United States Patent

Grove et al.

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[54] **PUMPING STATION SPHERE HANDLING METHOD AND SYSTEM**

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[51] **Int. Cl.** **B08b 9/04**

[58] **Field of Search** ....137/1, 268, 13, 15; 15/104.06 A

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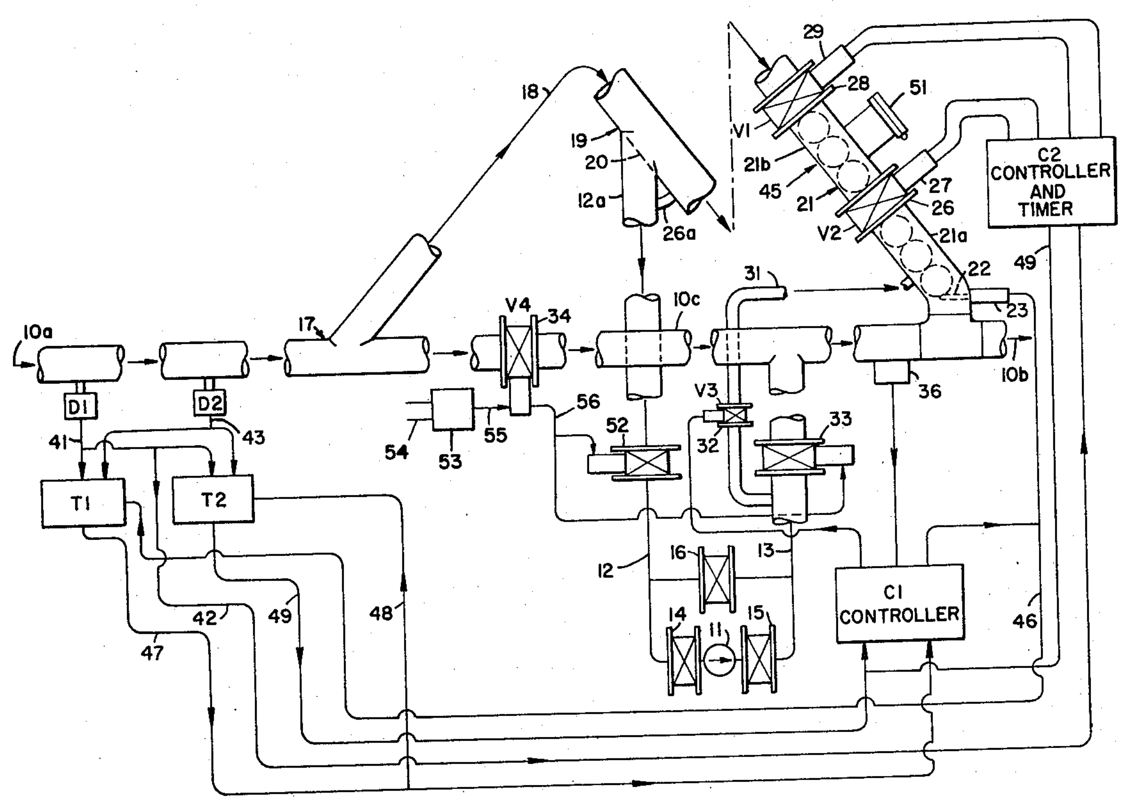
[57] **ABSTRACT**

A method and system applicable to pipeline systems for handling spheres at pumping stations. Particularly the invention serves to launch spheres into the line at the downstream side of a pumping station in predetermined relation to an interface region between different liquid products. Spheres arriving at the pumping station are detected and diverted and stored in a magazine. Previously diverted spheres in the magazine are launched successively into the downstream portion of the line in such a manner as to effectively divide different products. The method makes use of sphere detecting means in the upstream portion of the line to detect the arrival of a group of spheres, and also means for detecting the interface region between different products. Special timing means is provided for controlling the sequence with which the spheres are relaunched into the line, whereby the spacing between relaunched spheres corresponds to a particular volume.

