April 22, 1958 J. MANN 2,831,432

MULTI-STAGE CENTRIFUGAL PUMP

Filed March 17, 1953 4 Sheets-Sheet 1

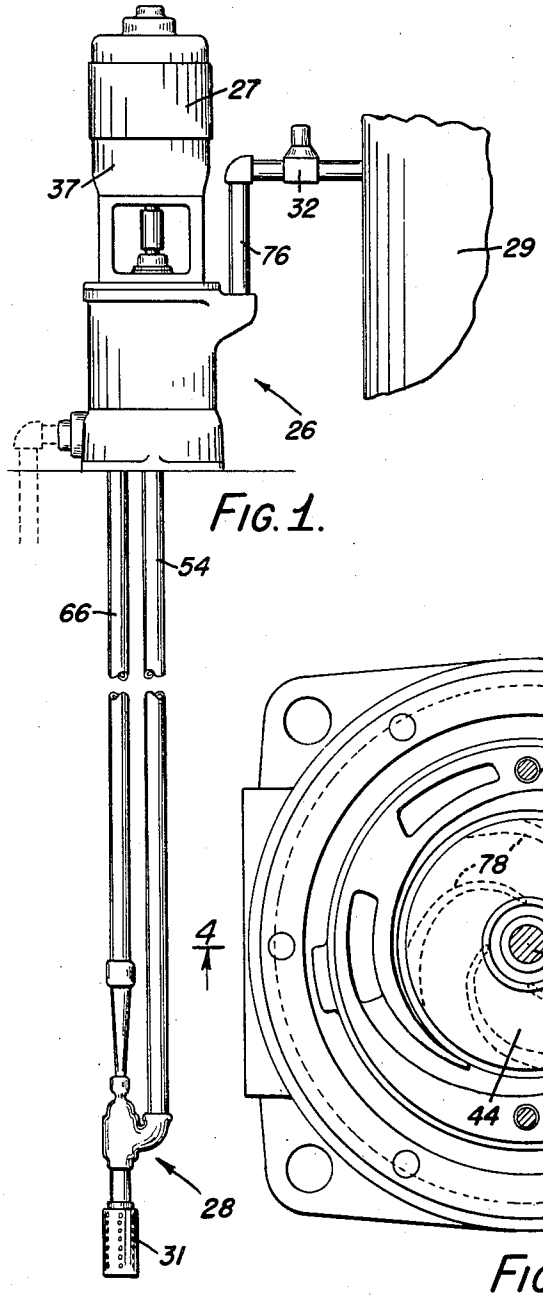


FIG. 1.

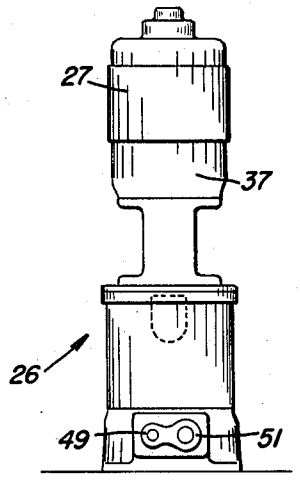


FIG. 2.

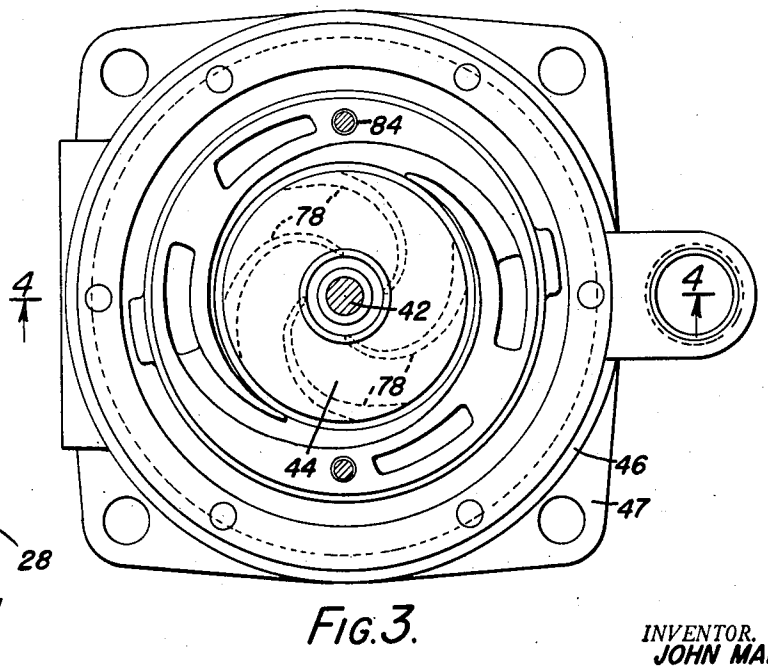


FIG. 3.

