

Feb. 4, 1936.

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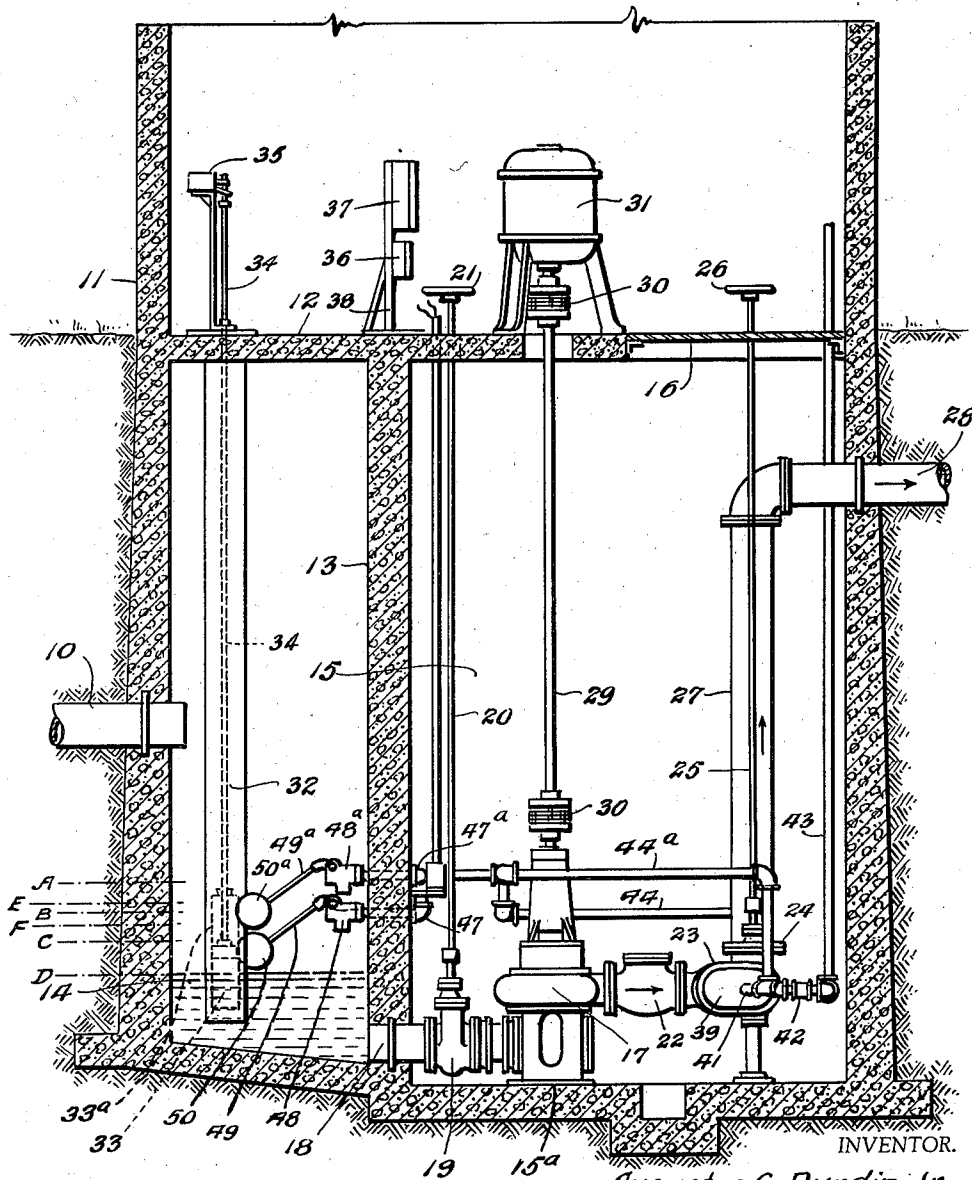
2,029,765

PUMPING APPARATUS

Filed April 7, 1934

3 Sheets-Sheet 1

Fig. 1.



