May 31, 1966 H. VREEDENBURGH 3,253,746

PUMPING SYSTEM FOR TANKS IN SHIPS

Filed Jan. 3, 1964 5 Sheets-Sheet 1

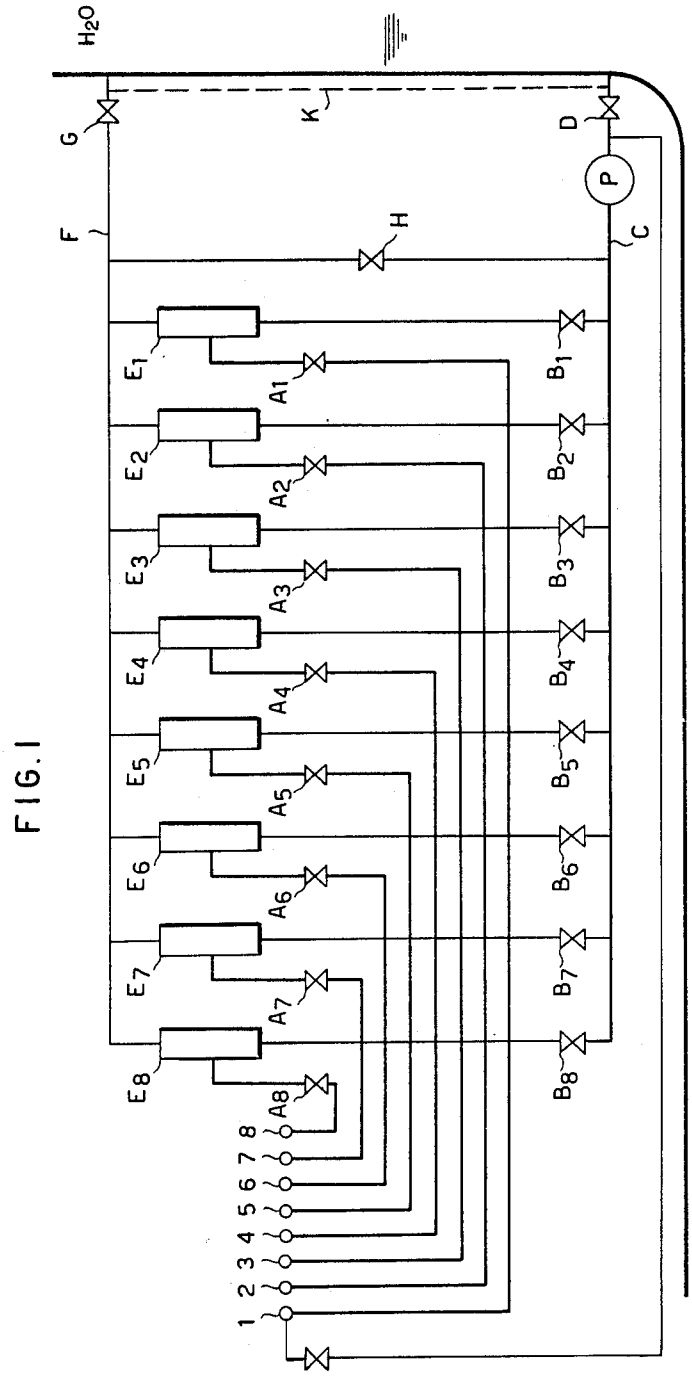


FIG. 1

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FIG. 2

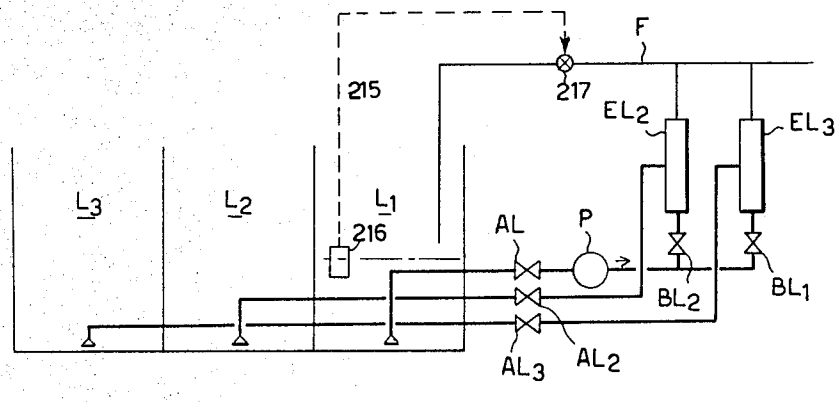
