[11] 3,620,236

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[54] PUMPING STATION BYPASS SYSTEM AND METHOD

7 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** 137/13 137/268, 137/268
[51] **Int. Cl.** **B08b 9/04**
[50] **Field of Search** ..... 137/13, 268, 544; 15/104.06 A, 3.5

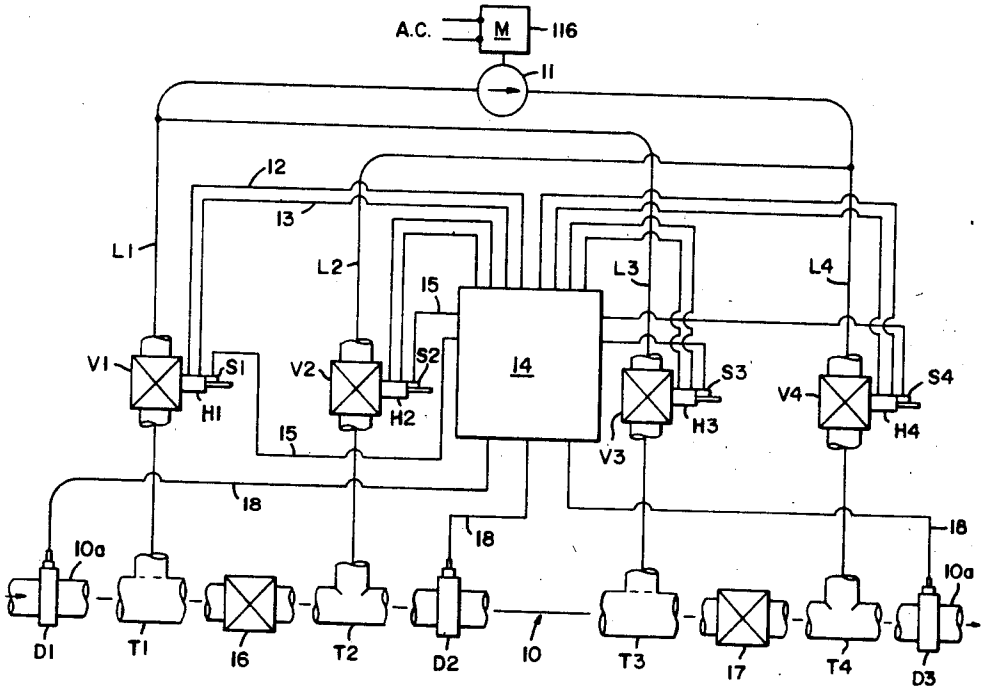
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ABSTRACT: A system and method for pumping stations of pipeline wherein product-separating spheres are passed by the pumps by controlling flow of liquid through a plurality of flow-tees. A special timing arrangement is employed whereby each sphere is reinserted into the flow downstream of the station in the same relative position that it occupied when it approached the station.