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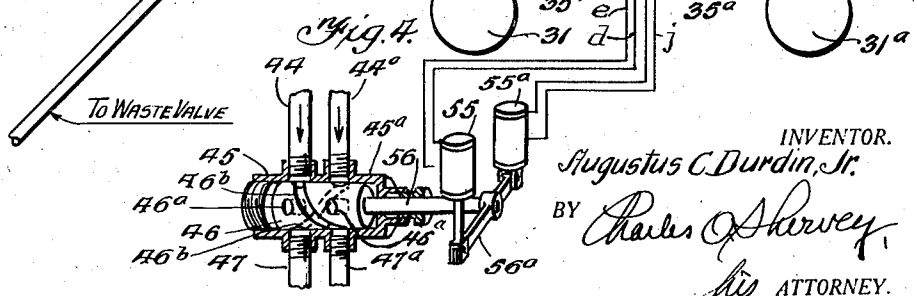
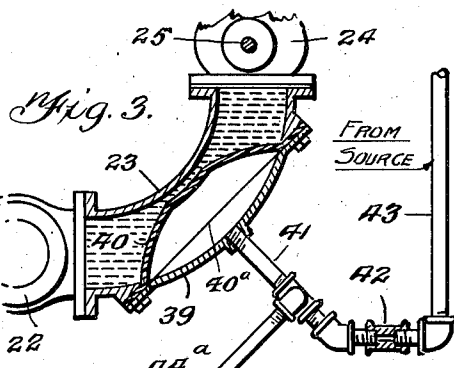
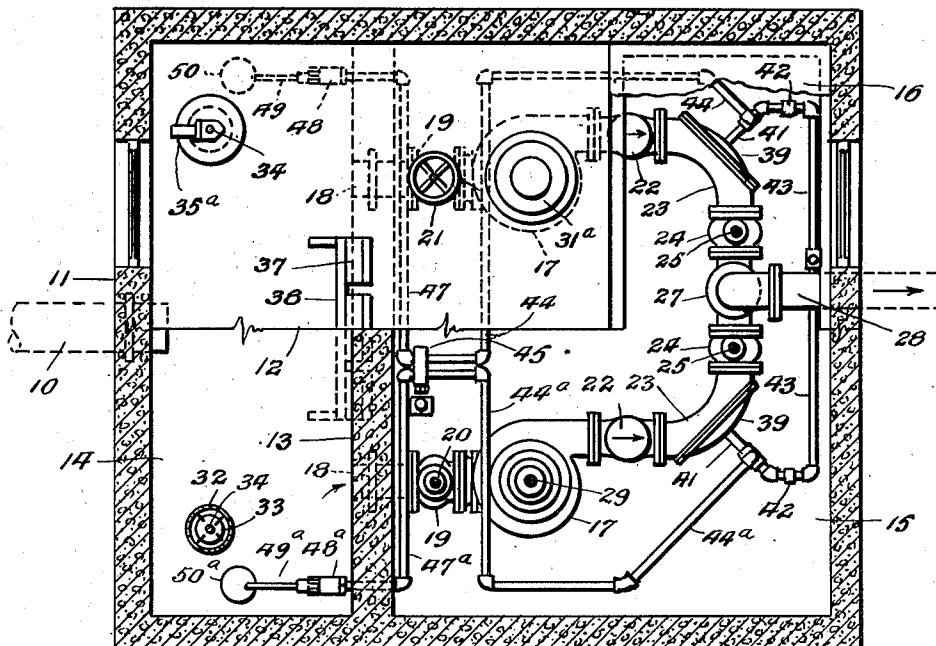
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3 Sheets-Sheet 2

Fig. 2.



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UNITED STATES PATENT OFFICE

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PUMPING APPARATUS

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Application April 7, 1934, Serial No. 719,463

5 Claims. (Cl. 103—11)

This invention relates to pumping apparatus, and more particularly to means for automatically regulating the capacity of one or more pumps, without varying the speed thereof, whereby the pump or pumps operate to pump liquid from a basin or other reservoir at approximately the same rate of pumpage as the inflow of the liquid thereto.

In many situations, as for example in sewage treatment plants, the desideratum is to deliver the sewage to the treatment plant at approximately the same rate of flow as the inflow of the sewage, and attempts have been made to accomplish this result by varying the speed of the pumps to correspond with the flow of the sewage, but it has been found that this method is not economical, the control apparatus is very costly and is prohibitive except when used in very large plants.

One of the objects of this invention is to provide automatic control means for pumping apparatus, which is simple, practical and economical in operation.

Another object is to provide automatic control means for pumping apparatus, responsive to the inflow of liquid, for regulating the capacity of a pump or a plurality of pumps, without varying the speed thereof, whereby the pumpage shall approximately equal the inflow of the liquid.

