PUMP AND PUMP SYSTEM

Filed May 31, 1941 2 Sheets-Sheet 1

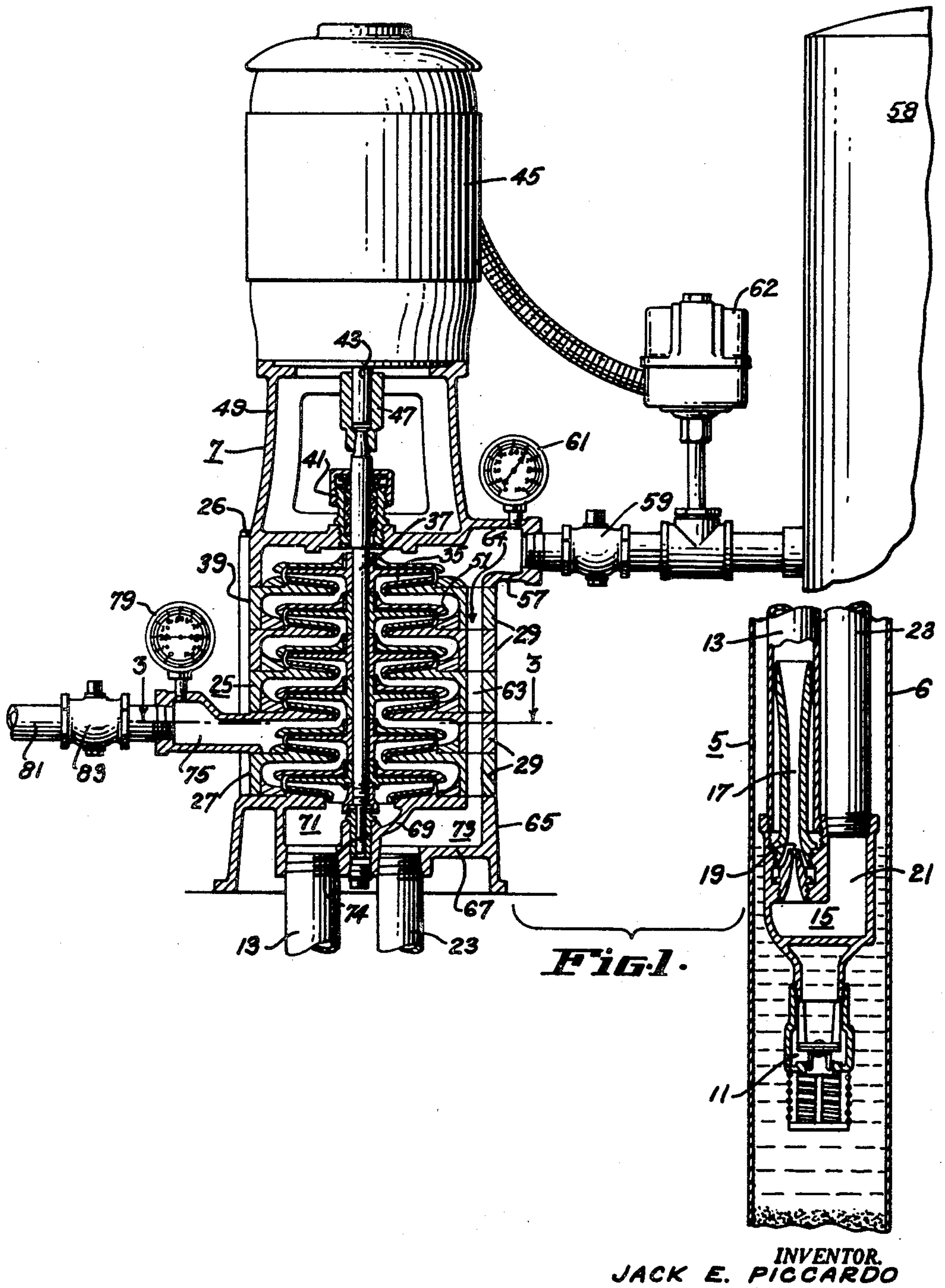

Fig.1.

