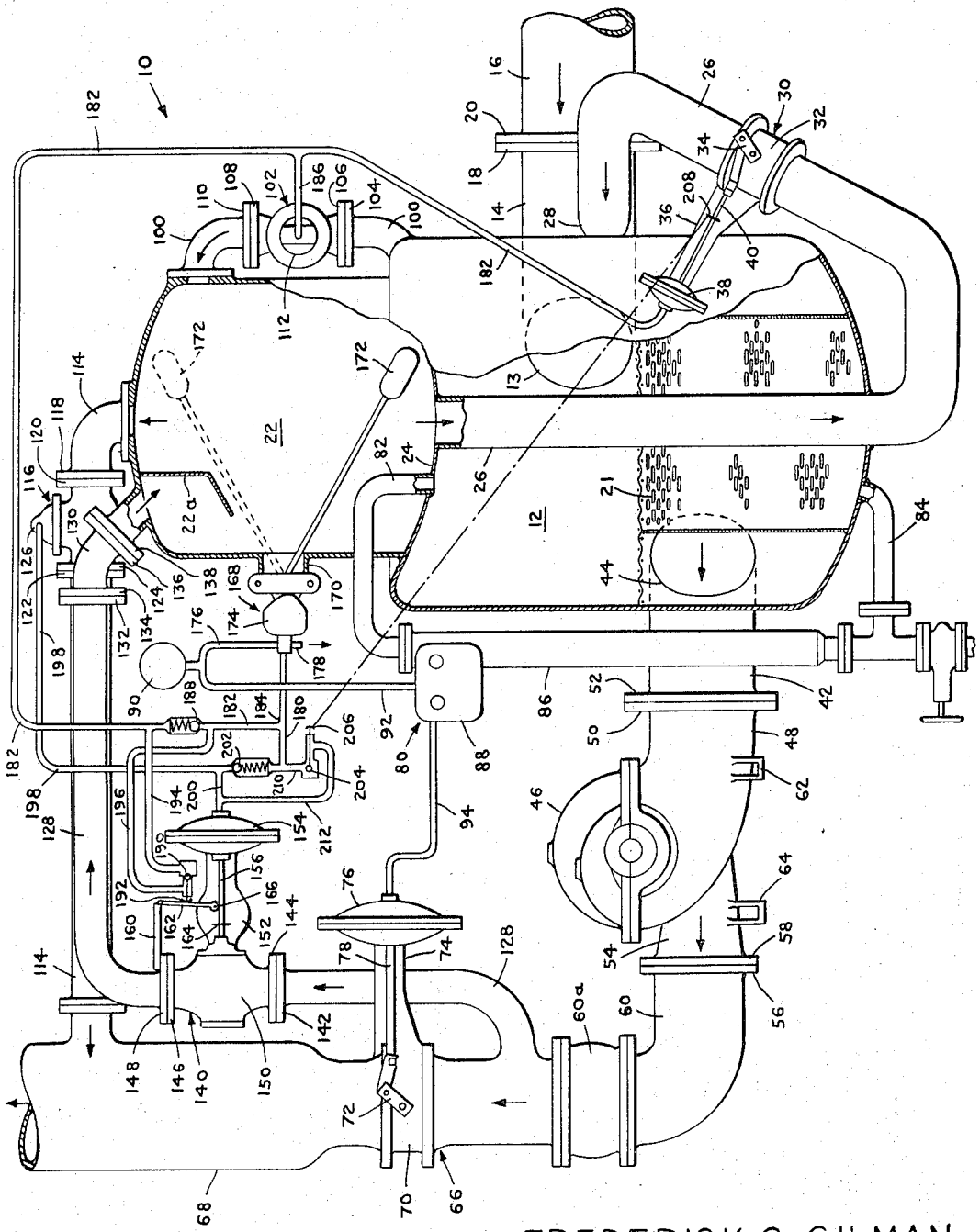
Jan. 9, 1968 F. C. GILMAN 3,362,337

SYSTEM FOR COLLECTING GASES AND VAPORS FROM THE SUCTION SIDE OF TANKER UNLOADING PUMPS AND DISCHARGING THEM WITH THE CARGO TO SHORE STORAGE

Filed July 27, 1966



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United States Patent Office 3,362,337
Patented Jan. 9, 1968

3,362,337

SYSTEM FOR COLLECTING GASES AND VAPORS FROM THE SUCTION SIDE OF TANKER UNLOADING PUMPS AND DISCHARGING THEM WITH THE CARGO TO SHORE STORAGE

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Filed July 27, 1966, Ser. No. 568,196
18 Claims. (Cl. 103—113)

This invention relates to pumping systems and, more particularly, to pumping systems which function through the collection of gases and vapors in a liquid to be pumped prior to the introduction of the latter to the pump, and the reintroduction to and discharge of the said gases and vapors with the said liquid after the discharge of the latter from the pump.

Centrifugal pumps have been used for discharging the major portion of the fuel oil from the compartments of tanker ships. However, because of the volatility of the cargo and the likelihood of gas entering the suction openings when tanks are nearly empty it has been found necessary to augment the centrifugal pumps with various gas and vapor handling system. Centrifugal pumps, especially the more efficient types, have a serious limitation on the volumetric proportion of gas which can be passed through the pump with the normal liquid load. When this volume fraction at the suction is exceeded, the rejected gas accumulates as a hollow core surrounding the pump shaft and eventually impairs the operation of the pump to the point where all flow stops.

