Aug. 8, 1961 M. A. REMKE ET AL 2,995,139

AUTOMATIC CUSTODY TRANSFER SYSTEM

Filed Nov. 16, 1959 2 Sheets-Sheet 1

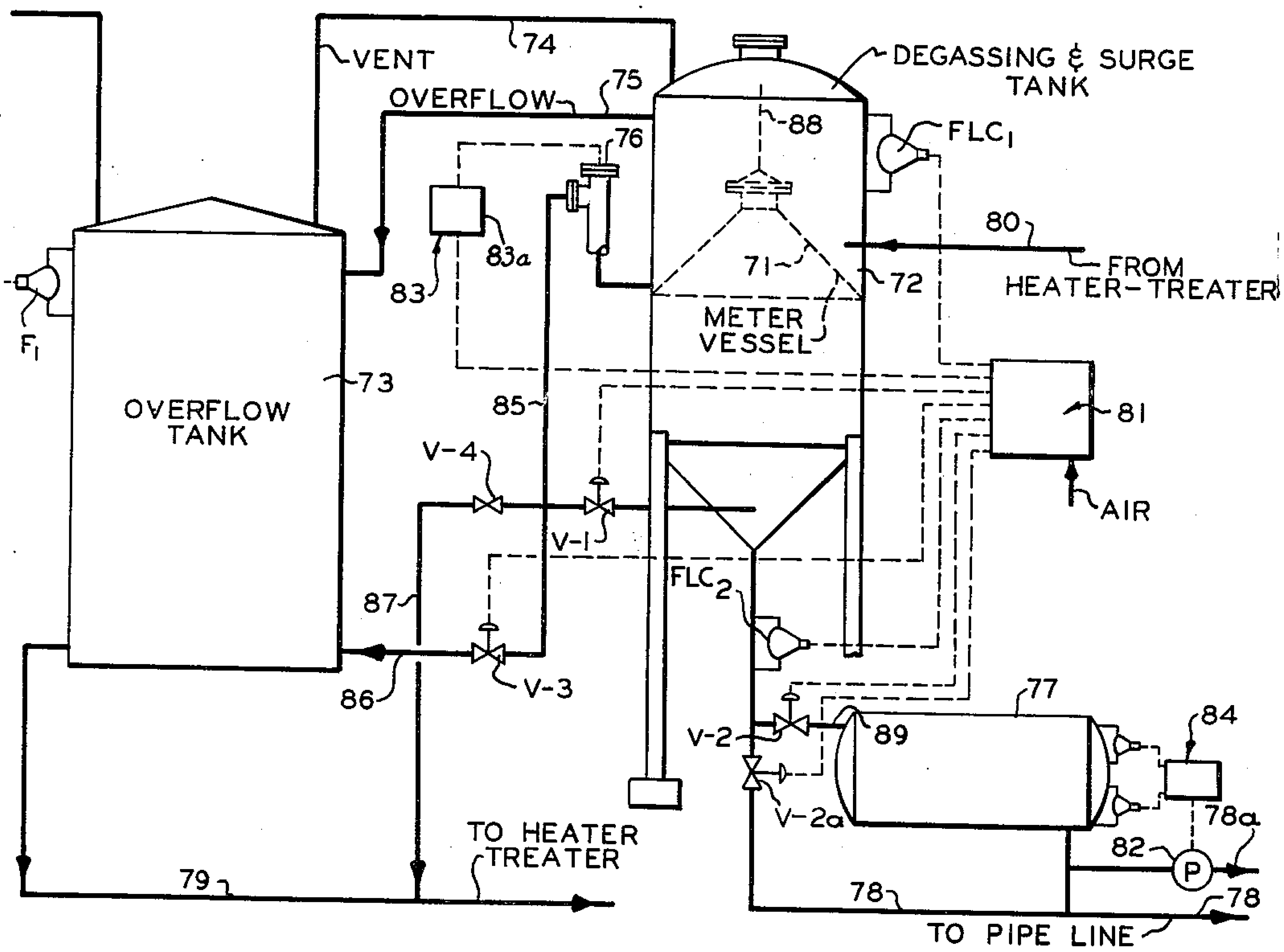

FIG. 1

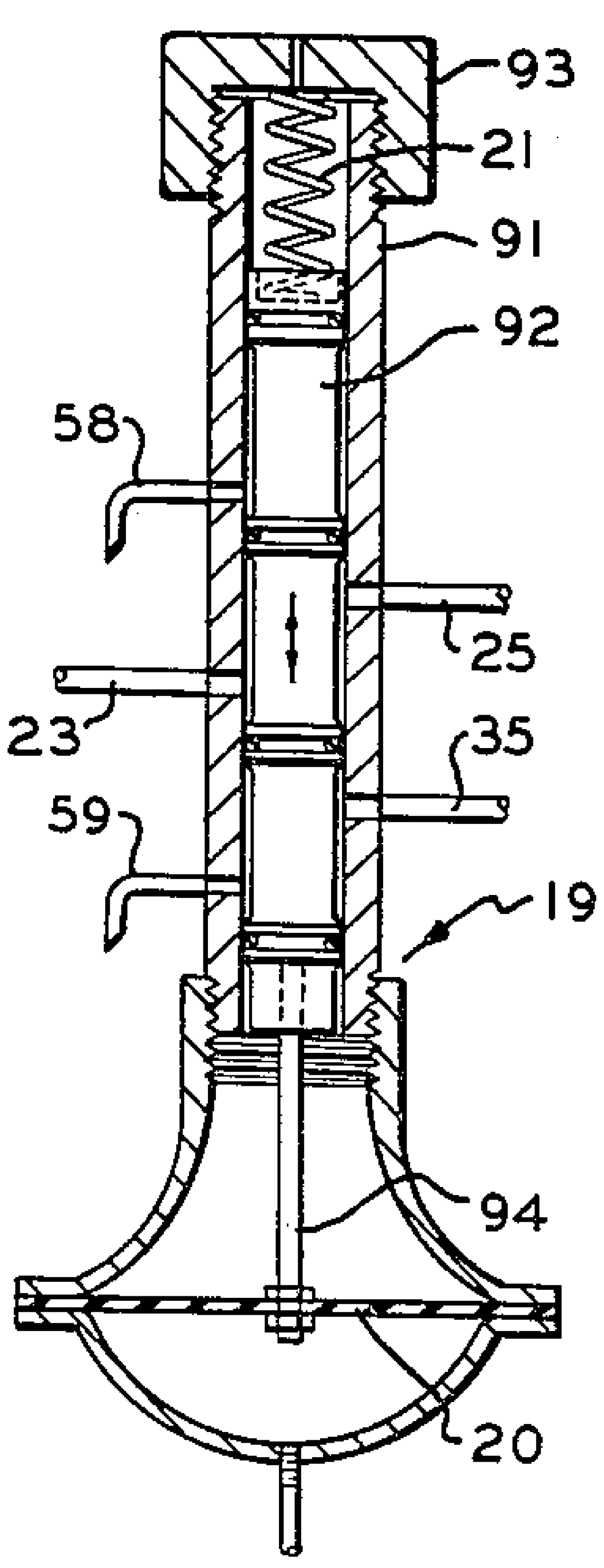

FIG. 3

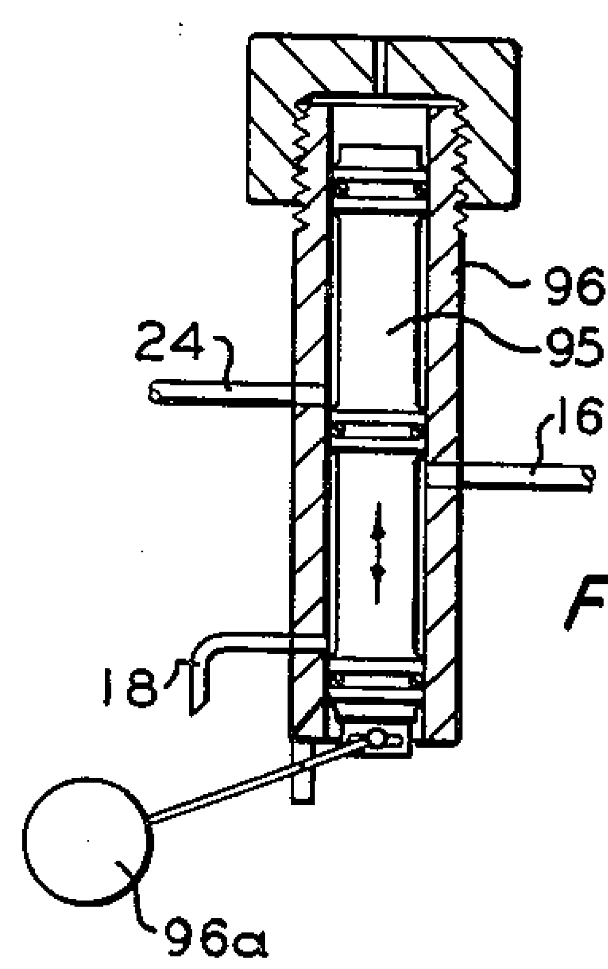

FIG. 4

INVENTORS
M.A. REMKE
G.G. HEBARD
BY Hudson & Young
ATTORNEYS

AUTOMATIC CUSTODY TRANSFER SYSTEM

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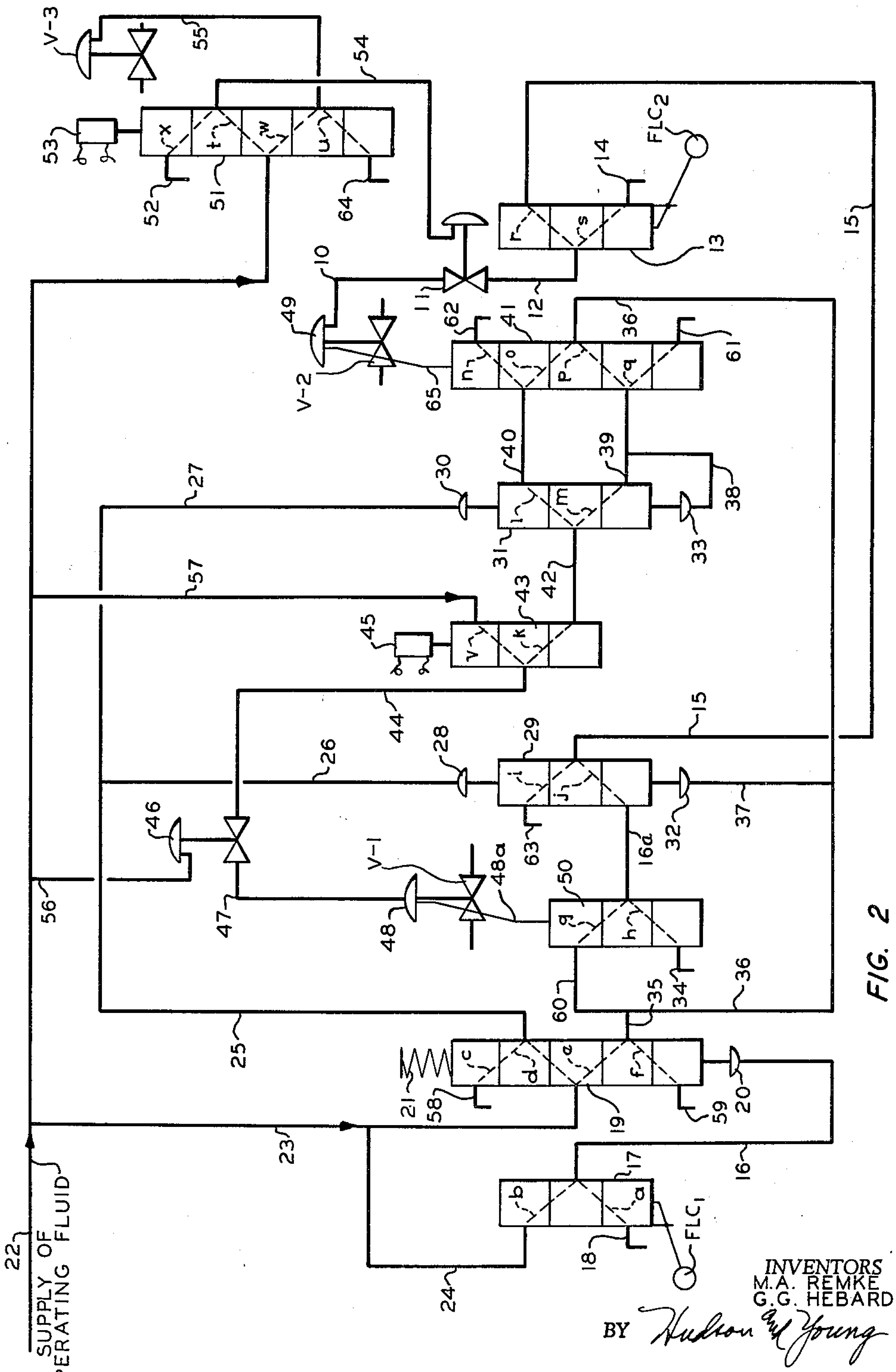

FIG. 2

INVENTORS
M.A. REMKE
G.G. HEBARD
BY Hudson and Young
ATTORNEYS

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AUTOMATIC CUSTODY TRANSFER SYSTEM
Marvin A. Remke and Glen G. Hebard, Bartlesville, Okla., assignors to Phillips Petroleum Company, a corporation of Delaware
Filed Nov. 16, 1959, Ser. No. 853,075
13 Claims. (Cl. 137—2)

This invention relates to the automatic metering and transfer of metered liquids. In one aspect it relates to the automatic transfer of measured volumes of crude oil of predetermined quality as regards B.S. and W. (basic sediment and water) content. In another aspect it relates to the automatic custody transfer of crude oils in areas removed from conventional electric power.

The pumping, transporting, treating and storing of crude oil on the lease has been made automatic to various degrees in recent years. However, the measurement and handling required for the sale or custody transfer of crude oil have not changed to any great extent until quite recently. As far as we are aware, automatic custody transfer of crude oils has not been carried out in regions beyond which conventional electrical power is available.

