Sept. 30, 1941.

J. MANN

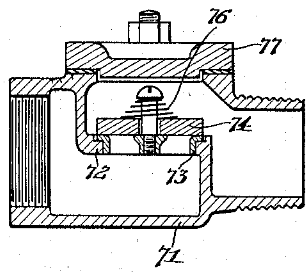
2,257,507

PUMPING APPARATUS

Filed March 28, 1940

2 Sheets-Sheet 1

Fig. 7



Described in literature of Goulds pump Co.

Fig. 1

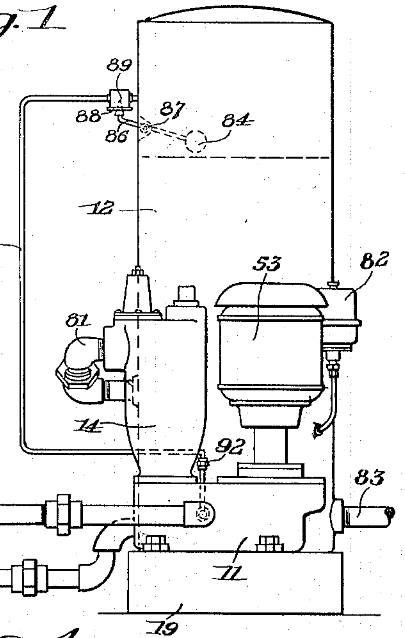


Fig. 4

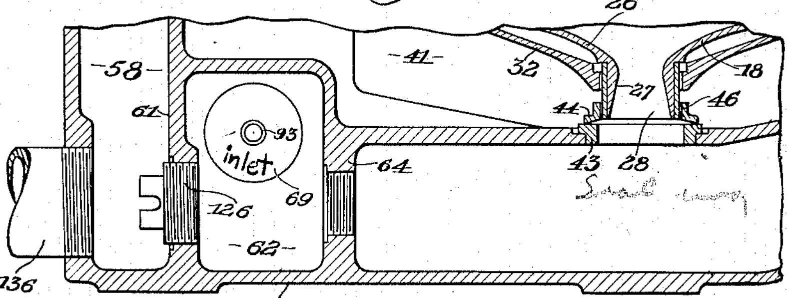


Fig. 5

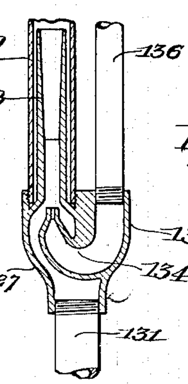


Fig. 6

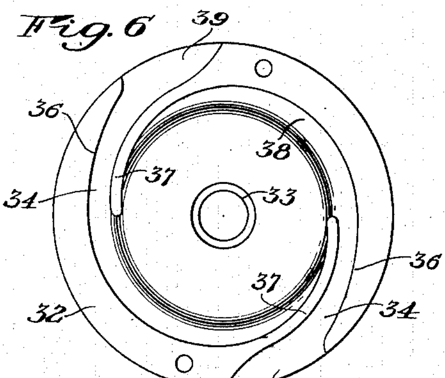


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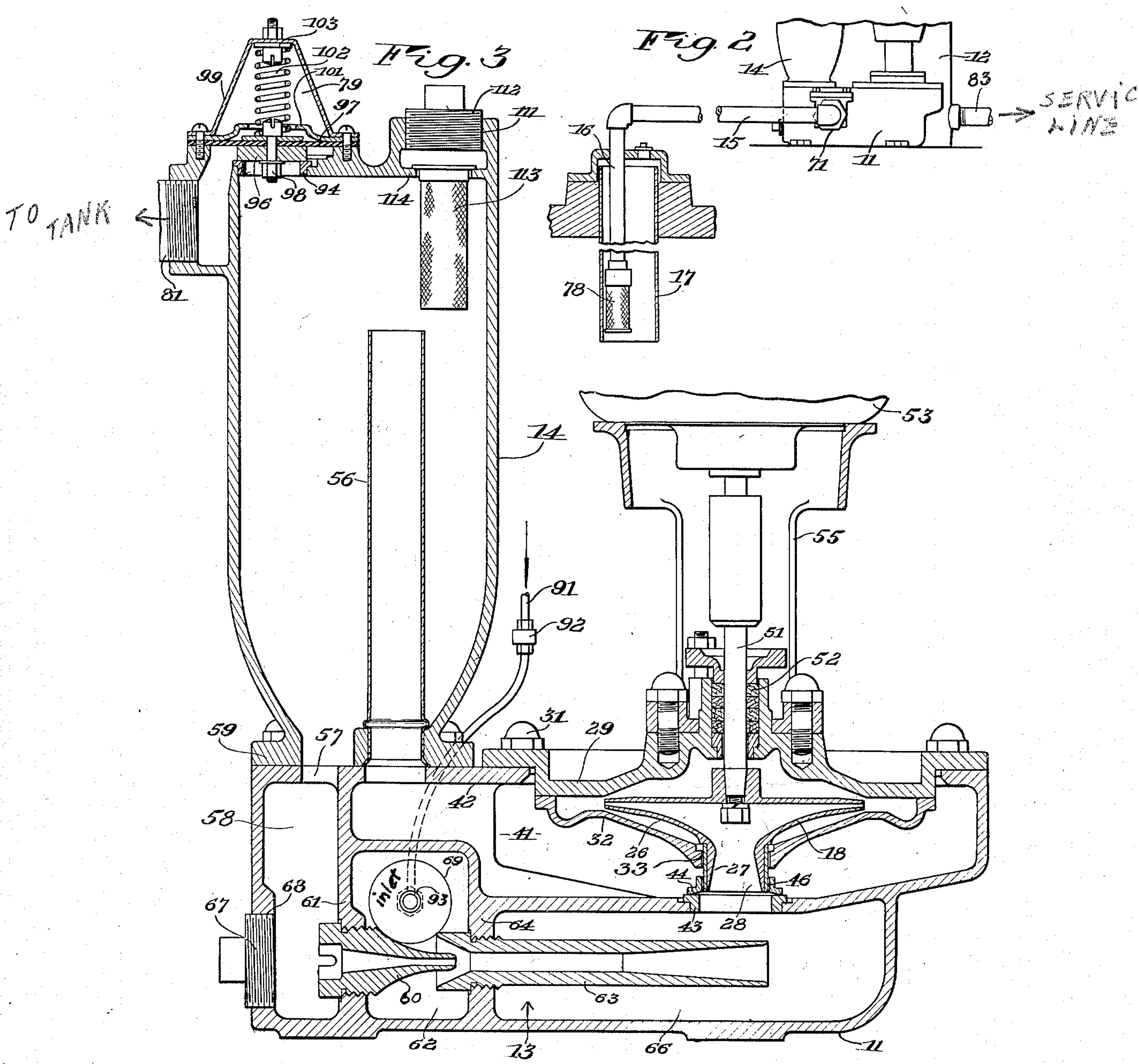
Fig. 3 Fig. 2



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UNITED STATES PATENT OFFICE

2,257,507

PUMPING APPARATUS

John Mann, Seneca Falls, N. Y., assignor to Goulds Pumps, Inc., Seneca Falls, N. Y., a corporation of New York

Application March 28, 1940, Serial No. 326,445

30 Claims. (Cl. 103—6)

My invention relates to pumping apparatus or systems, and is a continuation in part of my copending application, Serial No. 224,149, filed August 10, 1938.

The line of demarcation between a so-called shallow well pumping system and a deep well pumping system has usually been considered to be the practical suction lift of a centrifugal pump, in the neighborhood of 22 feet. While, of course, a properly designed centrifugal pump will draw water from a lower level than this, adequate margins of safety have limited the use of centrifugal pumps to wells where the draw down level of water in the well does not exceed approximately 22 feet. In fact most manufacturers will not recommend a centrifugal pump where the suction lift is in excess of 15 feet. Beyond this depth of well it has been customary to employ a reciprocating type of pump wherein the plunger of the pump is located in the well and is connected by a plunger rod to operating mechanism usually located at the ground level. In more recent years the jet type of deep well pump has attained considerable commercial success, primarily due to the fact that all the moving parts are located above the well and only the jet is located in the well.