Various means have been adopted to overcome the gas handling limitation of centrifugal pumps in tanker service. Traditionally, separate pumps of the positive displacement reciprocating type known in the trade as stripper pumps, were provded to finish unloading the oil tanks beyond the level to which the centrifugal pumps could operate effectively. More recently it has been found that separate stripper pumps may be dispensed with if some other means is provided to remove gases and vapors from the liquid cargo before it enters the centrifugal pump impeller. Another stratagem has been to provide a flow-responsive valve which permits recirculation of pumped liquid to the suction region of the pump when normal flow is sharply curtailed. In this way a limited rate of gas flow is carried thru the pump, eventually eliminating the gas from the pump suction and restoring the normal liquid flow rate. This latter system for re-priming or self-priming suffers by comparison with any method which continuously removes gases and vapors from the pumped liquid prior to its entry into the centrifugal pump impeller. This is because there will be a period of deteriorating performance prior to the activation of the re-priming cycle and the re-priming operation will itself require some time.

The present invention belongs to the class of equipments which provide for continuous withdrawal of gases and vapors from the pumped liquid and thus maintain full rated pump performance throughout the complete process of tanker unloading. Unlike previously disclosed systems of this class, this invention does not require a separate vacuum pump for its normal operation. Another advantage over previous systems other than those using positive displacement vacuum pumps is that the present invention permits discharging the removed gases and vapors into the cargo discharge line. This is preferred since it eliminates oil waste and the need for an above-deck atmospheric vent, otherwise required for fire safety. The system can, nevertheless, be readily adapted for atmospheric discharging of gases and vapors if the latter disposition is preferred.

The present invention in association with a standard centrifugal pump has proven to be not only more economical insofar as installed cost for a given rate of fuel cargo unloading is concerned but, because of the absence of auxiliary machinery, one that will require less expenditure for maintenance and repair.

It is, accordingly, an object of this invention to provide a pumping system which utilizes a centrifugal pump but is nonetheless fully capable, without auxiliary pump means, of pumping liquids which contain not insignificant portions of gases and vapors therein.

Another object of this invention is the provision of a pumping system as above which is capable of substantially continuous operation at high system performance efficiencies.

Another object of this invention is the provision of a pumping system as above which, though functioning through the separation and removal of the gases and vapors from the liquid to be pumped prior to the introduction of the latter to the centrifugal pump, enables the convenient re-introduction of the separated gases and vapors to the liquid after the discharge of the latter from the pump to thereby prevent the waste of the said gases and vapors and, in cases wherein the said liquid is of an inflammable nature, minimize the safety hazards inherent in the pumping theerof.

It is another object of this invention to provide a pumping system as above which requires the use of only readily available components of proven dependability, many of which are positioned therein in readily removable manner, whereby the costs of fabrication, installation and maintenance of the system are minimized and long periods of satisfactory and dependable operation thereof assured.

In a herein disclosed preferred embodiment of the invention, the pumping system is particularly adapted to the pumping of oil cargoes from oil tanker cargo tanks, to shore stores and, to that effect, comprises a centrifugal pump having inlet and discharge means. Gas and vapor separating means are connected to the ship's cargo tanks and to the pump inlet means and function to separate gases and vapors from the cargo oil before the introduction thereof to the centrifugal pump. Gas and vapor collecting means are connected to said separating means to collect gases and vapors therefrom, and means are provided to periodically return a portion of the oil discharged from the pump through the collecting means and therefrom back to the pump suction means for displacing the gases and vapors from the said collecting means and reintroducing the same to the said discharged liquid.

The above and other objects and advantages of the system are believed made clear by the following detailed description thereof taken in conjunction with the accompanying drawings wherein:

The figure is a diagrammatic view of the system of the invention.

Referring now to the figure, the system of the invention is generally indicated at **10** and may be seen to comprise a generally cylindrical suction tank **12** including a tangentially, as indicated at **13**, disposed inlet pipe **14** extending therefrom for readily removable connection, as shown, to oil supply pipe **16** thru abutting connection flanges **18** and **20**, respectively. Oil supply **16** extends into connection with the discharge areas of the non-illustrated ship's cargo tanks, whereby the ship's oil cargo may be readily supplied from the said cargo tanks to the system of the invention for satisfactory discharge therefrom as described in detail herein below.

A trash screen **21** of generally perforate plate construction is disposed as shown for obvious purpose in the lower portion of suction tank **12**, and is designed to provide minimum resistance to the rotating liquid flow and

thus conserve a major portion of the tangential velocity or whirl energy imparted to the oil as a result of the generally tangential direction of introduction thereof to the said suction tank thru inlet pipe 14. Alternatively, the construction of the said trash screen may take the form of a non-illustrated bar screen comprising a series of concentric circular bars which, though more expensive, would provide even less resistance to the rotating liquid flow.

A vent tank 22 is disposed as shown atop the suction tank 12 in generally concentric manner relative thereto, with the respective interiors of the said vent and suction tanks being separated as shown by a common tank wall 24 extending therebetween.

