Feb. 25, 1941. R. H. DICKINSON 2,232,678

PUMP FOR LIQUIDS

Filed March 17, 1938

Fig. 1.

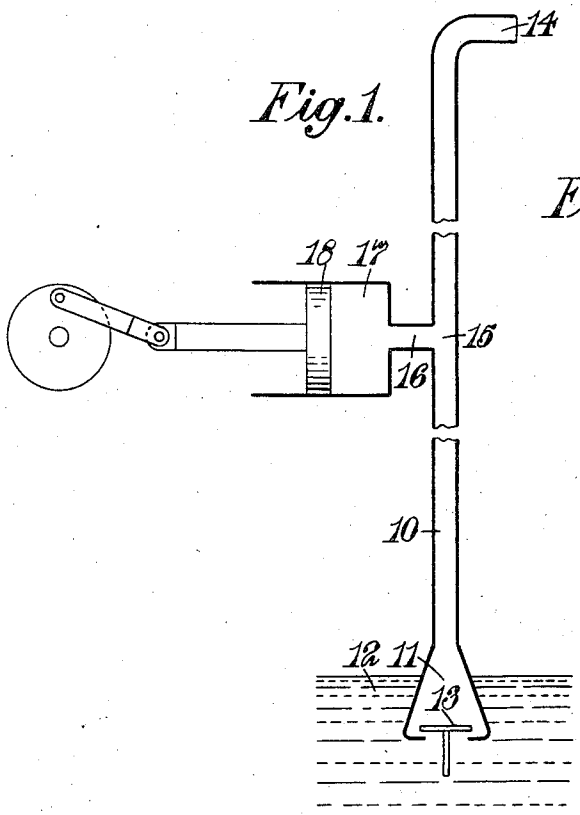


Fig. 2.

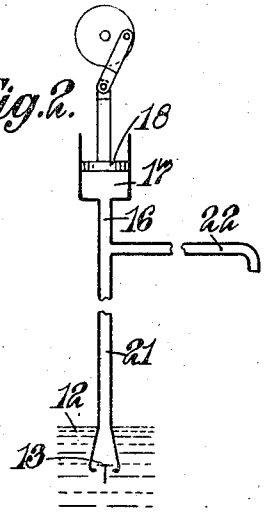


Fig. 3.

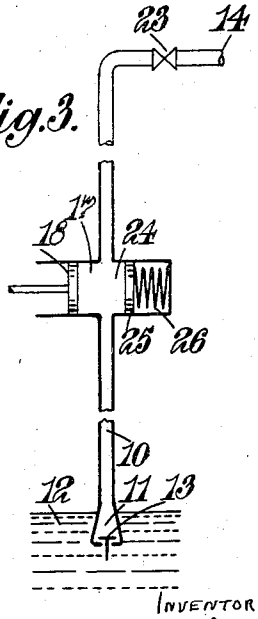
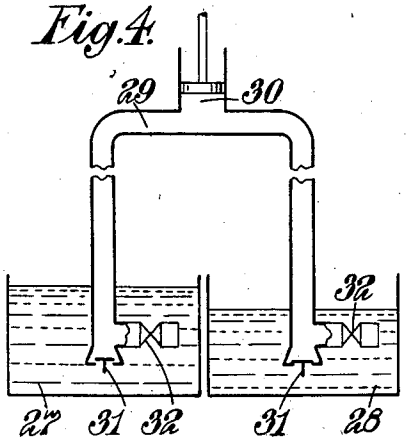


Fig. 4.



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PUMP FOR LIQUIDS

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4 Claims. (Cl. 103—75)

This invention is for improvements in or relating to pumps for liquids, and has for its object to provide an improved construction and arrangement of a pump which is extremely simple in its mechanical details, and is capable of raising liquids efficiently, even from a depth below the mobile portion of the pump greater than the barometric column, and of delivering it at any required pressure.

Pumps made according to this invention comprise as their essential features a submerged inlet pipe provided with a non-return inlet valve, situated as hereinafter described, an outlet pipe, communicating with the inlet pipe, and means for intermittently applying pressure at their junction, which point for convenience is hereinafter referred to as the "pressure chamber."