Another object is to provide automatic control means for regulating the capacity of the pump, by controlling the size of the discharge outlet of the pump, whereby the pumpage approximately equals the inflow.

Another object is to provide a duplex pumping equipment with automatic control means whereby the rate of discharge is varied from a minimum to a maximum flow, proportionate to the rate of inflow, and wherein the capacity of each pump, in succession, is gradually increased from a minimum to a maximum.

Another object is to provide a duplex pumping equipment having a variable capacity, with automatic means for alternating the operation of the two pumps of the equipment.

Another object is to provide pressure actuated means for varying the capacity of a pump, responsive to fluctuations in the inflow of the liquid.

With these and other objects and advantages in view, this invention consists in pumping apparatus having control means, responsive to fluctuations in the inflow of liquid, for regulating the capacity of a pump so as to conform to the rate of inflow, without varying the speed of the pump.

It further consists in control means employing pressure to vary the size of the discharge outlet of the pump, and responsive to fluctuations in the inflow of the liquid.

It further consists in control means for regulating the output of both pumps of a duplex equipment, in such manner that the capacity of each pump is increased from a minimum to a maximum, whereby the pumpage will conform approximately to an increase of inflow from a minimum to a maximum.

It further consists in the provision of means for alternating the operating of the pumps of a duplex pumping equipment and simultaneously therewith transferring the capacity control so as to operate first in connection with the leading pump.

It further consists in the several novel features of construction, arrangement and combination of parts hereinafter fully set forth and claimed.

The invention is clearly illustrated in the drawings accompanying this specification, in which:

Fig. 1 is a view, partly in side elevation and partly in vertical section of pumping apparatus embodying a simple form of the present invention in connection with a duplex pumping equipment;

Fig. 2 is a view thereof, partly in plan and partly in horizontal section, with a floor partly broken away to show parts located therebelow;

Fig. 3 is a plan, partly broken out, of the flow regulator of the capacity controlling means for the pumps;

Fig. 4 is a diagrammatic view illustrating one form of electrical control for the pump motors, and a transfer valve used in the capacity regulating control, and

Fig. 5 is a perspective view of one form of alternator used in the apparatus.

In the accompanying drawings, the invention has been illustrated as applied to a sewage treatment plant, although it is to be understood that its use is not limited thereto as it may be applied in any situation where the desideratum is to pump liquid approximately at the same rate of pumpage as the inflow to the pumping apparatus.

In the drawings, the reference character 10 designates the terminus of a trunk sewer, usually located several feet underground, and 28 designates a conduit, located at some considerable distance above the sewer terminus, through which the sewage is conveyed to a sewage treatment plant or to some other place for disposal.

pumping apparatus is housed in a structure 11 desirably composed of masonry, concrete or the like and having a pump pit 15 for the pumping apparatus and a motor room thereabove for the motors and other equipment. The motor room is usually roofed over and its floor 12 covers the pit and contains an opening for access to the pit, the opening being ordinarily closed by a trap door 16.

The invention is illustrated in connection with a duplex pumping equipment, and the two pumps 17 thereof are mounted on the floor 15^a of the pit, and connected to two electric motors 31, 31^a by shafts 29 and couplings 30. The pumps shown are of the centrifugal type and their suction inlets 18 communicate with the inlet conduit or sewer terminus 10, through a basin or other reservoir here shown in the form of a well 14 built into the structure 11, and separated from the pit by the wall 13. The sewer terminus 10 discharges into the basin, usually through a screen, and the inflow to said basin fluctuates considerably in any given station. The capacity and number of pumps required is determined by the approximate minimum and maximum inflow intended to be handled.

The discharge side of each pump is connected to a riser 27, which leads to the discharge conduit 28. Desirably a shut-off valve 19 is interposed between each pump and its suction inlet 18 and a shut-off valve 24 is interposed between the pump and riser 27 whereby the pumps and associated connections may be cut out of service for the purpose of repairs or for any other purpose. The shut-off valves 19, 24 may be operated from the motor room by extension rods 20, 25 that extend up through the floor 12 and have handwheels 21, 26 on their upper ends. A check valve 22 is employed on the discharge side of each pump to prevent return flow through the pump.