The deep well pumps of the prior art, that is the reciprocating type, have at least two disadvantages: first, the pump and its primed mover must be located directly over the well, necessitating usually a separate pump housing; and, second, certain operating parts for the pump, such as the well rod and plunger, are located in the well, with the attendant inconvenience and disadvantage of servicing these parts. These disadvantages, as mentioned above, have in recent years led to a wide use of a pump known in the art as a jet type deep well pump. In the jet type deep well pump the combination of a jet pump and a centrifugal or other pressure pump is employed, the jet pump being located below the level of the centrifugal pump, and part of the liquid discharged from the centrifugal pump being used as a source of energy for lifting water from the well through the jet pump to the suction of the centrifugal pump, and thence to a pressure tank from which the service lines lead.

The primary advantages of a jet type deep well pump are that no moving parts are located in the well and the centrifugal pump, together with its prime mover, need not be located directly over the well. This permits all moving parts of the system to be located in the basement of the building which the pumping system is to serve, or in any other convenient position.

While the jet type deep well pumps now commercially employed have distinct advantages over other types of deep well pumps, they also have serious disadvantages. Among these disadvantages is the fact that a portion of the liquid discharged from the centrifugal pump is continuously recirculated through the system and through the centrifugal pump. Air leaks into the system through the water being pumped and leaks into the system through the stuffing box of the centrifugal pump. This infiltration of air into the system and the lack of any adequate means for its disposal causes the centrifugal pump eventually to become air bound.

In a jet type deep well pump a certain quantity of liquid discharged from the centrifugal pump is continuously recirculated through the jet pump to supply energy for lifting water from the well. This quantity, for convenience, we shall call Q1. The usual manner of connecting the centrifugal pump, pneumatic tank, and jet pump, is to have a single discharge pipe connecting the centrifugal pump to the tank. The water discharged from the centrifugal pump to the tank we will designate, for convenience, Q2. The quantity Q1 which goes down the well to supply the necessary energy to the jet pump does not pass through the tank, but instead separates from the quantity Q2 at a branch fitting, preferably placed close to the centrifugal pump discharge. The pneumatic tank in this arrangement serves as an air separator, but only for the air entrained with the quantity Q2 which flows from the centrifugal pump discharge to the pneumatic tank. The remainder of the liquid discharged from the centrifugal pump, the quantity Q1, recirculates through the jet pump. Air entering the system through the stuffing box of the centrifugal pump, or the suction pipe, or other possible leaks in the system, does not readily separate from the water, but at least a portion of it continuously circulates in the system with the quantity Q1. Air entering the system is largely retained in the piping because it tends to cling to the inner side walls of the pipes. If there is a sufficient accumulation of air in the system, the centrifugal pump will become air bound and fail to create a difference in pressure between the suction inlet and the discharge outlet, and therefore will not supply energy to the jet pump to enable the jet pump to pick up water from the well. When this condition obtains the only way to remove the air is to stop the centrifugal pump for a sufficient length of time for the air to rise through the piping and pass to the pneumatic tank. This method of clearing the system of air is, of course, possible only where the system is carefully designed to avoid air pockets.

The second disadvantage of the jet type deep well pumps now commercially employed is that usually no adequate or reliable means are provided for maintaining the quantity of air in the pneumatic tank substantially constant or at least above a predetermined minimum. The pneumatic tank is used primarily as a storage chamber so that the centrifugal or other pressure pump will not operate every time liquid is drawn from the system. The quantity of liquid which can be drawn from the system for use without operation of the centrifugal pump depends upon the capacity of the tank, the maintenance of at least a minimum quantity of air in the tank, and the range of pressure which is allowed between starting and stopping the centrifugal pump. A good arrangement is to stop the centrifugal pump when the pneumatic tank has reached a pressure of 40 pounds, and as the pressure in the tank drops, due to drawing off liquid, start the pump again when the pressure in the tank reaches 20 pounds. At the starting pressure of 20 pounds the quantity of air in the tank may be about half the capacity of the tank.

Since the operation of the system is usually automatic, being controlled by a pressure switch, continued automatic operation of such a system is dependent upon the pneumatic tank always being properly charged with air. In most of the water pumping systems employing a jet pump, a centrifugal pump and a pneumatic pressure tank, with which I am familiar, the air in the tank either gradually diminishes, or else the quantity supplied thereto is excessive. Usually if an air replenishing system is employed the apparatus is rather complicated and requires considerable attention in order to insure its proper operation. If the air in the tank is not replenished from time to time, the tank becomes filled with water or water logged, and the quantity of air under pressure becomes insufficient to force the water through the service pipes. In those systems where no air quantity control is provided, it is necessary at intervals to recharge the system with air. However, even this is to be preferred as compared with some of the rather complicated devices now employed on some commercial systerms for supplying air to the pneumatic tank.

In wells where the draw down level of the well is in excess of 22 feet, it has been customary, in the past, to employ a reciprocating type of deep well pump. I am aware, while centrifugal pumps are not capable of reliable operation with a suction lift in excess of 22 feet unless specially designed, that special types of pumps, such as the so-called regenerative turbine pumps, have been used for wells where the suction lift is between 22 and perhaps 28 feet in depth. With my system I contemplate employing the combination of a jet pump and a centrifugal or pressure pump with the jet pump located in the well where the draw down level is in excess of 31 feet, and with the jet pump located adjacent or at the level of the centrifugal or pressure pump when the draw down level is less than 31 feet.

Moreover, with the systems of the prior art it is impossible or relatively expensive to convert a shallow well pumping system to a deep well pumping system. It is necessary for the customer to purchase a substantially completely new pumping system if the conditions of operation are not as originally contemplated. In some cases the draw down level of the well is difficult to estimate. Even an experienced person, in the art to which the invention applies, may incorrectly estimate the draw down level of the well. For example, he may estimate the draw down level at 15 to 18 feet, and hence recommend a shallow well centrifugal pump. The estimate may be incorrect, due to various factors, and it may ultimately turn out that the customer required a pump capable of lifting water from the well with a total suction lift of perhaps 25 or 26 feet. His purchased system will, therefore, be inadequate. In other cases, the draw down level of the well may be estimated at 26 or 27 feet, thus involving a recommendation on the part of the pump manufacturer to employ either a deep well pump, with its attendant additional expense, or a regenerative turbine type of pump. If the latter is purchased and it ultimately turns out that the estimate was incorrect and that the draw down level of the well is more nearly 31 feet or more, then the regenerative turbine type of pump will be inadequate for its intended purpose.

With the system of my invention, the purchaser may readily convert the apparatus from a shallow well unit to a deep well unit, with a minimum of expenditure. The parts of the shallow and deep well pumping systems are interchangeable, thus enabling considerable saving on the part of the dealers in pumps in the cost of stocking pumping systems and parts therefor.

An object of my invention is to provide a jet type pumping system which is of simple construction, economical to build, inexpensive to erect, and more reliable in operation.

Another object of my invention is to provide a jet type pumping system which is more reliable in operation than existing commercial systems, due to the provision of means for minimizing the possibility of the centrifugal pump becoming air bound.

Another object of my invention is to provide a jet type pumping system wherein extremely simple and reliable means is provided for automatically maintaining in the pressure tank an adequate quantity of air.

Another object of my invention is to provide a unitary, compact assembly for a jet type shallow well pumping unit in which the centrifugal pump and the jet pump are housed in a single casting, and which is particularly designed for wells of from 22 to 31 feet total suction lift.

A further object of my invention is to provide a jet type pumping apparatus or system which may be readily converted from a shallow well pumping system to a deep well pumping system.

My invention further contemplates a jet type pumping system wherein only substantially air free liquid is supplied to the jet. Moreover the pressure of liquid on the jet, where conditions require, is always above a predetermined minimum, adequate for insuring quick priming of the system and adequate to provide the required energy for drawing the liquid from the well.

Other objects and advantages of my invention will be more particularly pointed out in the claims, and will be apparent from the following description, when taken in connection with the following drawings, in which:

Fig. 1 is a view partly diagrammatic showing the system as applied to a deep well;

Fig. 2 is a view somewhat similar to Fig. 1 showing the system as applied to a shallow well;

Fig. 3 is a view of a portion of Fig. 2 showing the pump unit, the air separation chamber and associated parts in section, and showing how the apparatus is arranged for shallow well operation;

Fig. 4 is a view similar to Fig. 3 showing the changes required to adapt the system for deep well operation;

Fig. 5 is a sectional view of the jet pump as it is arranged for deep well operation;

Fig. 6 is a plan view showing the impeller side of the centrifugal pump casing;

Fig. 7 is a sectional view showing a check valve suitable for use in the suction line of the system.