As a result of such pressure the column of liquid above the pressure chamber is set in motion so as to separate, or tend to separate, it from that below the pressure chamber. This pressure also tends to compress the inlet column and to transfer energy to the inlet part of the system, thereby causing expansion and/or extension of the piping, and to a certain amount, compression of the liquid itself. On the removal of the pressure on the upper surface of the liquid in the inlet part this energy, or a portion thereof, is utilised to raise the liquid in such part, and thereby enable the foot valve to open (even in cases where the inlet column is of greater height than the barometric column) and further liquid to be admitted. It is therefore an essential feature of this invention that the foot valve should be situated at a sufficient distance below the pressure chamber to permit of a considerable amount of energy being stored in the inlet portion of the system, and preferably this valve is situated at the bottom of the inlet pipe, as any portion of such pipe below the foot valve is not available for storing energy.

We also prefer to arrange the outlet pipe, by which we mean that portion of the system which is above the pressure chamber, so that there is a substantial head of liquid therein, as this facilitates the imparting of energy to the inlet column, since it enables greater effective pressure to be developed thereon. In all cases the head of liquid must be adequate to enable sufficient pressure to be applied to the surface of the inlet column so as to transfer thereto the energy necessary to set this column in upward motion, and thereby enable liquid to enter through the foot valve. It is necessary that the pipes forming the inlet part of the system, and/or the liquid, should possess sufficient elasticity for storing the necessary energy, but we have found that with the comparatively small pumps with which we have experimented up to now the ordinary cast iron, steel or earthenware pipes are satisfactory, and we have also worked with rubber hose.

In order to start the pump it is necessary that it should be primed, i. e., there should be a sufficient column of liquid above the level of the pressure chamber.

Preferably pressure is applied by means of a piston reciprocating in a cylinder which is in free communication with the inlet and delivery pipes.

The invention contemplates the provision of an improved construction and arrangement of pump of the aforesaid type, in which all valves except the inlet valve are iliminated, and which operates on a cycle that is independent of its speed; it is thereby distinguished from known pumps of the said type which operate by setting up resonant pressure waves in the system and also from those which operate on a cycle determined by the operation of their valves.

In the accompanying drawing,

Figure 1 is a purely diagrammatic illustration of one embodiment of the invention.

Figure 2 is a similar illustration of a modified arrangement of inlet pipe and delivery pipe.

Figure 3 is a similar illustration showing means for controlling the delivery of the pump, and

Figure 4 is a similar illustration showing the novel pumping system adapted for transferring liquids in either of two directions.

Like reference characters indicate like parts throughout the drawing.

Referring first to Figure 1 which shows diagrammatically a pump system according to the present invention in its simplest form, a pipe 10 has its lower end 11 submerged in an intake source 12, and provided with a non-return inlet valve 13; the upper end of the pipe 14 constitutes the delivery point. At any convenient point 15 between its ends, a connection 16 provides communication with a cylinder 17 having a piston or plunger 18 reciprocated in it by any convenient driving mechanism. No valves need be provided in the cylinder 17 or in its connection with the pipe 10, the sole function of this cylinder and piston being to exert pressure intermittently on the contents of the pipe 10. It will be seen therefore that many other devices than a cylinder and piston may be used in its place.

The connection 16 to the pump cylinder may be situated at any convenient point in the length

of the pipe 10 and in the case of a deep-lift pump it may be situated above the height of a barometric column of the liquid which is being pumped. The pipe 10 is continuous from its inlet end 11 to its delivery end 14, and the portion of it between the inlet end 11 and the connection 15 constitutes the inlet pipe, and the portion of it between the connection 15 and the delivery end 14 constitutes the delivery pipe and these names will be used to designate these two parts hereinafter.

The operation of this pump is as follows:

The whole system is primed with liquid as above described, and preferably the connection 16 and cylinder 17 are also filled with liquid when the piston 18 is at the outer end of its stroke. The non-return inlet valve 13 is held closed by the pressure of this column of liquid. When the piston is forced inwards it exerts a pressure on the liquid in both the inlet and delivery pipes and since the non-return valve 13 is closed no liquid can escape from the inlet pipe and the liquid in the pipe itself is thus subjected to the full pressure exerted by the piston, and the inlet part of the system with the liquid in it is strained so that the piping is expanded and the liquid is compressed according to their respective physical characteristics.

Simultaneously, the application of the pressure by the piston 18 to the liquid in the delivery pipe causes it to be discharged therethrough, and preferably the dimensions of this pipe are so selected that the liquid is given a high velocity. Conveniently, this is effected by employing a delivery pipe of small diameter relatively to the cylinder of the pump.