Associated with each pump, either on its suction side or its discharge side, and formed as a part of the pump or separate therefrom, is a capacity regulating device 23 here shown as interposed in the connections between the discharge side of the pump and the riser 27. The capacity regulator is shown in the form of an elbow having an opening in one side (see Fig. 3) over which is a flexible diaphragm 40, held in place by a cover 39 bolted to the elbow around said opening. The diaphragm and cover provide a pressure chamber 40^a into which a fluid under pressure is admitted to extend the diaphragm more or less to thereby vary the cross sectional area of the passage through the elbow, and as a result vary the rate of flow of liquid discharged by the pump, and as a consequence varying the capacity of the pump. It will be observed that when the diaphragm is fully extended, it closes or substantially closes the passage through the elbow, and that the size of said passage may be increased to its full capacity by permitting the diaphragm to collapse.

Compressed air or other fluid under pressure is used to extend the diaphragm, and in the form of the invention illustrated, a supply pipe line 43, 41, having a fitting 42 therein, containing a restricted orifice, conveys the fluid under pressure to the pressure chamber 40^a. The pressure used to extend the diaphragm should be somewhat in excess of the pressure set up by the pump.

In order to regulate the rate of discharge from a pump to conform to the rate of inflow to the

basin 14, control means are provided for regulating the pressure in the pressure chamber 40^a, whereby to regulate the size of the opening through the capacity regulator so as to permit a rate of flow therethrough approximately the same as the rate of inflow to the basin, up to a maximum amount, namely the full capacity of the pump. The control means is here shown as comprising waste valves 48, 48^a, one for the capacity regulator of each pump, these valves being in the form of float valves located in the basin 14 and each connected to its associated capacity regulator by separate pipe lines 47, 44 and 47^a, 44^a. The float valves 48, 48^a are provided with floats 50, 50^a carried by arms 49, 49^a and arranged to be lifted to open the passage through the float valves as the liquid rises in the basin. It will be observed that as either float rises, due to the rise of the level in the basin, its associated float valve gradually opens the discharge orifice therein, thereby permitting the fluid under pressure to escape from the associated pressure chamber 40^a and consequently the diaphragm is collapsed more or less depending upon the leakage through the float valve. When the float is lowered to its extreme low position, the float valve closes and the pressure chamber thereupon receives the full amount of pressure and consequently the passage through the capacity regulator is closed or substantially closed, and when the float is raised to its extreme upper limit, the leakage through the float valve is sufficient to permit the complete collapse of the diaphragm under the pressure set up by the pump, consequently the latter operates at its full capacity.

In a duplex pumping equipment float switches are usually employed for starting and stopping the pump motors, and two switches 35, 35^a are shown for that purpose. The float 33 of the switch 35 is set at a lower elevation than the float 33^a of the switch 35^a, whereby the switch 35 will close when the liquid in the basin reaches a predetermined level and thereby start one of the pump motors, the other one remaining idle unless the inflow exceeds the capacity of the running pump, in which case if the liquid rises sufficiently it will raise the float 33^a and close the switch 35^a thereby starting the other motor. The floats 33, 33^a are connected to their switches by float rods 34 contained in casings 32.

In order that the capacity of each pump may gradually increase so that the pumpage may correspond to the rate of inflow to the basin, the float valve 48^a is set at a higher elevation in the basin than the float valve 48. As a result, when the inflow increases to the maximum, the capacity of the pump which is started first, is gradually increased to its maximum, the second pump is then cut in, at first operating at its minimum capacity, and then gradually increasing until it runs at full capacity.

It will be seen therefore that the first pump to start operates at its full capacity before the second one is cut in, and that the first pump continues to run at its full capacity when the second pump is cut in, until the liquid has been pumped out of the basin down to a level where the second pump has stopped, and then the capacity of the active pump is decreased only as the rate of inflow decreases.

In order to distribute the wear on the two pumps and their motors, an alternator 51 (see Fig. 5) may be provided for transferring the

circuit, controlled by the pilot switch 35, from one motor to the other. The alternator may be arranged to be actuated by time controlled mechanism so that one pump will operate first, for a predetermined length of time and then the other pump will operate for the same length of time. Mechanism for operating the two pumps during certain predetermined intervals of time is clearly shown and described in Letters Patent No. 1,780,380 issued to me November 4, 1930.

The alternator shown in the accompanying drawings is chosen for the purpose of illustration only and operates to transfer the circuit, controlled by the pilot switch 35, from one motor to the other so that the motors will be started alternately at the commencement of successive pumping operations.