INVENTOR.
JOHN MANN

BY

ATTORNEY

April 22, 1958 J. MANN 2,831,432

MULTI-STAGE CENTRIFUGAL PUMP

Filed March 17, 1953 4 Sheets-Sheet 2

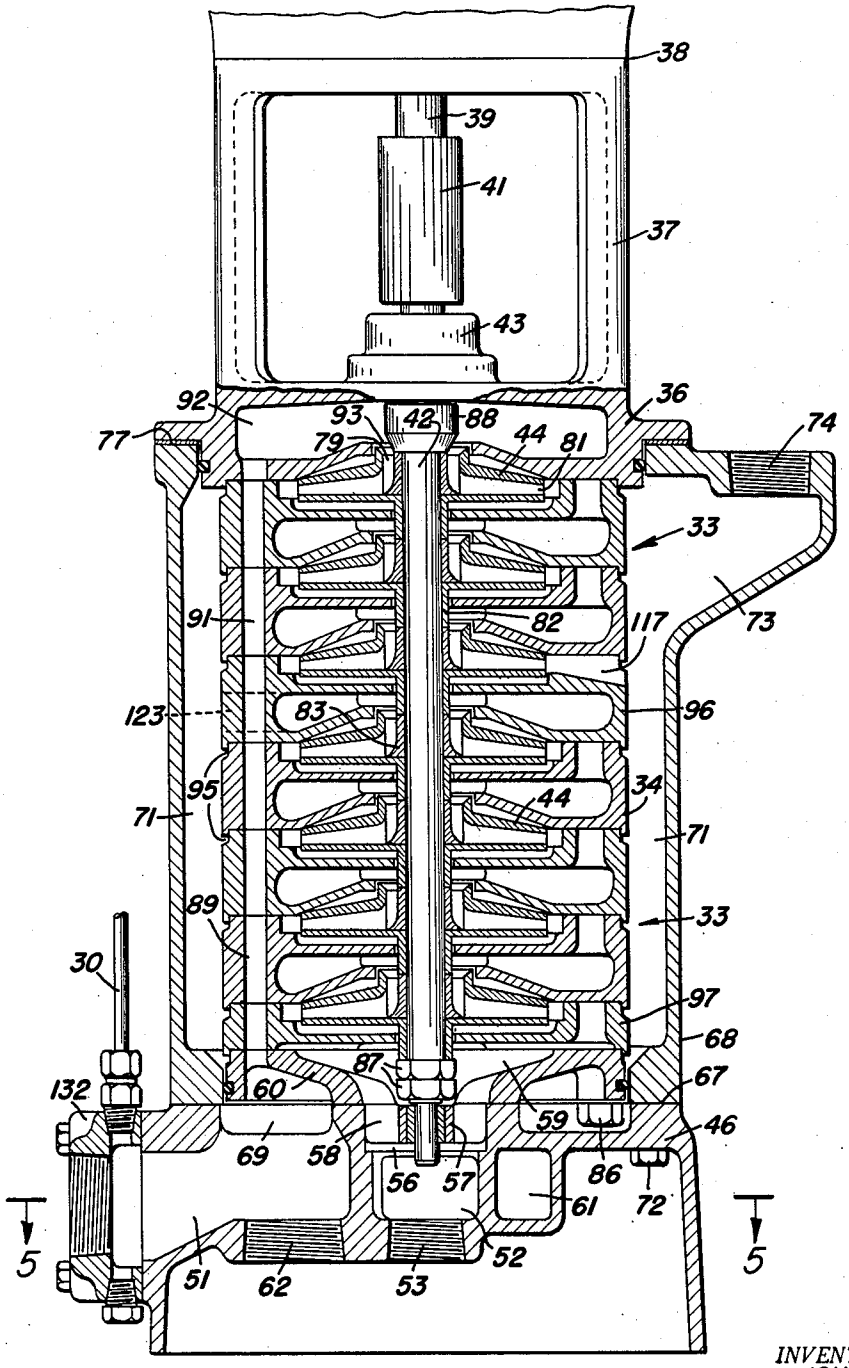


FIG. 4.

INVENTOR.
JOHN MANN

BY

ATTORNEY

April 22, 1958 J. MANN 2,831,432

MULTI-STAGE CENTRIFUGAL PUMP

Filed March 17, 1953 4 Sheets-Sheet 3

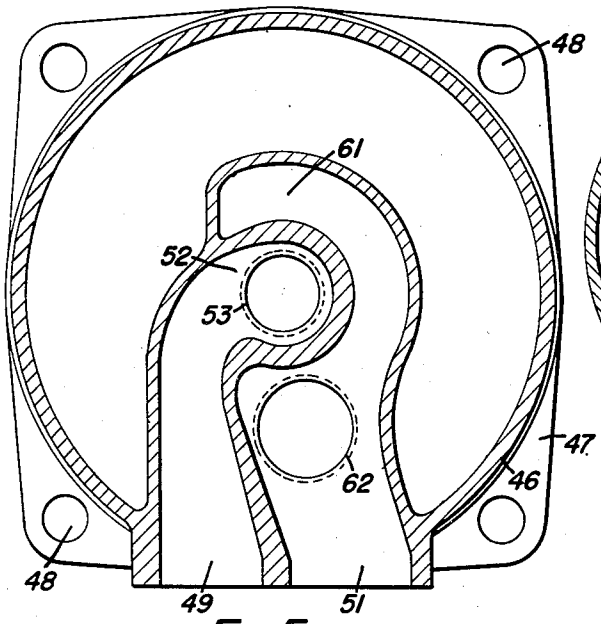


FIG. 5.