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Filed May 31, 1941 2 Sheets-Sheet 2

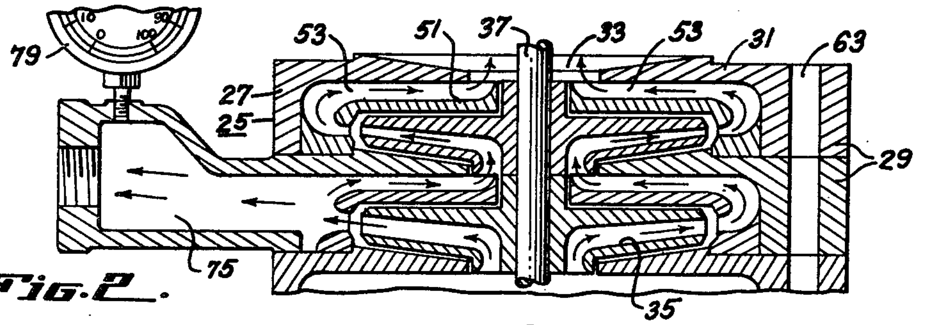

FIG. 2.

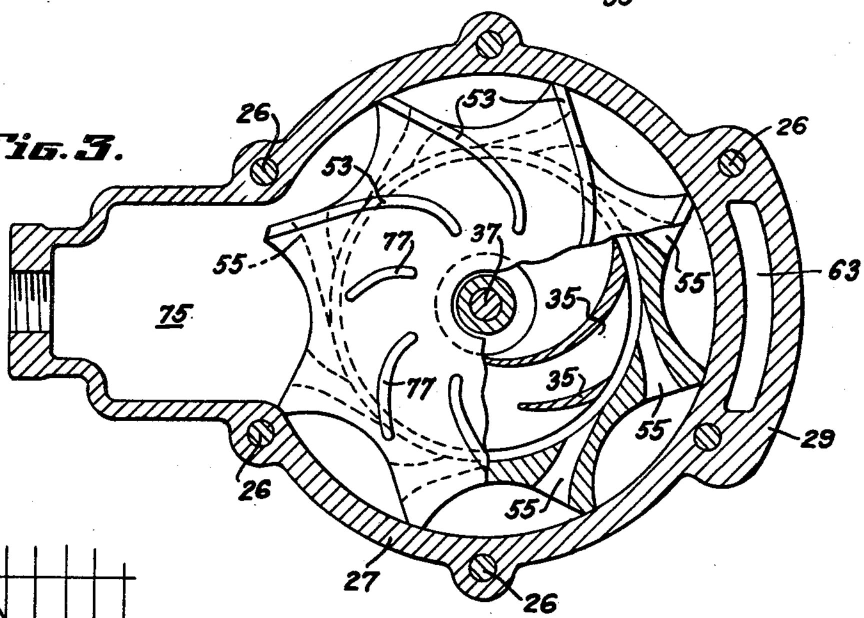

FIG. 3.

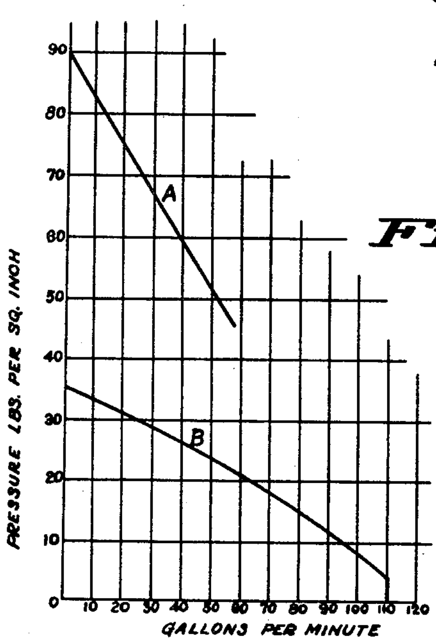

FIG. 4.