Where the delivery end 14 is open, the pressure in the system which can be generated by the piston 18 depends upon the mass of liquid in the delivery pipe and the acceleration which is imparted to it, and it is desirable that this pressure should be high and this is effected by ensuring either that there is a large mass in the delivery pipe, or that it is given a very high velocity, or both.

When the liquid in the delivery pipe has attained its maximum velocity the piston is approaching, or is at, the inner end of its stroke depending upon the mechanical arrangements used for operating the piston; if it is driven through a crank and connecting rod it will have an approximate harmonic motion and the maximum velocity of the liquid in the delivery pipe will occur at or shortly after the middle of the inward stroke of the piston. As soon, however, as the piston slows down or stops, the liquid in the delivery pipe having attained its maximum velocity will tend to continue in motion, by virtue of its inertia so that it will separate or tend to separate from the liquid in the cylinder and in the inlet part of the system. As the pressure on the inlet part of the system is relieved the energy which has been stored in the inlet part of the system is released and the liquid in the inlet part of the system is thereby set in motion towards the delivery pipe, and by being lifted off the inlet valve it relieves the pressure thereon so that an inflow of liquid takes place due to the atmospheric pressure outside; it will be seen therefore that when the piston is ready to start on its next inward stroke, some liquid has been discharged through the delivery pipe from the open end 14 thereof, some of the liquid in the inlet pipe has been transferred to the delivery pipe and to the pump cylinder, and additional liquid has entered the inlet pipe through the non-return valve 13. On the next stroke the cylce of operation is repeated and this continues so long as the piston is kept in motion so that liquid is lifted from the supply 12 and delivered from the outlet 14.

It will be seen that special advantages arise from this characteristic of the present invention as for example in the case of pumping a liquid which contains a gas in solution. This is troublesome with an ordinary type of suction pump since the gas tends to come out of solution, whereas in the present system the presence of gas in solution renders the liquid more highly compressible so that more energy can be stored in it, and the fact that the liquid is subjected to pressure prevents the gas from coming out of solution.

It also lies within the scope of the invention to provide special means in the inlet part of the system whereby energy may be resiliently absorbed, it being appreciated of course that such special means must always be capable of withstanding the pressure to which the system may be subjected in its operation.

In cases where comparatively small lifts are required on the inlet side, the inlet pipe may be made of a suitable resilient material such as stout rubber hose; alternatively, a metal pipe may for example be lined with rubber or other resilient material which will easily absorb and return energy to the system as required, and it will be appreciated that this is useful as for example when pumping corrosive liquids.

The following is an example of an actual construction of a pump used in practice.

The piston was of 2 ins. diameter and had a 4 ins. stroke and was actuated by a 1 H. P. motor. The inlet pipe was of mild steel of 1 inch diameter approximately 66 feet long. The water level was 46 feet below the bottom of the pump cylinder which was disposed vertically, and the foot valve was 20 feet below water level. The delivery pipe was 100 ft. long, the first 30 feet being of 1½ ins. diameter and the remainder of 3 ins. diameter, and the outlet point of such delivery pipe was 50 feet above the pressure chamber. When working at a speed of 340 strokes per minute, a delivery of 2,400 gallons per hour could be obtained, but the pump could be run at lower speeds absorbing less power.

It will of course be appreciated that the outlet and inlet pipe may form one continuous whole so long as there are efficient means for applying the intermittent pressure and that the term "pressure chamber" as here used covers any arrangement for the application of such pressure.

It is not essential that the piping should be arranged as shown in Figure 1, and Figure 2 shows a different arrangement in which the inlet pipe 21 with the non-return valve 13 is vertical and the delivery pipe 22 is horizontal. In this case the cylinder 17 is shown as arranged vertically and the connection 16 to the junction between the inlet and delivery pipes is apparently a continuation of the inlet pipe 21. Although this arrangement gives the appearance that the delivery pipe is situated on the inlet side of the pump, it is not so in fact because the delivery pipe is constituted as before by that part of the pipe between the connection to the cylinder and the open delivery end.

It will be appreciated therefore that any disposition of inlet and delivery pipes may be used, and the cylinder and piston may be situated at any point provided it communicates with the junction of the inlet and delivery pipes so that

the pressure can be applied intermittently to them. Preferably, this connection will be filled with liquid, as will the cylinder, in order that the requisite pressures can be obtained, but in some instances it may be possible to provide an air-cushion between the pump piston and the liquid in the main part of the system.