The present invention is intended to provide an automatic custody transfer system operable in regions which do not have available sources of electrical power. The system and its method of operation involves largely pneumatic controls. However, in such instances where electrical energy is required, the apparatus involved can be modified to operate on battery power.

The terms lease automatic custody transfer, lease automatic transfer, automatic transfer or automatic transfer system as used throughout this specification and claims are used synonymously and interchangeably, and are intended to mean any system, process carried out thereby, or apparatus particularly adapted for use therein and comprise automatic means to inspect a liquid for the presence of a predetermined undesirable amount of at least one selected undesirable constituent, and automatic means to reject the liquid when said constituent content is above said amount, to meter accurately said liquid when said constituent content is below said amount and pass the inspected and metered liquid to a dispensing line, and subcombinations thereof, such as metering means, inspection means, valving means and automatic control means particularly adapted for use therein, and processes carried out thereby. Furthermore, the automatic means to reject contaminated liquid, that is, liquid containing more than the predetermined undesirable amount of the undesirable component, are provided to operate continuously except as interrupted by automatic operation of the system.

The term custody as used in conjunction with lease automatic custody transfer is intended to convey the meaning of the transfer of a liquid, for example, from one owner to another owner. For example, it refers to the transfer of crude oil from the producer to a purchaser.

In this specification we will describe our apparatus and process as applied to the automatic transfer of measured volumes of crude oil of predetermined quality as regards B.S. and W. merely as an example of our process and apparatus. It is realized that measured volumes of other liquids of predetermined quality can be transferred by our apparatus according to the method disclosed herein, such as refined oils, natural gasoline, hydrocarbon products in process, finished hydrocarbon products, and such other hydrocarbon liquids as might be desired to be substantially continuously transferred.

An object of this invention is to provide an automatically operable system for custody transfer of a liquid,

particularly of crude oil. Another object is to provide such a system which is operable in regions beyond which conventional electrical power is available. Yet another object of this invention is to provide such a system and method of its operation involving largely use of pneumatic controls. Still another object of this invention is to provide a pneumatically operable system suitable for the inspection of crude oil for B.S. and W. content, for measuring volumes of the inspected crude oil and for transferring the measured volumes of oil to a pipe line or other source of disposal. Yet other objects and advantages of this invention will be apparent to those skilled in the art upon reading the following description which, taken with the attached drawing, forms a part of this specification.