An oil return pipe 26 extends, in the depicted generally central manner, from the lowermost portion of the vent tank 22 thru the interior of the suction tank 12 and therefrom into generally tangential connection with the suction tank inlet pipe 14, as indicated at 28. Thus, any oil returned to the inlet pipe 14 will be introduced so as to increase the oil velocity and the whirl energy imparted to the oil entering the suction tank 12.

A butterfly valve assembly, generally indicated at 30, is disposed in the oil return pipe 26 intermediate the vent tank 22 and inlet conduit 14 to control the flow of oil therebetween.

The said butterfly valve assembly 30 comprises a valve casing 32, with valve operating linkage means 34 pivotally positioned thereon, and diaphragm support bracket 36 extending therefrom. A valve actuating diaphragm assembly 38 is supported on the support bracket 36, and an elongated valve stem 40 extends as shown between the diaphragm assembly and valve operating linkage, whereby actuation of the butterfly valve may be readily effected through operation of the said diaphragm assembly.

A suction tank outlet pipe 42 extends, in the depicted generally tangential manner as indicated at 44, from the suction tank 12.

A centrifugal pump 46, of suitable performance characteristics, is disposed as shown adjacent the outlet line 42, and includes pump inlet casing 48 which extends into fluid flow communication with the said outlet line and is connected thereto, in readily removable manner, through abutting connection flanges 50 and 52, respectively. Thus is believed made clear whereby the tangential disposition of the suction tank outlet pipe 42 and direct connection thereof to the centrifugal pump inlet casing 48, will function to improve centrifugal pump operating efficiency by converting the tangential velocity of the oil in suction tank 12 to straight line flow in outlet pipe 42 and pump inlet casing 48, with minimum velocity loss, to thus materially improve suction condition in the said pump inlet casing.

Centrifugal pump outlet casing 54 is in turn connected, in readily removable manner, through abutting connection flanges 56 and 58, to main cargo discharge pipe 60 to provide for the discharge of oil from the suction tank 12 through the said main cargo discharge pipe as should be obvious. Mounting brackets 62 and 64 may, if desired, be provided as shown on the respective centrifugal pump inlet and outlet casings to facilitate the mounting of the pump at the desired location on the ship.

A second butterfly valve assembly, generally indicated at 66, is disposed as shown in main cargo discharge pipe 60 slightly upstream of a generally enlarged portion 68 of the latter.

In the manner of butterfly valve assembly 30, the butterfly valve assembly 66 comprises a valve casing 70, valve operating linkage means 72, diaphragm support bracket 74, valve actuating diaphragm assembly 76 and valve stem 78, respectively, to enable the actuation of this butterfly valve, and resultant control of the flow of oil through main cargo discharge pipe 60, through operation of diaphragm assembly 76.

A standard displacer type liquid level responsive controller of suitable performance characteristics, as for example one of the nature manufactured and sold by the Mason Neilan Division of the Worthington Corporation, is indicated generally at 80 and is set up for proportional control operation for purposes described in detail herein below.

The controller 80 comprises connecting pipes 82 and 84, respectively, which extend as shown from a displacer rod casing 86 into fluid flow communication with the respective upper and lower areas of the suction tank 12, whereby may be readily understood that the said controller will thus be proportionally operable in response to the level of oil within the said suction tank in the manner well known to those skilled in this art.

Connecting pipes 82 and 84 extend into relatively central portions of the upper and lower suction tank areas to minimize the effects of the tangential velocity of the oil within the said suction tank upon operation of the controller 80.

The control signal forming means of the controller 80 are indicated at 88 and are disposed as shown on the displacer rod casing 86. Compressed actuating air from any convenient source thereof, as for example the ship's normal compressed air system as indicated at 90, is communicated to the control signal forming means 88 by air conduit 92 extending therebetween, and the said forming means are in turn connected to the diaphragm assembly 76 of butterfly valve assembly 66 by air conduit 94 extending therebetween, whereby compressed air control signals, proportional to the level of oil within suction tank 12, may be fed to diaphragm assembly 76 to result in operation of the latter and attendant actuation of butterfly valve assembly 66.

In the herein disclosed preferred embodiment, controller 80 is set up for proportional operation in such manner that a lower level of oil within suction tank 12 will result in a proportionally higher pressure control signal to diaphragm assembly 76 to effect a progressively greater closing of the butterfly valve assembly 66 and attendant reduction in the flow area of main cargo discharge pipe 60.

A gas and vapor vent pipe 100 extends as shown from an upper corner of suction tank 12 to the upper portion of vent tank 22. Thus, any gas entering the suction tank 12 with the liquid oil cargo through the tangential inlet pipe 14 will be separated therefrom toward the center of the suction tank due to the centrifugal forces therewithin, and will concurrently rise upwardly therein due to the natural gas buoyancy, it being noted that the suction tank 12 is so sized to ensure that the downward progress of the liquid oil therein does not exceed the relative rising rate of any but the smallest of gas bubbles. In addition, the peripheral disposition of the suction tank outlet pipe 42 makes impossible the drawing of a gas vortex core into the inlet casing 48 of centrifugal pump 46. Thus, the gases and vapors which rise to the top of the suction tank will in turn rise therefrom through the gas and vapor vent pipe 100 to the top of the vent tank 22, with space therefor being provided by the return of an equal volume of oil from the bottom of the vent tank to the inlet pipe 14 of the suction tank, through oil return pipe 26 as described in detail hereinbelow.

