Sept. 24, 1940. A. HOLLANDER 2,215,505

VARIABLE CAPACITY PUMPING APPARATUS

Filed June 13, 1938 2 Sheets-Sheet 1

Fig. 1

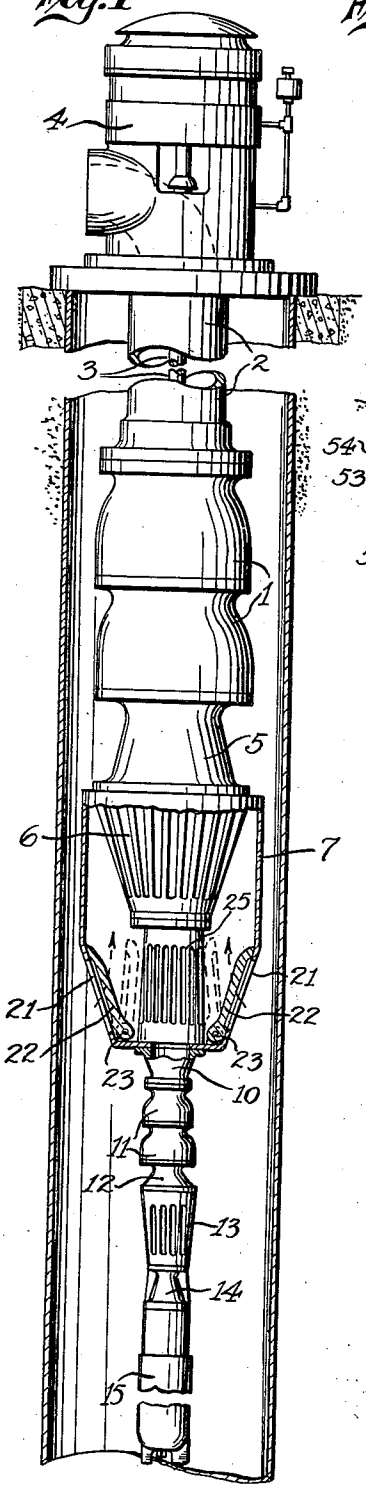



Fig. 2

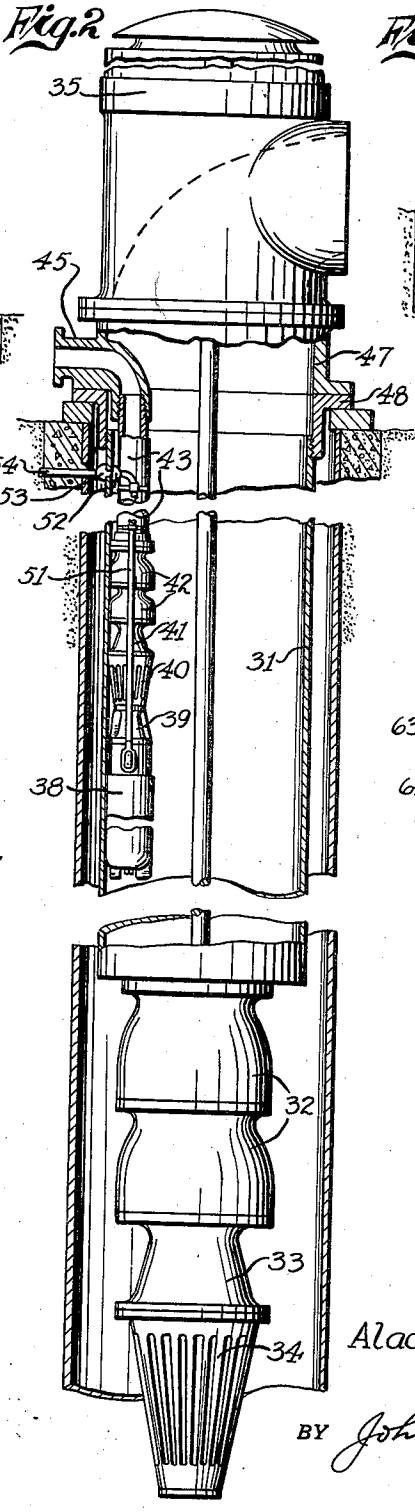
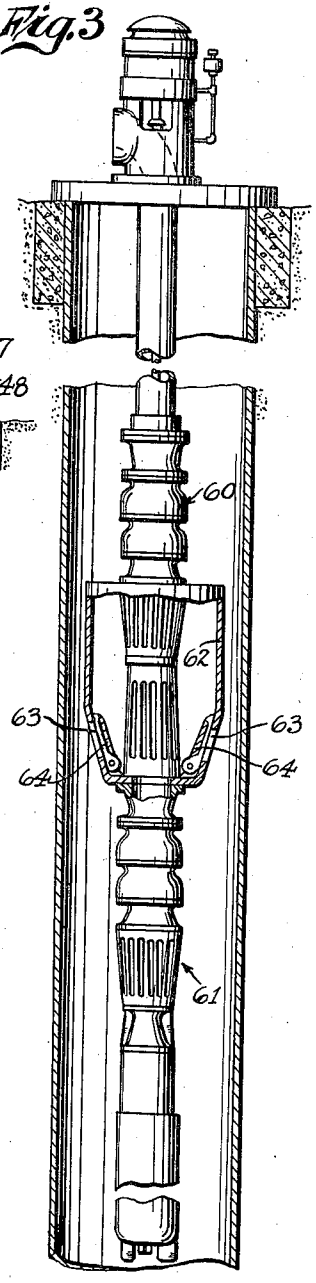



