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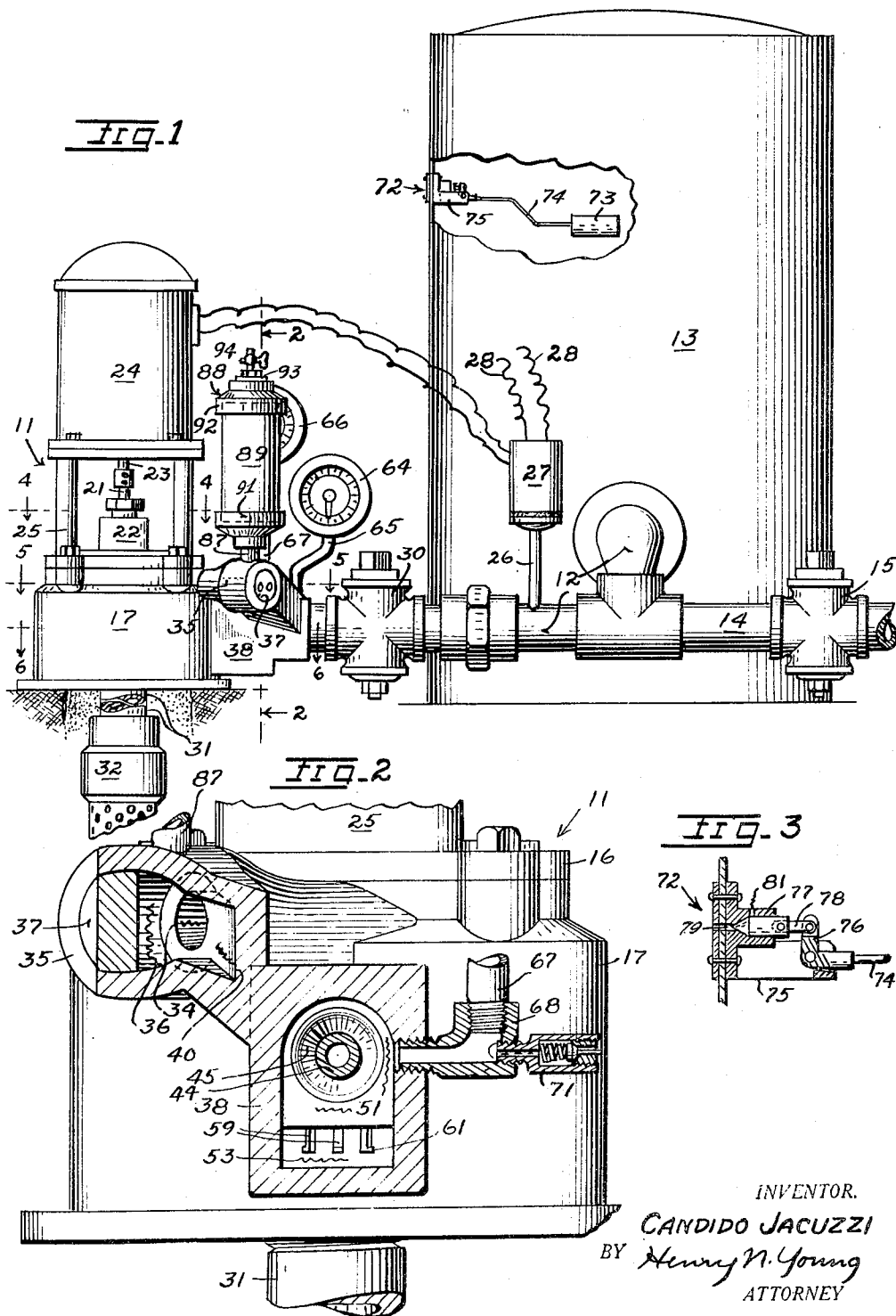
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2,205,121