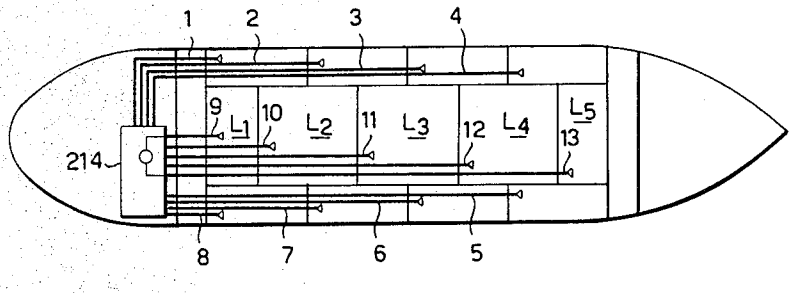


FIG. 3



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PUMPING SYSTEM FOR TANKS IN SHIPS

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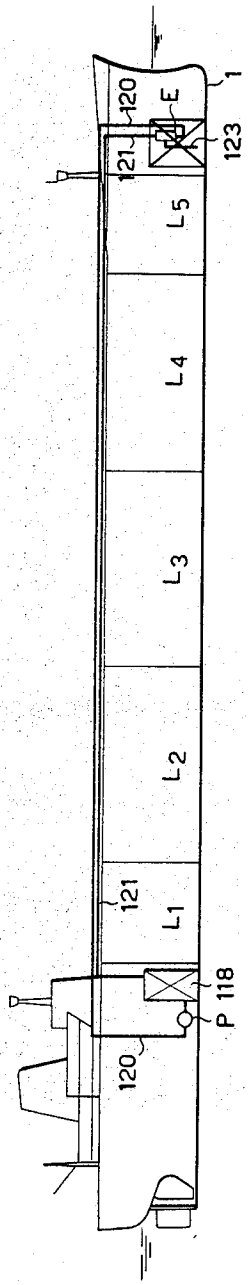


