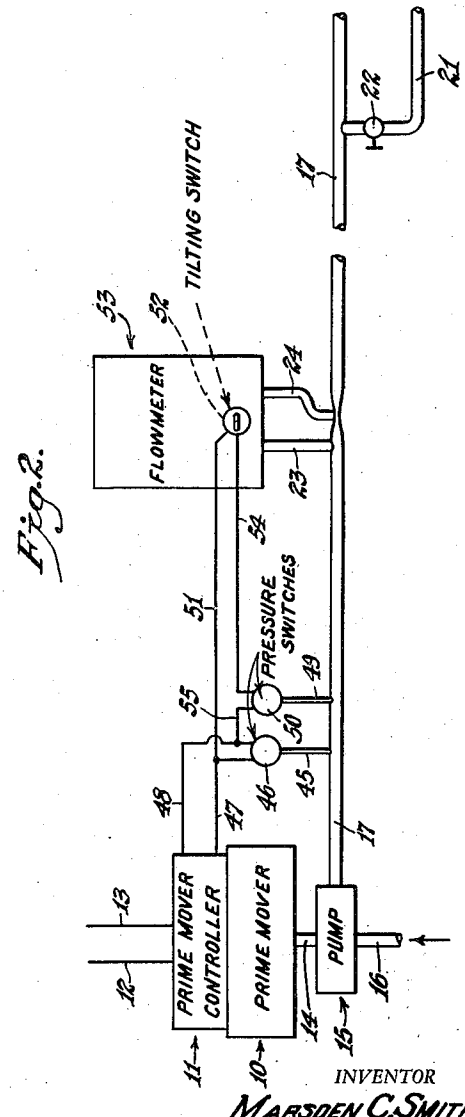


Fig. 2.

INVENTOR
MARSDEN C. SMITH

BY E. C. Sanborn

ATTORNEY

Patented May 4, 1948

2,440,981

UNITED STATES PATENT OFFICE

2,440,981

PUMPING SYSTEM

Marsden C. Smith, Richmond, Va., assignor to Builders Iron Foundry, Providence, R. I., a corporation of Rhode Island

Application December 29, 1944, Serial No. 570,330

11 Claims. (Cl. 103—11)

1

This invention relates to pumping systems and in one of its more specific aspects to a pumping system wherein pumping apparatus is employed to transmit a fluid medium to a storage tank that is located at a point remote therefrom.

The primary object of this invention is to provide a pumping system having devices responsive to both pressure and rate of flow of fluid transmitted through the system for controlling the operation of the pumping apparatus.

Another object of the invention is to provide means for placing pumping equipment into and out of service depending upon the pressure at the discharge of the pumping equipment and the rate of withdrawal of fluid from the system.

The invention has for another object the provision of control means within a pumping system, which means is adapted to maintain a pumping equipment in operation in response to predetermined flow through the system within a predetermined pressure range developed downstream of the pumping equipment.

A further object of the invention resides in the provision of an automatic pumping system wherein the pumping unit or units are maintained in operation so long as conditions within the system justify such operation. In this manner the pumping equipment is operated at a relatively high efficiency and the effectiveness of storage facilities that form part of the system is increased.

A still further object of the invention is to provide a pumping system of the character indicated which is relatively simple in design and trouble-free in operation.

While the apparatus of the instant invention may be advantageously employed in various types of systems, it is especially useful in systems for supplying water to a community. In city water systems it is customary to pump water from a reservoir to an elevated storage tank located at considerable distance from the reservoir. It has heretofore been the practice in city water systems to control the operation of the pumps either manually or automatically in response to the pressure head maintained in a storage tank. The level of the water within the tank is generally maintained between predetermind upper and lower limits. When the water level drops to the lower limit within the tank, the corresponding low pressure head is utilized to start the pump at the pump station. Once it starts, the pump continues in operation until the level in the tank reaches the upper limit at which time

2

the pump is automatically cut off. Experience has demonstrated that there are a number of objections to the ordinary simple form of control. For one thing, it is usually customary in such systems to set the pump in operation when the level within the storage tank has dropped to say 40% of the maximum level. For example, if the storage tank has an effective height of 25 feet, the pump is placed in operation when the level within the tank drops to 10 feet. The pump continues to supply water to the system until the level within the tank is raised to 25 feet at which time the pump is cut off. It will be noted that a rather substantial variation in pressure head occurs during the operation of the system. Also the effectiveness of the storage tank is materially reduced since necessary water is not supplied thereto until the level has receded a considerable distance, namely, 60% of the height of the tank. It will be apparent that if a sudden heavy demand is placed on the system due to a large fire or the like when the supply in the tank is at its lower limit, it may be difficult to supply the entire demand placed on the system under such circumstances.