PUMPING DEVICE

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FIG. 4

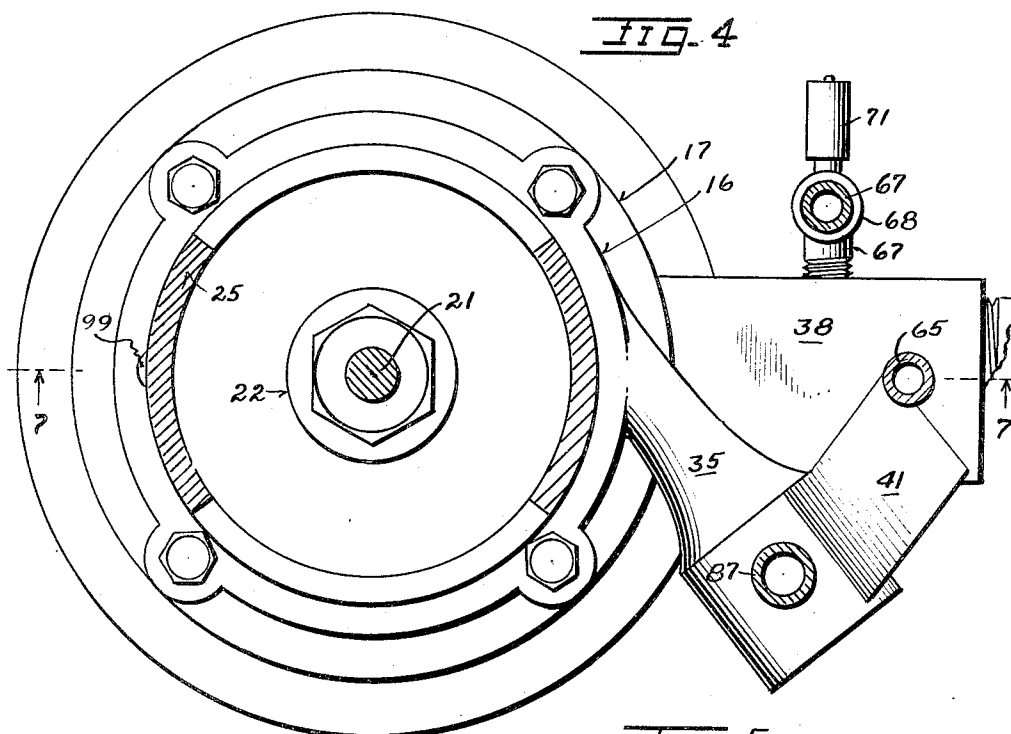
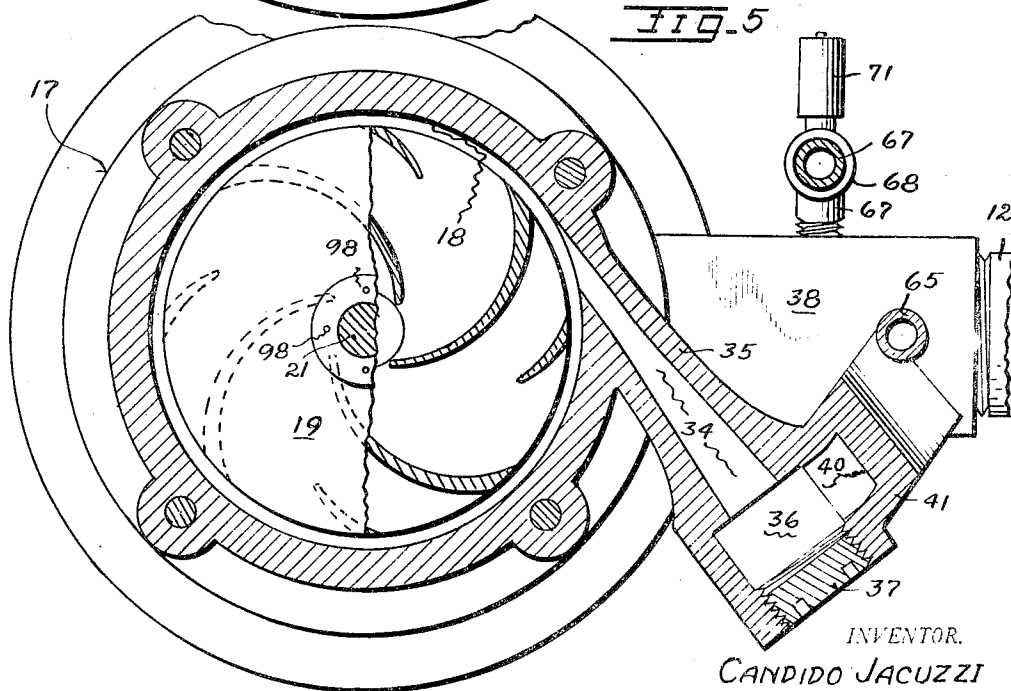