Fig. 3




Aladar Hollander
INVENTOR

BY John D. Chesnut
ATTORNEY

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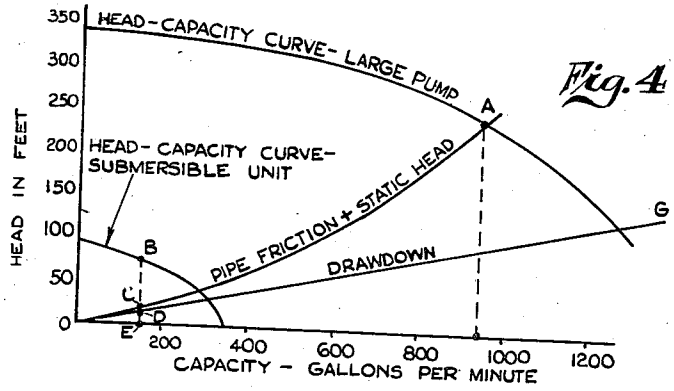



Fig. 4

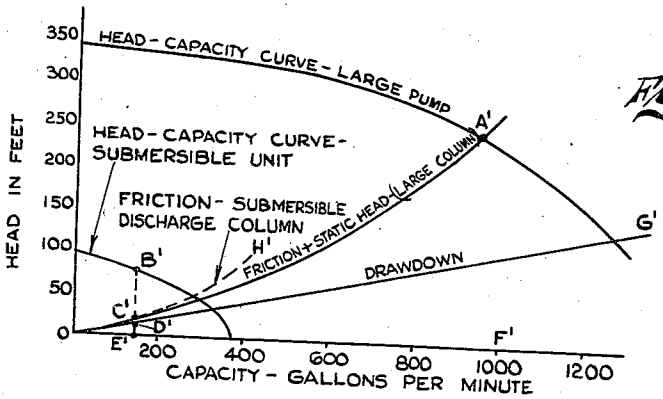



Fig. 5

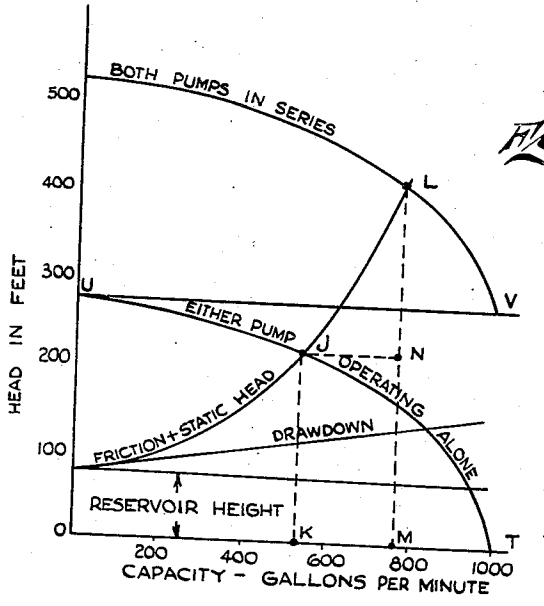



Fig. 6

Aladar Hollander
INVENTOR
BY John D. Chesnut
ATTORNEY

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# UNITED STATES PATENT OFFICE

2,215,505

## VARIABLE CAPACITY PUMPING APPARATUS

Aladar Hollander, Los Angeles, Calif., assignor to Byron Jackson Co., Huntington Park, Calif., a corporation of Delaware

Application June 13, 1938, Serial No. 213,431

5 Claims. (Cl. 103—105)

This invention relates generally to deepwell centrifugal pumps, and is directed particularly to the provision of a deepwell pump having a plurality of capacities to meet varying pumping requirements.