12 Claims, 3 Drawing Figures



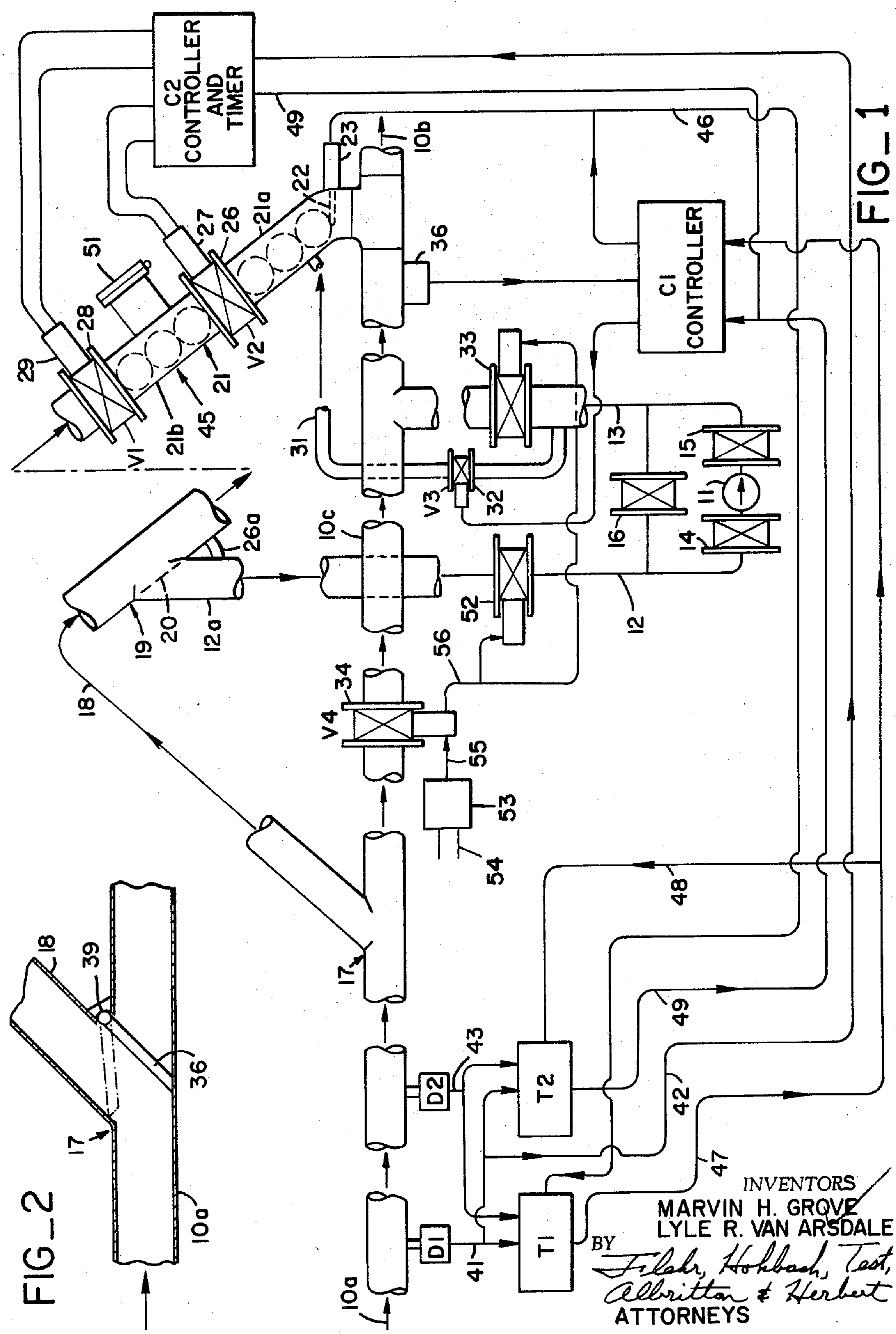


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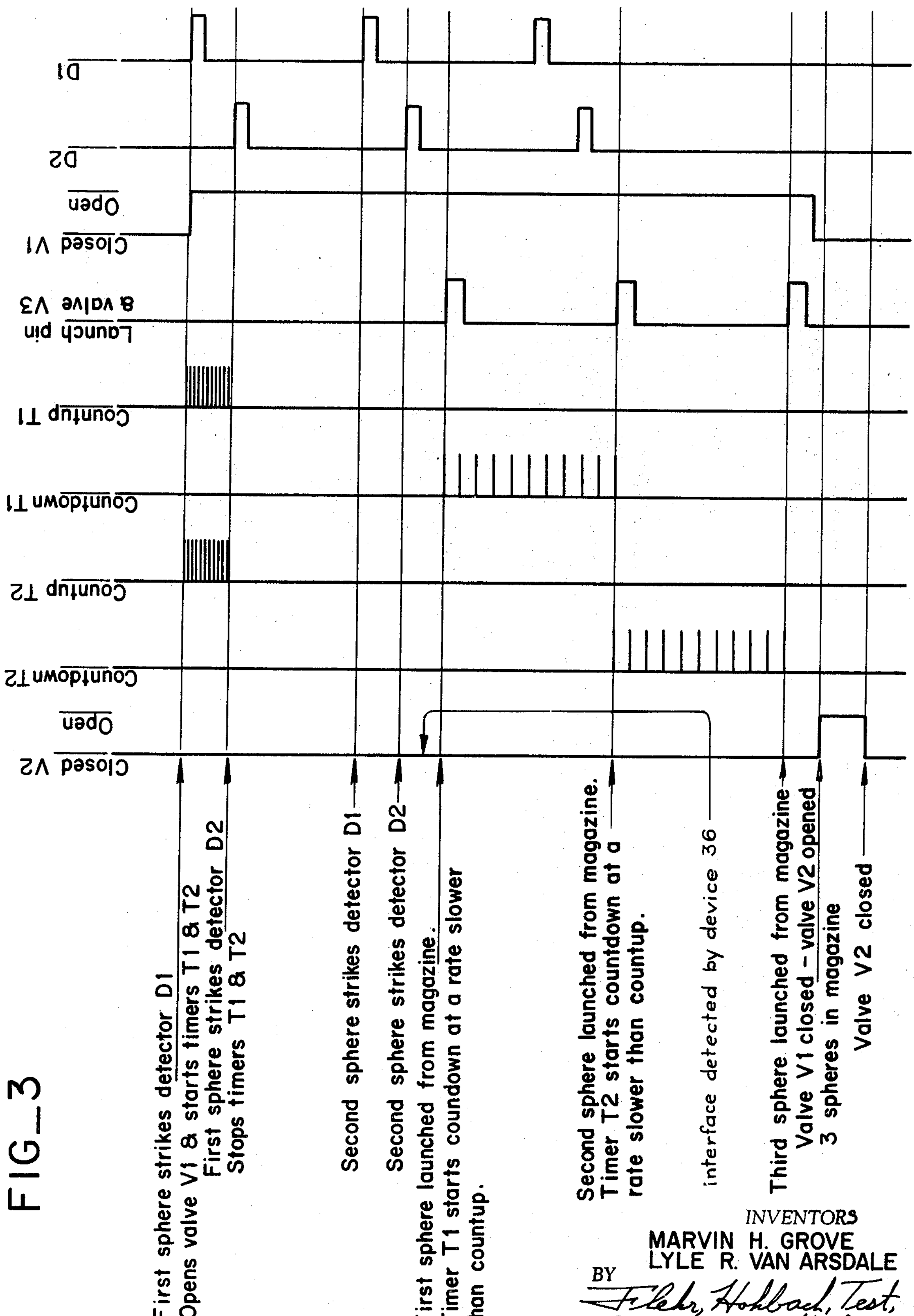
FIG_3



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PUMPING STATION SPHERE HANDLING METHOD AND SYSTEM

BACKGROUND OF THE INVENTION

In the operation of modern day pipeline systems for the transmission of various liquid products, it is common to introduce product separating spheres or plugs into the line, whereby the spheres are propelled by liquid flow between stations which may be many miles apart. It is also common to provide pumping stations at regular intervals along a pipeline for the purpose of boosting the line pressure and thus ensuring continual flow of liquid through the line. Such a station consists essentially of a pump having suction and discharge pipes connected to upstream and downstream portions of the line. When a sphere arrives at a pumping station it must be bypassed about the station, or it must be diverted from the line and the same or another sphere reintroduced into the downstream portion of the line. Assuming that the sphere is being used for the purpose of separating products of different gravities, it should be located and maintained at or near the interface region between the products. It has been observed that when such separating spheres have been propelled over considerable distances, there is a tendency for the sphere to lag behind the interface region, thus permitting some intermingling between the products. If the station bypass means employed serves to divert and then reintroduce the sphere back into the main line in the same general position which it previously occupied with respect to the liquid products, then the lag referred to above is not compensated for but in fact becomes cumulative as the sphere moves past successive stations.