FIG. 5



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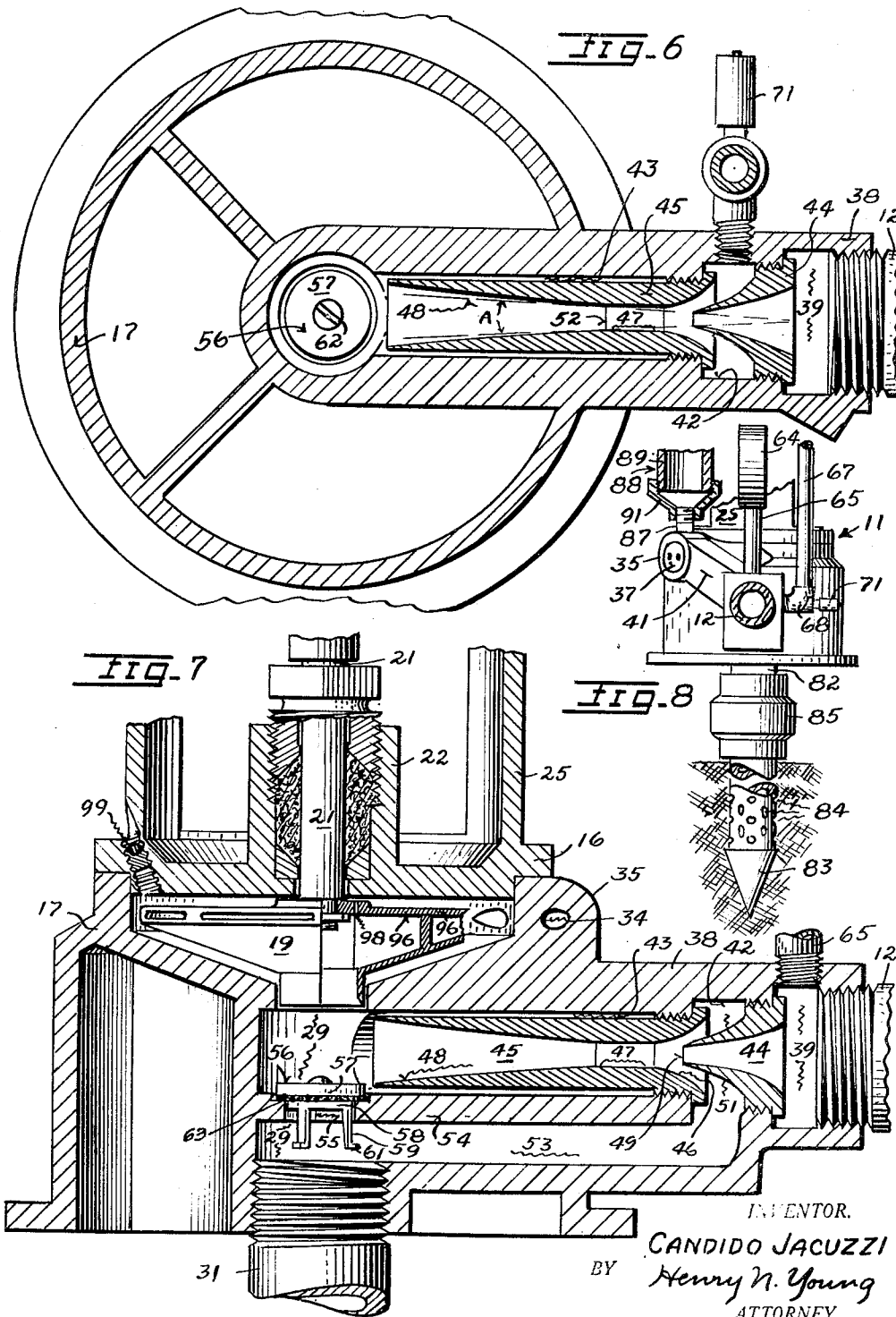
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UNITED STATES PATENT OFFICE

2,205,121

PUMPING DEVICE

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3 Claims. (Cl. 103—113)

The invention relates to a pumping device including a pump unit for discharging a pumped fluid against pressure.