A valve assembly, generally indicated at 102 is positioned as shown, in readily removable manner, in the gas and vapor vent pipe 100 through the medium of abutting connection flanges 104, 106, 108 and 110, respectively. A valve actuating, diaphragm assembly 112 is positioned on the valve assembly 102 and functions to control the opening and closing of the former with resultant control of the gas and vapor flow through the vent pipe 100.

A gas discharge pipe 114 extends as shown from the top of vent tank 22 to the enlarged portion 68 of the main oil cargo discharge pipe 60, and includes a pneumatically operable valve assembly, generally indicated at 116, positioned therein, in readily removable manner, through the medium of connection flanges 118, 120, 122 and 124. A

diphragm assembly **126** is positioned on valve **116** for operating the latter as described in detail hereinbelow.

A connecting pipe **128** extends as shown from the main cargo, oil discharge pipe **60** to the top of the vent tank **22**, and includes an elbow portion **130** positioned therein, in readily removable manner, through the medium of abutting connection flanges **132**, **134**, **136**, and **138**, respectively.

A pneumatically operable valve assembly **140** is disposed, in readily removable manner through the medium of abutting connection flanges **142**, **144**, **146** and **148**, in connecting pipe **128** to control the flow of oil through the latter. The valve assembly **140** includes a valve casing **150**, and a diphragm support bracket **152** extending therefrom, a valve actuating diaghragm assembly **154** supported on the said support bracket, and a generally elongated valve stem **156** extending between the said valve casing and diaphragm assembly for obvious purpose.

A support member **160** extends as shown from connection flange **148**, and includes an air valve actuator member **162** pivotally mounted on the remote extremity thereof. Abutment means **164** are disposed on valve stem **156** in such manner relative to the adjacent extremity **166** of actuator member **162** that the said abutment means will abut and move the said actuator member, for purposes described in detail hereinbelow, upon movement of valve stem **156** in the valve **140** closing direction, i.e. to the right as seen in the figure.

A float operated control assembly, generally indicated at **168** is disposed as shown on a control assembly mounting pipe **170** which extends from the central portion of the vent tank **22**.

The float operated control assembly **168** comprises pivotally mounted float means **172** which extends as shown through mounting pipe **170** into the interior of the vent tank **22** and is pivotally moveable therein between the upper and lower control limit positions thereof depicted in dashed and solid lines, respectively; and a snap acting type, two-way air control valve **174** which includes the compressed actuating air supply line **176** for communicating the source **90** of compressed actuating air therewith, an exhaust line **178** extending therefrom to atmosphere and an actuating signal air line **180** for purposes described in more detail below.

The snap acting type, two-way air control valve of the present invention is a pneumatic type float operated level switch manufactured by Instruments Inc., a division of National Tank Company, Tulsa, Okla., and is easily purchasable on the open market.

The snap acting, two-way air control valve **174** operates so that the float means **172** at the lower control limit of the valve will open communication between actuating air supply line **176** and actuating signal air line **180** to provide a control signal in line **180** and at the same time close the exhaust line **178**. Conversely, when the float means **172** is moved to the upper control limit position thereof, the air control valve **174** will close communication between the line **176** and **180** to discontinue the said control signal, and will open communication between lines **180** and **178** to vent the former to atmosphere.

An air line **182** extends as shown from a juncture thereof with line **180**, as indicated at **184**, into fluid flow communication with diaphragm assembly **38** of butterfly valve assembly **30** and, through the medium of connecting line **186**, into fluid flow communication with diaphragm assembly **112** of valve assembly **102**.

A spring loaded, ball check valve **188** is disposed in an enlarged portion of line **182** and is arranged to permit actuating air flow therein only in the direction toward the respective diaphragm assemblies **112** and **38**.

A mechanically operated air control valve **190**, including a valve actuating member **192** projecting therefrom into abutment with actuator member **162**, is connected in parallel with line **182** by lines **194** and **196**, respectively, in such manner as to provide a bypass for the flow of actuating air around the check valve **188** in line **182** in the direction toward line **180**.

An air line **198** extends as shown from the extremity of line **180** into fluid flow communication with diaphragm assembly **126** of valve **116** and, through the medium of connecting line **200**, into fluid flow communication with diaphragm assembly **154** of valve assembly **140**.

A spring loaded, ball check valve **202** is disposed as shown in an enlarged portion of line **198** and is arranged to permit actuating air flow in the latter only in the direction toward line **180**.

A mechanically operated air control valve **204**, including a valve actuating member **206** projecting therefrom into abutment with actuator member **208** of valve stem **40** as indicated by the dashed line extending therebetween, is connected as shown in parallel with line **198** by lines **210**, **212** and a portion of line **200**, respectively, in such manner as to provide a bypass for the flow of actuating air around the check valve **202** in line **198** in the direction toward the respective diaphragm assemblies **154** and **126**.