FIG. 4

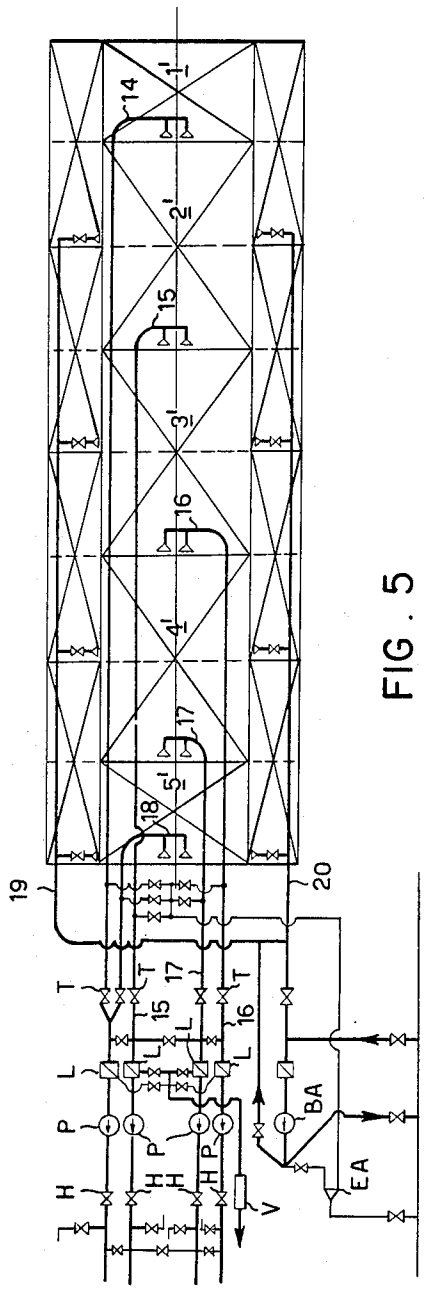


FIG. 5

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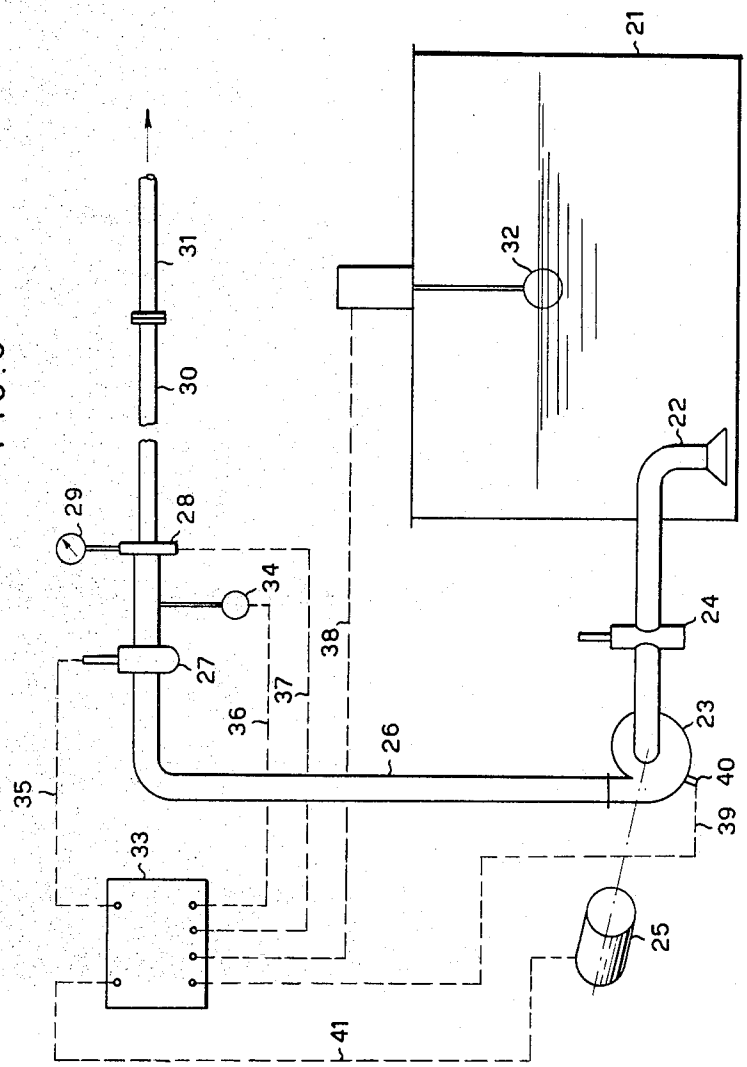
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PUMPING SYSTEM FOR TANKS IN SHIPS