A general object of the invention is to provide means in unitary association with a centrifugal pump to create a limiting discharge pressure which may be substantially double that generatable by the centrifugal pump alone and without increasing the required operating power over that required for the centrifugal pump.

Another object is to provide a pump unit of the character described which is particularly adapted to use in pressure systems of the type in which the pumped liquid is discharged into a closed storage tank against the pressure of air imprisoned in said tank.

A further object is to provide a pumping unit of the character described wherein the required operating power input is substantially constant for all discharge pressures of the unit.

An added object is to provide means in association with the pump unit and the tank of a pressure system for automatically maintaining a fixed amount of air in the pressure tank.

Yet another object is to provide the pump unit with an improved priming means for insuring its functioning when originally started, and subsequently.

A still further object is to provide the present pump features of invention in a particularly simple and compact pump unit.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth or be apparent in the following description of a preferred embodiment thereof, and in the accompanying drawings in which:

Figure 1 is a side elevation showing a pump unit embodying certain features of present invention in operative association with a pressure storage tank and installed at an open well.

Figure 2 is an enlarged and fragmentary sectional elevation taken on the line 2—2 in Figure 1.

Figure 3 is an enlarged sectional view of an air-release device of the tank.

Figure 4 is an enlarged plan view of the pump unit taken substantially at the line 4—4 in Figure 1.

Figure 5 and 6 are sectional plan views taken respectively at the lines 5—5 and 6—6 in Figure 1.

Figure 7 is a sectional elevation taken on the line 7—7 in Figure 4.

Figure 8 is a fragmentary elevation taken at

right angles to that of Figure 1 and showing the pump unit installed at a driven well.

By way of illustration, the various features of present invention are disclosed as embodied in the assembly of a pumping apparatus wherein a pump unit 11 is provided to supply liquid through a pipe 12 to a normally closed distributing system including a tank 13 in which the pumped liquid is stored under the pressure of air imprisoned in the tank. In the present showing, the distributing system beyond the tank 13 is represented by a discharge pipe 14 having a discharge valve 15 therein and comprising a branch of the pipe 14. When liquid is first drawn from the system, the storage tank pressure is primarily operative to effect the liquid discharge at the opened point of the system, and when the tank pressure falls below a predetermined minimum, the operation of the pump is automatically effected to directly maintain the discharge flow. When the distributing system is again closed, the pump unit continues to operate until the initial tank pressure is restored and is then automatically rendered inoperative.

The pump unit 11 essentially comprises centrifugal and injector pumps in unitary association for accomplishing certain important purposes herein set forth. As shown, the pump casing includes head and base members 16 and 17 respectively which jointly define a runner chamber 18 in which a centrifuging runner 19 of a usual type is operative. In the present instance, the axis of the centrifugal pump is vertical and the runner shaft 21 extends solely upwardly from the runner through a suitable stuffing box 22 to a fixed and supporting connection with the shaft 23 of a vertical-shaft electric motor 24 which is mounted on a suitable pedestal extension 25 of the casing head member 16. The connecting pipe for a suitable pressure-controlled electric switch which is indicated by the numeral 27, is tapped into the pump discharge pipe 12 beyond a normally open valve 30 therein, and the motor 24 is connected with power supply wires 28 through the switch 27 for providing the previously mentioned automatic control of the motor and pump operation in accordance with the pressure in the distributing system.