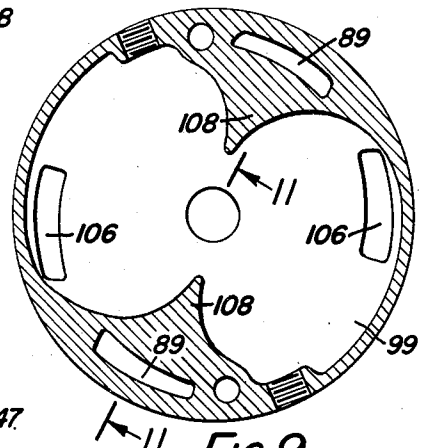


FIG. 9.

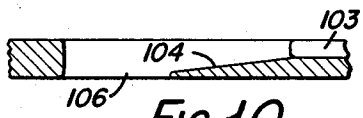


FIG. 10.

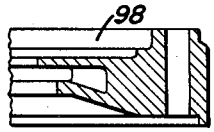


FIG. 11.

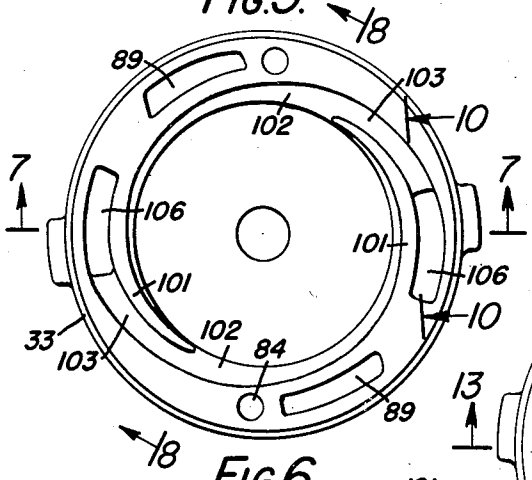


FIG. 6.

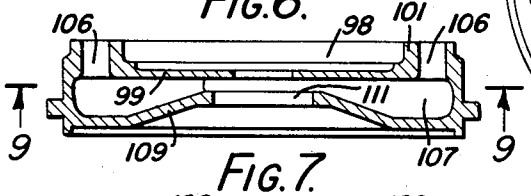


FIG. 7.

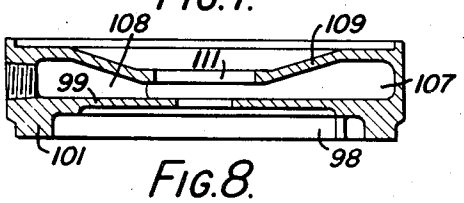


FIG. 8.

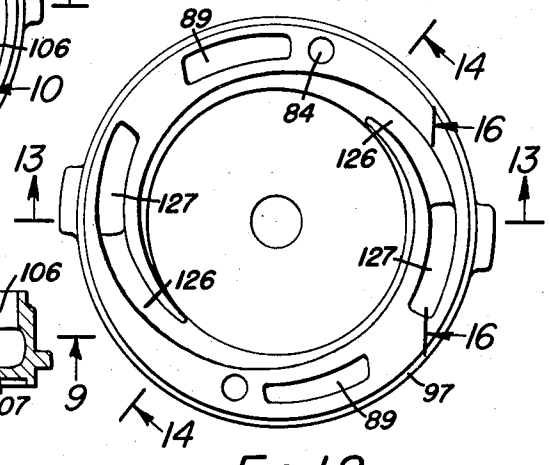


FIG. 12.

INVENTOR.
JOHN MANN

BY

ATTORNEY

April 22, 1958 J. MANN 2,831,432

MULTI-STAGE CENTRIFUGAL PUMP

Filed March 17, 1953 4 Sheets-Sheet 4

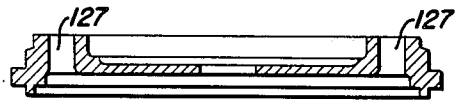


FIG. 13.

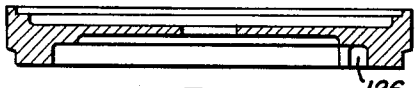


FIG. 14.

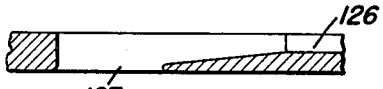


FIG. 16.



FIG. 17.



FIG. 19.

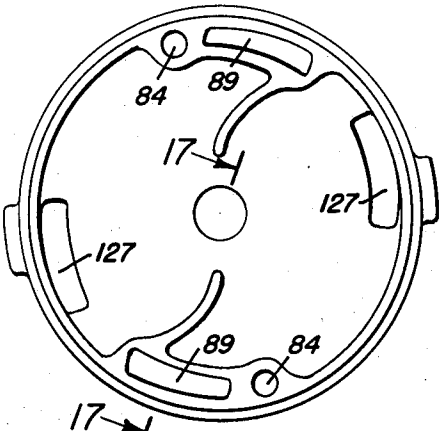


FIG. 15.