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PUMP AND PUMP SYSTEM

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18 Claims. (Cl. 103—5)

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Our invention relates to pumps, and will be discussed more particularly in connection with pumps of the injector type.

In pump systems of the injector type employed for pumping water from wells and the like, the injector assembly is customarily located in the well bore, and in the case of a deep well, the assembly may be positioned a substantial distance below the pump unit, which is located usually at ground level. In such cases a considerable lift is involved in bringing the water to within the influence of the pump unit. To assure efficient functioning of the injector assembly, under such conditions, a portion of the pump output must be by-passed to the nozzle of the injector assembly at high pressure, thereby necessitating the designing of a pump unit for high pressure discharge. Consequently, in a conventional pump system of the above character, designed for deep well operation, the total output of the pump must be brought to a pressure determined primarily by the pressure requirements of the injector assembly. Only that portion of the output necessary for operation of the injector assembly is by-passed down the pressure line to the injector nozzle, while the remainder is discharged from the pump unit, for use by the consumer. Usually, such discharge is directed into a pressure tank, where it is retained under pressure in readiness for subsequent use as desired.

The output pressure thus determined by the pressure requirements of the injector assembly is often much higher than what is customarily required for a pressure system, or for pumping directly into an overhead tank, as is sometimes the case. At such high pressures, the capacity output is necessarily limited, thus rendering such systems unsuited for low pressure uses, as for irrigation purposes, where large capacity output is of primary consideration.

Among the objects of our invention are—

(1) To provide a novel and improved deep well pump system, capable of discharging at low pressure;

(2) To provide a novel and improved deep well pump system having a selective low pressure or high pressure discharge;

(3) To provide an improved pump unit of increased output capacity for a given energy input;

(4) To provide a novel and improved pump system of the injector type adapted for deep well operation and capable of providing a discharge at low pressures;

(5) To provide an improved pump system adapted to be readily converted from high pressure discharge to low pressure discharge to satisfy demand requirements of varying character;

(6) To extend the pressure range of a conventional relatively high pressure pump system, in the direction of lower pressures.

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Additional objects of our invention will be brought out in the following description of the same, taken in conjunction with the accompanying drawings, wherein—

Figure 1 is a conventionalized sectional view of a pump system embodying our invention, said view being split and displaced to conserve space on the drawing and permit of a showing on a larger scale;

Figure 2 is an enlarged portion of the conventionalized section view of Figure 1;

Figure 3 is a sectional view taken along the line 3—3 of Figure 1, and partly broken away to expose underlying structure;

Figure 4 is a curve graph depicting operating characteristics of our improved pump unit and system.

For purposes of description, the invention is shown adapted to a pump system of the type forming the subject matter of the patent to Jacuzzi, No. 2,150,799, of March 14, 1939, although it is not necessarily limited to the particular structure of the patent referred to.

The pump system may be conveniently divided into two portions, that portion 5 located in the well casing 6 below ground level, and the pump unit 7 located above ground. The portion below ground and located in the well casing, is conventional structure and is not a part of the present invention, except in so far as it comprises an element of a new combination when considered in connection with the pump unit 7 above ground.

Such apparatus comprises a foot valve 11 disposed below the liquid level in the well, and forming the lower terminal of the suction line 13 which leads upward to the pump unit 7. Connected into the suction line is the injector unit assembly 15 comprising a venturi 17 and a nozzle 19. As is conventional, the venturi is disposed to receive water from both the well and the discharge end of the nozzle, the nozzle 19 being provided with a separate input passage 21 connecting to the pressure line 23, which in turn extends upwardly for connection to the pump unit.