Aside from the operation of pumping stations, it has been proposed to use more than one sphere to obtain better separation between products. Also it has been proposed to introduce a so-called buffer liquid between two liquid products, thus providing two interface regions, with a sphere being located at each region. In addition it has been proposed to provide three spheres for obtaining more effective separations, with the first sphere being located at the first interface region, and the second and third spheres being located at predetermined points behind the first sphere. For example, where a buffer liquid is introduced to provide two interface regions, it has been proposed to locate the first sphere at the first or advancing interface region, the second sphere at or near the second interface region, and the third sphere a short distance behind the second sphere. The use of several spheres in this manner seriously complicates the handling of spheres at pumping stations, particularly since it is necessary to launch the spheres at a relatively rapid rate, with proper relation to the interface region. Therefore, methods and systems have not been available for performing the required diverting and relaunching operations, where several spheres are employed for product separation.

SUMMARY OF THE INVENTION

This invention relates generally to methods and systems applicable to pipelines making use of flow propelled spheres to separate liquid products. More particularly it relates to methods and systems of this character which employ several spheres to separate products.

In general it is an object of the invention to provide a method and system of the above character which will rapidly launch a number of spheres into the downstream portion of the line at a pumping station and in predetermined relation to an interface region between different products.

Another object of the invention is to provide a method and system of the above character which will operate to effectively launch spheres in predetermined relation to an interface region, irrespective of any lag between the spheres and the interface region as received at the station.

Another object of the invention is to provide a method and system of the above character making use of novel timing means in such a manner that the spheres are rapidly and successively introduced into the downstream line portion with predetermined spacing.

Another object of the invention is to provide a method and a system of the above character which is capable of accurately launching spheres into the downstream portion of the line at a relatively rapid rate, and independent of the rate with which spheres are received.

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

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic diagram illustrating apparatus forming the present system, with electrical means to obtain automatic cycling.

FIG. **2** is a detail in section illustrating the sphere diverting tee indicated in FIG. **1**.

FIG. **3** is a diagram illustrating the various steps involved in a complete cycle of operation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The system illustrated in FIG. **1** consists of the upstream line portion **10*a*** located at the upstream side of a pumping station, and a downstream or outgoing line portion **10*b***. The pumping station may consist of the pump **11** having suction and discharge lines **12**, **13** provided with valves **14** and **15**. Also lines **12** and **13** may be connected by check valve **16**, which is normally closed by fluid pressure. The upstream line portion **10*a*** is shown including the spaced sphere detectors D1 and D2, and the sphere diverter **17**. This diverter may be a simple flow tee having a side duct connected to the bypass line **18**. When substantial flow occurs through line **18** in the direction indicated, spheres arriving at the flow tee **17** tend to be carried into the line **18**. Line **18** is provided with a flow tee **19**, which has a conduit **12*a*** connected to the suction line **12** of the station pump **11**. A grid or bars **20** prevent spheres from entering conduit **12*a*** and a wash line **26*a*** may be provided to aid movement of spheres past the grid. Flow tee **19** may be constructed as disclosed and claimed in U.S. Pat. No. 3,387,483.

The bypass line **18** also connects with the magazine tube **21**, which serves to store spheres for launching. The lower portion **21*a*** of tube **21** communicates with the downstream portion **10*b***, as illustrated in FIG. **1**. Spheres within the tube portion **21*a***, illustrated in dotted lines, are retained by the retractable launching pin **22**. This pin is actuated by energizing the external power operator **23**, and when energized the pin is briefly retracted to permit the nearest sphere to pass downwardly into the downstream portion of the line **10*b***.

Tube portion **21*a*** is separated from portion **21*b*** by the normally closed valve **26**, which is shown provided with a power operator **27**. Also a valve **28**, shown provided with power operator **29**, controls communication between the portion **21*b*** of the tube and the bypass line **18**. The internal diameter of the magazine tube is substantially greater than the diameter of the spheres, whereby when spheres are deposited into the magazine they move downwardly by gravity.