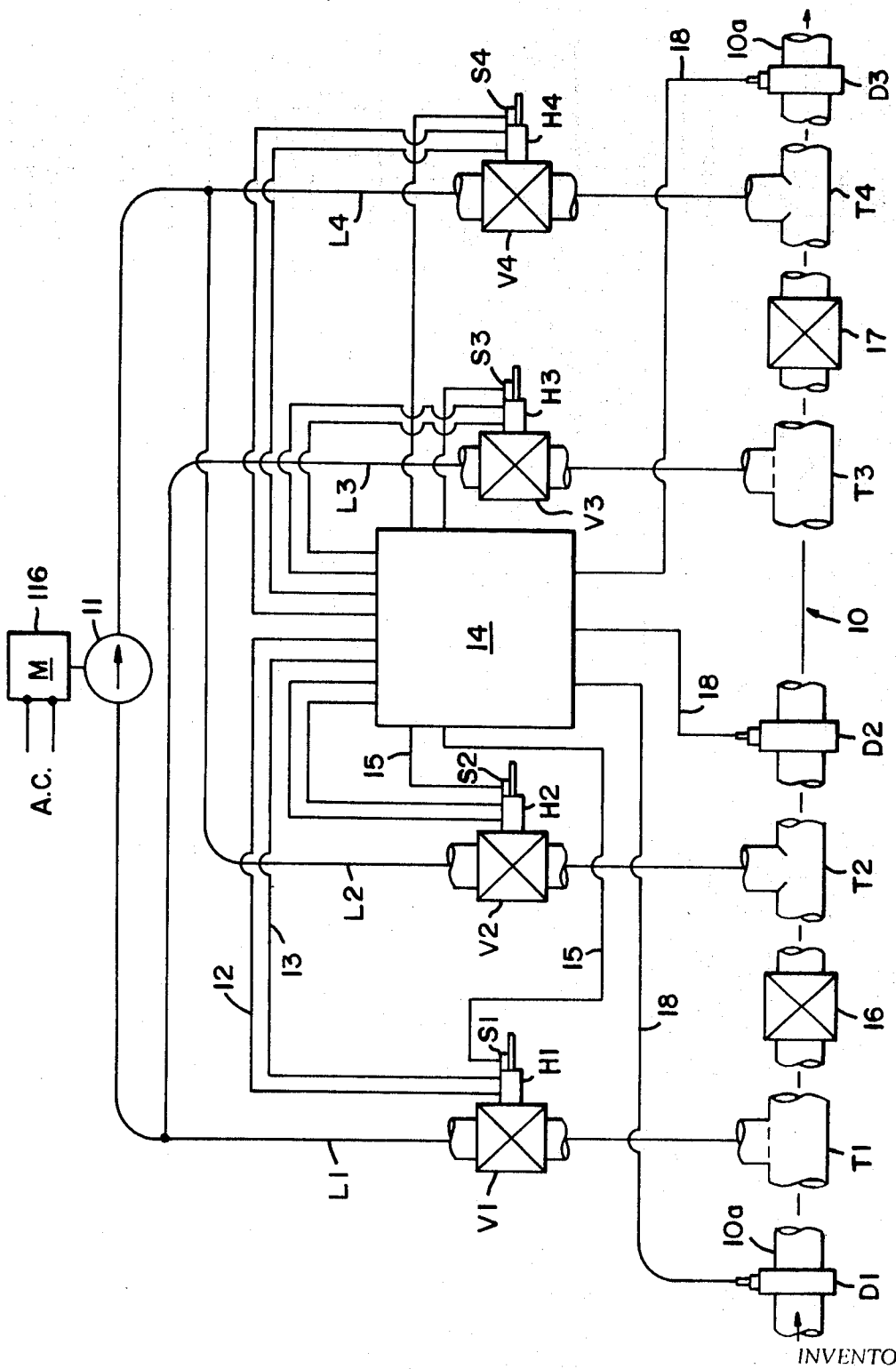


FIG_1

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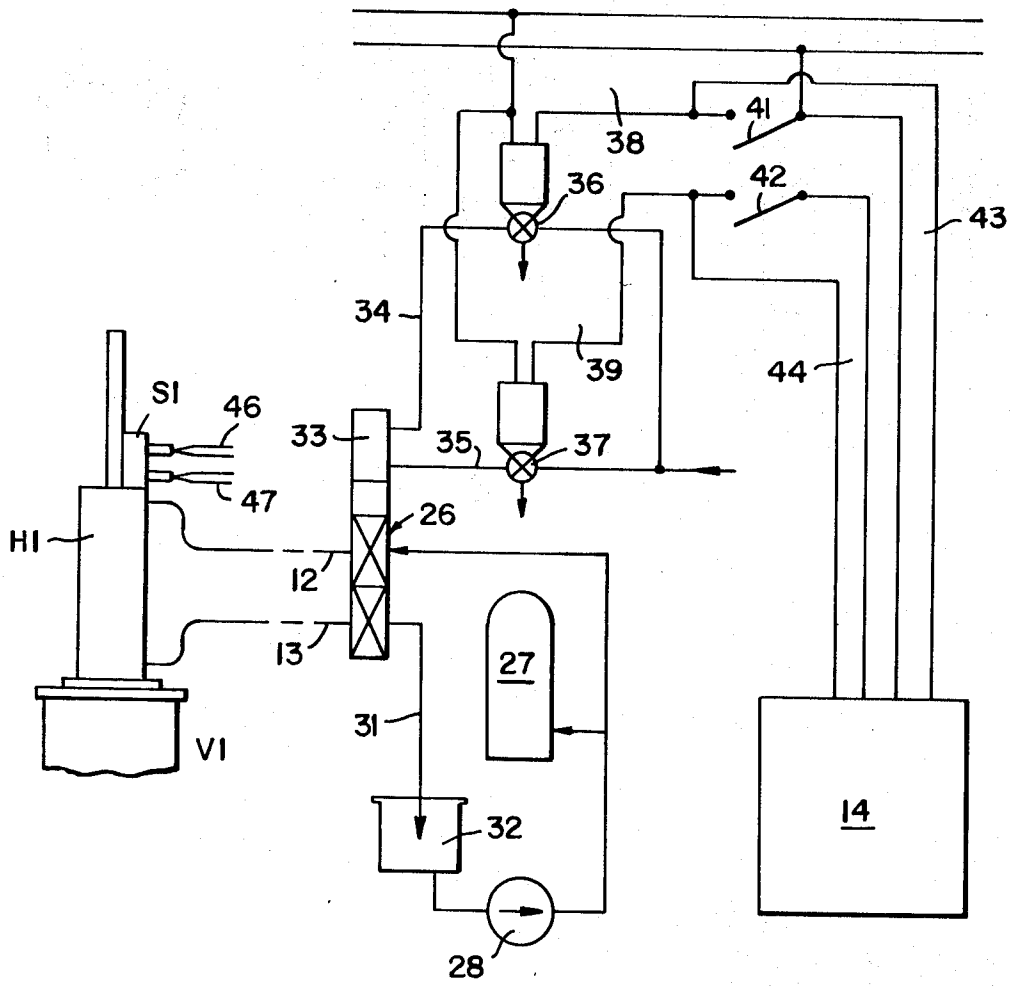