The alternator shown is provided with two sets of movable, spring actuated contactors 52, 53, and 52^a, 53^a, of which the contactors 52, 52^a will close circuits during one cycle, and then the contactors 53, 53^a will close circuits during the second cycle and so on. Stationary contactors 52^x, 53^x and 52^z, 53^z co-operate with the movable contactors to close the circuits therethrough. A shaft 60, journaled in brackets on the panel 51^a of the alternator, has toothed or notched wheels 61, thereon that act on the movable contactors to swing them back from the stationary contactors, when the teeth or high parts of the wheels engage them. The spaces between the teeth or high parts of the wheels permit the movable contactors to swing into contact with the stationary contactors. Conveniently all of the contactors are mounted on the panel 51^a.

Actuating mechanism comprising holding coils 54, 54^a, mounted on the panel, an armature 62, a pawl 63 connected thereto and a ratchet wheel 64 fast on the shaft 60, is provided for intermittently rotating the shaft 60, to thereby reverse the position of the movable contactors at the conclusion of each cycle of operation of the pumps. A holding coil 54 or 54^a is energized at the commencement of a cycle of operation and the armature is attracted, thereby setting the pawl in position to engage the ratchet wheel, and when the holding coil is de-energized the armature is swung back by a spring 64 thereby engaging the pawl with the ratchet wheel and partially rotating it so as to bring the notches of each toothed wheel into the position formerly occupied by the high places or teeth, thereby reversing the positions formerly occupied by the movable contactors and transposing the circuits. The holding coil 54 or 54^a holds the actuating mechanism in a set position as long as either of the float switches 35 or 35^a is in closed position, but as soon as the float switches 35 or 35^a are opened, either or both of the holding coils are de-energized and the actuating mechanism for the alternator transfers the relationship of the contactors 52, 53 and 52^a, 53^a. Lines lead from the float switches 35, 35^a to the alternator as shown in Fig. 4, and from the alternator, lines lead to the starters 37, 37^a. Motor safety switches 36, 36^a are ordinarily placed in the main line to the starters. In Fig. 5 are shown binding posts from which lines lead to the contactors and holding coils, and from which the lines lead to the pilot switches, the holding coils of the starters and the solenoids 55, 55^a that operate the valve 45 hereafter referred to.

The starting circuit for motor 31 from pilot switch 35, may be traced through line *a*, contactors 52, 52^x, line *b*, holding coil of starter 37,

to main line *L* and from main line *L*³ through line *c*, back to the pilot switch. The circuit for the holding coil 54 may be traced from line *a*, to contactor 52^x, line *d*, through holding coil 54, and line *e*, to main line *L* and from main line *L*³, through line *c*, back to pilot switch 35. The solenoid 55 is in parallel with the holding coil 54.

The starting circuit for motor 31^a from pilot switch 35^a may be traced through line *k*, contactors 52^a, 52^z, line *g*, to holding coil of starter 37^a and to main line *L*, and from main line *L*³ through line *l*, to pilot switch 35^a. The circuits through the holding coil 54^a and solenoid 55^a can be traced from the line *g*, line *i*, through holding coil 54^a, line *j* to main line *L* and through line *i* to solenoid 55^a, and line *j* back to main line *L*. From main line *L*³ through line *l*, to pilot switch 35^a.

When the contactors are in reverse position, the starting circuit for the motor 31^a from pilot switch 35 may be traced through line *f*, contactors 53^a, 53^z (when closed) line *g*, holding coil of starter 37^a to main line *L*. From main line *L*³ through line *c*, *h*, back to pilot switch 35, the circuit's through holding coil 54^a and solenoid 55^a run from contactors 53^a, 53^z and line *i* and back through line *j*.

In case pilot switch 35^a is closed the circuit for the starter of motor 31 may be traced from pilot switch 35^a, through line *m*, contactors 53, 53^x, line *b*, to holding coil of starter 37 and to main line *L*. From main line *L*³, through lines *l*, and *n* to pilot switch 35^a. Holding coil 54 and solenoid 55 are also energized without affecting any of the other mechanism.