By particular reference to Figure 7, it will be seen that an intake passage 29 extends upwardly and axially through the base member 17 for supplying liquid within the inlet opening of the runner 19 from a riser pipe 31 which is connected to the passage 29 for conveying liquid thereto from a well or other source of liquid to be

pumped. A check-valve 32 of the gravity type is preferably operative in the pipe 31 whereby to prevent a return of the lifted liquid and the relief of the pressure in the distributing system when the pumping operation is stopped; as is indicated in Figure 1, the valve 32 comprises the usual foot-valve at the intake end of the riser pipe 31. The present pump unit is shown as being installed as a lift, or suction, pump at a shallow open well whereby no further pump mechanism is needed or provided below it, the well bore freely receiving the pipe 31 and foot-valve 32.

It will now be noted that the discharge of liquid from the runner chamber 18 is arranged to take place through a straight passage 34 which extends tangentially from the periphery of the runner chamber through the casing and through a corresponding casing extension 35 in the manner particularly indicated in Figures 1 and 2 and 4 and 5. The passage 34 is flaring as a diffuser or Venturi port, and terminates at a cylindric cavity 36 defined within the outer end portion of the extension 35. The outer portion of the wall of the cavity 36 is internally threaded to facilitate the connection thereof of the discharge pipe 12 for the pump; in the present instance, however, the discharge pipe 12 is connected elsewhere to receive the liquid discharged from the diffuser passage 34, and a plug 37 seals the outer end of the cavity 36.

A radial casing extension 38 of generally rectangular cross-section lies generally below the casing extension 35, and has a cavity 39 provided in its outer end portion and connected with the cavity 36 of the extension 35 by means of a duct or passage 40 extending through a suitable connecting part 41 of the casing section 17. The cavity 39 is cylindrical about an axis radial and perpendicular to the pump axis, extends to the end of the extension 38, and has its outer part threaded for its connection with the discharge pipe 12 for conducting the pumped liquid to the distributing system to be supplied.

The extension 38 and the casing section 17 have a straight bore therethrough comprising a progressively stepped and reduced extension of the cavity 39 to the intake passage 29 below and adjacent the runner chamber 18, said bore having a relatively short part 42 and a relatively long inner part 43 of least diameter. The bore portions 42 and 43 are threaded at their outer end portions for receiving and fixedly mounting tubular members 44 and 45 respectively, which members comprise the nozzle and discharge tube of an injector assembly. The bore of the injector tube 45 has a funicular liquid-receiving portion 46 at its rearward end, an intermediate cylindrical portion 47 providing the smallest bore part, and a relatively long diffuser portion 48 which flares from its inner end at the portion 47 and discharges at the runner intake.

The discharge lip 49 of the injector nozzle 44 is relatively sharp and lies opposite an intermediate point of the bore part 46 in centered and spaced relation thereto whereby the discharge of liquid from the nozzle 44 into the tube 43 is operative to create a suction zone in the space or chamber 51 about the nozzle at the bore portion 42. In practice, it has been found that the present injector assembly will create the highest possible degree of vacuum in the suction chamber 51 if the conical angle A defined by the nozzle lip 49 and the juncture line 52 of the tube bore portions 47 and 48 is of the order of six

degrees; the relation is indicated in Figure 6 and is an important feature of design in the present pump unit. It will be understood that the injector nozzle 44 is supplied with part of the liquid from the space of the cavities 36 and 39 and the connecting passage 40, and that said space comprises the discharge passage for the pump unit.

Liquid is supplied to the suction chamber 51 through a passage or duct 53 which extends radially through the casing and its extension 38 from a point of the pump intake passage 29 beneath the bore 43 to a junction with the lower side of said chamber. A partition 54 transversely divides the intake passage 29 at a point between its side openings for the bore and passage 53, and is provided with a relatively large port 55 at which a check valve 56 is operative. As shown, the valve 56 is of the gravity type and comprises a disc 57 and a smaller plate member 58 from which extensions 59 depend axially through the port 55. The extensions 59 are provided at their extremities with radial stop lugs 61 for engaging beneath the partition 54 to limit the unseating of the valve. For facilitating a mounting of the valve 56 in its place, the disc 57 and plate 58 are detachably connected by means of a screw 62 which is operative to clamp a suitable sealing ring 63 between the disc and plate.