The jet type pumping system of my invention comprises in general, as shown in Fig. 1, a pressure pump housed in a casting, generally indicated by the numeral **11**, an air-tight pneumatic pressure tank **12**, and a jet pump, indicated as a whole by the numeral **13** (see Figs. 3 and 5). While the arrangement may be similar to that shown in the above mentioned copending application, for reasons which will later appear, I prefer to employ, between the pressure pump and the pneumatic pressure tank, an air separating chamber or compartment, generally indicated by the numeral **14**.

The pumping system of my invention is adapted for deep well operation in which case the apparatus is arranged as shown in Figs. 1 and 4. One of the features of my invention is the fact that the apparatus shown in Figs. 2 and 3, which is arranged for shallow well operation, may be readily converted to a system for deep well operation, in which case the apparatus is arranged as shown in Figs. 1 and 4. While the apparatus is particularly designed for well operation, it will, of course, be appreciated that the apparatus shown in Figs. 2 and 3 may be used for general pumping service where a high suction lift is desired, or where high temperature liquids are to be handled.

The apparatus of my invention will be first described in connection with its use for shallow well pumping, as shown in Figs. 2 and 3. The casting **11** which houses the pressure pump and the jet pump **13** is connected by a suction pipe or conduit **15** to a well pipe **16** which extends downward into the well **17**, as shown in Fig. 2.

One of the important features of my invention is the fact that the pressure pump, generally indicated by the numeral **18**, and the jet pump **13**, are mounted in a single casting, the casting **11**, closely adjacent each other so that an inexpensive, compact assembly is provided. The casting **11** may, if desired, be mounted on a suitable base. Or, if desired, the casting may be directly bolted or otherwise secured to a suitable foundation **19**.

The pressure pump **18** may be of any suitable type. In the drawings I have shown a pump of the centrifugal type, although it will be appreciated that other types of pumps may be substituted therefor as, for example, a regenerative turbine pump. The impeller **26** of the centrifugal pump may be of conventional construction except that it is provided, for a purpose which will later appear, with a relatively long cylindrically shaped portion **27** defining the suction inlet **28**. The casing of the centrifugal pump is defined by a cover plate **29**, which is secured, as shown at **31**, to the casting **11**. Bolted to the under side of the cover plate is a casting **32** which forms the other half of the centrifugal pump casing. The casting **32** is provided with a machined bore **33** (Fig. 6) which has a relatively close clearance with respect to the rotating cylindrical portion **27** of the suction inlet.

Adjacent the periphery of the casting **32** is a pair of discharge outlets or channels **34** which are formed, as shown more clearly in Fig. 6, partly by guide vanes or walls **36** and **37**. The channels gradually increase in cross sectional area toward their outlets and serve the same function as the conventional volute of a centrifugal pump. The liquid from the impeller is thrown outward into the space indicated by the numeral **38**, which gradually increases in cross sectional area, and flows out between the guide vanes **36** and **37** into enlarged portions **39** adjacent the periphery of the casting. The guide vanes serve to convert the velocity energy of the liquid after it is thrown from the impeller of the centrifugal pump into pressure energy. After the liquid is discharged through the guide vanes it enters an enlarged chamber or compartment **41** formed in the casting **11**.

One of the important features of my invention is the provision of means for preventing the centrifugal pump from becoming air bound. It will be appreciated, in pumping systems of the type disclosed herein, that air leaks are likely to develop in the piping and that a certain amount of air is entrained in the water drawn into the pump. This air accumulates in the system and if precautions are not taken it is likely to cause the centrifugal pump to become air bound. As will be presently described, all of the liquid discharged from the centrifugal pump passes to the separating chamber **14** so that air and liquid separation may take place. The liquid for feeding the jet is supplied entirely from the air separating chamber. Thus the liquid supplied to the jet pump is substantially air free.

In addition to designing the system so that all the liquid passing to the jet pump is substantially air free, I have taken the additional precaution of sealing the suction inlet of the centrifugal pump so that liquid discharged from the impeller, together with air, cannot recirculate back to the suction inlet of the centrifugal pump. Such means comprises a fixed sealing ring **43** secured in the casting **11** and a floating sealing ring **44** having a bore **46**. The bore of the floating sealing ring is only slightly larger in diameter than the cylindrical portion **27** of the suction inlet **28**. Thus there is but a slight clearance between the bore of the sealing ring **46** and the cylindrical portion of the suction inlet. The floating sealing ring is maintained against the fixed sealing ring **43** by the pressure differential on opposite sides thereof. The lower side of the sealing ring is exposed to the pressure of the suction inlet while the upper side of the ring is exposed to the greater pressure in the chamber **41**. To increase the effectiveness of this pressure differential in sealing the surfaces between the two rings, the lower side of the ring **44** is somewhat countersunk, as shown, so that the surface of the ring **44** bearing against the ring **43** is of limited annular area.

As previously mentioned the guide vanes or channels **34** in the casting **32** serve to convert velocity into pressure energy. For this reason the pressure in the chamber **41** is greater than that in the pump casing defined by the cover plate **29** and the casting **32**. As shown in the drawings, a slight space exists between the casting 32 and the floating sealing ring 44 so that the cylindrical portion 27 of the suction inlet 28 is subjected to the pressure in the chamber 41. Thus the liquid from the chamber 41 will tend to flow through the clearance provided between the cylindrical portion 27 of the suction inlet 28 and the sealing ring 44 to the suction inlet and also from the chamber 41 through the space between the bore 33 in the casting 32 and the cylindrical bore 27 of the suction inlet into the pump casing. The chamber 41 is of sufficient volume and the velocities of the liquid therein are sufficiently low so that liquid flowing from the pressure chamber 41 to the suction inlet is substantially air free.

The above sealing arrangement for preventing air from recirculating through the centrifugal pump is particularly important in a pumping system of the type with which my invention is concerned, for the reason that the system is designed for relatively high suction lifts. With a suction lift approaching 31 feet, the vacuum produced at the suction inlet is extremely high and this high vacuum tends to draw all the air in the system to the suction inlet. Unless sufficient precautions are taken, the air might continuously recirculate through the centrifugal pump and gradually accumulate, as it enters the system through leaks in the piping or from other sources. Sufficient accumulation of air may cause the centrifugal pump to become air bound.

The impeller 26 is secured in any suitable manner to the end of a shaft 51. The shaft extends through a specially constructed stuffing box 52 which, since it constitutes no part of my present invention, need not be particularly described. The motor indicated at 53 for driving the centrifugal pump is supported from the casting 11, as shown in the drawings, by bolting it to an adapter 55 which in turn is bolted to the cover plate 29. The motor shaft, while it may be integral with the pump shaft, is preferably connected to the impeller shaft by a coupling, diagrammatically illustrated at 54.

The air separating chamber 14, as shown in the drawings, is mounted on the top of the casting 11, and is preferably of relatively small size as compared to the pneumatic pressure tank 12. However, it is preferably of sufficient size to maintain the centrifugal pump flooded under even abnormal conditions of operation, as will be presently explained. Moreover it should be of sufficient size to reduce the velocity of liquid therein so that effective air separation may take place. Mounted in an opening in the casting 11 and extending through an opening in the chamber 14 is a pipe (or passage in the casting) 56 which extends upward into the chamber 14. As shown more clearly in Fig. 3, the pipe or passage 56 preferably rises to a considerable distance above the bottom of the pressure chamber so that, as will appear more clearly later, air and liquid separation may take place in the pressure chamber.

The chamber 14 communicates, through an opening 57 in the casting 11, with a passage 58 formed in the casting 11. Suitable sealing means are provided between the flange 59 at the lower end of the chamber 14 and the casting 11 adequately to seal the parts against leakage. The passage 58 communicates with the nozzle 60 of the jet pump 13. The nozzle 60 is preferably removably mounted on a dividing wall 61, formed in the casting 11, and which separates the passage 58 from the inlet chamber 62 of the casting 11. The nozzle 60 discharges into a diffuser 63 which is threaded into a dividing wall 64 separating a chamber 66 from the inlet chamber 62. The diffuser discharges into the compartment or chamber 66 into which the suction inlet 28 of the centrifugal pump opens.

As shown in the drawings, the dividing walls 61 and 64 have threaded openings for the reception of the nozzle and diffuser, respectively, which enables the parts of the jet pump to be readily removed from the casting, upon removal of a plug 67 which closes an opening 68 leading to the passage 58. The particular design of the jet pump constitutes no part of my present invention, except that the design thereof, in a manner well known in the art to which this invention applies, should be such as to provide a maximum sub-atmospheric pressure in the chamber 62 so as to draw water from the well or other source of supply. The combination of a jet and a centrifugal pump will maintain a higher vacuum than will a centrifugal pump alone because of the ability of the combination to handle air. This increased sub-atmospheric pressure enables the use of the system with suction lifts as high as 31 feet.