When the capacity control mechanism, is used with automatic means for alternating the operation of the motors, it is desirable that the float valve 48 which is set at the lowest elevation, shall control the capacity regulator of the pump which first starts to pump when the liquid rises sufficiently to close the pilot switch 35. A duplex (three way valve 45 in the pipe lines 44, 47 and 44^a, 47^a, for the two capacity regulators is provided for this purpose (see Fig. 4). The valve has a cylindrical casing 45^a which contains a bore in which is a rocking plug 46 having a stem 56 by which it is rocked. The two pipes 44, 44^a from the capacity regulators, enter the valve casing from one side thereof and the pipes 47, 47^a enter the casing from the other side. The plug 46 contains two ports 46^a which in one position of the plug, form direct connections between the pipes 44, 47 and 44^a, 47^a, and the plug also contains ports 46^b which in another position of the plug, form connections between the pipes 44, 47^a and 44^a, 47. When the plug occupies one of these positions, the passage from the lower most float valve 48 is open through the pipe 47, port 46^a, and pipe 44 to the capacity regulator 23 shown at the upper half of Fig. 2, and the passage from the upper float valve is open through pipe 47^a port 46^a and pipe 44^a to the other capacity regulator. When the plug is shifted to the position shown in Fig. 4, the passage is open from the lower float valve to the capacity regulator shown at the lower half of Fig. 2 and the passage from the upper float valve is open to the other capacity regulator. Regardless of which pump starts first in any cycle of operation, the lowermost float valve is always in connection with the capacity regulator of the pump which starts first.

The valve 45 is arranged to operate synchronously with the alternator. As shown the plug stem 56 has an arm 56^a on its outer end, connected to and operated by two electro-magnetic

devices such as the solenoids 55, 55^a, the lines of which lead to the alternator. The windings of the solenoids 55, 55^a are connected in parallel with the holding coils 54 and 54^a, so that when either float switch causes the holding coil 54 to become energized, the solenoid 55 is also energized, and this rocks the valve stem 56 to set the valve plug in one position, and when the holding coil 54^a is energized, the solenoid 55^a is also energized and the valve plug is rocked back to its former position.

The operation of the duplex equipment illustrated is substantially as follows:

Sewage from the trunk sewer 10 enters the basin 14 and commences to fill up the storage capacity thereof. As the float 33 of the pilot switch 35 is set at a lower elevation than the other one, the water level soon reaches the place at which the lower float will close the circuit through the float switch 35. This will start either motor 31 or 31^a depending upon which one is in circuit through the alternator and its attendant starter 37 or 37^a. Fluid under pressure enters through the supply pipes 43, 41 and passes through the restricted orifices 42 into the pressure chambers 40^a of the capacity regulators for the two pumps. As the valve 48^a is set higher than the valve 48 the valve 48^a remains closed, and the float 50 of the lower valve 48 will be acted upon first by the rising water level. With the valve 48 closed until its float 50 is lifted, the pressure entering the pressure chamber of the active pump causes the diaphragm to be extended to close, or at least greatly restrict the flow through the discharge line and thereby cut down the capacity of the pump. As the water level rises, the float 50 is lifted and the valve 48 is partially opened, thereby permitting the escape of some of the fluid under pressure, passing through the restricted orifice 42, and as the fluid under pressure escapes in increasing amounts as the valve 48 opens, it permits the diaphragm to retract and open the passage of the discharge line proportionately. When sewage enters the basin in increased quantities, the float 50 rises to open the valve 48 fully, and as this relieves the pressure behind the diaphragm, the latter fully retracts and fully opens the discharge passage so that the active pump delivers at its full capacity.

As the flow through the trunk sewer 10 approaches its peak load, sewage enters the basin faster than the active pump can discharge it. Shortly after the float 50 has fully opened the valve 48, the level of the water reaches the float 50^a of the higher valve 48^a and also reaches the float 33^a of the float switch 35^a thereby starting the other pump motor. As the water level rises in the basin, the valve 48^a is gradually opened and the capacity of the second pump is gradually increased to its maximum, whereby the second pump delivers at its full capacity, if the level rises sufficiently to fully open the valve 48^a.

As the peak period passes, the two pumps empty the basin, and when the water level falls to predetermined points, the second pump to start will gradually reduce its capacity until the float switch 35^a opens the circuit thereto. Then as the level continues to recede, the pump which started first, gradually reduces its capacity and stops when the water reaches a low level and the float switch 35 opens the circuit. The alternator then transposes contactors 52 52^a and 53 53^a so that upon the next cycle of operation the pilot switch 35 starts motor 31^a. With the transfer in the sequence of operation of the motors,

the transfer in the sequence of operation by the float valves 48, 48^a will be brought about by the duplex three way valve 45.