It is well known that the capacity of a deepwell centrifugal pump is determined by the static head, the friction head, and the draw-down of the well, and when installed in a well the capacity becomes substantially fixed so long as the draw-down remains constant. In many instances, however, the output of a water well is used for different purposes requiring widely varying head and volume characteristics. It is, therefore, a principal object of this invention to provide a deepwell pump the discharge of which is capable of being varied as to head and volume to meet widely different requirements.

This object is accomplished by combining a standard shaft-driven deepwell pump with a submersible motor-pump unit. The relative sizes and capacities of the two pumps may be selected according to the particular conditions encountered.

An instance in which this invention has particular utility is that in which water is required both for irrigation and for domestic use. The former requires a large volume, usually with surface discharge, while the latter requires a higher head but relatively small volume. Under these conditions a relatively small capacity, submersible motor-pump unit may be connected to the lower end of a large capacity shaft-driven deepwell pump. The domestic water supply is furnished by the submersible pump, which discharges through the larger pump when the latter is idle, while for irrigation the large pump is operated. A separate inlet from the well, with inwardly opening check valves, may be provided between the two pumps if desired, to permit independent operation of the larger pump.

The arrangement described above may be modified by mounting the submersible unit in the discharge column of the large pump, if the draw-down of the well at the capacity of the small pump is not great. The relative sizes of the submersible unit and the discharge column of the large pump are such that the former does not interfere with the discharge from the latter. With this arrangement the two pumps are not only operable separately, as in the arrangement described above, but may be operated simultaneously to provide a relatively small volume at high pressure from the submersible unit while the large capacity shaft-driven pump is operating.

Many instances of wide variations in head and volume requirements may be met by combining a standard shaft-driven deepwell pump and a submersible motor-pump unit of equal capacity. When connected in end-to-end relation with a separate valved inlet for the upper pump between the pumps, either pump may be operated singly to deliver a relatively small volume of water at low head, or both pumps may be operated in series to deliver a larger volume at higher head. This arrangement is useful in irrigation when part of the land to be irrigated is below the ground surface and requires only surface discharge, and part of the land is at a higher elevation than the top of the well.

The foregoing are typical examples of the uses to which a standard deep-well pump and a submersible motor-pump may be put when combined in a single well to provide variable capacity to meet widely varying requirements. The manner in which they may be combined will be apparent from the following description, taken in conjunction with the accompanying drawings, wherein:

Figure 1 is an elevational view, partly in section, illustrating a small submersible motor-pump unit suspended from the lower end of a shaft-driven deepwell pump of large capacity;

Figure 2 is an elevational view of a modification of the arrangement shown in Figure 1, with the submersible unit mounted in the discharge column of the large unit;

Fig. 3 is an elevational view, partly in section, showing a submersible unit mounted on the lower end of a shaft-driven deepwell pump, the two pumps being of equal capacity; and

Figs. 4, 5, and 6 illustrate graphically the operating characteristics of the combinations shown in Figs. 1, 2, and 3, respectively.

Referring to Fig. 1, a standard shaft-driven deepwell pump is shown as comprising a series of pump bowls 1 connected to the lower end of a discharge column 2 and having impellers mounted on the pump shaft 3 extending to the surface and driven by the motor 4. The usual suction piece 5 and strainer 6 are mounted below the pump bowls, and connected between the bolting flanges of the suction piece and strainer is the upper, inwardly extending flange of a shell 7. The shell has an upper cylindrical portion surrounding the strainer 6, and a lower downwardly tapered portion.

Secured to the lower end of the shell is the discharge piece 10 of a submersible motor-pump unit comprising a series of impeller bowls 11, a suction piece 12, a strainer 13, a motor adapter 14, and a submersible electric motor 15. The details of construction of this unit form no part of this invention, and hence a detailed description thereof is unnecessary.