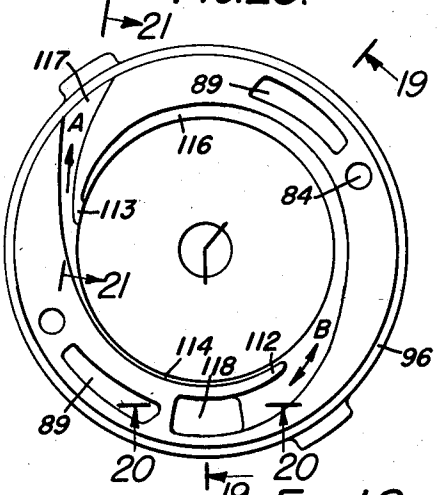


FIG. 18.

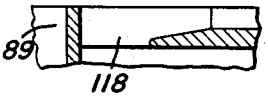


FIG. 20.

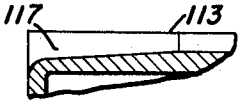


FIG. 21.

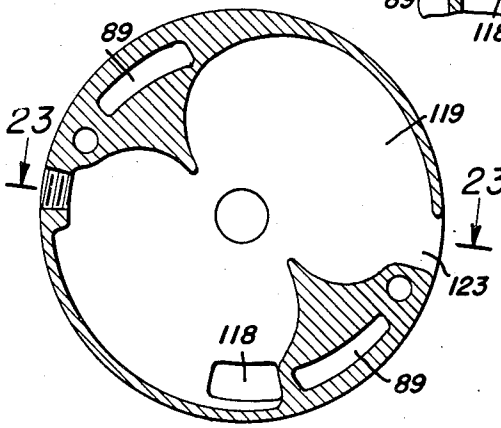


FIG. 22.

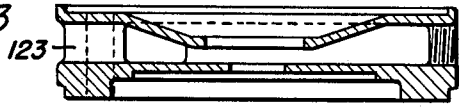


FIG. 23.

INVENTOR.
JOHN MANN

BY

ATTORNEY

United States Patent Office 2,831,432
Patented Apr. 22, 1958

2,831,432

MULTI-STAGE CENTRIFUGAL PUMP

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

Application March 17, 1953, Serial No. 342,798

3 Claims. (Cl. 103—5)

My invention relates to multi-stage centrifugal pumps and more particularly to that type of multi-stage pump which is combined with a jet pump located at a substantial distance below the ground level, the combination of the multi-stage centrifugal pump and the jet pump being normally employed in connection with a pneumatic pressure tank and other accessories to form a domestic water system.

The principles of the multi-stage centrifugal pump of my invention may be employed in multi-stage pumps generally where a high discharge pressure is desired or may be employed in connection with a shallow well with or without a jet pump where a high discharge pressure is desired. However, the principles of my invention will be shown and described in connection with a multi-stage centrifugal pump wherein a jet pump is located a substantial distance—a hundred feet or more—below the ground level or the level at which the multi-stage centrifugal pump is mounted.

An object of my invention is to provide a multi-stage centrifugal pump which may be made up to a large extent of standardized parts which are easy to assemble and a pump which is reliable in operation.

Another object of my invention is to provide a multi-stage centrifugal pump in which the impellers are in series, at least one stage of the multi-stage pump which may be any stage of the series, being a self-priming stage, whereby the pump will handle relatively large volumes of air or other gas without loss of prime and without appreciable loss in efficiency or pressure.

More specifically, my invention contemplates the provision of a series of centrifugal pumps each including a pump casing and a centrifugal pump impeller mounted therein, the pump casings being interfitting and similar in construction whereby they may be stacked and bolted together to provide an assembled unit, the assembled unit being substantially barrel shaped and being surrounded by an air separation chamber into which at least one of the pumps discharges, said pump being a self-priming pump whereby the assembly may be employed in connection with an aerated well to the end that the efficiency and discharge head produced by the pump is maintained at a maximum when relatively large quantities of air or gas are drawn from the well.

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

Fig. 1 is an external elevational view of the multi-stage pump of my invention with the parts broken away and indicating the multi-stage pump in use in connection with a deep well jet pump and a pneumatic tank which, together with accessory elements, constitutes a deep well multi-stage jet pump water system;

Fig. 2 is a view similar to Fig. 1 with the multi-stage pump and motor being turned through 90° to show the alternate suction and discharge which may be employed;

Fig. 3 is a top plan view of the multi-stage centrifugal pump of my invention with the electric motor and motor adapter removed;

Fig. 4 is a vertical sectional view taken substantially on the line 4—4 of Fig. 3 in the direction indicated by the arrows with certain elements thereof being shown out of their normal relation to better illustrate the invention;

Fig. 5 is a sectional view taken substantially on the line 5—5 of Fig. 4 in the direction indicated by the arrows;

Fig. 6 is a top plan view of one of the multi-stage casing elements showing the volutes or guide vanes and the passages for water flow through the casing element;

Fig. 7 is a sectional view taken substantially on the line 7—7 of Fig. 6 in the direction indicated by the arrows;