The pump unit 7 which, in a conventional system, may straddle the upper end of the well casing 6, or as in some installations, may be located off to one side, comprises in the present instance, a plurality of impeller stages 25 stacked one upon the other for operation in series, and secured together by a plurality of casing bolts 26. Each stage comprises a generally cylindrical casing section 27 provided with an offset 29, having an end wall 31 with a central opening 33. Housed within each casing section is an impeller unit 35 of the centrifugal type. All such impeller units are affixed to a common impeller shaft 37, extending longitudinally through the casing 39 formed by the casing sections, and are accordingly adapted to rotate upon rotation of such shaft. This shaft extends through a suitable packing gland 41 in the end wall of the last stage, and is connected for rotation to the shaft 43 of a driving motor 45, through a suitable coupling 47, the driving motor being mounted on a bracket 49 formed integral with the upper casing section.

To provide for smooth stream-lined flow of water through the various stages in series, intermediate guide elements, or spiders 51 as they are sometimes termed, are provided, one for each stage. Each of said spiders is of star-shaped contour, having a plurality of ribs 53 across the upper surface, extending from the points of the star toward the center. The ribs are curved to define passages offering minimum resistance to flow of liquid from the outer edge inwardly toward the input end of the impeller of the next stage. These passages each receive the output of a preceding impeller, via a Venturi opening 55 in each alternate peripheral wall of the spider whereby the velocity of the impeller discharge is converted to pressure. Each guide element is press fitted or otherwise secured within its associated casing section and has an internal diameter permitting free rotation of the impeller therein. By reason of the presence of a plurality of guide channels distributed uniformly about the guide element or spider, it is well adapted to receive the discharge from an associated impeller during continuous rotation thereof and guide such discharge, with a minimum of loss, to the input of the impeller associated with the following stage in the series. This applies to all guide elements, except the guide element of the last stage, which is designed to receive the output of its associated impeller and direct the greater portion of the same into a discharge spout 57 conventionally formed in the casing section of the last stage.

The discharge spout 57 may be connected for open discharge or for discharge into the pressure tank 58 of a conventional pressure system, such, for example, as is illustrated in Jacuzzi Patent No. 2,205,121 of June 18, 1940. A manually adjustable control valve 59 is desirably placed in the discharge line, and the spout may carry a pressure gauge 61 for visually indicating existing pressure as the adjustments in the system are made. When connected to a pressure system, an automatic pressure switch 62 is conventionally included, its function being to start the pump when the air pressure in the tank falls to a certain minimum and stop the pump when maximum air pressure is restored in the tank.

Each of the casing sections 27, except the section of the last stage, is cast with an independent passage 63 longitudinally through the offset 29 of the casing section, which, upon assembling of all the sections of the pump unit, cooperate with the last stage, to provide a by-pass channel 64 for a portion of the discharge from the last stage.

The entire assembly of stages is supported upon a base section 65 which is secured thereto by the casing bolts 26 and is adapted to straddle the well casing 6. This base section is cast with a transverse wall 67 and a partition 69 dividing the base section into two chambers 71 and 73. One of these chambers, 71, opens into the input side of the impeller of the first stage, and the transverse wall 67 is provided with a threaded opening for receiving the upper end of the suction line 13. The other chamber, 73, connects with the by-pass 64 and terminates in a threaded

opening in the transverse wall of the base section to which the pressure line 23 is connected.

The impeller shaft 37 extends centrally through the base section 65 which carries an end bearing 74 for the shaft.

In a conventional system of the character described, the number of stages is determined, not so much by the pressure requirements of the consumer, but by the pressure needs of the injector unit for efficient operation thereof. As previously indicated, such pressure oftentimes is far in excess of the pressure requirements of the consumer.

We have found that, under certain conditions, the lower pressures of an intermediate stage in a high pressure system, can be availed of to advantage to more closely meet the pressure requirements of the consumer, and also that under such conditions, the output capacity of the pump system can be increased considerably, even to the extent of doubling the output capacity at the lower pressures, which means a decided increase in the quantity of water obtained for a given power input. In other words, we have, through the establishment of certain conditions, been able to extend the pressure range of a pump system in the direction of lower pressures and increase the output accordingly. The pump characteristics are thereby altered from those of the conventional pump, all in favor of the consumer, as will be subsequently pointed out.