A plurality of inlets 21 are provided in the lower tapered portion of the shell 7, and inwardly opening check valves 22 are pivotally mounted at 23 in the base of the shell for closing the inlets against outward flow of fluid. A strainer 25 is mounted in the shell between the lower end of

strainer 6 and the base of the shell, to prevent entrance of large size solids into the submersible unit.

In operation, either pump may be operated singly, depending on the capacity required. The relatively small capacity submersible unit is adapted to supply water for domestic use while the large shaft-driven pump is idle. Since the draw-down of the well will be much less when operating the small capacity submersible unit than when operating the large pump, the submersible unit will deliver water at ample pressure for domestic use. During operation of the submersible unit the discharge thereof passes through the idle upper pump, the check valves 22 being held closed by the excessive pressure in the shell 7 and by gravity. If desired, the valves may be spring-pressed to closed position, as by torsion springs mounted on the pivot pins 23.

When a large amount of water is desired, as for irrigation, the shaft-driven pump is operated. During this operation the check valves swing inwardly and admit well fluid directly from the well into the strainer 6, the inward movement of the valves being limited by the strainer 25 to the dotted-line position shown. The valves when open form a substantially solid protecting wall about the strainer 25 and deflect the water upwardly to strainer 7, while at the same time reducing to a minimum the amount of sand tending to enter the screen 25 and thence into the lower pump.

Since the two pumps are driven by separate motors, they may be driven at different speeds, the speed of each pump being selected to provide most efficient operation.

In Figure 2 is shown a modification of the arrangement shown in Figure 1, in which a small diameter, small capacity submersible unit for domestic supply is mounted in the discharge column of a large capacity pump. The shaft-driven deepwell pump is of standard construction, except that if desired the discharge column 31 may be extra large to compensate for the space occupied by the submersible unit. The impeller bowls 32, suction piece 33, strainer 34 and motor 35 are of conventional design.

The submersible unit is similar to that shown in Figure 1, and comprises the usual submersible electric motor 38, adapter 39, strainer 40, impeller bowls 41, discharge piece 42, and column pipe 43. The discharge elbow 45 is formed in a casting 47 resting on the base flange 48 which supports the discharge column 31.

The submersible motor 38 is connected to a suitable source of current by a conductor cable 51. The motor is preferably of the oil-filled, pressure balanced type, the cable 51 being also under equalized internal and external pressures. Inasmuch as the motor is located in the discharge column of the large pump and subjected to the discharge pressure thereof when the latter is operating, the cable 51 is sealed off at the point where it extends through the discharge column 31. A pothead 52 is provided for this purpose, the conductors in the cable extending through the column 31 in fluid-tight relation thereto and terminating in contact posts on the outer side of the column. A second pothead 53 detachably secured to the exterior of the column contains sockets to receive the contact posts, and is connected to a cable 54 leading to the source of current.

In this form of the invention, as in Figure 1, either pump may be operated independently of the other in accordance with the demand, the small pump delivering a small volume at a higher head than the large pump because of the lesser draw-down at small capacity. This form has an advantage over that of Figure 1 in that the submersible unit may be removed from the well without removing the large column and pump.

As mentioned previously this arrangement has another distinctive advantage over that of Figure 1, in that the discharge of the submersible is separate from that of the large pump, and consequently both pumps may be operated simultaneously to deliver water through their respective discharge columns. Since the inlet of the submersible pump is in the large discharge column, the suction pressure of the submersible unit will be relatively high and the discharge pressure thereof will be correspondingly higher than when the submersible unit is operating alone.

Referring now to Figure 3, there is shown a combination of a standard shaft-driven deepwell pump generally designated 60, and a submersible motor-pump unit generally designated 61. In this case the two pumps are of substantially equal capacity, and either pump may be operated singly to deliver water at relatively low head or the two pumps may be operated simultaneously in series to provide increased head and capacity. A shell 62 similar to the shell 7 of Figure 1 is connected to the lower end of the upper pump, and is provided with inlets 63 and check valves 64, as in Figure 1.