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FIG. 6



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FIG. 7

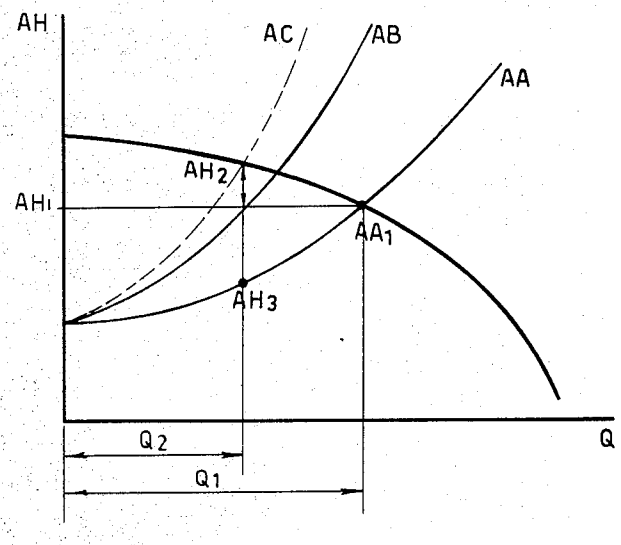
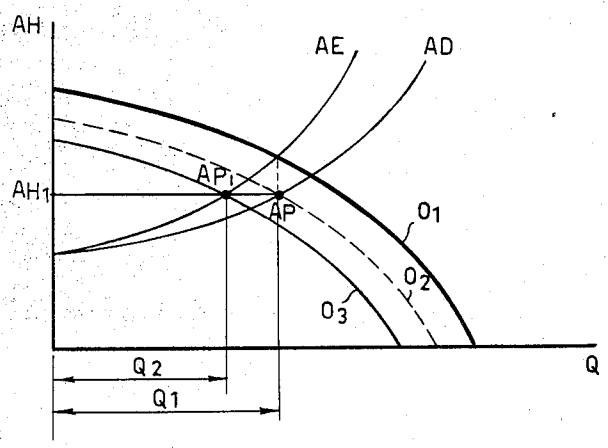


FIG. 8



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United States Patent Office 3,253,746 Patented May 31, 1966

3,253,746

PUMPING SYSTEM FOR TANKS IN SHIPS

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Filed Jan. 3, 1964, Ser. No. 335,639
Claims priority, application Netherlands, Jan. 9, 1963, 287,607; Mar. 19, 1963, 290,379
3 Claims. (Cl. 222—67)

The invention relates to a pumping system for tanks in ships.

Up to now it has been common practice to provide a ship having tanks, pumps and ducts connecting said tanks and said pumps, with a duct system in which near or in the several tanks valves are mounted. The emptying or filling of the tanks requires repeated switching from one tank to another, actuation of valves outside the pumping chamber and continuous human control of the pumping circuits.

In many instances, e.g. in case of tankers, the pumping system was further complicated by the fact that ballast pumping facilities as well as cargo pumping facilities had to be provided. Operation of such pumping systems necessitated important man power and time. In practice it has been shown that the time period necessary for emptying or filling a tanker is far more than the theoretical minimum calculated on the tank volume and the pumping capacity. Further the valves at or in the tanks have to be connected by a long actuating rod with an operating apparatus placed on deck and rather often gave rise to difficulties and even failure.

The invention aims at a pumping system, that is easy in operation, highly efficient and less liable to fail or need repair.

Accordingly the invention provides a pumping system for a ship, provided with pumps, ducts, valves and tanks, the pumps being concentrated in one or more pumping chambers and the ducts connecting the tanks with said pumping chamber or chambers, characterized in that each one of a number of tanks or groups of tanks is provided with an individual duct leading to the pumping chamber.

Preferably at least some of the ducts leading from the tanks to the pumping chamber are free flow ducts, i.e. ducts without valves, outside the pumping chamber.

Even if such valves outside the pumping chamber are provided it must be pointed out that actuation of these valves is not necessary during the normal pumping activities.

The term "pumping chamber" in this specification is used in the sense of a space in the ship containing one or more pumps for pumping cargo and/or ballast water. In most tankers a special room is provided for the pumps, but it is also possible for the pumps to be installed in the engine room. In that case the pumping chamber mentioned in this specification is the engine room. It is also possible that the pumps are installed in different rooms in which case each one of these rooms is indicated as a pumping chamber.

The invention may be applied to the cargo tanks of a tanker and/or the ballast tanks of any type of ship including tankers.