Moreover, one of the important factors is that of friction loss. In many instances the pump is arranged to deliver water directly to outlets as well as to the storage tank. The friction loss through the conduit arrangement will vary considerably depending to a large extent upon the demand for water at various outlets. When the friction loss is high, the combined pressure which must be developed by the pump to overcome the head in the tank and the friction loss may exceed the pressure at which the tank is normally placed out of operation, even though the water within the tank may not have reached the predetermined upper level at which it is intended to stop the pump.

The instant invention overcomes the foregoing objections to pressure control pump systems by controlling the operation of the pump in response to a combination of conditions. I utilize both the pressure developed within the system and the rate of flow of fluid therethrough for controlling the pump or pumps. The pump is initially placed in operation in response to the pressure head within the storage tank. However, when the pump is once started it will not be cut out as soon as the pressure builds up to the maximum head provided by the tank, but will continue in operation so long as there is a substantial draft from the system. In other words, the system is so arranged that the pump

is automatically operated so long as the conditions within the system justify the supplying of water thereto. By virtue of the practice of this invention, the pumps may be operated at a relatively high efficiency and at the same time conserve the water that is stored in the tank for emergency use.

The above enumerated objects, as well as other objects, together with the advantages attainable by the practice of this invention, will be readily understood by reference to the following detailed description taken in conjunction with the annexed drawings, wherein

Figure 1 is a somewhat diagrammatical representation of a system embodying apparatus for practicing the invention; and

Figure 2 is a diagrammatical illustration of a modified embodiment of the invention.

Referring now to the drawings wherein like reference numerals designate corresponding parts throughout the several figures, and more particularly to Figure 1 thereof, a prime mover 10 which is preferably an electric motor is provided with a controller or starter 11 which is connected to a source of electrical supply (not shown) by leads 12 and 13. A drive shaft 14 actuated by prime mover 10 imparts rotation to a suitable pump 15 such as a centrifugal pump. Water from a reservoir (not shown) is supplied in the inlet of pump 15 by a conduit 16 and is discharged through the pump outlet into a flow or main line 17 that communicates with an elevated storage tank 18 generally located at a distance from the pump. An altitude valve generally designated by numeral 19 automatically cuts off the supply of water to the storage tank when the water reaches a predetermined maximum level L.

A Venturi tube or other known type of differential pressure producer is placed in series in line 17. One or more branch or distribution lines 21 having a control valve 22 is connected to line 17 intermediate the Venturi tube and the storage tank. Pressure pipes 23 and 24 communicate with the upstream side and throat of the Venturi tube and the interior of a flow meter 25 which is preferably of the recording type. The differential pressure across the Venturi tube serves as a measure, as indicated and recorded by meter 25, of rate of fluid flow through line 17. A switch arm 26 pivoted at 27 is positioned by the meter 25 in accordance with the rate of flow through line 17. A conductor 28 forming a leg of an electric circuit is connected to controller 11 and to switch 26. It will be observed that switch 26 is rotatable about pivot 27 and is so constructed and arranged as to successively form electrical contact with arcuate conductor members 29, 30 and 31. The individual arcuate member contacted by switch 26 at any particular time will depend upon the rate of fluid flow through the line 17. As illustrated, switch 26 is in contact with arcuate member 30. The meter is of a type that switch 26 contacts arcuate member 29 when the rate of fluid flow is within a predetermined range such as R_1. Switch 26 contacts arcuate member 30 when the rate of fluid flow is increased to a higher range R_2 and correspondingly contacts member 31 when the rate of fluid flow is within an upper range of rate of flow R_3. Conductors 32, 33 and 34, respectively, establish electrical connection between members 29, 30 and 31 and corresponding pressure-responsive switches generally denoted by reference numerals 35, 36 and 37. A conductor 38 is connected with each

of the pressure responsive switches and controller 11.

Pressure responsive switches 35, 36 and 37 communicate with flow line 17 by way of conduits 39, 40 and 41, respectively. Each of these switches is subject to the pressure in line 17 on the discharge side of pump 15 and each switch is adapted to be actuated into circuit breaking position in response to different maximum pressures. For example, switch 35 remains closed until the pressure of the fluid in conduit 39 exceeds a predetermined value such as P_1 at which time the switch opens. Correspondingly, switches 36 and 37 remain closed until the pressure in lines 40 and 41 exceeds corresponding predetermined maximum values P_2 and P_3, respectively.