It is to be noted that in the actual construction of the apparatus of the invention, air control valve **204** would most probably be placed in much closer proximity to actuator member **208** of valve assembly **30** in any convenient manner, as for example through a substantial lengthening of air lines **210** and **212**, to make unnecessary the inconvenient use of an overly long valve actuating member **206**.

Prior to a detailed description of the operation of the system of the invention, it is to be noted that butterfly valve assembly **66**, although not normally so positioned, can be biased so that the said valve will provide an approximately 5 p.s.i. oil pressure differential thereacross with normal discharge oil flow through main cargo discharge pipe **60**. This, combined with the oil pressure differential which will normally exist between the said main cargo discharge pipe and the generally enlarged portion **68** thereof may thus be readily understood to insure an oil pressure differential between the juncture of connecting pipe **128** with pipe **60** and the juncture of connecting pipe **114** with the said enlarged portion **68** for purposes described in detail hereinbelow. In addition, it is to be noted that each of valve assemblies **30** and **102** are arranged so that the respective valves thereof are in the open positions when there is no pressurized air being communicated to the respective valve diaphragm assemblies **38** and **112**; while valve assemblies **140** and **116** are arranged so that the respective valves thereof are in the closed positions under the same conditions.

Further, a check valve **60***a* is provided in line **60** to prevent back flow of oil to the suction side of pump **46**, more particularly when the gas collecting and stripping means of the present system goes into operation.

Operation

With the ship's oil cargo tanks full at the commencement of operation, and the system of the invention disposed in the ship at a lower level than the surface of the oil in the ship's cargo tanks, the oil from the latter will substantially fill the pipes **14**, **16**, **26**, **100**, **82**, **84**, **48**, **60** and **68**, the suction tank **12**, the vent tank **22**, the displacer rod casing **86** and the centrifugal pump **46**, respectively, and will accordingly be pumped from the said cargo tanks through the system of the invention for ultimate discharge therefrom enlarged discharge pipe portion **68**.

During this stage of the ship's cargo tanks pumping operation, the high level of oil within the vent tank **22** will maintain the float means **172** at the upper control limit position thereof, whereby air control valve **174** will communicate line **180** and exhaust line **178** to result in the venting of the former to atmosphere through the said exhaust line to thus insure that the valves of valve assemblies **30** and **102** are in the respective open positions thereof, and that the valves of valve assemblies **116** and **140** are in the respective closed positions thereof. In addi-

tion, the high level of oil within suction tank 12 will be sensed by proportional controller 88 and utilized thereby to insure that the valve of butterfly valve assembly 66 is in the open position thereof. With regard to this latter valve, it is again noted that the same can be arranged to provide an approximately 5 p.s.i. oil pressure difference thereacross when biased from the full open position thereof.

As pumping continues, oil vapors—formed primarily at this stage due to the high vacuum in oil suction and inlet pipes 16 and 14, respectively, occasioned by operation of centrifugal pump 46—will be separated from the oil in the suction tank 12, as should be obvious, and rise therefrom, through connecting pipe 100 and open valve assembly 102, into the vent tank 22. As this occurs, a volumetrically equivalent portion of the oil in the vent tank will be displaced therefrom by the said oil vapor and returned to inlet pipe 14, through oil return pipe 26 and the open valve assembly 30, to thus commence the lowering of the level of oil in the said vent tank 22. This continues will float means 172 has assumed the lower control limit position thereof, at which time snap acting valve 174 will be shifted to the position thereof wherein compressed actuating air will be communicated from line 176 to line 180 and therefrom, through check valve 188 and line 182 to the respective diaphragm assemblies 112 and 38 of valve assemblies 102 to 30 to close the valves of the latter and effectively prevent further oil vapor or oil flow between the vent tank 22 and the suction tank 12.

As valve stem 40 of valve assembly 30 moves downwardly, as seen in the figure, abutment means 208 will abut and move valve actuator member 206 of mechanically operable air control valve 204 to open the latter and permit the flow of compressed actuating air from line 180 through line 210, the now open valve 204, and lines 212 and 200, to thus effectively bypass ball check valve 202 and enable the communication of the compressed actuating air to diaphragm assembly 154 of valve assembly 140 to open the valve of the latter and enable the flow of a portion of the pressurized oil from the discharge pipe 60 through pipe 128 and elbow 130 into the vent tank 22.

Concurrently therewith, the pressurized actuating signal air will also be communicated from line 200 through line 198 to the diaphragm assembly 126 of valve 116 to open the valve of the latter and provide communication between the interior of the vent tank 22 and the enlarged portion 68 of the discharge pipe through pipe 114 extending therebetween. Thus, oil from discharge pipe 60 downstream of the valve 60*a* which can be at least 5 p.s.i. higher in fluid pressure than the oil in discharge pipe portion 68, due to the effect of butterfly valve assembly 66 as discussed in detail hereinabove, will flow through pipe 128 and elbow 130 into the vent tank 22.

At the point of entry into vent tank 22 from the line 130 oil will impinge on a baffle member 22*a* which distributes the oil laterally to avoid interfering with the signal arm 172 of the float control 168 and to prevent extensive intermixing of the oil with the collected gas and vapors present in the vent tank 22.

The oil in vent tank 22 acts to replace the collected gases and vapors and positively drives them through pipe 114 to the discharge pipe 68 for discharge with the oil being pumped by the system.