In the drawing, FIGURE 1 illustrates, in diagrammatic form, an arrangement of apparatus parts suitable for the purpose of this invention. FIGURE 2 illustrates, diagrammatically, the principles upon which the control mechanism operates. FIGURE 3 illustrates, diagrammatically, one form of a pilot valve used in the controls of this invention. FIGURE 4 illustrates, diagrammatically, another form of a pilot valve used in the controls of this invention.

In FIGURE 1, reference numeral **71** identifies a metering vessel of predetermined volume. The outer walls of vessel **71** extend upward above this vessel to form the walls of a surge or degassing vessel **72**. The bottom of the metering vessel is of an inverted conical shape while the top thereof is of conical shape, with the apex pointing upward. The conical-shaped metal top of the metering vessel also serves as the bottom for the degassing vessel **72**. A tank **73**, herein termed an overflow tank, is provided with a float control F_1. A pipe **74** provides for passage of gas separated from oil in vessel **72**, while a pipe **75** is a liquid oil overflow line. A pipe **79** provides for return of oil from tank **73** to a heater-treater system, not shown, for retreating the crude oil for reduction of its B.S. and W. content to a predetermined value. A pipe **80** provides for passage of crude oil from the heater-treater to the degassing vessel **72**. A conduit **85**, provided with a capacitance cell **76** extending into the conduit, leads from the lower portion of degassing vessel **72** to the lower portion of the metering vessel **71**, as shown. This conduit, provided with a diaphragm-operated, normally open motor valve V–1, is connected tangentially to the lower conical portion of the meter vessel so that oil entering the vessel therethrough flows tangentially around the inner walls thereof. Solid matter, such as wax, deposited from the oil tends not to settle on the lower conical wall when oil is added tangentially. A conduit **86**, provided with a normally closed, pneumatically-operated motor valve V–3, leads from conduit **85** upstream from valve V–1 as regards direction of oil flow to the overflow tank **73**. Also, a conduit **87** leads from about the same portion of conduit **85** to pipe **79**. Conduit **87** is provided with a manually operable valve V–4. Normally closed, pneumatically-operable motor valves V–2 and V–2*a* are provided in outlet pipe **89** and in pipe line **78**, respectively. A sump tank **77** is provided, as shown, and may be provided with a level control apparatus **84** in conjunction with a pipe line pump **82** in pipe **78*a***. Pipe line **78** communicates through valve V–2*a* with the bottom of the meter vessel.

A small diameter pipe **88** extends upward from the apex of the meter tank to a level above the level of the outlet to pipe **75**. A float FLC_1 is positioned in the degassing vessel at about the elevation indicated in FIGURE 1, i.e., somewhere along pipe **88** but well below the outlet to pipe **75**. Another float FLC_2 is positioned at the bottom of the meter vessel.

Briefly, the operation of this apparatus is as follows, At the time of starting, valve V–2 and V–2*a* are closed, valve V–1 is open, and oil enters the degassing vessel through pipe **80**. With valve V–1 open, oil flows through conduit **85** and in contact with the capacitance cell **76** of the monitor **83** into the meter vessel **71**. This oil flow continues until the meter vessel is full, that is, until the oil rises into pipe **88**. The levels of the oil inside and outside pipe **88** are then the same. When the oil level outside pipe **88** reaches the float of FLC_1, the valve V–1 closes and valve V–2 or valve V–2*a* opens to allow the metered volume of oil to run to pipe line. When the meter tank goes empty the float of FLC_2 goes down and valve V–2 or V–2*a* closes and valve V–1 opens and oil flows again through conduit **85** into the metering vessel **71**. When the monitor assembly senses bad oil in conduit **85**, regardless of the status of the apparatus, the monitor **83** operates to close valve V–1 and to open valve V–3, thereby running oil from the degassing vessel to the overflow tank **73** until the monitor senses good oil, at which time valve V–3 closes and valve V–1 opens. If bad oil is sensed at a time at which valve V-1 is closed, this valve stays closed and valve V–3 opens.

By the use of such a small diameter pipe as pipe **88**, which can be from one-half inch to one inch in inside diameter, any error in oil level in pipe **88**, as detected by float FLC_1 (i.e., oil level in tank **72**) is negligible, particularly when it is realized that meter tank **71** is of from 10 to 25 barrels' (of 42 gallons) capacity.

When the oil levels in the degassing tank and in pipe **88** reach a predetermined common level as sensed by the float of FLC_1, valve V–1 closes and valve V–2 opens to drain the meter tank. Oil continues to flow into the degassing tank from the heater-treater through pipe **80**. In case the level of oil in the degassing vessel reaches the level of pipe **75**, oil merely overflows into the overflow tank. The float F_1 in the overflow tank **73** is merely for the purpose of shutting in the wells which produce the oil being metered until sufficient oil in this tank is transferred to the heater-treater that the float F_1 drops. At this time oil continues to go to the heater-treater and the wells are opened up for production.