FIG_2

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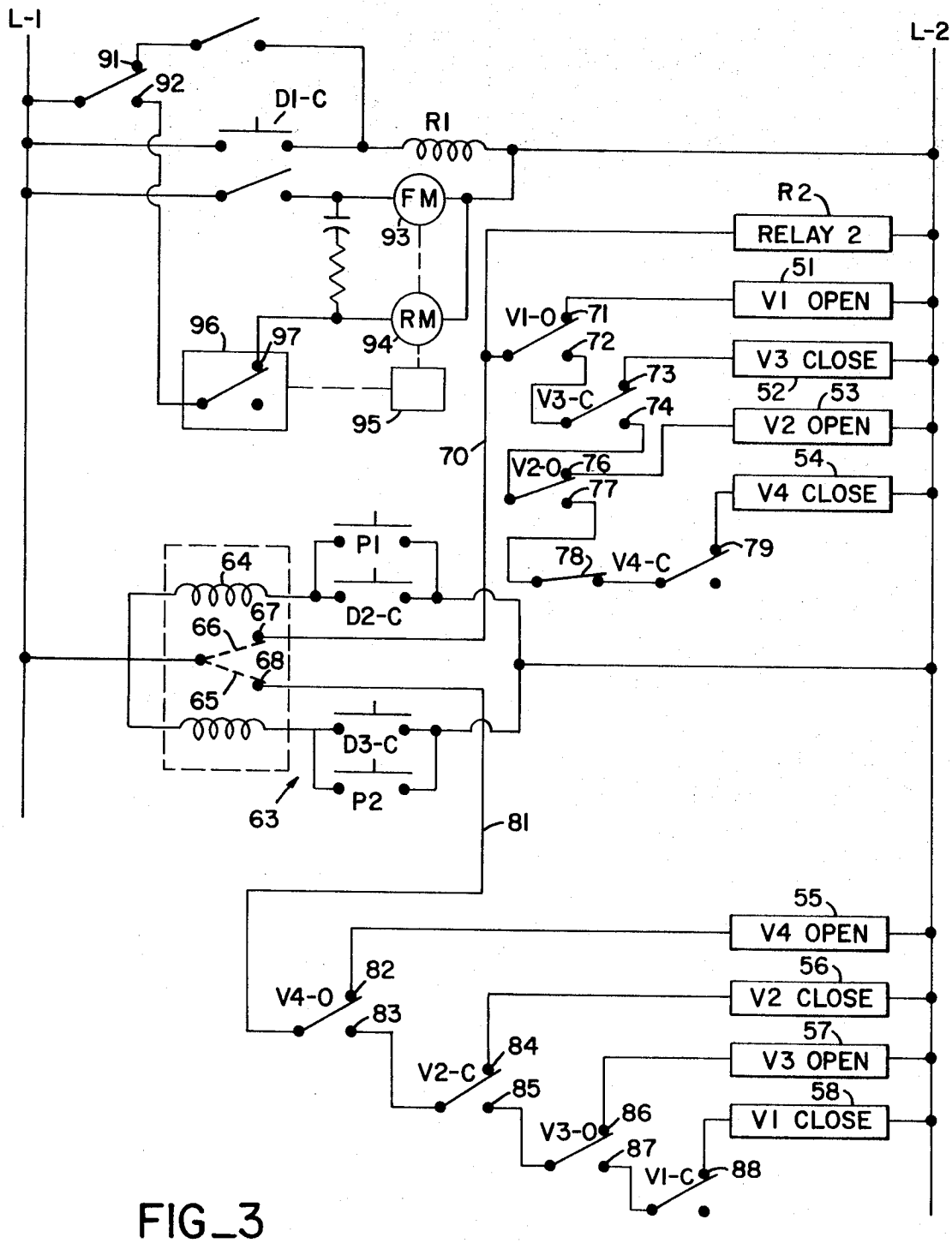