It will be appreciated that in the system so far described the only valve present in the system is the automatic non-return inlet valve 13, so that the rate of delivery of fluid by this pump is dependent solely on the speed of operation of the piston 18. If it is desired to provide a manual valve control this may be effected as shown diagrammatically in Figure 3. A manually operated stop valve 23 is shown at the delivery end 14 of the system, and in order to prevent pressure building up in the system when this valve is closed and the piston is left running a cylinder 24 having a capacity equal to that of the cylinder 17 is provided in direct communication with the inlet and delivery pipes, and a piston 25 in this cylinder is provided wth a controlling spring 26 normally holding the piston 25 at the inner end of its stroke. This spring is of such stiffness that in normal operation of the system it does not move, but when the valve 23 is closed the pressure which developed on the inward movement of the piston 18 moves the piston 25 so that the liquid is merely transferred between the cylinders 17 and 24 and the pressure on the inlet part of the system is never relieved so that no fresh liquid enters the system and therefore the pressure does not build up.

If the valve 23 is partly opened a restricted delivery is obtained, but the pressure on the inlet part of the system is not released to the same extent and therefore a correspondingly reduced intake of liquid through the valve 13 takes place.

Sometimes it is required to transfer liquids between two points in either direction and the pumping system according to the present invention lends itself to such an arrangement. This is diagrammatically illustrated in Figure 4 in which there are shown two tanks 27, 28. The pipe 29 between them is connected to a pumping cylinder 30 in the manner above described, and each end of the pipe is provided with an automatic non-return valve 31 and with a stop valve 32 which can be opened or closed at will, the stop valve opening into the inlet pipe above the inlet valve 31. If one valve 32 is closed and the other is opened, the second valve 31 is thereby rendered inoperative and pumping takes place, in the manner previously described, from the tank in which the stop valve 32 is closed into the tank in which the stop valve is open. If it is desired to reverse the direction of pumping all that is necessary is to close the second valve 32 and open the first valve 32; whichever of the non-return valves 31 is rendered operative by the closing of its stop valve determines that that end of the pipe constitutes the inlet and the other end of the pipe the outlet or delivery end.

Finally, it is to be pointed out that the drawing accompanying this specification is purely diagrammatic and is not intended to limit in any way the mechanical design or arrangement of the system, and any suitable types of valves and any other kind of pump capable of intermittently producing pressure may be used, the only requisite being that a sufficient interval of time should be provided between the pressure impulses to allow of the transfer of liquid in the manner hereinbefore described and that the valves shall effectively accommodate such flow.

The present invention thus provides an improved construction and arrangement of pump of the aforesaid type in which all valves except the inlet valve are eliminated, and which operates on a cycle that is independent of its speed; it is thereby distinguished from known pumps of similar types which operate by setting up resonant pressure waves in the system, and also from those which operate on a cycle determined by the operation of their valves.

I claim:

1. The method of raising liquids from a depth unrelated to the barometric column of said liquid, which comprises establishing a column of liquid in a suitable inherently resilient containing system having non-return inlet valve means adjacent the bottom thereof, establishing another column of liquid of considerable length beyond and in communication with the upper end of said first named column, and in a suitable containing means comprising a free and unobstructed delivery system, causing a forward acceleration of the liquid in the delivery system and simultaneously causing a compression impulse in the first named or inlet system by applying pressure at the point of junction of said two bodies of liquid, thus tending to separate the two bodies of liquid at said point, storing the energy of the latter impulse in the first named or inlet system by the inherent resilience thereof, and then releasing the stored energy by removing said pressure, and causing the body of liquid in the inlet system to follow the still moving body of liquid into the outlet system, and thus admitting more liquid through the inlet valve means to replace the portion of the liquid which has moved into said delivery system.