The invention further may be applied by only connecting separate tanks to the pumping chamber by means of separate ducts, or by using a separate duct for a number of tanks, indicated as a group of tanks. Generally these tanks will be chosen in such a way that they normally have to be filled or emptied simultaneously, so that, even if dividing valves for separating these tanks are present, they will not be actuated during normal pumping activities. Such valves may, however, be necessary for safety reasons.

According to a further elaboration of the invention at least one of the ducts connected to the tanks is connected to the suction side of an ejector in the pumping chamber.

Ejectors have important advantages over pumps provided with moving parts in that failure is practically impossible and maintenance is extremely limited. Further they are very cheap as compared to mechanical pumps. When, the several ducts leading to the pumping room have their own pump allotted to each or a group of them, as is preferable when applying the invention, important savings are obtained by the use of ejectors. This especially is the case if a number of ejectors is fed parallelly by one or more driving pumps.

A special advantage of parallel ejectors is, that the pumping circuits proper of the several tanks to be emptied simultaneously are still independent of one another. A further advantage lies in the fact, that an ejector pumping air instead of liquid is not endangered and does not need immediate action of the operator. Nevertheless it would be a disadvantage that with a single ejector connected to a number of tanks the pumping pressure suddenly drops as soon as one of the tanks is empty and air is drawn in. This disadvantage is obviated by the independent pumping circuits depicted in the above.

When ejectors are provided it is necessary also to provide an auxiliary liquid driving the ejectors. In case of ballast pumps this may be water from out-boards, but in case of pumping valuable liquids such as cargo or fuel it is necessary to use a driving liquid that allows of being mixed with the liquid to be pumped. In practice generally a liquid of the same composition as the liquid to be pumped, will be used.

Accordingly the invention provides a pumping system as described, in which the suction side of the driving pump is connected to a tank.

In order to overcome difficulties, which might arise if the tank to be emptied by the driving pump and the one to be emptied by the ejector(s) are not empty at the same moment the discharge side of the ejector or ejectors is connected to said tank.

With the invention it is possible to have all pumping control carried out in the pumping chamber, so that a considerable saving in personal is possible. It is then that it is especially useful to have the pumping action automatically controlled.

Accordingly the invention provides a pumping system of the described type provided with a control device for controlling the pumping speed.

Preferably this control device controls the rotational speed of a cargo pump.

A further means for controlling the pumping action consists in a control valve in a discharge duct leaving the ship, which valve is controlled by said control device.

A special embodiment of the invention consist in a pumping system in a ship that is provided with a bunker trim tank in her fore peak, in which system two ducts lead from a pump provided in the stern part of the ship to the fore peak, one of said ducts being connected to the pressure side of an ejector located near or in said bunker trim tank and the other duct being connected to the discharge side of said ejector, whilst the suction side of the ejector is connected to the inside of said bunker trim tank.

This embodiment obviates the necessity of a special fuel pump placed in the fore ship. This consequently saves space and working time of the personal.

The above depicted and further features of the invention will be elucidated in the following specification with reference to the accompanying drawings in which:

FIG. 1 shows a schematic representation of an embodiment of the invention;

FIG. 2 shows schematically a further embodiment of the invention;

FIG. 3 shows a schematic plan view of a tanker provided with the invention;

FIG. 4 shows a special embodiment of the invention;

FIG. 5 shows a more detailed system according to the invention, in which the invention only is applied for the cargo tanks of a tanker but not for her ballast tanks;

FIG. 6 schematically shows a control apparatus used with the invention;

FIGS. 7 and 8 show diagrams relating to pumping characteristics.

In FIG. 1 the references **1**, **2**, **3**, **4**, **5**, **6**, **7** and **8** schematically indicate ducts connected to the tanks (not shown) and provided with valves A_1 through A_8 respectively. The ducts have no valve in the part of the ship outside the pumping chamber and the valves A_1–A_8 inclusive are all mounted inside the pumping chamber.