The inlet chamber 62, through an opening 69 in the casting 11, communicates with the pipe 15 which, as previously described, is connected with the well pipe 16. As shown in Fig. 2, preferably closely adjacent the casting 11 is a check valve 71, the details of which are shown in Fig. 7. The valve comprises a valve seat 72, a spider 73, and a valve element 74 normally held in engagement by a spring 76 with the valve seat. A removable cover plate 77 enables access to the valve for the purpose of cleaning, repairing or replacing the same. As shown in Fig. 2 the bottom of the well pipe is equipped with a strainer 78, and if desired, a foot valve may be employed, although this is not entirely necessary when the check valve 71 is used.

A pipe or conduit 81 connects the pneumatic tank and the air separating chamber. The motor 53 for driving the centrifugal pump is automatically controlled so as to start and stop in accordance with desired conditions of operation. As diagrammatically shown in Fig. 1, a pressure switch 82 is connected to the pneumatic pressure tank 12 in such manner as to be subjected to the pressure of the liquid in the tank. While I have shown the pressure swich as subjected to the pressure of the pneumatic tank, it will be appreciated that the starting and stopping of the motor may be controlled by the pressure in other portions of the system. For example, the pressure switch may be connected to the air separating chamber and this arrangement may be particularly desirable where the pump unit and the pneumatic tank are located at some distance from each other. Upon actuation of the pressure switch the motor for driving the centrifugal pump is stopped. When the pressure falls in the tank to a predetermined value, the pressure switch automatically starts the motor again. A suitable arrangement is to stop the motor when the pressure in the tank reaches 40 pounds, and to start it again when the pressure falls to 20 pounds. Since pressure switches of a type suitable for my purpose are well known in the art to which this invention applies, and since the pressure switch per se constitutes no part of my present invention, except as it enters into combination with other elements of the system, it need not be more particularly described.

A disadvantage of some of the jet type pumping systems of the prior art is that the pneumatic tank in service becomes water logged. In other systems, while means are provided for automatically supplying air to the pneumatic pressure tank, these systems are either so complicated that they are subject to failure, or else they do not operate to maintain substantially constant quantity of air in the air separating tank. As will be appreciated, water drawn from the pneumatic pressure tank through a service line **83** draws a certain amount of air with it from the tank. Continuous automatic operation of the system is dependent upon the pneumatic tank at all times being properly charged with air. In my system I provide a simplified means for always maintaining a minimum quantity of air in the air pressure tank, or what may be called an air quantity control. This air quantity control comprises a float **84** which is attached to an arm **86** pivoted at **87**. The arm extends outwardly through a suitably packed opening in the tank, and the outer end thereof actuates a valve, diagrammatically illustrated at **88**. As the level of the water in the pneumatic pressure tank rises the float **84** moves upward and opens the valve **89** to atmosphere. Air may then be sucked through a tube **91**, a check valve, diagrammatically illustrated at **92**, and into the inlet chamber **62**, as shown at **93**, Fig. 3. The end of the tubing **91** should be located on the suction side of the centrifugal pump as, with the particular air volume control employed, in order for air to be drawn into the system a suction must exist in the tubing **91**.

In the drawings I have shown a valve **79** located at the top of the air separating chamber and between the air separating chamber and the pneumatic pressure tank. While I have shown the valve **79** at the top of the air separating chamber, it may be located between the air separating chamber and the pneumatic tank. The valve **79**, the purpose of which will be later explained, need not be employed in the case of a shallow well pumping system. Its use is more important in a deep well pumping system for reasons which will later appear. It will be understood, although I have shown the shallow well system with the valve **79** therein and its use in a shallow well system may be desirable in some instances, that I contemplate, in most shallow well systems, that the air separating chamber and the pneumatic tank will be directly connected without the interpositioning of a valve so as to permit a free flow of fluid from the chamber to the tank.

An important feature of my invention (considering the system with the valve **79** omitted) is the arrangement of the air separating chamber and the pneumatic pressure tank with respect to each other so as to maintain the centrifugal pump flooded and still permit a drawing off of substantially all the water in the pneumatic pressure tank. It will be noted from the drawings that the pump and pneumatic pressure chamber are preferably mounted on a common level. This brings the air separating chamber well above the bottom level of the pneumatic tank. Since the pipe **81** is connected to the pneumatic tank from a point adjacent the top of the air separating chamber it is impossible to drain the water from the air separating chamber into the pneumatic tank. Thus it is possible, when desired, to drain off all the water from the pneumatic tank and still retain the water in the air separating chamber so as to maintain the centrifugal pump in a flooded condition. The importance of this feature lies in the fact that the pneumatic tank must always be partially charged with air. The considerable volume of air required for forcing the water through the supply system considerably reduces the volume of water which the tank will hold under normal conditions of operation. This volume of water, available with a given size tank, would be considerably further reduced if it were necessary to maintain a quantity of water in the tank to maintain the centrifugal pump flooded. By the arrangement shown, a much greater quantity of water is available in the tank to be drawn off through the service lines, and still there is available in the relatively small volume air separating chamber sufficient water to maintain the centrifugal pump flooded.

In a number of installations, particularly deep well systems, it is desirable to insure the maintenance of at least a minimum of pressure in the air separating chamber. This may be desirable particularly where high suction lifts are involved or where it is desired to maintain the system at as high a capacity as possible. In other cases it may be desirable to prevent any leakage back through the system from the air separating chamber so as to insure quick priming. Under any of these or other conditions it may be desirable to employ the valve **79**.

When the valve **79** is arranged at the top of the air separating chamber, the upper end of the air separating chamber is provided with an opening in which is preferably press fitted a valve seat **94**. A valve element **96** is carried by a diaphragm **97** by means of a nut and bolt assembly **98**. The diaphragm is confined between an annular surface formed on the top of the air separating chamber and a housing **99**. A backing plate **101** is provided for limiting the movement of the diaphragm. A spring **102** having one end confined, as shown at **103**, normally presses the diaphragm **97** downward, and the valve **96** into engagement with its seat **94**.

While I have shown the valve as being located at the top of the air separating chamber, it would be possible to locate the valve in the side of the air separating chamber, in the conduit **81**, or at the inlet of the pneumatic tank. I prefer, however, to locate the valve as shown so that, under normal conditions of operation, the system will operate with the air separating chamber in a flooded or substantially flooded condition. Since the use of the valve is more important in connection with deep well pumps its operation will be later explained.

For the purpose of priming the system the air separating chamber is provided with a tapped opening **111** which may be closed by a plug **112**. Upon removing the plug, the priming liquid may be poured into the air separating chamber. A strainer **113**, carried by a ledge **114** formed in the chamber wall, prevents the entrance of foreign matter into the system with the priming liquid. Preferably the system is primed so that the air separating chamber is substantially filled with liquid and the system is flooded to the check valve **71** thereby completely covering the jet pump nozzle and the centrifugal pump.

One of the important features of my invention is the fact that the apparatus, thus far described may be converted from a shallow well system to a deep well system with a minimum of time and expense. This is extremely important for a unmber of reasons. Pumps of this character are normally sold through distributors and dealers generally who deal in farm machinery, mill supplies, or hardware. The character of the business is such that large investments must be made in stocking equipment and repair parts of the various manufacturers. With applicant's arrangement the dealer need stock only a few stock sizes of pump units and readily convert the apparatus from a shallow well system to a deep well system or from a deep well system to a shallow well system.

Moreover, the fact that the system of my invention may be readily converted to meet various conditions, is of importance to the user. For example, it may be estimated that the draw down level of the well will not exceed 25 or 26 feet, in which case the shallow well apparatus above described may be employed. However, should it develop that the draw down level of the well is substantially in excess of this amount, perhaps 33 or 34 feet, then the user may readily convert the system for deep well operation.

The conversion of the system is accomplished by removing the plug **67**, the jet **60** and the diffuser **63**. The opening in the dividing wall **64** is left open and a plug **126** (Fig. 4) separates the passage **58** and the inlet chamber **62**. A jet pump body **127** (Fig. 5) is then secured in the well to the end of the suction pipe with the diffuser **128** thereof extending upward into the suction well pipe **129**. The well pipe **129** connects with the pipe **15**. A tail pipe **131** is connected to the jet pump body **127** and carries a strainer **132**. A foot valve **133** is provided in the tail pipe preferably located close to the nozzle **134** of the jet pump. The check valve **71** is unnecessary in a deep well system.