Thus collected gases and vapors are discharged from the system without passing through the centrifugal pump 46 to cause the inherent difficulties as has occurred in many prior devices.

This replacement of the oil vapors in the vent tank with the liquid oil and attendant transfer of the said vapors through pipe 114 continues until the level of liquid oil within the vent tank again rises sufficiently to place float means 172 in the upper control limit position thereof. As this occurs, snap acting valve 174 will again be shifted to the position thereof wherein the supply of compressed actuating air from the source 90 thereof is again blocked and lines 180 and 178 communicated to vent the former to atmosphere through the latter.

The immediate effect of this venting of line 180 to atmosphere will be the venting of valve diaphragm assemblies 154 and 126, respectively, to atmosphere through, in the case of the former, ball check valve 202, and lines 198 and 200, and in the case of the latter, ball check valve 202 and line 198. This will result in a re-closing of the respective valves of the valve assemblies 140 and 116 to prevent the further flow of oil, at discharge pressure, through the vent tank.

The re-closing of the valve of valve assembly 140 will in addition function—through the abutment of abutment means 164, which are carried on valve stem 156, and extremity 166 of valve actuator member 162 and the attendant abutment of the latter with valve actuator member—to re-open mechanically operated air control valve 190. This re-opening of valve 190 provides a path for the re-venting of diaphram assemblies 112 and 38 to atmosphere through, in both cases, line 182, line 194, the now open valve 190, line 196, line 182, line 180 and exhaust line 178. This re-venting of diaphragm assemblies 112 and 38 enables the re-opening of the valves of valve assemblies 102 and 30, respectively, whereby oil return pipe 26 and gas and vapor vent pipe 100 are re-opened and communication between the vent tank 22, the suction tank 12, and inlet pipe 14 is again provided to complete one vapor removal cycle of the system of the invention and provide for continued oil discharge operation thereof as described hereinabove.

Of particular interest is believed that fact that the cooperative relationships between valve assembly 30 and mechanically operated air control valve 204, and between valve assembly 140 and mechanically operated air control valve 190, in essence provide time delays which are inherent in the operation of the system of the invention and insure proper performance thereof. Thus, the cooperative relationship between valve assembly 30 and air control valve 204 insures that no oil at substantially discharge pressure will be admitted to the vent tank 22 to purge the latter of oil vapors until such time as both the valves of valve assemblies 102 and 30 are closed to thus make impossible the undesirable flow of this pressurized oil from the vent tank to the suction tank 12 through either of oil return pipe 26 or vent pipe 100 until it has completed its work of displacing vapors and gases. Similarly, the cooperative relationship between valve assembly 140 and air control valve 190 insures that the purging flow of substantially discharge pressure oil into the vent tank 22 has been discontinued before the re-opening of the valve of valve assemblies 102 and 30 insure that no more oil than necessary is communicated to the suction tank. In each of these cases it is to be understood that the optimum time delay is that which brings about the maximum rate of gas and vapor removal and not necessarily that which provides for the fastest cycling.

In addition, it is believed well to stress that the system of the invention functions to discharge the ship's oil cargo, including any oil vapors formed therein during the oil discharge operation, totally without waste by returning the said vapors to the enlarged portion 68 of the discharge pipe through pipe 114 rather than wastefully, and in many instances hazardously, venting the said vapors to atmosphere as is common in many of the centrifugal pump operated discharge systems of the prior art. Further, it is to be understood that the operation of the system of the invention effects the purging of the accumulated vapors from the vent tank 22 concurrently with the continued discharge of the ship's oil cargo, no temperoary shutdown or discontinuance of the oil discharge operation being required for the performance of the purging operation.

However, during each purging cycle a quantity of pumped oil nearly equal to the volume of the vent tank is returned to the suction side of the pump and constitutes

a reduction of system output relative to the capability of the pump. It is to be noted that under cargo tank conditions which bring about regularly repeated vent tank cycling some reduction in net flow below the maximum pump capability may be the optimum rate as determined by cargo tank oil flow.

Operation of the system of the invention continues in the manner described above with the intermittent and fully automatic vent tank purging cycle occurring whenever the float means **172** have assumed the lower control limit position thereof in the vent tank **22** to thus indicate the substantial filling thereof by vapors and the need for purging.

During the later stages of operation of the system, the gases in the oil cargo delivered to the suction tank **12** will probably consist more of air rather than oil vapors, the former being entrained in the ship's oil cargo due to oil surface conditions, for example whirling, at the suction points in the ship's oil cargo tanks from which the oil is withdrawn. In either event, that is whether the gases in the oil consist primarily of oil vapors or entrained air, or a mixture of both, the volumetric capacity of the vent tank **22** multiplied by the maximum system cycling rate must, of necessity, be at least as great as the required volumetric rate of gas removal.

If, during operation of the system of the invention, the amount of gas drawn thereinto with the oil begins to exceed the venting capacity of the vent tank **22**, an accumulation of gas ocurs in the upper portion of the suction tank **12** with an attendant reduction in the level of oil in the suction tank. This condition is sensed by the proportional controller **80**, which transmits a signal of increased pressure through line **94**, to the diphragm assembly **76** of butterfly valve assembly **66**. This increased pressure will in turn effect a progressive closing of the valve of the said butterfly valve assembly with attendant reduction in the intake rate of centrifugal pump **46**, as should be obvious, and corresponding reduction in the rate at which gas is drawn into the system.