FIG_3

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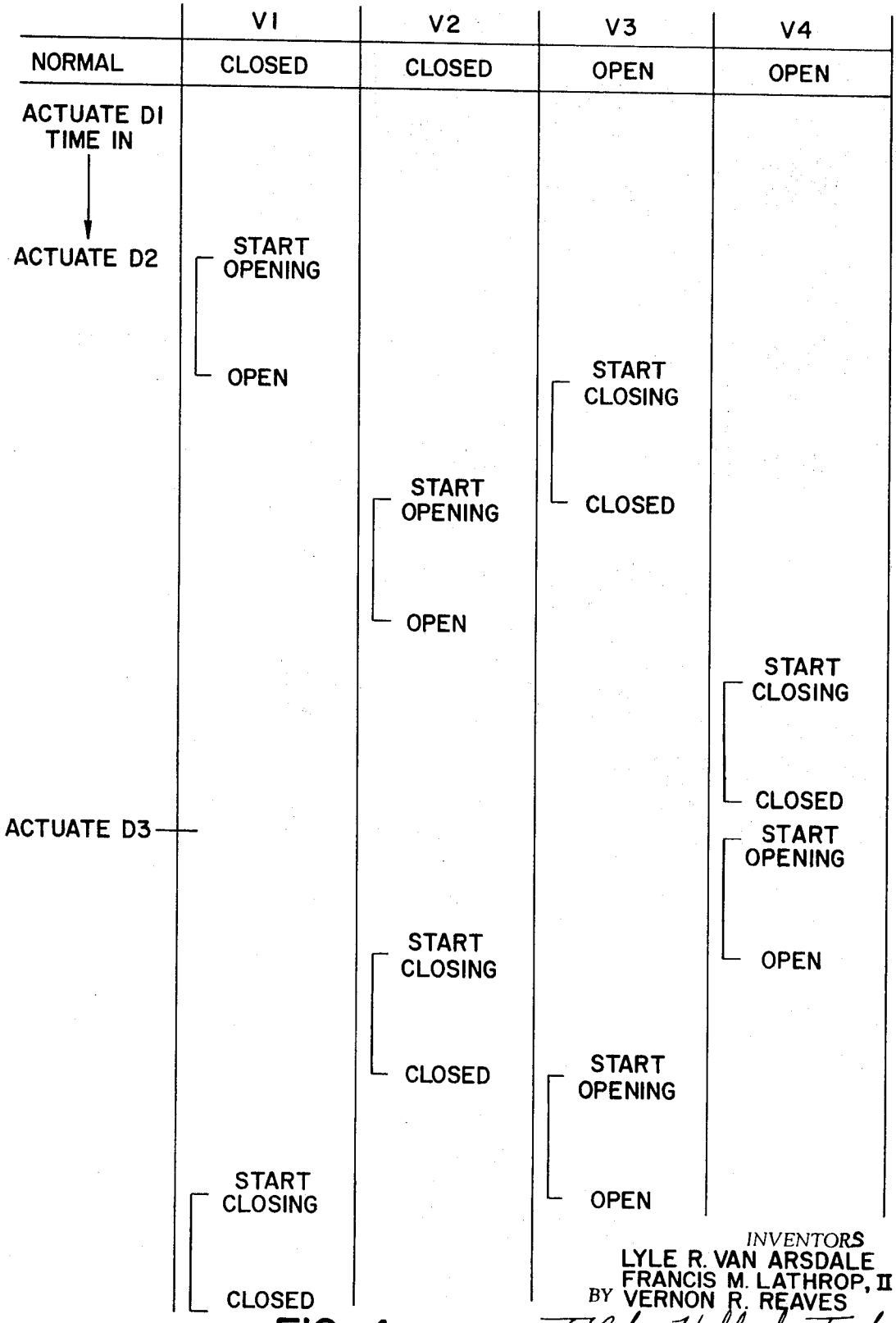


FIG_4

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PUMPING STATION BYPASS SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application is an improvement to subject matter disclosed in Van Arsdale and Lathrop copending application Ser. No. 796,619, now abandoned filed Feb. 4, 1969 for "Pipeline By-Pass Flow Control System and Method."