It will now be noted that whenever the present pump unit is operating as a lift pump and is discharging liquid through the pipe 14 at a super-atmospheric pressure, part of the liquid discharging through the discharge cavity 39 will be returned to the intake passage 29 at a point thereof above the valve 56 through the nozzle 44 while effecting an entrainment of liquid taken from the intake passage below the valve 56 and creating a superatmospheric pressure above the valve 56 and at the runner intake. Under these circumstances, the valve 56 will be held closed whereby the liquid will be supplied to the runner chamber solely by way of the injector device in the pump unit, it being understood that the passage 53 and injector tube 45 jointly provide a by-pass around the valve 56, which by-pass constitutes the sole supply passage for the centrifugal pump of the unit when the valve is closed. If, on the other hand, the pump is discharging at substantially atmospheric pressure, as when the tank 13 is empty and the distributing system is fully open, the injector will not be appreciably operative and the suction of the centrifugal pump may open the valve 56 to permit a direct upward flow of liquid through the passage 29 to the pump runner 19.

Means are preferably provided for ascertaining the pressure conditions at certain points of the present pump unit. As particularly shown, a meter 64 is provided for indicating the pressure at the discharge side of the centrifugal pump, said pressure being that behind the nozzle 44 and also that in the distributing system; in the present instance, the meter connection pipe 65 is tapped into the casing portion 38 to connect the meter with the cavity 39. A meter 66 is connected with the suction chamber 51 of the injector structure by means of a pipe 67; as shown in Figures 2 to 6, the pipe 67 is tapped into the side of the casing portion 38 at the chamber 51 and includes an elbow 68 whereby the meter 66 may be disposed upright.

Since the quantity of air in the pressure tank should be substantially constant, and air under pressure may dissolve in a contacting liquid,

means are provided for automatically maintaining the proper amount of air in the tank 13 above the liquid therein. Essentially, the quantity of air in the tank is controlled by inducing air into the liquid at the injector chamber 51, and releasing excess air from the top of the tank 13. As illustrated, a spring-controlled air inlet valve 71 is connected with the passage of the meter pipe 67 at the elbow 68 thereof whereby the suction in the chamber 51 may be operative to draw air into the liquid therein in general proportion to the degree of suction, but without appreciably relieving the suction, and to aerate the liquid in excess of requirements. The necessary escape of excess air from the tank 13 is effected through the operation of a suitable float-controlled air valve 72 which discharges through the tank wall above the permitted water level in the tank.

As is particularly illustrated in Figures 1 and 3, a float 73 is mounted at the free end of the arm 74 of a bell-crank lever pivoted on a base member 75 mounted on the side wall of the tank 13, and has the extremity of its other arm 76 connected to a valve plug 77 by means of a link 78. The base member 75 provides a cylinder bore receiving the member 77 as a piston therein, and the inner cylinder end provides a conical valve seat against which the complementary opposed end of the plug 75 may sealedly engage. A discharge duct 79 extends axially of the cylinder from the seat thereof and through the tank wall, and a relatively small port opening 81 is provided in the side of the cylinder for the retarded discharge of air through the valve when the plug is unseated. It will be understood that the present valve must be opened against the tank pressure, that the weight of the float is positively operative to open the valve when the liquid level is below its maximum, that the retarded air escape at the opened valve permits a building up of the required tank pressure as the tank is filled, and that the control afforded is independent of the pressure control for the motor operation.

Referring to the installation of the pump unit shown in Figure 8, it will be noted that the riser pipe 82 is a driven pipe having an imperforate and conical driving tip or bit 83, liquid inlet openings 84 just above said tip, and a check valve 85 operatively interposed in the pipe 82 above the top of the well bore which, having been provided by driving the pipe into the ground, closely receives the pipe and prevents the disposal of the valve 85 within the bore. For this installation and for that shown in Figure 1, the pump unit must be initially and constantly primed by having liquid therein from the check valve in the intake pipe to the runner chamber, and means are provided to manually effect such priming when required.