While I have shown in the drawings a somewhat different type of jet pump, in connection with the deep well system shown in Fig. 1, than the jet pump shown in Fig. 3, it would, of course, be possible to employ the same type of jet pump so that all that would be necessary in converting the system would be to change the location of the jet pump, plug the opening in the dividing wall **61**, remove the plug **67** and substitute therefor a pressure pipe **136**, connected to the jet pump body **13**.

Thus the dealer in pumping units employing my system need stock only a few standard units which by suitable rearrangement of the parts may be converted to meet the conditions desired. In most cases it is desirable for best efficiency to select the centrifugal pump and the jet pump to meet the particular conditions for which the pump is to be used. Thus the dealer need only stock a standard pump casting, air separating chamber, pneumatic pressure chamber and appurtenances thereto, and stock several different centrifugal pump impellers and jet pumps which may be interchangeably substituted in either a shallow well hook up or a deep well hook up to meet the conditions for which the unit is to be used.

When the system is arranged for deep well operation all of the liquid discharged from the centrifugal pump passes to the air separating chamber. The air contained in this liquid has an opportunity to separate out and rise to the top of the air separating chamber and then pass through the pipe **81** to the pneumatic pressure chamber. Liquid Q1 for operating the jet pump is supplied from the air separating chamber and is substantially air free. It will be particularly observed that the inlet **56** to the air separating chamber is located, with reference to the outlet **57**, so that air and liquid separation may take place in the air separating chamber. Thus the quantity of water Q1 recirculated through the jet pump is substantially free of air. Any air leaking into the system through the stuffing box, or the piping or contained in the water pumped from the well is conveyed first to the air separating chamber where it has an opportunity to separate out and pass to the pneumatic pressure tank. Moreover, the air supplied to the system by the air quantity control separates out in the air separating chamber and passes to the pneumatic pressure tank to maintain the quantity of the air therein substantially constant.

As previously mentioned, the pressure control valve is not entirely necessary in most shallow well installations. Moreover its use, as far as I am at present aware, is not necessary in all deep well pump installations. However, I find it desirable to use the pressure control valve in most deep well systems and particularly where high water lifts to the centrifugal pump are involved.

The purpose of the valve **79** is to prevent the pressure in the air separating chamber **14**, particularly in connection with a deep well pump, from falling below a predetermined minimum. This drop in pressure may occur should the demand for water be greater than the capacity of the system. For example, if substantially all the faucets in the service line are open, and perhaps sprinklers are in operation, the demand for water might be such as to draw, from the pneumatic pressure tank, water at a greater rate than the capacity of the system. Should this occur the pressure in the pneumatic pressure tank would drop below the cut-in pressure of the centrifugal pump and the pressure in the air separating tank would fall below that amount required to produce the desired differential in pressure across the nozzle **60** of the jet pump and give sufficient pressure at the diffuser discharge to raise water within the suction lift of the centrifugal pump impeller.

The valve **79** may be arranged to close at any desired pressure below the cut-out pressure or, in the specific example given above, below 40 pounds. However, a suitable arrangement is to adjust the spring pressure so as to close the valve **79** when the pressure in the air separating chamber falls below 15 or 16 pounds or, in other words, somewhat below the desired cut-in pressure. With this arrangement, if water is drawn through the service lines more rapidly than the capactiy of the system to supply water to the pneumatic pressure tank, the valve **79** will throttle the flow of water when the pressure in the air separating chamber **14** is maintained at 15 or 16 pounds. With this arrangement the pressure in the air separating chamber will always be adequate to give sufficient pressure at the diffuser discharge to raise water to a point within the suction lift of the centrifugal pump. While the valve will operate to maintain at all times at least a minimum pressure in the air separating chamber **14**, it will be apparent that it is controlled by the pressure in both the separating chamber and the pneumatic tank.

As soon as the pressure in the air separating chamber **14** rises above the value for which the valve **79** is set, liquid flows into the pneumatic pressure tank and the valve **79** is throttling. The pressure continues to build up until the valve **79** is maintained fully open and the shut off pressure of, for example, 40 pounds is reached. The centrifugal pump is then automatically stopped and liquid may be drawn from the pneumatic pressure tank as required. As the pressure in the pneumatic pressure tank drops the pressure in the air separating chamber **14** will equalize therewith due to the fact that the valve **79** is maintained fully open, until the pressure is reached for which the valve **79** is set. The valve **79**, being set preferably below the cut-in pressure of 20 pounds, may not close during normal operation. However, at times, when the pressure in the pneumatic pressure tank approaches the lower level, the demand for liquid may be such as to draw the pressure in the pneumatic tank down well below the cut-in pressure. Under such conditions the valve **79** will throttle or tend to close and insure the availability of at least a minimum pressure in the separating chamber.

Under some conditions of operation the valve **79** may not act to maintain at least a minimum of pressure in the air separating chamber. Such a condition may occur, for example, if the valve **79** is set to close at a pressure above the cut-in pressure. Under such conditions, at times during the operation, the valve **79** will be closed and the centrifugal pump stopped. Leakage of water may occur adjacent the stuffing box or at other points in the system with the centrifugal pump idle. Even a slight leakage would probably in a short time drop the pressure in the air separating chamber substantially to atmospheric pressure. However, only a slight leakage could occur as a vacuum would be created at the top of the air separating chamber which would prevent further leakage of liquid therefrom. When the centrifugal pump starts again, due to the fact that the air separating chamber is substantially full of liquid, it immediately pumps water (or possibly air) into the air separating chamber to cause a substantially immediate build up in pressure in the separating chamber. Thus the maintenance of a pressure, even for deep wells, in the air separating chamber is not essential, providing the air separating chamber is maintained substantially flooded so that the value of the pressure may build up rapidly therein when the pump starts.

In starting the system, after a period shut down when arranged for deep well operation, the system is first primed through the priming connection **111**. After the air separating chamber, the casting **11** and the suction and pressure pipes have been filled with liquid, the centrifugal pump is started. Due to the fact that the air separating chamber is substantially filled with liquid an immediate build up in pressure occurs which creates a sufficient differential in pressure across the jet pump nozzle and velocity therethrough to draw liquid from the well. This additional liquid further builds up the pressure so that the system very quickly builds up to its full capacity and liquid is supplied to the pneumatic pressure tank.

Due to the suction of the centrifugal pump a suction lift column is maintained in the suction pipe. This causes a pressure drop across the nozzle of an equivalent amount, thereby causing a flow of water from the pressure pipe through the jet pump nozzle at a sufficiently high velocity to draw water from the well and convert the velocity of QI plus the volume of water drawn from the well into pressure energy and raise it so that the centrifugal pump may force the water through the system. As soon as the system starts drawing water from the well the excess over that required to operate the jet pump (the water drawn from the well) is forced to the pneumatic pressure tank and gradually increases in volume so as to build up pressure in the tank.

In some cases, and particularly when the valve **79** is used, it is desirable to locate the check valve **71** in the shallow well system or the foot valve **133** in the deep well system close to the jet pump. It will be appreciated that the level of the water in the well is sometimes rather critical. Should excessive use of water draw the well down somewhat, it may drop below the bottom of the well pipe. Under such conditions the pump may continue to draw until the pipes leading to the jet are substantially emptied of water and are full of air. The system may reach the shut-off pressure and the centrifugal pump may stop. If a check valve as shown is not employed, a large portion of the water in the air separating chamber may flow back down into the system after the pump stops.

I have found that either of two objectionable conditions may result, in some installations, if a check valve is not located closely adjacent the nozzle of the jet pump. Either the water level may drop below the level of the centrifugal pump, causing the centrifugal pump to lose its prime, or the water may drop sufficiently in the air separating chamber **14** to increase the priming time to an objectionable degree. This latter condition occurs by reason of the fact that, should the water in the air separating chamber **14** be substantially depleted by reason of a flow back through the system, the pressure in the separating chamber will fall. Thus the pressure differential across the jet pump nozzle or the velocity of flow through the nozzle will be insufficient to draw water from the well in any appreciable quantity. An abnormally long interval will be required to fill the air separating chamber **14**, due to the slow flow of liquid from the well and due to the presence of a large quantity of compressible air in the air separating chamber. When a check valve **71** is located close to the jet pump nozzle the air separating chamber **14** is always substantially full of liquid. Upon starting the centrifugal pump, a substantially immediate pressure difference of appreciable magnitude is caused across the jet pump nozzle, causing a substantially immediate high flow velocity therethrough. Thus the system rapidly develops substantially its full capacity for drawing water from the well.