In the unlikely event that the system of the invention is in effect overwhelmed by the sudden induction of a very large relative volume of gas which would materially reduce the level of oil in the suction tank **12**, proportional controller **80** would respond to this condition by substantially closing the valve of butterfly valve assembly **66**. Concurrently therewith, float means **172** would soon assume the lower control limit position thereof whereby the vent tank purging cycle would be initiated by the opening of the valves of the valve assemblies **140** and **116**. Under these conditions, however, the gases collected in the vent tank would, of necessity, have to be displaced from the vent tank through pipe **114** due to their lower density relative to oil in that there would be an insufficient pressure differential—due to the materially reduced amount of oil in the suction tank **12** and the effect thereof upon the suction conditions at the inlet side of centrifugal pump **46**—to cause the oil to flow from the pump through the partially open butterfly valve assembly **66** to the enlarged portion **68** of the discharge pipe. Thus, the cycling rate would be materially reduced with the oil simply filling the vent tank **22**, from enlarged portion **68**, returning through butterfly valve assembly **66** until float means **172** assumed the upper control limit position thereof, and the same oil being then returned to the suction tank **12**, through oil return pipe **26** upon the reopening of valve assembly **30**, for raising the oil level in the suction tank **12** and charging the vent tank **22** with gas.

This continuous recycling of the vent tank purging operation with the valve of butterfly valve assembly **66** being largely closed and no oil being discharged from the system, would thus continue until such time as the very large relative volume of inducted gas had been substantially purged from the system into discharge pipe portion **68** and the level of oil within the suction tank had accordingly risen sufficiently to effect re-opening of the butterfly valve assembly **66** and restore normal pumping.

The location of the suction tank outlet line **42**, which connects to the inlet casing **48** of the centrifugal pump **46**, well below the midpoint of the suction tank **12** will insure the maintenance of sufficient oil in the suction tank to re-prime the centrifugal pump. In addition, non-illustrated emergency priming equipment in the nature, for example, of vacuum operated pump priming equipment may be provided if desired.

The volume of the suction tank **12** above inlet pipe **14** is to be at least equivalent to the volume of the vent tank to permit the accumulation of gas in the said suction tank equal in volume to the capacity of the vent tank before the flow of oil into the suction tank through pipe **14** would commence to cascade into the former thereby entraining additional gas bubbles therein.

Termination of the operation of the system may be effected in various ways depending on whether the system is simultaneously drawing from a number of cargo tanks or arranged to be sequentially connected. Non-illustrated level sensing and control means within the several cargo tanks can be arranged to close the suction valve of each tank as it is emptied if several tanks are initially simultaneously connected, and upon closure of all suction valves a control signal may be transmitted to stop the driver of the cargo pump, whether electric motor or steam turbine. If sequential discharge is preferred, the closing of the suction valve of the first connected tank can provide the signal for opening the next suction valve in order. The closing of the final suction valve can provide the signal for terminating operation of the cargo pump. In any case the system of this invention includes a differential temperature sensing control which will terminate cargo pump operation if the temperature of the oil passing through pump **46** exceeds by a predetermined amount the temperature of the oil contained in suction line **16**. Thus if normal performance of the pump **46** is not reestablished after a reasonably small number of cycles, the repeated passage of the same oil through the pump will raise the oil temperature sufficiently above suction pipe temperature to cause shut-down.

It is to be understood that numerous details of the herein disclosed preferred embodiment of the invention may be altered without departing from the spirit and scope thereof as defined by the following claims.

What is claimed is:

1. In a pumping system for pumping a mixture of liquids and gases, centrifugal pump means, first tank means having outlet means connected to said pump means and inlet means connected to a source of a liquid-gas mixture to be pumped, second tank means positioned above said first tank means, first pipe means connecting the upper portion of said first tank means with the upper portion of said second tank means, second pipe means connecting said second tank means with said first tank means, discharge pipe means extending from said pump means, first bypass pipe means connecting said pump discharge pipe means to said second tank means, second bypass pipe means connecting said second tank means with said pump discharge pipe means at a point therein downstream of said first bypass pipe means, valve means in each of said first and second connecting pipe means and each of said first and second bypass pipe means, respectively, liquid level responsive means cooperatively associated with said second tank means, and control means responsive to said liquid level responsive means and operable to control the operation of said valve means in response to the level of liquid within said second tank means.

2. In a pumping system as in claim **1** further comprising, means in said pump discharge pipe means between the connections thereof with said first and second bypass pipe means for creating a pressure differential therebetween.

3. In a pumping system as in claim 1 wherein, said liquid level responsive means are float operated, said valve means are diaphragm operated, and said control means comprise means to selectively supply a pressurized actuating fluid to said diaphragm operated valve means to effect the opening and closing thereof.

4. In a pumping system as in claim 2 wherein said means in said pump discharge pipe means comprise valve means, and said pumping system further comprises liquid level responsive means cooperatively associated with said first tank means, said discharge pipe valve means, and said control means, respectively, for controlling the operation of said discharge pipe means valve means in response to the level of liquid in said first tank means.