Launching of the spheres is assisted by momentarily introducing a liquid stream into the region immediately above the lowermost sphere, at the time the pin **22** is retracted. Thus pipe **31** connects through one wall of the tube portion **21*a***, and its other end connects with the discharge line **13** of the pump **11**. Flow of liquid through pipe **31** is controlled by the valve **32**, which may be provided with operating means as indicated. When valve **32** is operated simultaneously with retraction of pin **22**, a stream of liquid is introduced into the space immediately above the lowermost sphere, thus propelling this sphere into the main line and tending to hold back the sphere immediately above the same until the liquid stream is discontinued. In this manner the sphere is rapidly and positively thrust into the line.

It is desirable to provide a shutoff valve **33** in the discharge line **13** from the pump **11**. Also it is desirable to provide a block valve **34** in an intermediate portion **10c** of the line, or in other words, that portion of the main line extending from the diverter **17** to the magazine tube **21**.

At a point on the discharge side of pump **11** suitable detecting means is provided which will detect an interface region between products of different gravities. Such a detector is illustrated schematically at **36** and is located adjacent the lower end of the launching tube. Known devices capable of continuously monitoring changes in specific gravity may make use of means for continuously diverting and reintroducing small quantities of liquid together with hydrometer means which indicates an increase or decrease in specific gravity.

For partial or complete automation it is desirable to provide timers T1 and T2 which respond to signals or demands from detector D1 and D2, and which perform operations as will be presently described. It is also desirable to provide electronic circuitry including controllers schematically indicated at C1 and C2, which receive and transmit demands as will be presently described. These controllers may comprise known types of electrical components, including amplifiers and the like.

To facilitate the following description the valves **28** and **26** have been designated V1 and V2 respectively, the valve **32** as V3, and the valve **34** as V4.

A suitable sphere diverter **17** is shown in FIG. **2**. It consists of spaced diverter bars **36** which are attached to shaft **37**. When these bars are in the position shown in solid lines, a sphere is diverted from line *10a* into the bypass line **18**. When the bars are swung to the position shown in dotted lines, the spheres are permitted to pass through the line portion **10c** and cannot enter the bypass pipeline **18**. When the station is in normal operation the bars **36** are in the position shown in solid lines. The shaft **37** may be provided with hydraulic or other type of power operator to permit remote operation.

While a flow tee with diverter bars may be desirable, it is not essential. A simple flow tee without bars may be used since the sphere will follow the direction of liquid flow.

In practice the sphere detectors D1 and D2 are located a predetermined distance apart, as for example a distance which provides a volume between sphere centers of ten barrels. Timers T1 and T2 are constructed to provide an upcount, and when initiated by a command a downcount at a relatively slower speed, as for example at a rate one fourth the upcount. Thus, if the complete upcount requires N seconds, the complete downcount may require four times N seconds.

A complete cycle of operation can now be described as follows. It will be assumed that liquid products (e.g., liquid petroleum products) flowing through the main line are being separated by the use of the three spheres, the first of which is intended to be at the advancing interface region. When the first of the three spheres passes the detector D1, a command **41** is sent to both timers T1 and T2, thus starting both timers on an upcount. At the same time command **42** is sent from detector D1 to the controller C2 whereby this controller causes the power operator **29** of valve V1 to open the same. After operating the detector D1 the first sphere operates detector D2, and this sends a command **43** to both timers T1 and T2 to stop the same. Since flow is now occurring through the lines **18** and **12** to the suction side of the pump **11**, the sphere after passing detector D2 is caused to pass through the line **18**, and to the entrance end of the magazine tube **21**. At this time valve V1 is open and the sphere is delivered into the upper portion **21*b*** of the magazine. After the first sphere passes the detector D2 the gravity of the products is being continuously monitored by the gravity detecting device **36**, and this device detects arrival of an interface region. It may be explained that the interface region generally reaches the monitoring device **36** before the first received sphere reaches the magazine tube **21**. In response to a command **44** from the device **36** the controller C1 energizes operator **23** to momentarily retract pin **22**, and also momentarily opens valve V3, thus causing the lowermost sphere to be propelled into the downstream portion **10b** of the main line. The command issued by the controller C1 also issues command **46** to timer T1 to start a countdown. As previously stated the rate of the countdown is substantially less than the countup and may be set according to the spacing desired between the launching of the first and second spheres. Thus, if the volume between detectors D1 and D2 were ten barrels and it is desired to relaunch the first and second spheres at a spacing corresponding to a volume of forty barrels, the countdown would be at a rate one fourth the rate of countup. When timer T1 reaches zero it issues a command **47** to the controller C1, whereby pin **22** is retracted and valve V3 momentarily opened to launch a second sphere into the line. Also T1 issues command **48** to T2 to start a second countdown. This countdown can be at the same rate as the countdown for timer T1 assuming that the spacing between the second and third sphere is to be the same as the spacing between the first and second. When timer T2 has returned to zero at the end of its countdown, it issues command **49** to the controller C1 whereby this controller again momentarily opens the valve V3 and retracts pin **22** to launch the third sphere.