In the preferred form of the invention the check or foot valve is arranged close to the jet pump nozzle so as to enable a reduction in the size of the air separating chamber **14**. The ideal condition is reached when the check valve is as close as possible to the nozzle so as to permit a reduction in the size of the air separating chamber to one just sufficient to act as an efficient air separator. However, if desired, the check or foot valve may be moved further away from the jet pump with some sacrifice in the efficacy of the result, or the size of the air separating chamber may be increased.

While I have shown the preferred forms of my invention and have described how the system may be arranged so as to eliminate or minimize the possibility of failure due to the centrifugal pump becoming air bound, and have described the preferred way in which the system may be converted from a shallow well system to a deep well system, it will be understood that the invention may be carried out in a number of ways. Modification of the system and rearrangement of the parts and connections will readily occur to those skilled in the art to which this invention applies, and it is intended to cover such variations, modifications and equivalents as fall within the spirit of the invention or the scope of the appended claims.

I claim:

1. A pumping system comprising, in combination, a pressure pump having a suction inlet, an air separating chamber located well above the level of the pressure pump and having an inlet into which said pressure pump discharges, means including a suction conduit and a jet pump having a nozzle for drawing liquid from a source of supply, said chamber having an outlet communicating with the nozzle of the jet pump and said jet pump communicating with the suction inlet of the pressure pump, said chamber inlet and outlet being arranged with respect to each other so that air and liquid separation take place in the chamber and the liquid flowing to said nozzle is substantially air free, and a pneumatic pressure tank connected to said chamber so that liquid and separated air flow thereto from said chamber.

2. A pumping system comprising, in combination, a pressure pump having a suction inlet, an air separating chamber having an inlet into which said pressure pump discharges, means including a suction conduit and a jet pump having a nozzle for drawing liquid from a source of supply, said chamber having an outlet communicating with the nozzle of the jet pump and said jet pump communicating with the suction inlet of the pressure pump, said chamber inlet and outlet being arranged with respect to each other so that air and liquid separation take place in the chamber and the liquid flowing to said nozzle is substantially air free, a pneumatic pressure tank communicating with said chamber, an automatically operable pressure responsive valve between said chamber and said pneumatic pressure tank arranged to close and prevent flow of liquid from the chamber to the tank, and means responsive to the pressure in a part of said system for starting and stopping the pressure pump between predetermined upper and lower pressure limits.

3. A pumping system comprising, in combination, a pressure pump having a suction inlet, an air separating chamber having an inlet into which said pressure pump discharges, said separating chamber having the major portion of its volume above said pressure pump, means including a suction conduit and a jet pump having a nozzle for drawing liquid from a source of supply, said chamber having an outlet communicating with the nozzle of the jet pump and said jet pump communicating with the suction inlet of the pressure pump, said chamber inlet and outlet being arranged with respect to each other so that air and liquid separation may take place in the chamber at all times when the pump is operating and the liquid flowing to said nozzle is substantially air free, a pneumatic pressure tank communicating with said chamber to which liquid and said separated air substantially continuously flow when the pressure pump is operating, and means for maintaining a substantially constant quantity of air in the pneumatic pressure tank.

4. A pumping system comprising a pressure pump, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped by the pressure pump to the chamber, and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, said chamber being arranged with respect to the pressure pump so that the pressure pump is flooded at all times, and a check valve between the jet pump and the source of liquid supply, said valve being sufficiently close to the jet pump so that should the suction conduit become at least partially filled with air, when the pressure pump stops the liquid in the chamber cannot back up through the system sufficiently to materially deplete the chamber of liquid.

5. A pumping system comprising a pressure pump, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped by the pressure pump to the chamber, and a portion of the liquid supplied to the chamber returns from the chamber to the jet pump for supplying energy thereto, said chamber being arranged with respect to the pressure pump so that the pressure pump is flooded at all times, a pneumatic pressure tank, a connection between the chamber and the tank located adjacent the top of the chamber through which liquid flows from the chamber to the tank, and a priming connection at the top of said chamber so that in starting the system the chamber may be substantially completely filled with liquid and the system operates thereafter with the chamber substantially flooded.

6. A pumping apparatus comprising, in combination, a pressure pump and a jet pump the discharge of which passes to the pressure pump and through which liquid is drawn from a source of supply, a chamber at least a large part of which lies above the level of the pressure pump into which the pressure pump discharges, a connection between said chamber and said jet pump through which liquid is supplied to said jet pump and a pneumatic pressure tank into which said chamber discharges, the connection between said chamber and said tank being arranged so that liquid may be drawn off from the tank until the tank is substantially emptied without depleting the chamber of liquid.

7. A pumping apparatus comprising, in combination, a pressure pump and a jet pump the discharge of which passes to the pressure pump and through which liquid is drawn from a source of supply, a chamber arranged with respect to the pressure pump so that liquid therein always maintains the pressure pump flooded, a pneumatic pressure tank, connections between the pressure pump, the chamber and the pneumatic tank so that the liquid flows from the pressure pump through the chamber to the tank, a connection between said chamber and said jet pump through which liquid is supplied to said jet pump and means for enabling substantially all of the liquid to be drawn from the tank without depleting the chamber.

8. A pumping system including the combination of an intermittently operated centrifugal

pressure pump located at one level and having a suction inlet, a pressure chamber into which said centrifugal pump discharges, means for driving said pressure pump, a jet pump located at a level below said pressure pump and having a suction connected to a source of liquid supply and having a discharge outlet connected to the suction inlet of said pressure pump, means through which liquid is forced from said pressure pump to said jet pump, means for maintaining the pressure in said chamber under normal conditions of operation between upper and lower limits, a discharge pipe from said pressure chamber for drawing off liquid from the chamber, and means comprising an automatically operating valve in connection with said discharge pipe for preventing withdrawal of liquid from said chamber, said valve being arranged to close and prevent said withdrawal at a predetermined pressure below the lower limit of normal chamber pressure.

9. A deep well pumping system including the combination of an intermittently operated centrifugal pressure pump located at one level above the well and having a suction inlet, an air separating pressure chamber into which said centrifugal pump discharges, means for driving said pressure pump, a jet pump located at a level below said pressure pump and having a suction connected to a source of liquid supply and having a discharge outlet connected to the suction inlet of said pressure pump, a foot valve connected between said jet pump and the source of liquid supply, a line leading from said pressure chamber to said jet pump to convey liquid under pressure from the pressure chamber to said jet pump, means comprising a pressure actuated device controlled by the pressure in a part of said system for stopping and starting the motor between upper and lower limits of pressure, a discharge pipe from said pressure chamber for drawing off liquid from the chamber, an automatically operating pressure actuated valve controlled at least in part by the pressure in said chamber for preventing withdrawal of liquid from said chamber through said discharge pipe, said valve being arranged to close and prevent said withdrawal at a predetermined pressure below the upper pressure limit, and means including a connection between atmosphere and the suction inlet of said pump for maintaining a substantially constant quantity of air in said system substantially at all times during the operation thereof, said connection being located entirely above the water level in the well.

10. A pumping system including the combination of an intermittently operated pressure pump having a suction inlet, means for driving said pressure pump, a pressure chamber into which said pressure pump discharges, a jet pump having a nozzle and a suction connected to a source of liquid supply and having a discharge outlet connected to the suction inlet of said pressure pump, a check valve between the jet pump and the source of liquid supply and located closely adjacent said jet pump, a passage leading from said pressure chamber to said jet pump to convey liquid under pressure from said pressure chamber to said jet pump nozzle, the liquid flowing to said nozzle being removed from the chamber at a point with respect to the liquid entrance from the pressure pump such that air and liquid separation take place in the chamber and the liquid flowing to said nozzle is substantially air free, means comprising a pressure actuated device controlled by the pressure in a part of said system for starting and stopping the motor between upper and lower limits of pressure, a discharge pipe from said pressure chamber for drawing off liquid from the chamber, and means comprising an automatically operating pressure actuated valve controlled at least in part by the pressure in said chamber for preventing withdrawal of liquid from said chamber through said discharge pipe, said valve being arranged to close and prevent said withdrawal at a predetermined pressure below the upper pressure limit.