The valves A_1–A_8 inclusive are each connected to the suction side of ejectors E_1–E_8 respectively. The discharge sides of the ejectors are connected to a common discharge duct F. Further the ejectors receive pressurized liquid through a duct C and the respective valves B_1–B_8. Duct C receives liquid from the pressure side of pump P, the suction side of which is connected with the water outboards, via a valve D.

The pumping system so far described can be used for ballast water.

It is, however, possible with some minor modifications to use the same system for pumping more valuable liquids, for instance cargo. Then the duct K, indicated by an interrupted line, is used and the valves G and D are opened, whereas the connection with the outboard water is closed by means of a valve (not shown). From an auxiliary small tank (not shown) or by means of a duct connecting one or more of the ducts **1** through **8** with the suction side of pump P the pumping circuit P; C; B_1–B_8; E_1–E_8, F, G, K, D is provided with liquid. When the ejectors drawn in liquid from the ducts **1**–**8** the surplus liquid can be discharged from a discharge duct (not shown) connected to duct F.

In FIGURE 2 some more details of an embodiment of such a pumping system are shown, in which case, however, only three tanks L_1, L_2 and L_3 and two ejectors EL_2 and EL_3 are shown. In this embodiment the pump P draws liquid through the valve AL from the tank L_1. This liquid is, by means of the valves BL_1 and BL_2, supplied to the ejectors EL_3 and EL_2. These ejectors draw liquid through the open valves AL_2 and AL_3 from the tanks L_2 and L_3 respectively. Normally this liquid is discharged through the right hand end of duct F. If, however, tank L_1 happens to be empty before tanks L_2 and L_3, the pumping action should be prematurely interrupted. In order to avoid this a control valve **217** is mounted in the left hand part of duct F, connected with tank L_1. In the tank L_1 a float **216** is mounted, that by means of some known control connection **215** controls valve **217**. This schematically shown connection may e.g. be a mechanical link, that opens valve **217** when float **216** drops below a predetermined level. Of course any electrical pneumatical or hydraulical servo system may be used too. The working is, that when the level in tank L_1 becomes too low valve **217** is opened and liquid is fed from duct F into tank L_1, so that the level in that tank cannot drop further. When tanks L_2 and L_3 are empty valve **217** is closed automatically or by hand and the last liquid is drawn from tank L_1.

FIG. 3 shows a schematical plan view of a tanker having a fore part, a cargo carrying portion proper and a stern part. In the stern part the pumping chamber **214** is situated. From this chamber the ducts **1** through **8** lead to ballast tanks and the ducts **9** through **13** to the cargo tanks L_1 through L_5. In FIG. 3 only the ducts have been shown, which connect the pumping chamber with the ballast and cargo tanks in the cargo carrying

portion proper of the ship; but it will be understood that any ballast, cargo or fuel tank in the fore or stern part of the ship may be connected in the same way.

In FIG. 3 tanks L_1 and L_5 together have approximately the same volume as one of the tanks L_2, L_3 or L_4. Accordingly the ducts **10**, **11** and **12** may be connected to a separate pump, whereas ducts **9** and **13** share a single pump.

In FIG. 5 this has been further elucidated in a further embodiment of the invention. It is pointed out, however, that in the embodiment of FIG. 5 in contradistinction to FIG. 3 the ducts for the ballast tanks are not according to the invention. This shows, that it is not necessary to apply the basic idea of the invention to all tanks, ballast as well as cargo, when designing a pumping system incorporating the invention.

FIG. 4 shows a further detail of the pumping system of a ship of the construction shown in FIG. 3. As shown in FIG. 4 the ship is provided with a bunker tank **118** in the stern portion of the ship and a trim bunker tank **123** in the fore part of the ship. The contents of these tanks are used for trimming the ship in the longitudinal direction, so that during the travel fuel has to be pumped repeatedly from tank **123** to tank **118** when the latter is partly emptied by the ship's fuel consumption. In the tank **123** an ejector has been mounted, the pressure side of which is connected to a duct **120** and the discharge side to a duct **121**. Filling of tank **123** is done by pumping fuel through line **120** and closing line **121**, whilst emptying of tank **123** is carried out by pumping fuel through duct **120** and opening duct **121**. In that case the ejector E will draw fuel from tank **123** and carry it off through line **121** together with the fuel from line **120**.