When starting the operation with meter vessel **71** and degassing surge vessel **72** empty, floats of FLC_1 and FLC_2 are down and with valve V–1 open and valve V–2 (V–2*a*) closed. Valves V–3 and V–4 also are closed. Under these conditions the controls illustrated in FIGURE 2 are as follows: Float FLC_1 being down, the valve of the pilot valve **17** is up, since the float is hinged to the housing of the pilot as illustrated, and pressure is vented from a diaphragm motor **20** of pilot valve **19** through tube **16** to vent **18** by way of conduit *a* in the pilot valve **17**. The valve of pilot valve **19**, being spring loaded by compression spring **21**, is down thereby making connection from tube **35** through conduit *f* of pilot **19** to vent through **59**. Tube **35** thus vents air pressure from the diaphragm of diaphragm motor **32** by way of tubes **37** and **36**. While pressure from diaphragm motor **32** of pilot **29** is vented and there is pressure in diaphragm motor **28** from tube **23**, conduit *d* in pilot valve **19**, and tubes **25** and **26**, the valve of pilot **29** is also down and no operation of importance occurs in pilot **29**. Air pressure from tube **25** also enters diaphragm motor **30** via tube **27** and forces the valve of pilot valve **31** downward thereby providing communication from tube **42** to tube **40** by way of conduit *l* of the pilot valve **31**. Valve **46** is open by air pressure through tube **56** as long as operating air pressure is available to the system, thus the diaphragm of motor **48** of valve V–1 is up and the valve is open, air pressure having been vented through tube **47**, valve **46**, tube **44**, conduit *k* in a solenoid (**45**) operated pilot valve **43** (the valve of pilot **43** being up), tube **42**, conduit *l* in pilot valve **31**, tube **40**, conduit *o* in pilot valve **41** (the valve of this pilot valve being down), tube **36**, tube **35**, conduit *f* in pilot valve **19** and through vent **59**.

The pipe line valve V–2 is closed with pressure being vented from the diaphragm motor **49** of valve V–2 through tube **10**, open motor valve **11**, tube **12**, conduit *s* in pilot valve **13** since float FLC_2 is down, and through vent **14**. Linkage **65** connects motor **49** with pilot valve **41** and linkage **48***a* connects motor **48** with pilot valve **50**.

Upon entry of oil through pipe **80** from a heater-treater system, not shown, into the degassing and surge vessel **72**, it flows through a capacitance cell **76** of a monitor **83** and through open valve V–1 into meter vessel **71**. This first oil lifts float FLC_2 thereby lowering the valve of pilot **13** to change the venting of air from tube **12**, conduit *s* and vent **14** in pilot **13** to conduit *r* in pilot **13** and through tube **15**, conduit *i* in pilot **29** to vent through **63**. These conditions exist until the meter tank **71** and the degassing tank **72** fill and the float of FLC_1 rises and the transfer valve V–1 then begins to close. The valve V–1 closes as follows: When the float of FLC_1 rises, the valve of the pilot **17** moves downward thereby closing conduit *a* therethrough and communicating tube **24** with tube **16** by way of conduit *b* in the pilot valve **17** thereby pressuring the diaphragm motor **20** and raising the valve of the pilot **19** against the compression of spring **21**. This operation allows presure from diaphragm motors **28** and **30** to vent through tubes **26** and **27**, respectively, and thence through tube **25**, and conduit *c* in pilot **19** to vent **58**. This operation also admits air pressure from tube **23** through conduit *e* in pilot **19** to tube **35**, tubes **36** and **37** to diaphragm motor **32** there-of spring **21**. This operation allows pressure from diaphragm motor has been vented. When air pressure enters tube **35**, it quickly enters the diaphragm motor **48** because tube **35** already is open thereto through tube **36**, conduit *o* in pilot **41**, tube **40**, conduit *l* in pilot **31**, tube **42**, conduit *k* in pilot **43** and through tube **44**, valve **46** and tube **47**. Valve V–1 thus closes and its closing pushes the valve of pilot **50** downward thereby admitting air pressure from tube **60** to the diaphragm motor **49** of valve V–2 by way of conduit *g* in pilot **50**, tube **16**, conduit *j* of pilot **29**, tube **15**, conduit *r* of pilot **13**, tube **12**, valve **11** and tube **10**. Valve V–2 thus opens.

With the opening of valve V–2, the valve of pilot **41** moves upward thereby changing the fluid passage from tube **36** to tube **42** from that just mentioned to the following: From tube **36** pressure air passes through conduit *p* of pilot **41** into tube **39**. From this tube pressure air passes through tube **38** to pressure diaphragm motor **33** thereby raising the valve in pilot **31** to cause pressure air from tube **39** to pass through conduit *m* to tube **42**, thus maintaining valve V–1 closed.

Valve V–1 is a spring-loaded, normally open valve. Valve V–2 is a spring-loaded, normally closed valve.

The above described condition exists while oil is running to pipe line and as long as float FLC_2 is up. When the meter tank becomes empty, float FLC_2 drops thereby raising the valve of pilot **13** and allowing air pressure from the diaphragm motor **49** of valve V–2 to bleed off through tube **10**, valve **11**, tube **12**, conduit *s* in pilot **13** and vent **14**, under which condition valve V–2 closes since it is a normally closed valve. The float FLC_1 remains up and the valve V–1 closed while the meter tank is running to pipe line.

When valve V–2 closes, the valve of pilot **41** moves downward thus allowing tube **39** to communicate through conduit *q* in pilot **41** with vent **61** thereby relieving air pressure from the diaphragm motor **48** of valve V–1 through tube **47**, valve **46**, tube **44**, conduit *k* in pilot valve **43**, tube **42**, conduit *m* in pilot **31** to tube **39** and out through conduit *q* and vent **61** as mentioned. When pressure is thus removed from diaphragm motor **48** valve V–1 opens since it is a normally open valve. The valve in pilot **50** then rises thereby opening tube **16***a* by way of conduit *h* in pilot **50** to vent **34**. When valve V–1 opens, oil flows from the degassing tank **72** through the capacitance cell **76** and valve V–1 into the meter vessel

Upon lifting of the float FLC_2, the venting of the motor 49 of valve V–2 is changed from vent 14 to tube 15, as hereinbefore set forth.