During or immediately after the time the three spheres are being launched, the three spheres which have been received by the system from the upstream line portion have been diverted through line **18** and delivered into the upper magazine portion **21*b***. Command **49** from timer T2 is shown also being applied to the controller and timer C2. The timing means of this controller is set whereby the operator **29** of valve V1 is energized to close the same. About the same time the operator **27** for valve V2 is actuated to open the same and retain this valve open a sufficient period of time for all of the spheres in the upper tube portion **21b** to gravitate downwardly into the lower tube portion **21*a***. Then the controller C2 causes the operator **27** to close the valves V1 and V2. The system is now ready to receive another group of spheres.

The schematic diagram of FIG. **3** illustrates the sequence of operations described above. The sequence of operations of the various components is shown by the vertical lines, while operating steps are shown in the left hand column.

It will be evident from the foregoing that the present invention provides a method and system which will effectively bypass pumping stations of pipelines with relaunching of spheres in such a manner as to promote optimum separation between liquid products. Because of the magazine storage feature the method and system is capable of relaunching spheres at a relatively rapid rate, that is, independent of the rate with which the spheres are received. The relaunching of the spheres into the line is controlled by the hydrometer monitoring, thus making it possible to correct any lag between the interface region and the spheres as received at the station.

In addition to the parts described above it is desirable to provide a normally closed access extension **51** which can be opened to insert, remove, inspect, or replace spheres. Also it is desirable to provide a valve **52** in the suction line **12** whereby when valve V4 is opened, valves **33** and **52** can be closed to isolate the pump. For automated shutdown the controller **53**, which is responsive to a circuit **54** adapted to sense an electrical power failure, issues command **55** to the power operator of V4 to open the same. Means such as a limiting switch on V4 sends command **56** to both the operators of valves **33** and **52** to close the same, thus isolating the pump from the line.

It will be evident that the method and system described above can be modified in certain respects. For example, the number of spheres launched in one overall cycle can be varied, or in some instances where multiple sphere separation is not desired, a single sphere can be launched. The launching of spheres, involving operation of pin **22** and valve V3 may be carried out manually or by manual supervision. Even with full automatic operation it is desirable to provide for monitoring, with suitable indicating means at a monitoring station whereby all operations are made known to a supervisor. This can be associated with suitable means whereby the supervisor may at any time intervene and override various operations as desired.

We claim:

1. A method of handling product separating spheres being flow propelled along a main pipeline which conducts a plurality of products of different specific gravities separated at one or more interface regions, the method making use of a magazine for retaining and storing a plurality of spheres in readiness to be released into the downstream portion of the line, the steps of detecting the arrival of an interface region between two liquid products at a point near the station, releasing a sphere from the magazine to launch the same into the downstream portion of the line in accordance with such detection whereby the sphere is launched into said interface region, and diverting spheres from the upstream portion of the line and supplying the same to the magazine.

2. A method as in claim 1 in which at least one additional sphere is launched from the magazine into the downstream portion of the line in predetermined spaced relationship with the first released sphere.

3. A method of handling product separating spheres being flow propelled along a main pipeline which conducts a plurality of products of different specific gravities separated at one or more interface regions, the method making use of means inserted in an upstream portion of the line to divert incoming spheres into a station pump bypass line and a magazine for retaining and storing a plurality of spheres in readiness to be released into the downstream portion of the line, the steps of diverting a sphere from the main line into a bypass line, delivering such diverted sphere into the storage magazine, detecting the arrival of an interface region at a point near the station pump, releasing a sphere from the magazine into the downstream portion of the line in response to such detection whereby it is launched into said interface region, and then releasing a second sphere from the magazine into the downstream portion in predetermined spaced relationship with the first released sphere.