FIG. 5 shows five cargo tanks **1'**, **2'**, **3'**, **4'** and **5'** corresponding to L_5, L_4, L_3, L_2 and L_1 respectively of FIG. 3. Each of these tanks is connected by means of a separate duct **14**, **15**, **16**, **17** and **18** respectively, to a pumping chamber (not shown) in the stern part of the ship. All valves, air separators and pumps shown to the left of tank **5'** are physically mounted within the pumping chamber.

The pumps P all have the same pumping capacity. Liquid cargo from tanks **2'**, **3'** and **4'** flows through a pair of nozzles, ducts **15**, **16** or **17**, a valve T, an air separator L, a pump P and a head valve H to ducts or tubes leading from the ship to the shore. Tanks **1'** and **5'** are connected to ducts **14** and **18**, each containing a valve T and beyond these valves united to a single duct, that contains an air separator L, a pump P and a head valve H. Normally first one of these valves T is closed until the related tank **1'** or **5'** is empty, after which this valve T is closed and the other one is opened, until the other tank **5'** or **1'** is empty.

The scheme further shows interconnections for the case that one of the pumps P fails, or to be used, if for some reason or other, some tanks are empty whereas others are not.

FIG. 5 further shows a vacuum duct V for drawing air from the air separator L and priming pumps P.

The ballast tanks are connected with ducts **19** and **20** and are each provided with a valve at or near said tanks. Ballast water can be pumped by ballast pump BA into and from the tanks with a circuit known per se. The drawing shows, however, a further interesting detail in that the ballast pump BA can be used for feeding an ejector EA, which creates a vacuum, that can be used for priming purposes. Because ballast and cargo pumps, in practice, need not work simultaneously this vacuum can be used for priming the cargo pumps.

FIG. 6 shows a scheme for controlling the pumping of liquid from a tank **21**.

A nozzle is connected by means of a duct **22** to a centrifugal pump **23** via an air separator **24**. A motor **25** drives pump **23**. The pressure side of pump **23** is con-

nected to a duct **26**, that is provided with a control valve **27**, a manometer **34** and a flow rate measuring device **28** having a scale **29**. Via the schematically shown connection between ducts **30** and **31** the liquid leaves the ship and passes on to the shore.

The control device **33** has four inputs: **38** from a float **32** in tank **21**; **39** from a cavitation detecting device (for instance a microphone with an amplifier) **40**; **37** from the flow rate measuring device **28** and **36** from the manometer **34**. The control device **33** has two outputs viz **41** for controlling motor **25** and **35** for controlling valve **27**.

The working of the control device shown is as follows:

After starting pump **23** the hydrostatic pressure in tank **21** is sufficient to prevent cavitation, whilst aspirating air is not possible. Consequently the pump will function normally. The pressure, at which the liquid is delivered to the shore should, however, be kept between predetermined limits. This is done by controlling valve **27** in such a way that the pressure measured by **34** stays between said limits.

When the liquid level in tank **21** is lowered, the possibility that cavitation will occur increased. Therefore the signal from float **32** is used for somewhat closing valve **27** or reducing the speed of motor **25**. Should cavitation nevertheless occur, then the control of valve **27** in the closed direction or of motor **25** in the direction for reducing its speed (or both of these controls) are progressively put into action until the cavitation stops. The occurrence of a cavitation signal in control line **39** reduces or annihilates the influence of the control signals of lines **36** and **38**. Consequently the cavitation control overrules the pressure and/or level control. Whilst cavitation is only apt to occur when the tank **21** is almost empty this hardly afflicts the optimal pumping speed, whilst a very steady and quiet working is obtained.