When valve V–1 is fully open, oil ordinarily passes into the meter vessel from the degassing vessel at a faster rate than it enters the degassing vessel through pipe 80 from the heater-treater. In this manner float FLC_1 drops thereby placing the valves of pilots 17, 19, 50, 29 and 40 in the same positions they occupied at the beginning of the operation.

The system operates as above-described as long as the oil is of a marketable B.S. and W. content. A capacitance cell 76 is included in the conduit leading from the degassing vessel 72 to the meter vessel to keep a continuous check on the B.S. and W. content of the oil in pipe 85. In case the oil ever becomes unmarketable as regards B.S. and W. content, apparatus is provided to return the oil to the heater-treater for retreatment. Since this present lease automatic custody transfer equipment is intended for use in remote areas, that is, in areas in which electrical power is not available, the monitor 83, which includes a capacitance cell and certain electronic recording equipment, is adapted to be operated with batteries as a source of current. A transistorized monitor, with a minimum of changeover to make suitable for battery operation, is described in the Oil and Gas Journal, September 7, 1959, page 215, and can be obtained from United Engineers, Inc., 824 E. Sixth Street, Tulsa, Oklahoma. A similar monitor is also available from The Fisher Governor Company. The electronic and recording equipment of the monitor is housed in a box 83*a* with proper conduit communication to the capacitance cell and to the controller 81. If desired, the contents of box 83*a* can be positioned within the box of controller 81, or box 83*a* can be positioned adjacent the controller 81, as desired.

Also, conventional monitors can be operated with a sufficient number of batteries in series to give the required voltage.

The two solenoid valves 43 and 51 are also battery operated and are connected in the monitor system. On reference to FIGURE 1, the monitor is arranged with the solenoid valves (FIGURE 2) positioned in controller 81 (FIGURE 1) to open or close the operating air supply to valves V–1, V–2 and V–3. Upon sensing bad oil with the monitor while starting up the metering operation, the solenoid 45 connected to valve 43 operates to disconnect tube 44 from tube 42 and to admit air pressure from tube 57 through conduit *v* in valve 43 to tube 44 thereby closing the valve V–1 so that the bad oil cannot enter the meter vessel. Furthermore, solenoid valve 51 is provided to regulate air flow to the diaphragm motor of valve V–3 to open this normally closed valve for the bad oil sensed by the monitor to flow to the overflow tank 73 and thence return by way of pipe 79 to the heater-treater for retreatment. Valve 11 is a normally closed valve and during operation in which the oil contains a suitable low B.S. and W content, the solenoid circuit is open and the valve of pilot 51 is down and air pressure from tube 22 flows through conduit *t* in the valve of pilot 51 and through tube 54 to the motor of valve 11 thereby maintaining this valve open. When bad oil is sensed, the solenoid 53 circuit is closed thereby raising the valve in pilot 51 to admit air pressure from tube 22 through conduit *w* in pilot 51 and tube 55 to the underside of the motor of valve V–3 thereby opening this valve for gravity drainage of oil from the degassing vessel to the overflow tank. This valve V–3 remains open as long as the monitor indicates bad oil. Upon passage of good oil through the monitor cell, the solenoid 53 circuit opens and the valve of pilot 51 drops to bleed pressure air from the motor of valve V–3 through tube 55, conduit *u* and out vent 64. At the same time air flow from tube 22 is re-established to motor valve 11 to open same for passage of meter tank oil to pipe line in normal operation. A time delay feature could, if desired, be installed to cooperate with the monitor assembly so that bad oil would need to flow through the capacitor for 15 to 30 seconds before the monitor controls would operate to close valve V–1 and open valve V–3.

If bad oil is indicated at the time the valve V–1 is closing (full meter vessel), the metered oil will run to pipe line through valve V–2 but valve V–1 will close and remain closed and valve V–3 will open in the manner just described until the oil is cleaned up.

In case bad oil is indicated by the monitor system while valve V–1 is closed, the solenoid valve 43 will admit air pressure to the diaphragm motor 48 and valve V–1 cannot open, but valve V–3 will open. These valves will remain in these latter positions until the oil is cleaned up. At the time the meter vessel has just emptied and valve V–2 is closing, bad oil in the monitor will not permit valve V–1 to open or, if opened, will close the valve. Also pivot valve 51 will hold valve V–2 closed so that bad oil cannot possibly enter the pipe line.

Referring to FIGURE 1, a branch pipe is provided by-passing valve V–2 to pipe line 78. Also, a sump tank 77 is illustrated as positioned between valve V–2 and pump 82 or pipe line 78. When pump 82 is used on the pipe line, the tank provides some storage capacity for oil so that in case a pump is used, oil will be available to the pump so that it will not go on air. Also, by providing tank 77 of suitably large capacity, continuous oil pumping by pump 82 to pipe line 78*a* can be obtained. In case it is desired to pass oil directly from the meter vessel to pipe line by gravity flow, valve V–2*a* is provided, as illustrated. This valve is exactly like valve V–2, and it can be operated in the system as herein explained by merely disconnecting the operational conduit from valve V–2 and connecting it with valve V–2*a* so that controller 81 functions to operate this valve. The sump tank 77 can also be used when a pipe line pump is not employed. In this case, the meter tank rapidly dumps into the sump tank, which is much less rapidly discharging to pipe line. In this manner, by the time the meter tank is empty, the sump tank is full, the meter tank quickly fills and starts discharging into the sump tank before the sump tank is empty of its previously metered oil. In this manner, gravity flow to pipe line is continuous as long as good oil is available from the heater-treater.