The levels indicated by the lines A, B, C, D, E and F in Fig. 1 may serve to indicate the sequences in operation under different conditions. With the pumps at rest and sewage flowing into the basin during an approach to a maximum inflow, when the water rises to level C, one pump starts. As the water approaches the level B, this pump delivers at its full capacity. At level E the other pump starts and at level A both pumps operate at full capacity. As the sewage is withdrawn from the basin, and its level falls to line F the second pump to start cuts out, and when level D is reached the first pump to start cuts out.

A capacity regulator having a flexible diaphragm has a particular advantage in that there is no likelihood for material to collect in the regulator and interfere with its operation. When the passage through the regulator is very restricted, solid matter may clog the passage temporarily, but the rise of water in the basin will cause the float valve to open, permitting the diaphragm to collapse, thereby allowing the collected material to pass on, after which the parts function normally again.

While a pressure operated diaphragm device has been shown for regulating the rate of discharge by each pump, equivalent means such as a valve operated by pressure or by other power may be substituted therefor. Furthermore, any number of pumps may be used at one station to take care of extreme cases. The several pumps may be caused to operate in sequence upon an abnormal inflow by arranging the float switches and float valves at different elevations in the basin.

Furthermore various types of alternators may be used, or the alternator may be omitted and ordinary hand switches may be used to change the sequence of operation of the two pumps.

I claim as new and desire to secure by Letters Patent:

1. In duplex pumping apparatus, a pair of sequentially operated pumps, each having fluid pressure operated capacity regulating means, and sequentially operating waste valves for regulating the amount of pressure admitted to said capacity regulating means, pipe connections between the capacity regulating means and waste valves, and a valve for connecting the initially operated waste valve with the capacity regulating means of the initially operated pump.

2. In duplex pumping apparatus, a pair of motor operated constant speed pumps, capacity regulating means associated with each pump, automatic means for causing alternate and sequential operation of the two pumps, separate sequentially operable control means for the capacity regulating means, responsive to fluctuations of a liquid level in the pumping system in which the apparatus is used, and automatic means for connecting the capacity regulating means of the pump which starts first in a sequence of operation, with the control means which operates first in sequence.

3. In duplex pumping apparatus, a pair of motor operated constant speed pumps, pressure operated capacity regulating means associated with each pump, each having control means responsive to the fluctuations of a liquid level in the pumping system in which the apparatus is used, one control means functioning at a higher

level than the other, automatic means for causing alternate and sequential operation of the two pumps, and means for connecting the capacity regulating means of the pump which starts first in any sequence of operation, with the control means which is set at the lower level.

4. In pumping apparatus, the combination of a pair of motor operated, constant speed pump units connected to a basin arranged to receive a fluctuating source of liquid supply, float controlled, minimum to maximum capacity regulating means associated with each pump for varying the capacity thereof to conform to fluctuations in the rate of inflow to the basin, said floats being located in the basin, and individual float switches for starting and stopping the motors of the pumps, the two floats for one pump unit being set at a higher liquid level than those of the other pump unit, whereby one pump unit starts when the liquid level reaches one level and its capacity is increased from minimum to maximum upon the rise of the liquid level to a higher level and the other pump starts upon the rise of the liquid level above said higher level and its capacity increases from minimum to maxi-

mum upon continued rise of the liquid level above said higher level.

5. In pumping apparatus, the combination of a pair of motor operated, constant speed pump units connected to a basin arranged to receive a fluctuating source of liquid supply, fluid pressure operated minimum to maximum capacity regulating means associated with each pump for varying the capacity thereof to conform to fluctuations in the rate of inflow to the basin, float operated waste valves for controlling the capacity regulating means, the floats being located in the basin, and individual float switches for starting and stopping the motors of the pumps, the two floats for one pump unit being set at a higher liquid level than those of the other pump unit, whereby one pump unit starts when the liquid level reaches one level and its capacity is increased from minimum to maximum upon the rise of the liquid level to a higher level and the other pump starts upon the rise of the liquid level above said higher level and its capacity increases from minimum to maximum upon continued rise of the liquid level above said higher level.

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