As one step toward attaining these ends, we provide one of the intermediate stages with a low pressure discharge spout 75. This by itself, however, will not necessarily satisfy the conditions in question. We have found it to be quite an important factor, for one thing, to assure a full supply of by-pass liquid to the injector 15 at the higher pressure, for maintaining operation of such injector, without which the pump system would cease pumping. The normal tendency of the low pressure spout 75 would be to divert the output from such intermediate stage and thus would naturally work against supplying the injector with its requirement of water. Therefore, the internal construction of the pump unit 7, and the particular intermediate stage in question, must be designed either to assure positive feed of liquid to the stages beyond, or to favor the flow of water into the upper stages to the extent of supplying the necessary volume to the injector, even under the extreme condition prevailing, with the low pressure discharge spout 75 wide open. At the same time, the intermediate stage must also satisfy the demands placed upon it by the low pressure discharge spout.

The stages of the pump unit under consideration, quite effectively lend themselves to such changes as are necessary to satisfy these conditions. In the absence of any further changes, and except for the relatively small angle bounded by the low pressure discharge spout, the discharge of the associated impeller, throughout a substantial portion of its rotational movement, is guided directly toward the many Venturi openings in the spider, the output of which will be directed by the associated ribs 53 to the impeller of the next stage, thereby assuring positive feed of liquid to the subsequent stages, irrespective of the presence of the discharge spout 75.

To realize maximum free flow of liquid through the low pressure spout, sufficient to supply its demands, it has been found to be advantageous to construct the spider of the intermediate discharge stage with short ribs 77 over an extended angle greater than that angle normally subtended by the spout. This change in spider structure serves to expose the low pressure spout to the output from a plurality of the Venturi discharge openings 55 to one side of the spout, instead of confining it to the discharge from one such opening as would previously be the case; and the ability of the spider to fulfill the requirements of the subsequent stages is not thereby impaired.

Like with the high pressure end of the pump unit, the low pressure spout 75 may carry a pressure gauge 79, and discharge either openly or through a pipe 81. A control valve 83, in either case, may be provided to fix the low pressure range.

With an intermediate stage designed along the lines described, the subsequent stages in the series may be formed on a smaller scale, or, as illustrated in Figures 1 and 2, the passages therethrough may preferably be restricted in cross-section. By this change in relationship, an appreciable increase in efficiency of operation may be effected.

Although the conventional high pressure discharge spout 57 may be actually eliminated under the circumstances, such as by casting the section of the last stage without such a spout, we prefer to retain the same, for in many installations, water at a wide range of pressures may be very desirable, and in the event the high pressure discharge is not needed, it may be shut off by the valve 59 or suitably plugged with a closure.

The invention is not limited to pumps of the deep well type, where the discharge pressure is so often far in excess of that required by the consumer, but may be adapted to pump systems of lower pressure characteristics. Thus, for example, where the pressure requirements of the injector unit may approximate the pressure desired in the tank of a pressure system, which may be of the order of 20 to 40 lbs., the discharge spout 57 of the last stage will be connected to the pressure tank 58 in the customary manner, and a specially designed intermediate stage including a discharge spout 75 may be utilized for irrigation purposes, where the volume requirement is large and the pressure requirement is practically nil. A higher efficiency arrangement under the circumstances, is obtained by making the stages beyond the low pressure spout of smaller capacity per stage.

In installations embodying a discharge spout, both in the last stage of the series, and at an intermediate stage, the desired pressure range of the pump unit may be selected at will, merely by manipulating the control valve in each of the discharge lines until proper adjustment has been realized, and then leaving them undisturbed thereafter. These valves, thereby, determine the lowest pressure at which either discharge spout may deliver, and the maximum rate of discharge which may be drawn therethrough. The actual volume of pump delivery will be determined by the consumer when he manipulates one or more of the many taps or spigots customarily connected into such a system at conveniently located outlets.