BACKGROUND OF THE INVENTION

Pipeline systems for the handling of various petroleum products commonly employ so-called booster pumping stations for increasing the effective fluid pressure head. In a typical instance a flow-tee inserted in the main line is connected by a branch line to the suction side of the station pump. The discharge side of the station pump connects through another branch line with a flow-tee located downstream from the first tee. A check valve is interposed between the two flow-tees to prevent backflow. When product-separating spheres or cleanout devices are passed through the main line, retrieval means may be provided near the upstream end of the bypassed portion of the line whereby these devices are removed. At the downstream end of the bypassed portion suitable means can be provided for reintroducing the spheres or cleanout devices back into the line whereby these devices are removed. At the downstream end of the bypassed portion suitable means can be provided for reintroducing the spheres or cleanout devices back into the line. A system and method of this character is disclosed and claimed in the above-mentioned copending application, Ser. No. 796,619, and is characterized by an automatic cycle for causing spheres or cleanout devices to be moved progressively from the upstream to the downstream side of the pumping station.

In instances where the spheres or cleanout devices are separating different liquid products, they should be reintroduced into the downstream side of the line in such a manner that they then occupy the same relative position with respect to the different liquid products as they had when approaching the pumping station. This serves to minimize intermingling of adjacent liquid products. This requirement is complicated by the fact that the flow rate through the line may vary, thus causing a factor of error if operation is based upon fixed time cycling.

SUMMARY OF THE INVENTION AND OBJECTS

This invention relates generally to systems and methods for use in connection with booster or pumping stations of pipelines, and particularly to a system and method which will handle product-dividing spheres in such a manner that the spheres are introduced back into the line in a desired relationship to the products being conveyed.

In general, it is an object of the invention to provide a system and method of the above character which will control the point of introduction of the dividing sphere into the line in conjunction with a system and method of the type disclosed in said application, Ser. No. 796,619 now abandoned.

Another object is to provide a system and method of the above character which inherently compensates for changes in flow rates.

Additional objects and features of the invention will appear from the following description in which the preferred embodiments have been set forth in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 schematically illustrates a complete system incorporating the invention;

FIG. 2 schematically illustrates means associated with each valve for opening and closing the same;

FIG. 3 is a circuit diagram circuitry for the electrical components;

FIG. 4 is a diagram illustrating the manner in which the valves are cycled as a sphere is being progressed between the upstream and downstream of the station pumps.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 schematically represents a system for a pumping station used in conjunction with a pipeline for the transmission of various liquid products (e.g., petroleum products.) The portion bypassed by the pumps is indicated at **10** and in practice may range in length from about 6 to 100 feet. The main station pump is indicated at **11** and has its suction and discharge sides connected by branch lines L1 and L4 with the flow-tees T1 and T4. These flow-tees are at the ends of the line portion **10**. Likewise in the embodiment illustrated, two additional branch lines L2 and L3 connect respectively with the intermediate flow-tees T2 and T3. Branch line L2 connects with the discharge side of pump **11** and line L3 connects with the suction side. Tees T2 and T4 may be conventional, while tees T1 and T3 are constructed to detain until differential flow pressure is applied, as will be presently explained.

Each of the valves V1, V2, V3 and V4 preferably are power operated and capable of remote control. We have found it satisfactory to use valves of the gate-type provided with hydraulic operators H1–H4 of the cylinder-piston-type. Each of the hydraulic operators are provided respectively with electrical switch devices (i.e., limiting switches) S1, S2, S3 and S4 which are provided with switch contacts that are operated when the valve is in its extreme limiting (i.e., open and closed) positions. In other words, one switch has its contacts closed when the associated valve is moved to full open position, and the contacts of the other switch are closed when the valve is moved to full open position. Such a hydraulic operator and control means is shown for example in U.S. Pat. No. 3.402,270. Electrical cables **15** are indicated for circuit wires connecting the switch contacts with the control panel **14**. In addition to the flow tees a plurality of devices are provided for detecting the arrival of the sphere or like object at particular points along the length of the line. Thus a sphere detecting device D1 is located at a point that is a substantial distance upstream from the pumping station. A second detecting device D2 is located intermediate the tees T2 and T3. A third detecting device D3 is located in the downstream portion **10** *b* of the main line adjacent the tee T4.

A check valve **16** is interposed between the flow lines T1 and T2, and a second check valve **17** is interposed between the flow tees T3 and T4. These check valves prevent backflow of liquid but are constructed to pass the spheres.

The detecting device may be of the electrical type utilizing contacts or photoelectric cells and serving to activate a circuit upon the arrival of a sphere. Cables **18** represent circuit connections between the detecting devices and the control panel **14**.