11. A pumping system comprising, in combination, a pressure pump of the rotatable impeller type, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said chamber having at least a portion of its volume located above both of said pumps and said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, flows from the jet pump to the pressure pump, is pumped from the pressure pump to the chamber, and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, a pneumatic pressure tank, a connection between the chamber and the tank located adjacent the top of the chamber through which liquid flows from the chamber to the pneumatic tank, the connection from the pressure pump to the chamber and the connection from the chamber to the jet pump being arranged with respect to each other so that liquid and air separation take place in the chamber with the separated air, together with liquid, flowing to the pneumatic tank and substantially air free liquid flowing to the jet.

12. A pumping system comprising, in combination, a pressure pump, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped by the pressure pump to the chamber and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, said chamber being arranged with respect to the pressure pump so that the pressure pump is flooded at all times, a pneumatic pressure tank, a connection between the chamber and the tank through which liquid flows from the chamber to the tank, the connection from the pressure pump to the chamber and the connection from the chamber to the jet pump being arranged with respect to each other so that and said chamber being of substantial size and sufficient to appreciably slow down the liquid velocity and enable liquid and air separation to take place in the chamber so that the liquid flowing to the jet is substantially air free, the separated air being substantially continuously removed from the chamber through the connection between the chamber and the tank.

13. A pumping system comprising, in combination, a pressure pump, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped from the pressure pump to the chamber and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, said chamber being ar-

ranged with respect to the pressure pump so that the pressure pump is flooded at all times, a pneumatic pressure tank, a connection between the chamber and the tank located adjacent the top of the chamber, the connection from the pressure pump to the chamber and the connection from the chamber to the jet pump being arranged with respect to each other so that liquid and air separation take place in the chamber with the separated air, together with liquid, flowing to the pneumatic tank and substantially air free liquid flowing to the jet, and means for supplying air to said chamber in such quantities as to always maintain a substantially constant quantity of air in said tank.

14. A pumping system comprising, in combination, a pressure pump, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped by the pressure pump to the chamber and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, a pneumatic pressure tank, a connection between the chamber and the tank, the connection from the pressure pump to the chamber and the connection from the chamber to the jet pump being arranged with respect to each other so that and said chamber being of substantial size and sufficient to appreciably slow down the liquid velocity and enable liquid and air separation to take place in the chamber with the separated air, together with liquid, flowing to the pneumatic tank and substantially air free liquid flowing to the jet, and means for supplying air to said chamber in such quantities as to always maintain a substantially constant quantity of air in said tank.

15. In a pumping apparatus for use with either deep or shallow wells, casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a wall provided in said casting means having an opening therethrough, a nozzle removably mounted in the margins of said opening, a second wall in said casting means having an opening therethrough, a diffuser removably mounted in the margins of said opening, said walls defining a compartment in the casting means and said nozzle and diffuser being in spaced alinement with each other, a suction pipe connected to the casting means in such position that liquid drawn therethrough flows into the compartment and through the space between the nozzle and the diffuser, said diffuser being arranged in the casting means so that liquid flowing to the nozzle and drawn through said suction pipe and flowing from said diffuser passes in an upward direction to the suction of the pressure pump, a passage through said casting means connected to the pressure pump discharge from which the liquid flow divides into two branches, a portion flowing through a branch to said nozzle and a portion flowing through a branch to an external point of use, and a removable solid closure plug in said casting means and located in the branch to said nozzle which when open enables communication between said passage and a point externally of said casting means.

16. In a pumping apparatus for use with either deep or shallow wells, a casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a wall provided in said casting means having an opening therethrough, a nozzle removably mounted in the margins of said opening, a second wall in said casting means having an opening therethrough, a diffuser removably mounted in the margins of said opening, said walls defining a compartment in the casting means and said nozzle and diffuser being in spaced alinement with each other, a suction pipe connected to the casting means in such position that liquid drawn therethrough flows into the compartment and through the space between the nozzle and the diffuser, said diffuser being arranged in the casting means so that liquid flowing to the nozzle and drawn through said suction pipe passes through the diffuser to the suction of the pressure pump, a chamber to which the liquid flows from the discharge of the pressure pump, said chamber being of sufficient size to slow down the velocity of the liquid to an appreciable extent and sufficient to permit liquid and air separation to take place in the chamber, a passage from said chamber to the nozzle, the air and a portion of the liquid rising in the chamber and flowing from substantially the top thereof to a point of use and another portion of the liquid substantially free of air flowing to said nozzle, and a removable plug which when open enables communication between said chamber and a point externally thereof.

17. In a pumping apparatus for use with either deep or shallow wells, casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a wall provided in said casting means having an opening therethrough, a nozzle removably mounted in the margins of said opening, a second wall in said casting means having an opening therethrough, a diffuser removably mounted in the margins of said opening, said walls defining a compartment in the casting means and said nozzle and diffuser being in spaced alinement with each other, a suction pipe connected to the casting means in such position that liquid drawn therethrough flows into the compartment and through the space between the nozzle and the diffuser, said diffuser being arranged in the casting means so that liquid flowing to the nozzle and drawn through said suction pipe passes through the diffuser to the suction of the pressure pump, a chamber to which the liquid flows from the discharge of the pressure pump, said chamber being of sufficient size to slow down the velocity of the liquid to an appreciable extent and sufficient to permit liquid and air separation to take place in the chamber, a passage from said chamber to the nozzle, a removable plug which when open enables communication between said chamber and a point externally thereof, a pneumatic pressure tank, a connection between said tank and said chamber, the parts of the apparatus being arranged so that the flow from the diffuser to the pneumatic pressure tank is at all times in an upward direction to the pneumatic pressure tank to thereby enable air to rise through the system, separate in the chamber and pass, together with a portion of the liquid, to the pneumatic pressure tank while substantially air free liquid is fed through said passage to the nozzle.

18. In a pumping apparatus for use with either deep or shallow wells, casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a wall provided in said casting means having an opening there-

through, a nozzle removably mounted in the margins of said opening, a second wall in said casting means having an opening therethrough, a diffuser removably mounted in the margins of said opening, said walls defining a compartment in the casting means and said nozzle and diffuser being in spaced alinement with each other, a suction pipe connected to the casting means in such position that liquid drawn therethrough flows into the compartment and through the space between the nozzle and the diffuser, said diffuser being arranged in the casting means so that liquid flowing to the nozzle and drawn through said suction pipe passes through the diffuser to the suction of the pressure pump, a chamber having an inlet connected to the discharge of the pressure pump and an outlet connected to the nozzle, the effective inlet and the effective outlet being located remote from each other and said chamber being of sufficient size to slow down the velocity of the liquid to an appreciable extent and sufficient to permit liquid and air separation to take place in the chamber, said chamber being located with respect to the pressure pump so that a large proportion of the volume thereof lies above the level of the pressure pump, a pneumatic pressure tank to which liquid and separated air flow from adjacent the top of said chamber, and a removable plug located remote from said inlet which when open enables communication between said chamber and a point externally thereof.

19. In a pumping apparatus for use with either deep or shallow wells, casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a compartment in said casting means defined by a pair of walls having alined openings therein, a suction pipe connected to said casting means and opening into said compartment, said compartment having access to the suction of the pressure pump through one of said openings, a removable jet pump located in the well connected to the suction pipe, a passage connecting the discharge of the pressure pump with said pressure pipe, a removable plug closing the other of said openings and separating the suction side of the pressure pump from the discharge side thereof, a pressure connection connected between the discharge of the pressure pump and the jet pump and separated from the suction side of the pressure pump by said plug and a connection from the discharge of the pressure pump to a point of use.

20. In a pumping apparatus for use with either deep or shallow wells, casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a compartment in said casting means defined by a pair of walls having alined openings therein, a suction pipe connected to said casting means and opening into said compartment, said compartment having access to the suction of the pressure pump through one of said openings, a removable jet pump located in the well connected to the suction pipe and having a pressure pipe, a passage connecting the discharge of the pressure pump and said pressure pipe, a pneumatic pressure tank connected to the discharge of said pressure pump, the parts of said apparatus being arranged so that the liquid flowing to said pneumatic pressure tank substantially continuously rises from the jet pump through the pressure pump into the tank, and a removable plug closing the other of said openings and separating the suction side of the pressure pump from the discharge side thereof and separating the passage connected to the pressure pipe from the suction side of the pressure pump.