The controller assembly 81, in FIGURE 1, contains most of the apparatus illustrated in FIGURE 2. Parts not included in 81 are such elements as valves V–1, V–2, V–2*a* and V–3, and of course the floats of FLC_1 and FLC_2.

Controller box 83*a* may contain such equipment as the batteries for operation of the monitor and solenoids 45 and 53.

While it is possible to provide automatic starting and stopping equipment for a gas engine used to power a pipe line pump, the present lease automatic custody transfer system is intended to be used in areas which do not have electrical power available. In such a case a pipe line pump is not used and the metered oil runs through valve V–2*a* to the pipe line merely by gravity flow, or by way of the sump tank 77. When the sump tank 77 is used without a pipe line pump, floats and controller 84 obviously are not employed.

In FIGURE 1 is illustrated the construction of the degassing tank-meter tank combination. As mentioned above, the inside diameter of pipe 88 (one-half inch to one inch) is so small when considered relative to, for example, a 10 to 25 barrel capacity meter tank 71, that an error of even several inches in the level sensed by float FLC_1 for closing valve V–1 and opening valve V–2, or V–2*a*, is negligible.

FIGURES 3 and 4 illustrate forms of pilot valves which can be used for pilot valves **17**, **19**, **50**, **29**, **43**, **39**, **41**, **13** and **51**.

In FIGURE 3 is illustrated a spring loaded valve, like pilot valve **19**. This valve, as illustrated also in FIGURE 2, is provided with a diaphragm motor **20** and at the other end a compression spring **21**. Tubes **23**, **25** and **35** and vents **58** and **59** are illustrated as used with pilot valve **19** of FIGURE 1. Pilot valve **41** is not provided with a spring but a linkage **65** attaches the valve of the pilot to the diaphragm motor. Linkage or rod **65** is, in this case, attached to the top of valve **92** (FIGURE 3) in such a manner that rod **94** is attached to the valve.

The valve body **91** and spring **21** are provided with a cap **93**, as shown.

The valve of pilot **51** is attached to the solenoid **53**.

Pilot valves **17**, **50**, **29**, **43**, **31** and **13** are, in general, similar to the valve illustrated in FIGURE 4. Specifically, FIGURE 4 shows pilot **17** having a slidable valve **95** in case **96** and operatively pivoted to a float **96a**. It is shown having inlets and outlets **24**, **16** and **18**.

While this system is described as being pneumatically operated and thus adapted for operation in isolated areas, it can be provided with electrical controls for use in areas in which electric power is available. In this respect the utility of the system is thus extended.

While this system is herein described as having the meter vesssel **71** directly under the receiving vessel **72**, this particular arrangement of vessels is not critical because, if desired, the meter vessel can be positioned at one side of the receiving vessel or even at some distance therefrom. However, the meter vessel must be placed at an elevation below the receiving vessel in such a manner that liquid can flow by gravity from the receiving vessel into the meter vessel.

In the operation of the degassing tank-meter tank combination of this invention, it is intended that the outlet pipe from the meter tank to the pipe line or to other disposal be quite large in diameter. The conduit **85** leading from the degassing tank to the meter vessel also should be quite large in diameter. The oil inlet pipe **80** should be small in diameter in comparison to conduit **85** and the outlet from the meter vessel so that the meter vessel can be filled and emptied before the oil level in the degassing vessel reaches the level of the overflow pipe **75**, in which case oil will overflow to the tank **78**. Such overflow oil then is unnecessarily handled.

Pipe line companies frequently refuse to purchase crude oils having B.S. and W. contents greater than ½%. In such case the monitor is set to actuate apparatus to close valve V–**1** and to open valve V–**3** when oil having a higher B.S. and W. than ½%. However, such monitors can be adjusted to actuate the control mechanisms at other B.S. and W. contents, when necessary.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto.

That which is claimed is:

1. A method for transferring a known volume of a liquid having less than a predetermined concentration of an impurity to a point of delivery comprising continuously passing liquid containing said impurity into a receiving zone, flowing liquid from said receiving zone by gravity flow into an impurity sensing zone and therein sensing the concentration of said impurity, flowing by gravity flow only liquid having less than said predetermined concentration of said impurity from said impurity sensing zone into a metering zone of known volume until the level of liquid in said metering zone and the level of liquid in said receiving zone reach a predetermined common level, terminating the gravity flow of liquid into said metering zone and passing the liquid from the metering zone to said point of delivery.

2. A method for transferring a known volume of a liquid having less than a predetermined concentration

of an impurity to a point of delivery comprising continuously passing liquid containing said impurity into a receiving zone, flowing liquid from said receiving zone by gravity flow into an impurity sensing zone and therein sensing the concentration of said impurity, flowing by gravity flow only liquid having less than said predetermined concentration of said impurity from said impurity sensing zone into a metering zone of known volume until the level of liquid in said metering zone and the level of liquid in said receiving zone reach a predetermined common level, terminating the gravity flow of liquid into said metering zone and passing the liquid from the metering zone to said point of delivery, the minimum possible rate of liquid flow from said receiving zone being greater than the rate of passing of said liquid into said receiving zone.