2. A pumping system for liquids comprising an inlet pipe with a non-return inlet valve at its intake end, a normally open unobstructed delivery pipe having one end in direct communication with the outlet end of the inlet pipe, the inlet pipe being of considerable length to provide sufficient inherent resilience and expansion for the storage of energy resulting from intermittently applied pressure, the delivery pipe also being of considerable length to provide a body of liquid of sufficient mass and inertia to ensure the production of adequate pressure on the liquid in the inlet pipe to store said energy and to provide sufficient momentum to exert a pull upon the body of liquid in the inlet pipe, a cylinder in free communication with said system at the junction of said inlet and delivery pipes, a piston adapted to reciprocate in said cylinder and means for reciprocating said piston at a rate of speed unrelated to the dimensions of natural period of vibration of said system but adapted to intermittently apply pressure to the bodies of liquid contained in said pipes, whereby the liquid in the delivery pipe is moved therethrough during the application of pressure so that it tends to separate from the liquid in the inlet pipe, and further whereby the pressure applied to the inlet part of the system resiliently stores energy uniformly throughout the whole volume thereof until such energy is released, whereupon the movement of the liquid in the delivery pipe becomes operative on the liquid in the inlet pipe to transfer a portion thereof to the delivery pipe and thereby permit the inflow of further liquid through the inlet valve, cut-off means provided in the delivery pipe for turning the flow of liquid

on or off as the need requires without stopping the operation of said piston, and normally inoperative and ineffective means in the system for absorbing and nullifying only the pressure impulses due to a continued operation of the piston while the cut-off means is closed.

3. A pumping system for liquids comprising an inlet pipe with a non-return inlet valve at its intake end, a normally open unobstructed delivery pipe having one end in direct communication with the outlet end of the inlet pipe, the inlet pipe being of considerable length to provide sufficient inherent resilience and expansion for the storage of energy resulting from intermittently applied pressure, the delivery pipe also being of considerable length to provide a body of liquid of sufficient mass and inertia to ensure the production of adequate pressure on the liquid in the inlet pipe to store said energy and to provide sufficient momentum to exert a pull upon the body of liquid in the inlet pipe, a cylinder in free communication with said system at the junction of said inlet and delivery pipes, a piston adapted to reciprocate in said cylinder and means for reciprocating said piston at a rate of speed unrelated to the dimensions or natural period of vibration of said system but adapted to intermittently apply pressure to the bodies of liquid contained in said pipes, whereby the liquid in the delivery pipe is moved therethrough during the application of pressure so that it tends to separate from the liquid in the inlet pipe, and further whereby the pressure applied to the inlet part of the system resiliently stores energy uniformly throughout the whole volume thereof until such energy is released, whereupon the movement of the liquid in the delivery pipe becomes operative on the liquid in the inlet pipe to transfer a portion thereof to the delivery pipe and thereby permit the inflow of further liquid through the inlet valve, cut-off means provided in the delivery pipe for turning the flow of liquid on or off as the need requires without stopping the operation of said piston, a chamber in the system adjacent said cylinder and piston, and a spring-pressed piston in said chamber for absorbing and nullifying only the pressure impulses due to the continued operation of the pressure applying piston while said cut-off means is closed, said spring being of sufficient stiffness that in normal operation, when said delivery pipe is open and unobstructed, the spring pressed piston does not move.

4. A pumping system for liquids comprising an inlet pipe with a non-return inlet valve at its intake end, and a normally open unobstructed delivery pipe having one end in direct communication with the outlet end of the inlet pipe, the inlet pipe being of considerable length to provide sufficient inherent resilience and expansion for the storage of energy resulting from intermittently applied pressure, the delivery pipe also being of considerable length to provide a body of liquid of sufficient mass and inertia to ensure the production of adequate pressure on the liquid in the inlet pipe to store said energy and to provide sufficient momentum to exert a pull upon the body of liquid in the inlet pipe, a cylinder in free communication with said system at the junction of said inlet and delivery pipes, a piston adapted to reciprocate in said cylinder and means for reciprocating said piston at a rate of speed unrelated to the dimensions or natural period of vibration of said system but adapted to intermittently apply pressure to the bodies of liquid contained in said pipes, whereby the liquid in the delivery pipe is moved therethrough during the application of pressure so that it tends to separate from the liquid in the inlet pipe, and further whereby the pressure applied to the inlet part of the system resiliently stores energy uniformly throughout the whole volume thereof until such energy is released, whereupon the movement of the liquid in the delivery pipe becomes operative on the liquid in the inlet pipe to transfer a portion thereof to the delivery pipe and thereby permit the inflow of further liquid through the inlet valve, said delivery pipe and said inlet pipe each being adapted to be placed in communication with a body of liquid and provided with branched ends, one of the branches of each of said ends being provided with a non-return valve and the other branch being fitted with a manually controlled valve, rendering the pipes interchangeable in function to effect transfer of liquid in either direction.

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