In accordance with conventional practice, the valve 59 is customarily set at the lowest pressure value which will still permit operation of the injector. The control valve 83 is not thusly limited as to adjustment as will be subsequently pointed out, and may preferably be left off altogether.

The general effect of the intermediate stage discharge on the pump system characteristics, is indicated in a rather striking manner, by the pressure-volume characteristic curves of a pump system embodying our invention. The curve "A" is representative of the variation in volume output with a lowering of discharge pressure in a conventional system, which in the pump system described, would be approximated with the valve 83 completely closed. Zero output at maximum pressure, namely 90 lbs./sq. in. in the particular system under consideration, represents the condition when the discharge valve 59 is closed tight. As this valve is opened, the pressure as read on the gauge 61, drops and the output will increase in accordance with the curve. It will be noted, however, that the curve "A" has a sharp cut-off at 45 lbs./sq. in. This occurs at the pressure value, where the injector unit 15 can no longer function, and the pump ceases to operate. The pressure value at which cut-off occurs, therefore, constitutes the lower limit of operation of the conventional pump system, and such pressure may still be well above the pressures one may ordinarily desire. In our improved system, a corresponding discharge characteristic at a low pressure spout, when connected in the first stage of a pump unit, for example, will look like curve "B." Under these conditions, the injector assembly 15 will function regardless of valve adjustments at the low pressure spout 75, by reason of the positive feed of water to the subsequent stages in the series. Consequently, the injector 15 no longer determines the minimum value of operating pressure in the system, which is now limited only by the full open discharge of the particular stage which carries the spout 75. It will be apparent from this, therefore, that by operating along the curve "B," not only can the pressure range of the pump system be extended from approximately the region of the cut-off pressure of the conventional system, to a value approaching zero, but in so doing, the output of the system can at the same time be increased to the extent of practically doubling the same. A large output at practically no pressure is ideal for irrigation purposes, whereby it will be appreciated that the utility of the pump system has been expanded by our invention to embrace regions of operation formerly delegated to pump systems of different types entirely, whose inherent characteristics ideally adapted them for operation within such regions only. Thus, our improved system may be looked upon as a wide range system of many applications.

In using the term "intermediate" with reference to the low pressure discharge stage, we intend thereby to include any such stage up to but exclusive of the last stage. Therefore, the "intermediate" stage in accordance with the broad meaning given to the term, may even constitute the initial stage in the series.

Where no pressure system is tied in with the pump unit, starting and stopping of the pump operation may be effected manually as by the throwing of a switch if motor driven, or by the cranking of an engine if driven by a gas engine or the like. In installations, however, embodying a pressure system, such pressure system customarily includes an automatic switch for controlling the starting and stopping of the pump operation. In this connection, it is of interest to note that without making any changes in the pressure system set-up, the automatic switch will also function to start the pump in response to opening of the petcock or spigot which controls the flow from the low pressure irrigation discharge stage.

While we have described one embodiment of our invention in considerable detail, the principles thereof are applicable to structures of other types, without departing from the broad scope of our invention. We accordingly do not desire to be limited in our protection to the specific structure described and illustrated by us, except as may be necessitated by the prior art and the appended claims.

We claim:

1. A pump system comprising, a pump assembly including a plurality of stages and having an input opening and a discharge outlet; a suction line leading to said input opening; an injector assembly including a nozzle and a venturi, connected in said suction line; means within one of said stages for dividing the input to said assembly between said discharge outlet and a subsequent stage, and means for directing fluid from said subsequent stage to said nozzle.

2. A pump system comprising, a pump assembly including a plurality of stages and having an input opening and a discharge outlet; a suction line leading to said input opening; an injector assembly including a nozzle and a venturi, connected in said suction line; means within said assembly for dividing the input to said pump assembly between said discharge outlet and said injector nozzle to assure an operating supply to said injector assembly; and means for subsequently increasing the pressure of the nozzle supply by an amount equal to at least the pressure developed in one of such stages.