Let us assume that valve 22 is closed and that storage tank 18 is filled to its maximum level L. Under these conditions, switch 26 will be in the position indicated in dotted lines and switch 35 will be open since the pressure within the system will exceed P_1. Prime mover 10 and therefore pump 15 will be placed out of service. If the level in tank 18 drops below L and there is still no flow through line 21, switch 26 will remain in the dotted position but switch 35 will be closed since the pressure within the system at this time is below value P_1. The circuit to controller 11 is completed under these circumstances through conductor 28, switch 26, member 29, conductor 32, pressure switch 35 and conductor 38 with the result that the prime mover is placed in service and water is supplied to tank 18 until the pressure in the system exceeds P_1 at which time pressure switch 35 is open.

Let us next assume that there is a substantial demand on the system through distribution line 21 and that the level of the water within tank 18 is at some intermediate point between L and *l*. Under these conditions, switches 35 and 36 will both be closed since the pressure acting thereon is assumed as being below either P_1 or P_2. The pump will be initially set in operation through the circuit containing switch 35 and member 29. If the rate of fluid flow through line 17 is within the range R_2, then switch 26 is rotated to the position illustrated in full lines in the drawing, thereby completing the circuit to controller 11 through member 30 and switch 36. The pump is maintained in operation through the last mentioned circuit until changes in either the rate of fluid flow or the pressure cause this circuit to be opened.

The embodiment of the invention illustrated in Figure 2 amounts to a modification of that illustrated in Figure 1. This embodiment of the invention includes a pressure conduit 45 establishing communication between flow line 17 and a pressure responsive switch 46 that may be similar to the pressure responsive switches shown in Figure 1. Pressure switch 46 comprises one leg of a circuit including controller 11 and conductors 47 and 48. A second pressure conduit 49 establishes communication between flow line 17 and a second pressure switch 50. Pressure switch 50 is connected across conductors 47 and 48 through a conductor 51, a tilting switch 52 in a flow meter 53, and conductors 54 and 55.

With the arrangement shown in Figure 2, switch 46 is so constructed and arranged as to be closed when the pressure in the system is within a predetermined range, such as between P_4 and P_5. Pressure switch 50 is adapted to remain closed until the pressure within the system exceeds a preselected pressure that is higher than the maxi-

mum pressure P_5 at which switch **46** is set to open. Switch **46** will be closed so long as the pressure in the system is within the range P_4 and P_5. Should the pressure within the system drop below P_4 or rise above P_5, switch **46** will open.

Tilting switch **52** is of a character and is so selected as to be opened by meter **53** when the rate of fluid flow through line **17** is below a predetermined value such as R_4 but to be closed when such rate of flow is the same as or greater than R_4. When the rate of fluid flow through conduit **17** is the same as or greater than the value R_4 and pressure switch **50** is closed, the pump will continue to supply water to the system so long as conditions permit. Should the pressure increase to a value greater than that at which switch **50** is set, that switch will be opened, placing the pump out of service; or should the rate of fluid flow through line **17** decrease to a value below R_4, tilting switch **52** will be opened, similarly placing the pump out of service.

As above described, the various controls are discussed in connection with the operation of a single pump. It will be apparent that the operation of a plurality of pumps may be properly controlled by similar arrangements of apparatus.

While the present invention has been discussed in detail in connection with storage tanks, it will be apparent to those skilled in the art that it may be used with various other systems; for example, the arrangements herein described may be used advantageously in supplying water to a tall building that does not have a storage tank. Also, the invention is adapted to be used with beneficial results in a booster arrangement, such as the type employed in transmitting oil or the like considerable distances.

From the foregoing, it is believed that the construction, operation and advantages obtainable by the practice of my instant invention will be readily understood by persons skilled in the art. It is to be borne in mind, however, that various changes in the apparatus herein illustrated and described may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and means responsive to the pressure of the fluid in the conduit and to the rate of fluid flow through the conduit for controlling the operation of the pump.

2. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and means responsive to the pressure of the fluid in the conduit and to the rate of fluid flow through the conduit for controlling the operation of the pump, said means comprising a plurality of electric circuits each including a pressure actuated switch and a switch actuated in response to the rate of flow of the fluid.

3. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and at least a pair of electric circuits for controlling the operation of the pump, one of said circuits including a pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a predetermined pressure and a switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a predetermined range, the other of said circuits including a pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a second predetermined pressure and a switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a second predetermined range, said circuits being so arranged that only one thereof may be closed at a time.

4. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and at least a pair of electric circuits for automatically controlling the operation of the pump, one of said circuits including a serially connected pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a predetermined pressure and a serially connected switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a predetermined range, the other of said circuits including a serially connected pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a second predetermined pressure and a serially connected switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a second predetermined range, said circuits being so arranged that only one thereof may be closed at a time.

5. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and at least a pair of electric circuits for automatically controlling the operation of the pump, one of said circuits including a serially connected pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a predetermined pressure and a serially connected switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a predetermined range, the other of said circuits including a serially connected pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a second predetermined pressure and a serially connected switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a second predetermined range, said circuits being so arranged that only one thereof may be closed at a time, depending on the rate of fluid flow through the conduit.

6. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and at least a pair of electric circuits for automatically controlling the operation of the pump, one of said circuits including a serially connected pressure responsive switch that is maintained in circuit closing position so long as the fluid pressure in the conduit is within a predetermined range and that is actuated to and maintained in circuit opening position in response to fluid pressure in the conduit outside said range and a serially connected switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a predetermined range, the other of said circuits including a serially con-

nected pressure responsive switch that is actuated to circuit opening position upon a rise in fluid pressure in the conduit above a second predetermined pressure and a serially connected switch that is actuated to circuit opening position in response to rates of fluid flow through the conduit outside a second predetermined range, said circuits being so arranged that only one thereof may be closed at a time depending on the rate of fluid flow through the conduit.

7. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, and a plurality of electric circuits for automatically controlling the operation of the pump, a switch serially connected in each of said circuits, each of said switches being actuated to circuit opening position in response to a rise in fluid pressure in the conduit above a coresponding predetermined pressure, serially connected switch means common to all of said circuits, and means responsive to variations in the rate of fluid flow through the conduit for actuating said switch means to selectively place the same in circuit closing position in one of said circuits at a time.

8. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, a plurality of electric circuits for automatically controlling the operation of the pump, one of said circuits including a serially connected switch that is constructed and arranged to be maintained in circuit closing position so long as the fluid pressure in the conduit is within a predetermined range and to be actuated to circuit opening position in response to fluid pressure in the conduit outside said range, another of said circuits including a serially connected switch that is constructed and arranged to be maintained in circuit closing position so long as the fluid pressure in the conduit is within a second predetermined range and to be actuated to circuit opening position in response to fluid pressure in the conduit outside said second range and a serially connected switch that is maintained in circuit closing position in response to rates of fluid flow through the conduit at least as great as a preselected rate and that is maintained in circuit opening position in response to rates of fluid flow through the conduit below said preselected rate.

9. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, means responsive to the static pressure of fluid in said conduit, means responsive to the differential pressure of fluid flowing between certain points in said conduit, and means responsive to both said pressure responsive means for controlling the operation of said pump.

10. A pumping system comprising a pump including an inlet and an outlet, means for delivering fluid to the pump inlet, a discharge conduit connected to the pump outlet, a plurality of circuit-controlling switches responsive to the static pressure of fluid in said conduit, one of said switches being adapted to be closed until said pressure exceeds a certain value, and the other of said switches being adapted to be closed until said pressure exceeds a higher value, means for controlling operation of said pump, connections between said switches and said controlling means, differential pressure means responsive to flow of fluid in said conduit for cooperating with the last mentioned switch to maintain said pump in operation when said fluid flow exceeds a certain value despite opening of the first mentioned switch.

11. A pumping system comprising a conduit and pumping means for discharging fluid into said conduit, a plurality of means responsive to the static pressure of fluid in said conduit, means connected to both said pressure responsive means for controlling operation of said pumping means, one of said pressure responsive means being arranged to maintain said pumping means in action until said static discharge pressure increases to a predetermined value, and differential pressure means responsive to the flow of fluid in said conduit for cooperating with the other pressure responsive means to maintain said pumping means in operation when said fluid flow exceeds a given rate despite increase in said static pressure above said predetermined value.

MARSDEN C. SMITH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,717,814	Strong et al.	June 18, 1929
2,223,415	Groves	Dec. 3, 1940
2,237,574	Persons	Apr. 8, 1941
2,246,940	Hood	June 24, 1941