As is particularly shown in Figures 1 and 4 and 7 and 8, the pump discharge passage is tapped at the top of the chamber 36 by an upright pipe 87 through which priming liquid may be introduced into the pump unit from a normally closed container 88 which is mounted on said pipe. It will be noted that the connection for the pipe 87 is made at the highest point of liquid flow through the pump, and that the container 88 is above that point; this provides for relieving any air pocket in the discharge passage, as is necessary.

The container 88 preferably provides a cavity which is at least as large as the liquid capacity of the pump unit 11 whereby, at least in the

case of the arrangement of Figure 8, one filling of the container may provide sufficient liquid for effecting a primary filling of the pump cavities above the valve 85. In the present instance, the container 88 comprises a laterally imperforate tubular element 89 sealedly engaged between the upper and lower end elements 92 and 91 respectively; the element 91 provides the container connection with the pipe 87, and the element 92 is provided with a central opening which threadedly receives a closure plug 93 and is large enough, when open, to readily receive the priming liquid therethrough. A normally closed pet-cock 94 is connected with an axial port in the plug 93 to provide a limited outlet for the container 88.

When the operation of the present unit 11 is to be initiated and priming is required, the container 88 is opened by removing the plug 92, and the priming liquid is introduced into the container until the runner 19 may operate in liquid. The element 92 is then replaced with the pet-cock 94 open to provide a relatively small passage, the valve 30 is closed, and the motor 24 is energized to rotate the runner. Under these conditions, the combined operation of the runner and injector is arranged to build up a super-atmospheric pressure in the pump discharge passage and the container while creating an increasing degree of vacuum in the riser pipe below the check valve therein whereby to finally cause a flow of liquid through the intake check valve and into the pump.

As the liquid lift is accomplished in the riser pipe, the air from said pipe may enter the container 88 and escape through the pet-cock 94, it being noted that the pet-cock is set to retard the air escape therethrough for building up the before-mentioned super-atmospheric pressure in the pump. When the water level in the container 88 reaches the pet-cock, the valve 30 is opened, and the pet-cock is closed as having completed its service. It will be understood that the container 88 is arranged to be substantially full of liquid while the pump is operating for the delivery of liquid, and that any air accumulating in the container 88 may be released while the pump is operating and merely by opening the pet-cock 94.

By particular reference to Figure 7, it will be noted that the top wall 96 of the runner cavity provides a flat inner face 97 which is horizontally disposed, and that it is desirable to insure against the formation and retention of air bubbles at said face. Accordingly, a plurality of minute bleeder holes 98 are provided in the wall 96 axially thereof and as close as is practicable to the runner shaft 21 whereby air may not accumulate at the face 97. During the operation of the pump, the necessary air venting for the runner chamber 18 above the level of the inlet end of the diffuser passage 34 may take place through the packing at the stuffing box 22, this having been assumed in the present instance instead of providing an air relief valve for the purpose. A normally plugged outlet 99 extends through the upper casting member 16 for opening to permit the escape of air from the chamber top, as may be required.

It will be understood that the present pump unit 11 will operate as described for providing a pressure discharge against a lift head rather than against the air pressure in a closed tank. Also, for providing an open discharge of liquid at the same level, the pressure tank would be omitted and the valve 30 partly closed as a

back-pressure valve whereby the injector pump of the unit may operate as described, and liquid discharge may take place at an increased pressure determined by the setting of the valve 30.

Referring more specifically to the operation and advantages of the pumping device now described, it will be noted that the present unitary association of centrifugal and injector pumps wherein the injector pump feeds part of the pumped liquid back to the centrifugal pump at the same level, does not increase the required operating power for the unit as it provides an increased discharge pressure for it through the added action of the injector, since the quantity of discharge is correspondingly lowered. Thus, as the required discharge pressure increases, the discharge flow of liquid through the pipe 12 into a closed distributing system decreases until a limiting pressure is reached at which no flow occurs; with the present unit, said limiting discharge pressure is about double that which the centrifugal pump of the unit might generate alone.