Fig. 8 is a sectional view taken substantially on the line 8—8 of Fig. 6 in the direction indicated by the arrows;

Fig. 9 is a view taken substantially on the line 9—9 of Fig. 7 in the direction indicated by the arrows;

Fig. 10 is a sectional view taken substantially on the line 10—10 of Fig. 6 in the direction indicated by the arrows;

Fig. 11 is a sectional view taken substantially on the line 11—11 of Fig. 9 in the direction indicated by the arrows;

Fig. 12 is a top plan view of the lowermost casing element of the multi-stage pump of my invention;

Fig. 13 is a sectional view taken substantially on the line 13—13 of Fig. 12 in the direction indicated by the arrows;

Fig. 14 is a sectional view taken substantially on the line 14—14 of Fig. 12 in the direction indicated by the arrows;

Fig. 15 is a bottom view of Fig. 12;

Fig. 16 is a sectional view taken substantially on the line 16—16 of Fig. 12;

Fig. 17 is a sectional view taken substantially on the line 17—17 of Fig. 15 in the direction indicated by the arrows;

Fig. 18 is a top plan view of the casing part of the self-priming stage of the multi-stage centrifugal pump of my invention;

Fig. 19 is a sectional view taken substantially on the line 19—19 of Fig. 18 in the direction indicated by the arrows;

Fig. 20 is a sectional view taken substantially on the line 20—20 of Fig. 18 in the direction indicated by the arrows;

Fig. 21 is a sectional view taken substantially on the line 21—21 of Fig. 18 in the direction indicated by the arrows;

Fig. 22 is a view taken substantially on the line 22—22 of Fig. 19 in the direction indicated by the arrows; and

Fig. 23 is a sectional view taken substantially on the line 23—23 of Fig. 22 in the direction indicated by the arrows.

The multi-stage centrifugal pump of my invention has been shown and will be described in connection with a deep well domestic water system. However, as mentioned above, the multi-stage centrifugal pump of my invention may be employed otherwise than in connection with a jet pump and otherwise than in connection with a domestic water system.

As shown in Fig. 1, the multi-stage jet centrifugal pump system of my invention comprises a multi-stage centrifugal pump, generally indicated by the numeral 26, an electric motor 27 for driving the pump, a jet pump, generally indicated by the numeral 28, usually located a substantial

distance below the multi-stage centrifugal pump—perhaps a hundred feet or more—and a pneumatic tank 29 which has been shown fragmentarily in Fig. 1. The system also includes a foot valve 31, a pressure control valve 32, a means (not shown) for starting and stopping the pump in accordance with the pressure existent in a portion of the system, for example in the pneumatic tank, and a means partly indicated at 30 for supplying air to the pneumatic tank to replenish air withdrawn from the system. The foot valve 31, the pressure control valve 32 and the air volume control have only been diagrammatically illustrated and the pressure switch has not been shown at all for the reason that these basic elements of a domestic water system are well known in the art to which this invention applies.

The multi-stage pump 26 includes a series of castings generally indicated by the numeral 33. As will presently appear these castings are so constructed and arranged that they may be stacked in abutting relation and bolted together to define a unitary assembly presenting an external wall 34 which is essentially barrel shaped or cylindrical.

The multi-stage pump further includes a cover plate 36 which is preferably formed integral with an adapter 37 bolted or otherwise secured to the motor frame as indicated at 38. The motor shaft 39 is connected to a coupling diagrammatically illustrated at 41 which is connected, as shown, to a pump shaft 42. The pump is supported from the motor bearing and the shaft 42 extends through a housing 43 enclosing a suitable mechanical seal, and suitable means are provided for preventing leakage of liquid upwardly along the shaft. As will presently appear, the shaft 42 drives a series of centrifugal pump impellers 44.

The multi-stage centrifugal pump also includes a base casting 46 which serves as a support for the stack of castings or pump casing elements 33. As shown most clearly in Fig. 5, the base casting includes a flange 47, by which the multi-stage pump may be bolted to the floor or other support as indicated at 48.

The base casting has cored therein (Fig. 5) two passages 49 and 51 which extend outwardly to the side of the base casting 46. The passage 49 constitutes a passage for liquid discharged by the last stage of the multi-stage pump to supply liquid under pressure to the jet pump 28 (Fig. 1). The inner end of the passage 49 preferably is in substantially concentric relation with the drive shaft 42 to define a pressure chamber 52 (see also Fig. 4). The casting 46 has a threaded opening 53 below the pressure chamber 52 for the reception of a pressure pipe 54 (Fig. 1) connecting the pressure chamber 52 with the nozzle of the jet pump.

The upper part of the pressure chamber 52 is bridged by a spider 56 which supports a bearing 57 for the lower end of the pump shaft 42. Around the bearing passages 58 are provided which connect the pressure chamber 52 with a pressure passage 59 formed in a casting 60. The upper face of the casting 46 has a machined surface defining the exterior of the passage 58 and which serves as a support for the multi-stage pump, the lowermost casting 60 of which rests upon it.