3. In combination, a pump unit comprising, a plurality of impeller stages each having an input opening and a discharge opening, said stages being stacked for operation in series with each stage feeding directly into the next higher stage in the series; a discharge passage leading from an early stage of said pump unit; a discharge passage leading from a subsequent stage of said pump unit; a by-pass passage directed downwardly from a stage of high pressure in said series, an injector assembly including a venturi and a nozzle, means connecting said injector assembly to the input opening of the initial stage in said series, and means connecting said nozzle to said by-pass passage.

4. A pump unit assembly comprising, a plurality of impeller stages arranged in series, each stage having a passage connecting with a corresponding passage in each of the other stages to form a by-pass around said stages from the terminal stage of said series; a discharge spout extending from the terminal stage of said series; a separate spout extending from an intermediate stage of said series; and valve means cooperating with said terminal stage spout to limit the minimum pressure of flow therethrough.

5. A pump unit assembly comprising, a plurality of impeller stages arranged in series, each stage having a passage connecting with a corresponding passage in each of the other stages to form a by-pass around said stages from the terminal stage of said series; a discharge spout extending from the terminal stage of said series, said by-pass and discharge spout being connected with the output of said terminal stage; a separate spout extending from an intermediate stage of said series; and a valve controlling the discharge from both said terminal stage spout and said intermediate stage spout independently of said by-pass, to enable distribution of liquid through said spouts at widely different pressures without diminishing either the volume or pressure of the by-passed liquid to a degree sufficient to cause cessation of pump operation.

6. A pump system including, a pump unit comprising a plurality of impeller stages arranged in series, each stage having a passage connecting with a corresponding passage in each of the other stages to form a by-pass around said stages, a discharge spout extending from the terminal stage of said series, a separate spout extending from an intermediate stage of said series; a suction line leading to the input of said pump unit; an injector assembly comprising a venturi and nozzle, connected in said suction line, with said nozzle in communication with said by-pass; and valve means cooperating with said terminal stage spout and said intermediate stage spout to enable distribution of liquid through said spouts at widely different pressures.

7. A pump stage assembly comprising, a casing having a discharge spout extending therefrom at one location and a discharge opening at another location in said casing, a rotatable impeller within said casing, and a plurality of discharge channels distributed about said rotatable impeller, certain of said discharge channels leading to said discharge spout while others of said discharge channels lead to said discharge opening.

8. A pump stage for a multi-stage pump comprising, a casing; a rotatable impeller within said casing adapted for discharge at all points along the peripheral path defined by its outer edge; said casing having a discharge opening exposed to the discharge from said impeller over a portion of said peripheral path; and a substantially independent discharge path exposed to the discharge from said impeller over another portion of said peripheral path, and adapted for connection to a succeeding stage of such pump.

9. A pump system for a well, comprising a pump unit having a plurality of stages stacked for operation in series, with each stage feeding directly into the succeeding stage in the series; a suction line connected to the input of said pump unit; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to said pump unit at a point of high discharge pressure; and a discharge connection from said pump unit at a pressure value lower than that to said nozzle by an amount sufficient to maintain said injector assembly operative at the lowest normal level of water in said well.

10. A pump system for a well, comprising a pump unit having a plurality of stages stacked for operation in series, with each stage feeding directly into the succeeding stage in the series; a suction line connected to an early stage of said pump unit; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to a stage of said pump unit of relatively high discharge pressure; and a discharge connection from a different stage of said pump unit of a pressure value lower than that to said nozzle by an amount sufficient to maintain said injector assembly operative at the lowest normal level of water in said well.

11. A pumping system for deep-well pumping, in combination; a low-pressure pump having an intake and a discharge; a pump line connected to said intake and having a foot valve in communication with a source of water, and a jet installed in said pump line; a high-pressure pump having an intake and a discharge; a low-pressure

discharge chamber in communication with the discharge of said low-pressure pump and having an outlet and having communication with the intake of said high-pressure pump; a booster line connecting the discharge of said high-pressure pump to said jet for delivering all of the water pumped by said high-pressure pump to said jet for maximum efficiency and lift of water from said source.