Actual tests made with a pumping unit constructed as shown and described, and having a runner of four and five-eighths inches diameter and powered with a one-half horse-power electric motor to rotate at thirty-four hundred fifty revolutions per minute and designed to deliver twenty gallons of water per minute on open discharge, have produced a limit tank pressure of sixty-seven pounds per square inch when the centrifugal and injector pumps fully cooperated, and a limit pressure of but thirty-six pounds with the centrifugal pump operating alone at the same lift; the injector pump of the unit may be rendered inoperative by substituting a plug for the injector nozzle 44.

It will be understood that the normal discharge pressure of the centrifugal pump of the unit 11 is increased by reason of the described action of the injector discharging at the intake of the centrifugal pump, whereby a super-atmospheric pressure is provided at the runner intake and all original input to the unit occurs through the passage 53 and the suction chamber 51 and the injector tube 45. Also, and in view of the operative principles involved in the present cooperative combination of a centrifugal pump and an injector, it will be noted further that such a pump unit to deliver a given quantity of liquid at a given pressure may be designed for operation at a very much lower rotative speed of its centrifuging runner than that required by a centrifugal pump acting alone to accomplish the same results, thereby providing a more efficient application of power and minimizing bearing wear for the runner and motor.

From the foregoing description taken in connection with the accompanying drawings, the advantages of the construction and method of operation will be readily understood by those skilled in the art to which this invention appertains. While I have described the features and principles of operation of a structure which I now consider to be a preferred embodiment of my invention, I desire to have it understood that the showing is primarily illustrative, and that such changes may be made, as desired, as fall within the scope of the following claims.

I claim:

1. In a lift pump unit, a casing disposed above the liquid and providing a discharge passage at the top thereof and an intake passage, a riser

pipe extending upwardly from within the liquid and providing an extension of the intake passage, a mechanically operable pump in the casing for discharging into said discharge passage, a check valve operative in the intake passage, an intake by-pass around said valve, an injector pump operative in said by-pass, means providing a passage to feed liquid back from the discharge passage to the injector pump nozzle to operate the latter pump, a one-way inlet valve operative in the intake passage below the first valve and the by-pass and above the liquid level for retaining liquid within the pump, means to close the discharge passage beyond its connection with the passage to the injector pump nozzle whereby the operation of the mechanically operable pump is operative to circulate the liquid entirely within the pump to create a vacuum at the lower inlet valve, and means to permit the escape of air at the top of the pump unit.

2. In a liquid pumping unit, a pump casing providing intake and discharge passages therefor, a mechanically operable pump in the casing for discharging into said discharge passage, a check valve in the intake passage, an intake by-pass around said valve, an injector pump operative in the by-pass to induce an intake flow of liquid to the first pump around the check valve, means providing a passage to feed liquid back from the discharge passage to the jet of the injector pump, means operative for automatically introducing air into the liquid in the jet-feeding passage, a pressure tank containing air and receiving the pumped liquid from the first pump, an actuating means for the first pump, means automatically controlling the operation of said pump actuating means whereby the latter means is rendered inoperative whenever the tank pressure exceeds a predetermined maximum, and means controlled by the liquid level in the tank to automatically release excess air therefrom for permitting the rise of liquid in the tank to a predetermined height as said maximum tank pressure is reached.

3. In a liquid-pumping unit, a casing providing suction intake and pressure discharge passages for the unit, a mechanically operable pump operative in the casing for effecting a continuous pressure discharge of liquid into said discharge passage, means automatically operative to limit the pressure generatable in the discharge passage to a predetermined value, a check valve in the intake passage arranged for its opening by and under a relatively low degree of suction in the intake passage portion between the valve and the said pump, means providing an intake by-pass around said valve, an injector pump operative in the by-pass to induce an intake flow of liquid around the check valve and under positive pressure into the aforesaid intake passage portion whereby the discharge pressure of the injector pump will tend to neutralize the suction of the first pump, and means providing a passage to feed liquid back from the discharge passage to the jet nozzle of the injector pump to operate the latter, the discharge pressure of the injector pump being arranged to over-neutralize the intake suction of the first pump when the pressure in the discharge passage approximates the limiting value therefor whereby the check valve is held closed and the full intake stream to the first pump is supplied through the by-pass.

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