The suction passage 51 (Fig. 5) extends inward from the side of the base casting 46 and extends around the wall defining the pressure chamber 52 as shown at 61. The lower wall defining the suction passage 51 has a threaded opening 62 (Fig. 4) for the reception of a suction pipe 66 (Fig. 1) which receives the discharge from the jet pump. The base casting 46 is provided with an annular machined surface 67 which supports a casting 68. The upper wall of the passage 51 is cut away at two positions, one of which has been indicated at 69, the function of which will later appear.

The casting 68 is cylindrical in cross section and is spaced from the exterior wall 34 defined by the castings 33 to form an annular air separation space or chamber 71. The lower annular end of the casting 68 is machined to mate with the machined surface on the case casting 46 and the two castings are bolted together as indicated at 72.

The upper end of the casting 68 is enlarged at 73 to define a discharge passage. A threaded opening 74 is provided in the casting to which the discharge pipe 76 (Fig. 1) is connected. The upper end of the casting 68 has an annular machined surface 77 adapted to receive a flange on the cover plate 36 which is bolted (not shown) to the cylindrical casting 68.

The centrifugal pump impellers are preferably of the closed type although open type impellers may be employed. The impellers include a plurality of impeller vanes 78, the construction of which is well known in the art, a suction inlet 79 and a series of discharge outlets 81. The rearward wall of the impellers is bored for the reception of the shaft 42 and has a hub 82. The impellers are rigidly secured to the shaft by keys (not shown) and the assembly of impellers and shaft 42 includes spacing collars 83 which rotate with the shaft 42.

Each of the castings 33 which house the impellers and the casting 60 has a pair of bores 84 (see Figs. 6, 12 and 18) adapted to receive elongated bolts (not shown) which extend through the castings to rigidly connect them together and secure them to the cover plate. This is indicated by the nut 86 (Fig. 4). The lower end of the shaft is provided with a pair of lock nuts 87 and the shaft is shouldered for their reception to support the shaft assembly between the nuts and an enlargement on the upper end of the shaft indicated by the numeral 88.

Each of the castings 33 and the casting 60 has a pair of openings 89 which are elongated in a direction circumferentially of the axis as shown in Figs. 6, 12 and 18. The castings are placed in stacked relation so that these openings in adjacent castings are in alignment with each other to constitute a through passage 91 extending from the bottom of the stack of castings or pump casings to the top thereof. The lower ends of these through passages 91, only one of which is shown in Fig. 4, connects with the openings 69 in the base plate 46 and from thence with the suction inlet 51 (Fig. 5). The upper ends of the through passages 91 connect with a chamber 92 formed in the cover plate 36. The cover plate 36 has a central bore 93 which enables access of the liquid entering the suction of the pump and flowing through the passages 91 into the chamber 92 to have access to the suction opening 79 of the first impeller of the series.

The castings 33 are all of the same general configuration to enable assembly of them into a stack. Each of the castings has interfitting parts 95 to maintain them in stacked relation. It will be particularly noted that no packing is employed between the castings as the tightly stacked assembly minimizes leakage and any slight leakage which may occur is immaterial since the castings are enclosed by the air separation chamber. In the particular illustration shown, seven stages are provided which are formed in seven castings. Five of the castings are similar to those shown in Figs. 6 to 11 inclusive, a sixth casting, the casting 96 of the series, constitutes the casting for a self-priming stage and is shown in detail in Figs. 18 to 23 inclusive. The seventh casting which is the lower casting 97, is shown in Figs. 12 to 17 inclusive.

Referring now to Figs. 6 to 11 inclusive, the five castings previously mentioned include a dish shaped cavity 98 defined by a lower wall 99 and an approximately annular wall 101. The lower wall 99 constitutes half of the casing wall which encloses one of the centrifugal pump impellers. As shown most clearly in Fig. 6, the wall 101 is broken or interrupted by two peripheral openings 102. The wall 101 recedes from the axis of the shaft 42 to form with the openings 102 two volute passages or guide vanes 103. The lower walls of these guide vanes slope downward, as indicated at 104 in Fig. 10, and con-

nect with passages **106** which extend through part of the casting into cavity **107**. These volute shape passages form liquid flow passages for the liquid discharged by the rotating impeller. The liquid discharged through these passages flows downward through the passages **106** into the cavity **107**.

The cavity **107** is partly broken up by walls **108** which projects into the cavity for the purpose of preventing rotation of the liquid. Except for the shaft opening, the cavity **107** (Fig. 7) is closed by the wall **99** at the top thereof and is closed by a wall **109** at the bottom thereof except for a bore **111**. As shown in Fig. 4, the wall **109** constitutes the upper wall of a casing for the second impeller of the series. That is, the walls **99** and **109** constitute the walls of the pump casings but one of these walls is in one casting and the other in an adjacent casting. The bore **111** in the wall **109** constitutes the opening through which liquid flows to the suction **79** of the second impeller of the series.

It will now be apparent that liquid flowing into the suction passage **51** (Fig. 5) flows through the elongated vertical passages **91** to the chamber **92**, hence into the suction opening **79** of the first impeller. Liquid discharged by the first impeller is thrown outwardly through the guide vanes on the upper side of the first casting, as shown in Fig. 6, then flows through the passages **106** into the chamber **107** and thence to the bore **111** (Fig. 7) and to the suction of the second centrifugal impeller of the series.