The control panel equipment may vary in its specific nature, but should be such as to make possible an automatic cycle of operation in which the various valves are opened and closed in accordance with a predetermined operating cycle to be presently explained.

Normally the pump **11** is in continuous operation. Valves V1 and V2 are normally closed, and valves V3 and V4 are normally open. Therefore normal flow occurs through flow-tee T1, check valve **16**, flow-tee T2, detector D2, flow-tee T3, valve V3 and line L3 to the suction side of the pump **11**. Pump **11** discharges through line L4, valve V4, flow-tee T4, and the sphere detector D3 to the downstream side **10***b* of the main line.

The flow-tees T1 and T3 are preferably constructed in such a manner that when a sphere enters the inlet flow passage of the tee, it is caused to roll down a ramp to a position adjacent the outlet. While the sphere is detained in this position, flow may occur freely through the inlet passage of the tee and out through its branch-connecting line. When the branch line is closed and flow induced through the tee, the sphere is carried through the flow tee outlet passage. A suitable flow-tee of this type is disclosed in copending application, Ser. No. 689,627, filed Dec. 11, 1967 now U.S. Pat. No. 3,511,272.

FIG. 2 illustrates parts that may be incorporated in the control panel **14** for effecting controlled hydraulic operation of

the valves V1–V4. In this instance a small four-way control valve 26 connects with the two lines 12 and 13 leading to the hydraulic operator H1 of the valve V1. As representative of a hydraulic pressure system, there is shown a pressure accumulator 27 connected to the discharge side of the pressure pump 28, and a pressure connection by line 29 to the four-way valve 26. The liquid exhausted from the four-way valve 26 is shown passing line 31 to the reservoir 32, which connects with the suction side of pump 28. Normally the pump is controlled by a pressure switch whereby it maintains a quantity of hydraulic liquid in the accumulator 27 at a desired pressure level. When the pressure drops, pump 28 automatically starts an operation to restore the pressure. A pneumatic cylinder 33 is provided with a piston connected to the operating member of the four-way valve 26. Air is supplied or exhausted from the ends of the cylinder through the lines 34 and 35, which are controlled by the electrical solenoid operated valves 36 and 37. The two circuits 38 and 39 for the solenoid valves 36 and 37 can be controlled by the closing and opening of the manually operated switches 41 and 42 which may be the contacts of relays. Thus assuming that the valve V1 is open, operation of switch 41 serves to supply air under pressure to the pneumatic operator 32 which in turn sets the four-way valve 27 to supply liquid to the line 12 while exhausting liquid through line 13. When the switch 41 is opened, the solenoid valve 36 is conditioned to vent air in that part of line 34 between the solenoid valve and the cylinder 33. Similarly, the operation of switch 42 serves to open the valve V1.

FIG. 3 is a circuit diagram for the various electrical parts including the closing and opening relays for the various valves V1–V4. The rectangular blocks represent the closing and opening solenoids for the valves or relays which in turn may control operation of the solenoid. As previously explained, the valves have limiting switches or contacts corresponding to the limiting switches 41 and 42 of FIG. 2. Thus 51 is the open solenoid for valve V1, 52 is the close solenoid for valve V3, 53 is open solenoid for valve V2, 54 is the close solenoid for valve V4, 55 is the open solenoid for valve V4, 56 is the close solenoid for valve V2, 57 is the open solenoid for valve V3, 58 is the close solenoid for valve V1.

A bistable device 63 consists of windings 64 and 65 which when separately energized serve to position the switch member 66 into contact with either one of two contacts 67 and 68. The circuitry is energized by current supplied by the lines 1 and 2 as indicated. One side of the windings 64 and 65 connects with line 1. The contact 67 is connected by conductor 70 to line 2 in series with relay R2. Also it connects with the blade of the open limiting switch V1–0 for controlling valve V1. All of the limiting switches shown in the upper part of the diagram, namely, V1–0, V3–C, and V4–C, have their contacts 71, 73, 76 and 79 connected to line 2 in series with solenoids 51, 52, 53 and 54 for the valves V1, V3, V2 and V4 as indicated. The contact 72 of switch V1–0 is connected to the blade of switch V3–C and the contact 74 of the latter is connected to the blade of switch V2–O. Likewise, contact 77 of V2–0 is connected with the blade of normally closed switch 78 and from thence, with the blade of switch V4–C.

The group of limiting switches shown in the lower portion of the diagram are connected as follows. The blade of switch V4–O is connected by conductor 81 with the contact 68 of the bistable device. The contacts 82, 84, 86 and 88 of limiting switches V4–O, V2–C, V3–O and V1–C connect respectively with the solenoids 55, 56, 57 and 58 of valves V4, V2, V3 and V1. The contact 83 of switch V4–O connects with the blade of switch V2–C, contact 85 of the latter connects with the blade of switch V3–O, and likewise 87 of V3–O connects with the blade of switch V1–O.