12. A pump system comprising, a pump assembly including a plurality of stages adjacently disposed on a common shaft and feeding one into the other in series, and having an input opening at one stage and a discharge outlet at a stage of higher pressure; a suction line leading to said input opening; an injector assembly including a nozzle and a venturi, connected in said suction line; means for delivering to said discharge outlet, fluid at one pressure; and means for delivering fluid to said nozzle at a pressure in excess of that at said discharge outlet.

13. A pump system for a well, comprising a pump unit having a plurality of stages stacked for operation in series, with each stage feeding into the succeeding stage in the series; a suction line connected to the input of said pump unit; an injector assembly in said suction line and including a venturi and a nozzle; a pressure line connecting said nozzle to said pump unit at a point of high discharge pressure; and a discharge connection from said pump unit with a pressure value lower than that to said nozzle by an amount sufficient to maintain said injector assembly operative at the lowest normal level of water in said well.

14. A pump unit comprising a plurality of stages each having an input opening and a discharge opening, said stages being arranged for operation in series, a discharge passage leading from the last stage of said pump unit, a discharge passage leading from an intermediate stage of said pump unit, a by-pass passage directed downwardly from a stage in said series, above said intermediate stage, and valve means in at least one of said discharge passages for limiting the minimum pressure of flow therethrough.

15. A pump unit comprising a plurality of stages connected for operation in series, each of said stages involving a rotatable pump component; a discharge spout connected with one of the preliminary stages of said series, such preliminary stage having a discharge connection to a subsequent stage in the series; and means within said preliminary stage, intermediate said rotatable pump component and both said discharge spout and discharge connection, providing substantially independent paths of flow for the liquid output of said rotatable pump component, one of said paths leading to said discharge spout while another of said paths leads to the aforementioned discharge connection to the subsequent stage.

16. A pump unit comprising a plurality of stages connected for operation in series, each of said stages involving a rotatable pump component and having a passage connecting with a corresponding passage of adjacent stages to form a by-pass around said stages from the terminal stage of said series; a discharge spout provided on one of the preliminary stages of said series, said preliminary stage having a discharge connection to the next stage in said series; and means within said preliminary stage, intermediate said rotatable

pump component and both said discharge spout and discharge connection providing substantially independent paths of flow for the liquid output of said rotatable pump component, one of said paths leading to said discharge spout while another of said paths leads to the aforementioned discharge connection to the subsequent stage.

17. A pump system comprising a pump unit; a pressure chamber associated with said unit to which said pump unit delivers; said pump unit being capable of developing a desired pressure in said chamber during operation of said pump unit; a discharge connection from a location in said pump unit where pressure developed during operation of said pump unit is materially different from that developed in said chamber; said system having communication passage between said pressure chamber and said discharge connection whereby during quiescent periods of said pump unit, equalization of pressure will occur in at least that portion of said system involving said pressure chamber and said discharge connection; an automatic pressure switch; and means connecting said switch in pressure responsive relationship to that portion of said pump system in which such pressure equalization occurs during quiescent periods of said pump unit, whereby to determine operating periods of said pump unit.

18. A pump system comprising a pump unit having a plurality of stages and a driving motor therefor; a pressure system connected to one of said stages, said pressure system including a pressure tank to which said pump unit delivers; a separate controllable discharge connection from one of said stages other than that stage to which said pressure system is connected; said system having communication passage between said pressure tank and said discharge connection whereby during quiescent periods of said pump unit, equalization of pressure will occur in at least that portion of said system involving said pressure chamber and said discharge connection; an automatic pressure switch; and means connecting said switch in pressure responsive relationship to that portion of said pump system in which such pressure equalization occurs during quiescent periods of said pump unit, whereby to determine operating periods of said pump unit.

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