In the particular illustration shown the third stage which is defined by the casting **96**, is a self-priming stage. The volutes, discharge passages or guide vanes of this casting are preferably made substantially in accordance with Mann application Serial No. 595,019 filed May 21, 1945, entitled "Pumps" (Patent No. 2,627,812 issued February 10, 1953); and Mann-Shuster application Serial No. 103,644 filed July 8, 1949, entitled "Self-Priming Centrifugal Pumps" (Patent No. 2,627,817 issued February 10, 1953). If desired, other types of self-priming pumps may be employed.

Since the construction of the self-priming stage is described in the above mentioned applications (Patent Nos. 2,627,812 and 2,627,817), it is sufficient to state that the start of the volutes may be considered to be at the cutwaters **112** and **113** (Fig. 18). These cutwaters are unequally spaced from the periphery of the impeller and the volutes **114** and **116** which commence at these cutwaters and encircle the impeller in a clockwise direction, as viewed in Fig. 18, preferably are of different volumetric capacities which in accordance with the disclosures of the above mentioned application results in a self-priming pump, the action of which will be briefly described.

With the system full of water and no air being admitted to the system, water is discharged through both volute passages **114** and **116** as indicated by the arrows A and B. The discharge from the passage A opens, as indicated at **117**, into the air separation chamber **71** (see also Fig. 4). The discharge from the passage **116** flows to a passage **118** which is somewhat similar to the passages **106** of Fig. 6. Water flowing through the passage **118** flows into a cavity **119** at the bottom of the casting which cavity is similar to the cavity **107** of Fig. 9. Water flowing into the cavity **119** flows through a bore **121** similar to the bore **111** of Fig. 7 and from thence to the suction opening of the next stage impeller. The casting for this next stage and succeeding stages are similar to that described above in connection with the description of Figs. 6 to 11 inclusive. The peripheral edge of the casting **96** on its under side as shown in Fig. 22 is broken by an opening **123** which communicates with the air separation chamber **71**. This opening is indicated in Fig. 4 in dotted lines.

When the pump is operating normally, that is, with substantially solid water being fed to the pump, the self-priming stage functions in a manner not entirely unlike the other stages of the pump, that is, liquid is discharged through both volutes **114** and **116**. However, the water discharged into the air separation chamber through the volute passage **114** and opening **117** (Fig. 18) provides the water which discharges through the discharge outlet **74** and the discharge pipe **76** (Fig. 1) to the pneumatic tank where it is stored for use.

Whether inflow or outflow of liquid will occur through the opening **123** (Figs. 4, 22 and 23) depends upon whether air or gas is entering the system as will presently appear. It will be understood that the multi-stage pump must supply liquid to the jet pump at a pressure sufficient to create such subatmospheric pressure in the jet pump as is required to draw liquid from the well, overcome friction in the piping and the other losses. The pressure at which the liquid will be supplied to the jet pump is determined at least partly by the setting of the pressure control valve **32**. When a high pressure is desired, this valve is in a restricted position. With the pressure control valve properly set, sufficient liquid will flow through the bore **121** (Fig. 19) to supply liquid to the succeeding stages of the series and build up the pressure to the required pressure for operating the jet pump to lift water from the well and overcome the losses necessary to pump the water up to the cavity or chamber **92**.

When air or gas enters the system with the water being pumped or if small leaks exist in the long lengths of piping, the pump will handle such air or gas without great loss in efficiency or discharge head. If the concentration of air is sufficient, a reversal of flow in the volute passage **116** will occur as indicated by the double ended arrow B of Fig. 18. Moreover, in aerated wells with long lengths of piping, if the pump is allowed to stand for a considerable length of time, air will bubble up through the piping and fill the upper part of the casing. When the pump starts again under automatic control, this air must be exhausted from the casing before liquid pumping will start. With one of the pumps of the multi-stage pump being a self-priming pump, the water in the multi-stage pump may drop to a level at or slightly below the suction of the self-priming stage **96** and still reprime when the pump is started again. The system will gradually exhaust the air which collects in the top of the pump casing and discharge it through the discharge outlet **74** until normal conditions are again restored to the system.

When the pump is operating under such conditions or air is being drawn into the centrifugal pump stage in relatively large volume, as previously mentioned, liquid substantially free of air will be drawn into the pump casing through the volute passage **116** past the wide cutwater **112**, while liquid and air will be discharged through the discharge volute passage **114** and into the air separation chamber **71**. This air bubbles upward through the air separation chamber and is released through the outlet **74**. Liquid from which a large proportion of the air has been removed in the air separation chamber then flows inward through the opening **123** (Fig. 22), upward through the opening **118**, and inward through the volute passage **116**. As soon as normal liquid conditions are restored, that is, the liquid flowing into the self-priming stage is substantially air free, then the flow of liquid in the volute passage **116** reverses and both this passage and the volute passage **114** become discharge passages and the system then operates normally as above described.