The circuitry of FIG. 3 also schematically illustrates timing means to provide time-in and timeout measuring operations. The timing means consists of motors 93 and 94 having their motors connected by a common shaft and capable of constant speed operation when energized. Motor 93 rotates clockwise and motor 94 rotates counterclockwise. Suitable means such as reduction gearing 95 driven by the common shaft serves to operate the switches 96 and 97. The two motors are marked "FM" and "RM" to indicate forward and reverse rotation. When motor 93 has been energized for a predetermined period of time and then the reverse motor 94 energized and operated for a sufficient period to return the timing means to its starting point, switch 96 is opened to deenergize motor 94 and switch 78 is closed. In other words, if motor 93 is operated for a period of time to drive the shaft of motor 93 *N* revolutions, the switches 96 and 97 will be reset after motor 94 has been operated to rotate the shaft by *N* revolutions but in a reverse direction.

FIG. 3 also includes the contacts of the sphere detectors D1, D2 and D3, the contacts being designated D1–C, D2–C, and D3–C. The contacts D1–C are connected in series with the winding of relay R1 and across the current supply lines 1 and 2. The contacts D2–C are connected in series with winding 64 of the bistable device and across lines 1 and 2. The contacts D3–C are connected in series with the winding 65 of the bistable device and across lines 1 and 2.

The contacts of a normally open pushbutton P1 are shunted across contacts D2–C. Also the contacts of a normally open pushbutton P2 are shunted across contacts D2–C.

The relay R1 has two contact sets R1–C1 and R1–C2. The relay R1 has one set of contacts R2–C1. The windings of contacts R1–C1 are in series with the contacts R2–C1 through the normally closed contact 81 and are shunted across D1–C to form a holding circuit.

The motor 93 is shunted to line 1 in series with relay contacts R1–C1. Motor 94 connects across lines 1 and 2 in series with switch 96 and contacts R1–C1.

Operation of the complete system can be described as follows. As the sphere approaches the station, it first trips the sphere detector D1. At that time the sphere is located in the flow line in such a manner that it divides two different liquid products. The closing of the sphere detector contacts D1–C energizes relay R1 to close the relay contacts R1–C2 together with the holding contacts R1–C1. Closing of contacts R1–C2 serves to energize and start the in-count motor 93 to rotate in a clockwise direction. As the sphere travels from detector D1 through flow-tee T1. check valve 16 and tee T2 to the detector D2, it displaces a volume of liquid that is equal to the liquid volume from valve V3 through the pump 11 and connecting lines to the valve V4. Therefore, the elapsed time for this sphere to travel from detector D1 to D2 is a measure of the flow rate that the liquid is travelling. This elapsed time also determines the number of revolutions made by the constant speed in-time motor 93. When the sphere reaches and trips the detector D2, this serves to initiate certain programmed operations of the valves. Particularly by closing contacts V2–C, the winding 64 of the bistable device 63 is energized whereby contact blade 66 closes upon contact 67. The relay R2 is thus energized to open its contacts R2–C1 to break the holding circuit for relay R1 and to deenergize the incount motor 93. Simultaneously, the counterclockwise motor 94 is energized by the closing of contacts R2–C1 on R2 to start the outcount. At the same time relay R2 is energized, the open solenoid 51 for valve V1 is energized to start movement of valve V1 from closed to pen position. When valve V1 reaches full open position it closes a limiting switch V3–C which energizes the close solenoid 52 for the valve V3. When valve V3 has reached closed position, it closes a limit switch V2–O which energizes solenoid 53 and valve V2 to start this valve toward open position. When valve V2 has reached full open position, it operates a limit switch V4–C which is not immediately effective to commence operation of valve V4 until switch 78 has been closed by motor 94. This provides a predetermined delay to permit liquid to clear the pump. When switch 78 closes the close solenoid 54 for valve V4 is energized to start the valve V4 toward the closed position. When valve V4 reaches full closed position, the station may be said to be in the pass position. Valves v1 and V2 are open, and valves V3 and V4 are closed. Liquid pump flow is being

diverted to the line on the upstream side of the sphere. Thus the sphere is caused to travel through the flow-tee T3, through check valve 17, through tee connection T4 and past detector D3. Closing of the contacts D3–C of detector D3 energizes the winding 65 of the bistable device to cause its blade to close upon contact 68. This supplies current through switch V4–O to the open solenoid 55 for valve V4, thus causing this valve to start from closed to open position. When valve V4 reaches full open position, a limit switch V2–C energizes solenoid 56 of valve V2 to start this valve from open to closed position. When this valve is fully closed, a limit switch V3–C energizes solenoid 57 to commence opening of valve V3. When valve V3 is fully open, a limit switch V1–C energizes the solenoid 58 of valve V1 to close the same. This ends the cycle of operation and in this conditions the valves V1 and V2 are closed and valves V3 and V4 are open. The station is now in ready position in that it is ready to receive another sphere, pig or scraper.