The flow rate measuring device **28** is provided with means for detecting a sudden change in the pumping speed. Control device **33** is made such, that a signal from **28** indicating such a sudden change stops motor **25** and preferably puts an alarm device in action.

The control device **33** in itself can be made or constructed in many ways as is known to any expert in control and automation technics. It may be provided with electronical, electrical, electro-magnetical, hydraulical and/or pneumatical devices.

It is possible to control by means of the valve **27** as well as by varying the rotational speed of pump **23**.

FIG. 7 illustrates diagrammatically the control by means of the valve **27**. In this figure the ordinate is the exit pressure AH and the abscission the flow rate Q.

The curve through points AH_2 and AA_1 is the pump characteristic and the curves AA, AB, and AC show different duct and pump resistances as a function of the flow rate Q.

The point AA_1 is the working point giving a flow rate Q_1 and a pressure beyond valve **27** of AH_1. If now, for some reason or other, the duct resistances change to the value characterized by the curve AB the pressure at the shore will rise. To overcome this the valve **27** is throttled until the resistance of pump, duct and valve **27** corresponds to line AC. The vertical distance from AH_2 to AH_1 is the pressure drop across valve **27** and the pressure beyond said valve is again AH_1.

FIG. 8 illustrated the control by means of rotational speed of the pump. The curves O_1, O_2 and O_3 are pump characteristics for three different rotational speeds. Curves AD and AE are flow resistance characteristics. AH_1 is the predetermined pressure with which the liquid should be discharged from the ship. The working point AP can be obtained with the rotational speed corresponding to O_2 and a flow resistance corresponding to AD. It could also be obtained by a rotational speed corresponding to O_1, if the vertical distance between curves AE and AD corresponds to the throttle pressure drop of valve **27**, so that it is clear, that speed control enables to work with a smaller rotational speed and energy consumption, to obtain the same working as could be obtained by throttling. Point AP_1 can be obtained by running the pump with the rotational speed O_3, if curve AE represents the flow resistance characteristic of the ducts and pump, exclusive the pressure drop in valve **27**. This makes it clear that control of the rotational speed of pump **23** suffices also to maintain a predetermined end pressure, when flow resistance conditions in the ducts change.

It is to be understood that in this specification and the appending claims the terms "connected" or "connecting" indicate, that permanent means (such as valves) are present, which by merely actionating them cause the situation, in which the indicated connection exists.

What is claimed is:

1. A pumping system for a tanker having a plurality of tanks and a plurality of ejectors equal to the number of tanks less one, a common chamber in which said ejectors are located, conduit means connecting the inlet of each ejector to a separate tank, and conduit means connecting the outlet of each ejector to a common discharge conduit; a pump located in the common chamber, conduit means connecting the inlet of the pump to the remaining tank and connecting the discharge of the pump to each of the ejectors to supply actuating fluid to the ejectors; a float in said remaining tank, a valve in said common discharge conduit, and means connecting the float and discharge valve for opening the valve when the fluid in the said remaining tank has lowered to a predetermined level.

2. A system as in claim **1** further including a valve in each conduit connected to a tank and a valve in each conduit connecting the discharge of the pump with an ejector, all said valves being located in said common chamber.

3. A pumping system for a tanker having a plurality of tanks and a plurality of fluid operated pumping means equal to the number of tanks less one, a common chamber in which said pumping means are located, conduit means connecting the inlet of each said pumping means to a separate tank, and conduit means connecting the outlet of each said pumping means to a common discharge conduit; a pump located in the common chamber, conduit means connecting the inlet of the pump to the remaining tank and connecting the discharge of the pump to each of the said fluid operated pumping means to supply actuating fluid to the said pumping means; a float in said remaining tank, a valve in said common discharge conduit, and means connecting the float and discharge valve for opening the valve when the fluid in the said remaining tank has lowered to a predetermined level.

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