5. In a pumping system as in claim 1 wherein, said liquid level sensing means, said control means, and each of said valve means are so arranged that, the respective valve means in said first and second connecting pipe means will be shifted from the open to the closed positions thereof, and the respective valve means in said first and second bypass pipe means will be shifted from the closed to open positions thereof, when the level of liquid in said second tank means assumes a lower control position thereof whereby, gases separated from said liquid-gas mixture in said first tank means will rise therefrom through said first connecting pipe means into said second tank means and may be purged therefrom into said pump discharge pipe means through said second bypass pipe means when the level of liquid in said second tank means assumes said lower control position thereof and the respective valve means in said first and second connecting pipe means are closed by the operation of said control means and the respective valve means in said first and second bypass pipe means are opened by the operation of said control means.

6. In a pumping system as in claim 1 wherein, said liquid level sensing means, said control means, and each of said valve means are so arranged that, the respective valve means in said first and second connecting pipe means will be shifted from the closed to the open positions thereof, and the respective valve means in said first and second bypass pipe means will be shifted from the open to the closed positions thereof, when the level of liquid within said second tank means assumes an upper control position thereof.

7. In a pumping system as in claim 5 wherein, said liquid level sensing means, said control means, and each of said valve means are so arranged that, the respective valve means in said first and second connecting pipe means will be shifted from the closed to the open positions thereof, and the respective valve means in said first and second bypass pipe means will be shifted from the open to the closed positions thereof, when the level of liquid within said second tank means assumes an upper control position thereof whereby, the bypassing of pump discharge liquid through said second tank means will be discontinued and said second tank means once again placed in communication with said first tank means.

8. In a pumping system as in claim 7 wherein, said control means further comprise means operable to provide a time delay between the closing of the respective valve means in said first and second connecting pipe means and the opening of the respective valve means in said first and second bypass pipe means, and means operable to provide a time delay between the re-closing of the respective valves in said first and second bypass pipe means and the re-opening of the respective valves in said first and second connecting pipe means.

9. In a pumping system as in claim 4 wherein, said liquid level responsive means cooperatively associated with said first tank means comprise a displacer type controller arranged for proportional control operation to cause said control means to close said pump discharge pipe means valve means to a progressively greater extent upon a drop in the liquid level in said first tank means.

10. In a pumping system as in claim 7 further comprising, valve means in said pump discharge pipe means, and liquid level responsive means cooperatively associated with said first tank means, said control means, and said discharge pipe means valve means, respectively, for controlling the operation of said last-mentioned valve means in response to the level of liquid in said first tank means.

11. In a pumping system as in claim 7 wherein, said first tank means is a suction tank, said second tank means is a vent tank, said first connecting pipe means is an oil return pipe which connects the bottom of said vent tank with said suction tank inlet means to enable the return of oil from said vent tank to said suction tank, and said second connecting pipe means is a vent pipe to enable the flow of gases from said suction tank to said vent tank.

12. In a pumping system as in claim 7 wherein, said valve means are fluid operated, said control means comprise a fluid circuit for the selective supply of a pressurized actuating fluid to said fluid operated valves to effect the opening and closing thereof, said liquid level responsive means comprise snap-acting valve means which control the supply of said pressured actuating fluid to said fluid circuit.

13. In a pumping system as in claim 8 wherein, said valve means are fluid operated, said control means comprise a fluid circuit for supplying a pressurized actuating fluid to said valves means, and said time delay means comprise first and second fluid control valves which are respectively, cooperatively associated with the valve means of one of said connecting pipe means and the valve means of one of said bypass pipe means.

14. In a pumping system as in claim 12 wherein, the fluid operated valve means of said first and second connecting pipe means are arranged to be closed only when pressurized operating fluid is supplied thereto by said control means, and the fluid operated valve means of said first and second bypass pipe means are arranged to be open only when said pressurized operating fluid is supplied thereto by said control means.

15. In a pumping system for pumping a liquid-gas mixture, pump means having inlet and discharge means, means cooperatively associated with a source of said liquid-gas mixture and with said pump inlet means and operable to separate said gas from said liquid prior to the introduction of the latter to said pump inlet means, means cooperatively associated with said separating means for collecting said gases therefrom, and means for periodically bypassing a portion of said liquid from said pump discharge means through said collecting means and therefrom back to said pump discharge means for purging said collecting means of said gases and re-introducing the same to said liquid downstream of said pump means.

16. In a pumping system as in claim 15 further comprising control means cooperatively associated with said collecting means and responsive to the volume of said gases contained therein for controlling the periodic operation of said bypassing means.

17. In a pumping system as in claim 16, wherein, said separating means comprises a suction tank, said collecting means comprises a vent tank positioned above said suction tank and cooperatively associated therewith by first and second pipe means extending therebetween, said bypass means comprise first and second bypass pipe extending from said pump discharge means to said vant tank means, and said control means comprise valve means positioned in each of said first and second pipe means and first and second bypass pipe means, respectively, and a control system for operating said valve means.

18. In a control system as in claim 17 wherein, said first and second bypass pipe means extend from different portions of said pump discharge means and said system futher comprises means disposed in said pump discharge

means between said first and second bypass pipe means to establish a pressure differential therebetween.

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