If at any time during passing of a sphere a second sphere arrives at the station, it will in effect be parked in the first flow-tee T1 and will remain in this flow-tee until the station returns to ready condition. At that time flow is directed to move this sphere out of flow-tee T1 to trip the detector D2 and to commence the sequence previously described. In practice it has been found that as many as three spheres can be parked at one time in this manner.

A feature of the method and system described above is that by virtue of the in-count and outcount operations, the delay between arrival of valve V4 in full open position and the commencement of closing of valve V4 is accurately related to the time required for the sphere to pass between the detectors D1 and D2. Thus the sphere is reinserted into the line in the same relative position which is occupied when it arrived at the station. In addition, the method and system inherently compensates for variations in flow rates which may be experienced from time to time so that under various flow rates the sphere is always launched in proper relationship to the liquids being conveyed through the line.

We claim:

1. A method for use at pumping stations for liquid-conveying pipelines to ensure movement of a sphere or cleanout device through a bypass portion of the line and to ensure reintroduction of the sphere into the flow in the same position which it occupied relative to the liquid when it arrived at the station, the bypass portion being provided with a plurality of serially connected flow-tees each connected to a valve-controlled branch line, the branch lines being connected with the suction and discharge sides of the station pump, the steps of detecting the arrival of a sphere at a point at the upstream end of the bypass portion, permitting the sphere to continue through a part of the bypass portion and a flow-tee until it reaches a second detecting station, measuring the time lapse required for movement of the sphere between the first and second detecting stations, carrying out a first series of programmed operations of the valves of the branch lines commencing when the sphere arrives at the second station, the programming including a final operation to divert flow from the pump into the bypass portion upstream from the second detecting station to cause the sphere to progress from the second station toward a third detecting station at the downstream end of the bypass portion, and then carrying out a second series of programmed valve operations commencing after a delay period following said final operation, the delay period being equal to the time lapse for movement of the sphere from the first to the second detecting station, the second programming series including valve-opening and closing operations to restore the valves to normal condition and to introduce the sphere back into the main flow line.

2. A method as in claim 1 making use of two flow-tees between the first and second detecting stations and two flow-tees between the second and third detecting stations, there being four branch lines connected to the tees and four valves for controlling flow through the valves, the method comprising carrying out programming in the sequence illustrated in FIG. 4.

3. Apparatus for use at pumping stations of liquid-dispensing pipelines where the station pump is normally connected to a bypass portion of the line, a plurality of flow-tees serially connected to the bypass line portion, a first sphere detector located at the upstream end of the bypass portion, a second sphere detector located intermediate the ends of the bypass portion, branch lines connecting between the flow-tees and the suction and discharge sides of station pump, power operated valves located in each of said branch lines, timing means for measuring the time required for movement of a sphere from the first to the second detector, means initiated by the second detector for programming the valves to cause flow through the bypass portion to move the sphere through said portion and into the main line, and means controlled by said timing means for controlling said programming whereby the sphere is returned to the main line in predetermined relation to the liquid flow.

4. Apparatus as in claim 3 together with a third sphere detector at the downstream end of the bypass portion, and means controlled by said third detector for restoring the valves to normal condition.

5. Apparatus as in claim 3 in which a check valve is provided, in the bypass portion between the first and second detector lines.

6. Apparatus as in claim 4 together with check valve in the bypass portion between the first and second sphere detectors and another check valve between the second and third detectors.

7. Apparatus as in claim 3 in which the timing means consists of two motors adapted to be sequentially energized to control common switch means, and electrical circuitry including the switch means, the motors and the sphere detectors whereby responsive to operation of the first detector one timing motor is energized and then deenergized at the end of a time period when the second detector is actuated and whereby upon opening of a valve in the first series of the programming to cause the sphere to be moved from the second detector toward the downstream end of the bypass the second motor is energized reversely whereby it operates said switch means after a reverse time lapse equal to the first time period, and means responsive to said operation of the switch means to initiate a second valve-programming series to move the sphere back to the main line.

* * * * *