21. In a pumping apparatus for use with either deep or shallow wells, casting means, a rotatable pressure pump having a suction and a discharge mounted in said casting means, a compartment in said casting means defined by a pair of walls having alined openings therein, a suction pipe connected to said casting means and opening into said compartment, said compartment having access to the suction of the pressure pump through one of said openings, a removable jet pump located in the well connected to the suction pipe and having a pressure pipe connected to said casting means, a passage connecting the discharge of the pressure pump and said pressure pipe, a chamber located in said passage of such volume as to cause an appreciable decrease in the velocity of the liquid to thereby enable liquid and air separation to take place therein, the air flowing upward through the chamber and being discharged with a portion of the liquid to a point of use while substantially air free liquid flows to said pressure pipe, and a removable plug closing the other of said openings and separating the suction side of the pressure pump from the discharge side thereof and separating the passage connected to the pressure pipe from the suction side of the pressure pump.

22. In a pumping apparatus for use with either deep or shallow wells, casting means, a pressure pump having a suction and a discharge mounted in said casting means, a compartment in said casting means defined by a pair of walls having alined openings therein, a suction pipe connected to said casting means and opening into said compartment, said compartment having access to the suction of the pressure pump through one of said openings, a removable jet pump located in the well connected to the suction pipe and having a pressure pipe connected to said casting means, a chamber having an inlet connected to the discharge of the pressure pump and an outlet connected to the pressure pipe, said chamber being of such volume as to cause an appreciable decrease in the velocity of the liquid and the effective inlet to said chamber and the effective outlet therefrom being located with respect to each other so that liquid and air separation take place in the chamber with air free liquid flowing to said pressure pipe and the air rising to the top of said chamber, which top is located a substantial distance above the level of the pressure pump, a pneumatic pressure tank having a connection to substantially the top of the chamber to which the separated air and a portion of the liquid flows, and a removable plug closing the other of said openings and separating the suction side of the pressure pump from the discharge side thereof and from said pressure pipe.

23 A pumping system comprising, in combination, a rotatable pressure pump having a suction and a discharge, a jet pump, a pneumatic pressure tank, and a suction conduit connected to a source of liquid supply, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump flows from the jet pump to the pressure pump with a portion of the liquid flowing to the pneumatic tank and another portion thereof flowing to the jet pump, a valve controlled connection to atmosphere connected on the suction side of the pressure pump for supplying air to said pneumatic pressure tank, and means between the dis-

charge side of the pressure pump and the pneumatic tank and arranged well above the pressure pump for preventing any substantial amount of air, drawn inward through said valve controlled connection, from returning to the suction side of the pressure pump.

24. A pumping system comprising, in combination, a rotatable pressure pump having a suction and a discharge, a jet pump, a pneumatic pressure tank, and a suction conduit connected to a source of liquid supply, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump flows from the jet pump to the pressure pump with a portion of the liquid flowing to the pneumatic tank and another portion thereof flowing to the jet pump, a valve controlled connection to atmosphere connected on the suction side of the pressure pump for supplying air to said pneumatic pressure tank, an air separating chamber having an inlet connected to the pressure pump discharge and an outlet connected to the jet pump, said chamber being of substantial volume so as to materially decrease the velocity of the liquid flowing thereto and the effective inlet and the effective outlet being located remote from each other and with the inlet above the outlet so that liquid and air separation takes place in the chamber, the top of said chamber being located well above the level of the pressure pump, and a connection from substantially the top of said chamber to the pneumatic pressure tank through which the separated air, together with a portion of the liquid, flows to the pneumatic pressure tank.

25. A pumping system comprising, in combination, a rotatable pressure pump having a suction and a discharge, a jet pump, a pneumatic pressure tank, and a suction conduit connected to a source of liquid supply, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump flows from the jet pump to the pressure pump with a portion of the liquid flowing to the pneumatic tank and another portion thereof flowing to the jet pump, a valve controlled connection to atmosphere connected on the suction side of the pressure pump for supplying air to said pneumatic tank, an air separating chamber having an inlet connected to the pressure pump discharge and an outlet connected to the jet pump, said system having the parts thereof arranged so that air entering the system either through leaks in the system or through said connection continuously rises until it passes, together with a portion of the liquid, into the pneumatic tank from said chamber, and a liquid level controlled float within the pneumatic tank for controlling the opening and closing of said valve.

26. A pumping system comprising, in combination, a rotatable pressure pump, a jet pump, a suction conduit connected to a source of liquid supply, and a chamber, said system having connections arranged so that liquid from the source of supply is drawn through the jet pump, flows from the jet pump to the pressure pump, is pumped from the pressure pump to the chamber, and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, a pneumatic pressure tank, a connection between the chamber and the tank located adjacent the top of the chamber, said top of the chamber being located a substantial distance above the level of the pressure pump, and a check valve on the suction side of said pressure pump for maintaining said chamber substantially flooded at all times and without substantial depletion when the pressure pump is not operating.

27. A pumping system comprising, in combination, a rotatable pressure pump, a jet pump, a suction conduit connected to a source of liquid supply, and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, flows from the jet pump to the pressure pump, is pumped from the pressure pump to the chamber, and a portion of the liquid supplied to the chamber continuously returns when the pressure pump is operating from the chamber to the jet pump for supplying energy thereto, a pneumatic pressure tank, a connection between the chamber and the tank located adjacent the top of the chamber, the inlet connection to said chamber from the pressure pump emptying into the chamber a substantial distance above the outlet connection to the jet pump so that liquid and air separation may take place in the chamber with the air rising to the top of the chamber and passing from thence to the tank, the top of said chamber being located well above the level of the pressure pump so that air entering the system continuously rises through the system and passes to the pneumatic pressure tank.

28. A pumping system comprising, in combination, a pressure pump of the rotatable impeller type, a jet pump, a suction conduit connected to a source of liquid supply and a chamber arranged above the pressure pump, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped from the pressure pump to the chamber, and a portion of the liquid supplied to the chamber continuously returns, when the pressure pump is operating, from the chamber to the jet pump for supplying energy thereto, a pneumatic pressure tank, a connection between the chamber and the tank through which liquid flows from the chamber to the tank, the connection from the pressure pump to the chamber and the connection from the chamber to the jet pump being arranged with respect to each other so that liquid and air separation take place in the chamber with the separated air, together with liquid, flowing to the pneumatic tank and substantially air free liquid flowing to the jet, means for supplying air to said chamber for replenishing the air in the tank which air passes through the connection between the chamber and the tank, and means for maintaining the quantity of air in said pneumatic tank substantially constant.

29. A pumping system comprising, in combination, a pressure pump of the rotatable impeller type, a jet pump, a suction conduit connected to a source of liquid supply and a chamber, said system having connections arranged so that liquid from the source of supply is drawn into the jet pump, is pumped from the pressure pump to the chamber and a portion of the liquid supplied to the chamber continuously returns, when the pressure pump is operating, from the chamber to the jet pump for supplying energy thereto, said chamber having a substantial portion of its volume above the pressure pump, a pneumatic pressure tank, a connection through which liquid and air flow from the chamber to the tank, the connection from the pressure pump to the chamber and the connection from the chamber to the jet pump being arranged with respect to each other so that liquid and air separation take place

in the chamber with the separated air, together with liquid, flowing to the pneumatic tank and substantially air free liquid flowing to the jet, and means including a connection to atmosphere connected on the suction side of the pressure pump for maintaining a substantially constant quantity of air in said pneumatic tank.

30. A pumping system comprising, in combination, a pressure pump of the rotatable impeller type, a discharge connection for said pressure pump, a suction connection for said pressure pump connected to a source of liquid supply and having a check valve, a jet pump located in said suction connection, a chamber located in said discharge connection and having an inlet from the pressure pump, a pneumatic pressure tank, said chamber having an outlet toward the top of the chamber through which liquid flows to said pneumatic pressure tank, means including a connection to atmosphere connected on the suction side of the pressure pump for admitting air to the system for replenishing the pneumatic tank with air, a connection between said chamber and said jet pump through which liquid flows from said chamber for supplying energy to the jet pump, said system having the parts and connections thereof arranged so that the liquid flowing through said outlet and air entering the system substantially continuously rises to the outlet, said chamber being arranged so that an appreciable portion of its volume and said outlet are above the pressure pump, said chamber being of a size sufficient to appreciably slow down the velocity of the liquid to enable liquid and air separation to take place therein and said inlet to the chamber and said connection to the jet pump being located with respect to each other so that substantially complete separation of air from the liquid flowing to the jet pump may take place and the air separated in said chamber flows through said outlet with the liquid flowing to said pneumatic tank to maintain a quantity of air in said pneumatic tank, the arrangement of parts being such that recirculation of air through the pressure pump is substantially prevented and the system after once being supplied with priming liquid will thereafter prime itself unless abnormal leaks develop in the system.

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