One important feature of my invention is that structurally the castings **33** are all the same insofar as their interfitting aspects are concerned, as will be apparent from a comparison of Figs. 6 to 11 inclusive and the corresponding views of Figs. 18 to 21 inclusive. This enables in the assembly of the stack of castings, placing the self-priming casting in any position in the series. In that particular illustration shown, the self-priming stage is the third stage in the series. Thus the maximum dis-

charge pressure available in the pneumatic tank is the pressure which three stages of impellers are capable of producing. If a higher pressure is desired in the pneumatic tank, the self-priming stage may be the fourth, fifth or sixth stage; or if, for example, the system is to be used for open flow discharge as in some irrigation systems, the self-priming stage may be the first or second stage.

While the location of the self-priming stage, because this is the system's only outlet into the air separation chamber and from thence into the pneumatic tank, determines the maximum pressure available in the pneumatic tank, a part of the liquid discharged by the self-priming stage flows to succeeding stages of the series to build up the pressure beyond that required in the tank to supply water to the jet pump **28** at a pressure sufficient to activate the jet to draw water from the well and overcome the losses through the jet pump and through the long lengths of piping. It will be understood that by varying the number of stages and the location of the self-priming stage, any desired pressure within reasonable limits may be obtained in the pneumatic tank and a different and higher pressure may be maintained on the jet of the jet pump.

The lowermost casting **97** is similarly provided with interfitting parts and its upper face is precisely the same as the upper face of the casting shown in Figs. 6 to 11 inclusive. However, since the lowermost casting **97** does not feed liquid to a succeeding stage, the lower wall **109** of Fig. 7 is omitted whereby the casting is of less height. The discharge from the lowermost centrifugal pump impeller is outward through volutes **126** downward through passages **127** (Fig. 12), thence through passage **59** in casting **60** and from thence to the annular passage **58**, the pressure chamber **52**, and the pressure pipe **54** to the jet pump.

In Fig. 1, I have shown the pressure and suction pipes **54** and **66** connected into the threaded openings **53** and **62** located directly below the pump. However, I have indicated in Fig. 1 in dotted lines a pipe extending sidewardly from the base casting **46** which position is employed when the pump is not located directly over the well. A side view showing the suction and pressure pipe openings **51** and **49** together with an adapter **132** has been shown in Figs. 2 and 4. Thus the position of the suction and pressure pipes may be varied and the set of openings **59—51** or the set of openings **53—62** are plugged when not used.

While I have shown and described the preferred form of my invention, it will be apparent that various changes and modifications may be made therein, particularly in the form and relation of parts, without departing from the spirit of my invention as set forth in the appended claims.

I claim:

1. A multi-stage jet-centrifugal pump comprising, in combination, a series of castings, a series of impellers mounted in said castings, said castings forming pump casings around the impellers and having passages formed therein to conduct liquid from one impeller to the other in staged series, a jet pump in the source of liquid supply and having a suction pipe and a pressure pipe, said suction pipe being connected to the first stage of the series, an air separation chamber, at least one of said castings having means formed therein for rendering the impeller associated therewith self-priming, said means comprising a pair of passages one of which is connected to the air separation chamber and the other of which is connected to both the air separation chamber and the pressure pipe, a connection from the air separation chamber to the point of use of the liquid, and means for rotating said impellers.

2. A multi-stage jet-centrifugal pump in accordance with claim 1 in which the self-priming stage of the series may be an intermediate stage whereby liquid may be supplied to the point of use at one pressure and to the jet pump at a higher pressure.

3. A multi-stage jet-centrifugal pump comprising, in combination, a series of castings at least two of which are substantially identical, said castings having interfitting parts so that they may be stacked in interfitting bolted together relation to form a unitary assembly, a series of impellers mounted in said castings, said castings forming pump casings around the impellers and having passages formed therein to conduct liquid from one impeller to the other in staged series, a jet pump in the source of liquid supply and having a suction pipe and a pressure pipe, said suction pipe being connected to the first stage of the series, an air separation chamber, at least one of said castings having means formed therein for rendering the impeller associated therewith self-priming, said means comprising a pair of passages one of which is connected to the air separation chamber and the other of which is connected to both the air separation chamber and the pressure pipe, a connection from the air separation chamber to the point of use of the liquid, said connections and passages being arranged so that when air enters the system the self-priming stage will assist in discharging the air to the point of use of the liquid and supply substantially air free liquid to the jet pump, and means for rotating said impellers.

References Cited in the file of this patent

UNITED STATES PATENTS

1,238,731	Anderson	Sept. 4, 1917
1,978,277	Noble	Oct. 23, 1934
2,601,828	Lobanoff	July 1, 1952
2,627,812	Mann	Feb. 10, 1953
2,627,817	Mann et al.	Feb. 10, 1953
2,631,539	Wolfe et al.	Mar. 17, 1953
2,651,998	Bergh	Sept. 15, 1953
2,653,546	Marlow	Sept. 29, 1953
2,694,365	Armstrong et al.	Nov. 16, 1954

FOREIGN PATENTS

32,960	Netherlands	Feb. 1, 1932
201,855	Germany	Sept. 21, 1908
494,877	Germany	Mar. 29, 1930
610,778	Germany	Mar. 16, 1935