3. A method for transferring a known volume of a liquid having less than a predetermined concentration of an impurity to a point of delivery comprising continuously passing liquid containing said impurity into a receiving zone, flowing liquid from said receiving zone by gravity flow into an impurity sensing zone and therein sensing the concentration of said impurity, flowing by gravity flow liquid having said predetermined concentration and more than said predetermined concentration of said impurity from said impurity sensing zone into an intermediate zone, flowing by gravity flow only liquid having less than said predetermined concentration of said impurity from said impurity sensing zone into a metering zone of known volume until the level of liquid in said metering zone and the level of liquid in said receiving zone reach a predetermined common level, terminating the gravity flow of liquid into said metering zone and passing the liquid from the metering zone to said point of delivery.

4. A method for transferring a known volume of a liquid having less than a predetermined concentration of an impurity to a point of delivery comprising continuously passing liquid containing said impurity into a receiving zone, flowing liquid from said receiving zone by gravity flow into an impurity sensing zone and therein sensing the concentration of said impurity, flowing by gravity flow liquid having said predetermined concentration and more than said predetermined concentration of said impurity from said impurity sensing zone into an intermediate zone, flowing by gravity flow only liquid having less than said predetermined concentration of said impurity from said impurity sensing zone into a metering zone of known volume until the level of liquid in said metering zone and the level of liquid in said receiving zone reach a predetermined common level, terminating the gravity flow of liquid into said metering zone and passing the liquid from the metering zone to said point of delivery, the minimum possible rate of liquid flow from said receiving zone being greater than the rate of passing of said liquid into said receiving zone.

5. A method for transferring a known volume of a liquid having less than a predetermined concentration of an impurity to a point of delivery comprising continuously and slowly passing liquid containing said impurity into a receiving zone, flowing liquid from said receiving zone by gravity flow into an impurity sensing zone and therein sensing the concentration of said impurity, rapidly flowing by gravity flow only liquid having less than said predetermined concentration of said impurity from said impurity sensing zone into a metering zone of known volume until the level of liquid in said metering zone and the level of liquid in said receiving zone reach a predetermined common level, terminating the gravity flow of liquid into said metering zone and rapidly passing the liquid from the metering zone to said point of delivery.

6. A method for transferring a known volume of a liquid having less than a predetermined concentration of

an impurity to a point of delivery comprising continuously and slowly passing liquid containing said impurity into a receiving zone, flowing liquid from said receiving zone by gravity flow into an impurity sensing zone and therein sensing the concentration of said impurity, rapidly flowing by gravity flow liquid having said predetermined concentration and more than said predetermined concentration of said impurity from said impurity sensing zone into an intermediate zone, flowing by gravity flow only liquid having less than said predetermined concentration of said impurity from said impurity sensing zone into a metering zone of known volume until the level of liquid in said metering zone and the level of liquid in said receiving zone reach a predetermined common level, terminating the gravity flow of liquid into said metering zone and rapidly passing the liquid from the metering zone to said point of delivery.

7. A metering system for liquids comprising a first vessel having a first liquid outlet near its bottom, a second outlet near its top and a liquid inlet intermediate these outlets, a second vessel having a bottom outlet line provided with a first valve, a conduit extending from said first liquid outlet to said second vessel, a second valve in said conduit, said second vessel being disposed at such an elevation below the elevation of said first vessel that liquid flows by gravity through said conduit filling said second vessel, an opening in the top of said second vessel, a tubular member extending from said opening to said first vessel at a level above the level of said second outlet, means for sensing liquid level in said first vessel at a level intermediate the levels of said inlet and said second outlet and closing said second valve.

8. The system of claim 7 incuding second means for sensing liquid level in said bottom outlet line intermediate said first valve and the bottom of said second vessel and adjacent said second vessel and closing said first valve.

9. In the system of claim 8, said second means also opening said first valve.

10. In the system of claim 9, a third vessel having its top at an elevation below the elevation of said second liquid outlet, a second conduit communicating said second liquid outlet with said third vessel, a third conduit communicating said first conduit intermediate the valve therein and said first outlet with said third vessel, a third valve in said third conduit, and means for sensing an impurity in a liquid in said first conduit intermediate said first liquid outlet and the point of communication of said third conduit with said first conduit and for closing said second valve, for opening said third valve, for closing said third valve and opening said second valve.

11. A metering system for liquids comprising an upright tank having a frusto-conical partition therein dividing said tanks into an upper first vessel and a lower second vessel, said frusto-conical partition having its smaller diameter end above its larger diameter end, a first liquid outlet in the upper vessel near said partition, a second outlet in said upper vessel near its top, a liquid inlet in said upper vessel intermediate the outlets, a tubular member sealed fluid-tight to the periphery of the smaller diameter end of said partition and extending upward to an elevation above said second outlet, a liquid outlet provided with a first valve in the bottom of said lower vessel, a liquid inlet in said lower vessel, a first conduit leading from said first liquid outlet to the liquid inlet of said lower vessel, a second valve in said conduit, means for sensing liquid level in said upper vessel at an elevation intermediate the elevations of said liquid inlet and said second outlet and for closing said second valve.

12. In the system of claim 11, a means for sensing liquid level in the liquid outlet of said lower vessel and intermediate said first valve and said lower vessel and for closing said first valve and opening said second valve.

13. In the system of claim 12, a third vessel having its top at an elevation below the elevation of said second liquid outlet, a second conduit communicating said second liquid outlet with said third vessel, a third conduit communicating said first conduit intermediate the valve therein and said first outlet with said third vessel, a third valve in said third conduit, and means for sensing an impurity in a liquid in said first conduit intermediate said first liquid outlet and the point of communication of said third conduit with said first conduit and for closing said second valve, for opening said third valve, for closing said third valve and opening said second valve.

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