4. A method as in claim 3 in which a third sphere is released from the magazine after release of the second sphere, the third sphere being released and introduced into the downstream portion of the line in predetermined relationship to the first and second released spheres.

5. A method as in claim 3 in which diverted spheres are stored in the magazine and spheres diverted in a preceding cycle of operation released into the downstream portion of the line.

6. A method as in claim 5 in which the time required for the arrival of the first one of two successive spheres at spaced points along the upstream portion of the line is noted and the spacing between the released spheres is determined by reference to such timing.

7. A system for the handling of product separating spheres at a pumping station where the station is connected to receive liquid from an upstream line portion and to deliver liquid into the downstream portion of the line, a storage magazine adapted to store a plurality of spheres, means for releasing spheres from the storage means and for introducing the same into the downstream portion of the line, means for diverting spheres arriving at the pumping station from the upstream portion of the line, and means for introducing such spheres into the magazine.

8. A system for the handling of product separating spheres at a pumping station where the station is connected to receive liquid from an upstream line portion and to deliver liquid into the downstream portion of the line, a storage magazine adapted to store a plurality of spheres, means for releasing spheres from the storage means and for introducing the same into the downstream portion of the line, and means responsive to the arrival of an interface region between liquid products at a point near the pumping station for controlling the release of spheres from the magazine.

9. A system for the handling of product separating spheres at a pumping station where the station is connected to receive liquid from an upstream line portion and to deliver liquid into the downstream portion of the line, the system including storage means for storing spheres diverted from the line, means for diverting incoming spheres from the upstream portion of the line and for delivering the same into the storage means, and means for successively releasing spheres from the storage means and for introducing the same into the downstream portion of the line, the storage means comprising two first and second spaces serving to store two separate first and second groups of spheres, the first group representing spheres previously diverted from the line and the second group representing spheres immediately diverted from the line, and a valve when closed serving to separate said spaces and said groups of spheres and when open permitting the first group of spheres to progress into the second space of the storage means for introduction into the downstream portion of the line.

10. A system for the handling of product separating spheres at a pumping station where the station is connected to receive liquid from an upstream line portion and to deliver liquid into the downstream portion of the line, the system including storage means for storing spheres diverted from the line, means for diverting incoming spheres from the upstream portion of the line and for delivering the same into the storage means, and means for successively releasing spheres from the storage means and for introducing the same into the downstream portion of the line, the storage means comprising an upright magazine tube, the lower end of the tube being in communication with the downstream portion of the line, an additional valve at the upper end of the tube adapted to be opened to permit introduction of spheres, said first named valve being disposed intermediate the ends of the tube to divide the tube into upper and lower first and second spaces, and a retractable sphere retaining pin at the lower end of the magazine tube.

11. A system as in claim 10 in which a liquid supply pipe is in communication with the magazine tube at a point intermediate the two lowermost spheres in the same, said pipe serving as means for introducing liquid to urge the lowermost sphere downwardly into the downstream line portion when the retaining pin is retracted.

12. A system for handling product separating spheres being flow propelled along a pipeline used for conducting a plurality of liquid products of different specific gravities separated at one or more interface regions, the system being applicable to pipelines at pumping stations where the station has suction and discharge connections to upstream and downstream portions of the line, the system comprising two sphere detectors on the upstream portion of the line, the detectors being spaced apart a predetermined distance representing a predetermined volume, two timing devices responsive to demands from said sphere detectors, each device providing an upcount and a downcount after the upcount is terminated, a sphere storage magazine consisting of a magazine tube having its lower end communicating with the downstream portion of the line, said tube having its upper portion adapted to receive spheres diverted from the line and having its lower portion adapted to store spheres previously diverted from the line, means for releasing spheres successively from the lower portion of the tube into the downstream portion of the line, means downstream from the pumping station but upstream from the point of communication of the magazine tube with the downstream portion of the line for detecting passing of an interface region between products of different specific gravities, means responsive to such detection for actuating and retracting said sphere retaining pin and means responsive to a demand from said gravity indication for causing successive downcounts by said timing devices and for releasing successive spheres after the first released sphere at intervals whereby successive spheres are introduced into the downstream portion of the line at predetermined positions relative to the first sphere.

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