This arrangement is particularly useful in municipal water supply systems, wherein relatively low pressure is required for domestic service and high pressure is required for fire extinguishing. Either of the pumps 60 or 61 when operating alone will deliver sufficient water and at adequate pressure for domestic use, while for fire extinguishing both pumps may be operated to deliver high pressure water directly from the well to the fire mains.

As stated in the introductory remarks, the combination disclosed in Figure 3 is also well adapted to irrigation service in instances where part of the land to be irrigated is situated below, and part above, the top of the well.

In Figures 4, 5, and 6 I have illustrated graphically the relative capacities and heads obtained in typical wells by the combinations of pumps described above. Figure 4 shows the performance of the combination of Figure 1. With surface discharge from the large shaft-driven pump, the point A at the intersection of the pump performance curve and of curve O—A, representing the summation of the static and friction heads, determines the operating point of the large pump under the fixed conditions of draw-down and column pipe friction. Under these conditions approximately 950 gal./min. are delivered against a total head of 250 feet. The small capacity submersible causes only a relatively slight draw-down, represented by D—E, and the friction head C—D is relatively small at small capacity. Consequently against a surface pressure of approximately 30 lbs. per sq. in., as represented by B—C, this pump has a capacity of approximately 150 gal./min.

Figure 5, representing the performance of the modification shown in Figure 2, differs from Figure 4 in that the friction curve for the submersible unit is different from that of the large shaft-driven pump because of the separate discharge columns of different diameters and

lengths. The higher friction head due to the small discharge column 43 of Figure 2 is partially offset by the fact that in this arrangement the column 43 is of less length than the main column, and the submersible unit does not discharge through the large pump. Consequently the performance of the submersible unit, as shown in Figure 5, closely approximates that shown in Figure 4.

Figure 6 shows graphically the head-capacity performance of the two pumps of equal size illustrated in Figure 3. The point J on the lower head capacity curve represents the operating point of either pump when operated singly with discharge into a reservoir located approximately 75 feet above the mouth of the well. In this case the capacity is approximately 530 gallons per minute against a head of 220 feet, as represented by J—K. The upper head capacity curve is that of the two pumps operating in series, the operating point being indicated at L. When combined, the two pumps have a capacity of about 760 gal./min. against a head of 420 feet, represented at L—M, thus providing an additional head of 200 feet above the reservoir.

It will be understood that the foregoing graphs, and particularly the numerical values, are solely by way of example to illustrate typical head-capacity combinations. While I have described three specific examples of the manner in which a submersible motor-pump unit may be combined with a standard shaft-driven deepwell pump, it will be appreciated that other combinations with different relative capacities may be provided within the scope of this invention.

I claim:

1. Variable capacity deep well pumping apparatus comprising, in combination: a relatively large capacity pump and a relatively small capacity pump both suspended within a well from the lower end of a common discharge column, said large capacity pump being connected to said discharge column and adapted to discharge directly thereinto and said small capacity pump being suspended from said large capacity pump and adapted to discharge through the latter and into the discharge column; driving means for selectively operating said pumps independently of each other comprising a submersible electric motor suspended below said small capacity pump and operatively connected thereto and a prime mover at the ground surface and operatively connected to said large capacity pump; said large capacity pump having an inlet, and means for selectively connecting said inlet directly with the well or with the discharge from said small capacity pump, said connecting means comprising an inlet chamber surrounding said inlet and having a valved port in the wall thereof and an opening communicating with the discharge end of said small capacity pump, and an inwardly opening check valve adapted to open said port during operation of said large capacity pump to admit well liquid therethrough, said valve being adapted to close said port during operation of said small capacity pump whereby the discharge therefrom is constrained to flow from said chamber through said large capacity pump and into said discharge column.

2. Deepwell pumping apparatus comprising, in combination: a discharge column extending downwardly within the well from the surface; a pair of multistage centrifugal pumps suspended one below the other from the lower extremity of said discharge column, each pump comprising a group of stages connected in series and including impeller means mounted on common shafting individual to each of said pumps; each pump having a screened inlet, the inlet of the lower pump communicating directly with the well, and the inlet of the upper pump communicating with an inlet chamber surrounding the same, said inlet chamber having an inwardly opening check valve permitting flow of well liquid into said chamber during operation of said upper pump but preventing outward flow from the chamber to the well during operation of said lower pump; said lower pump having a screened outlet communicating with said inlet chamber; and means for operating said pumps independently of each other, said operating means comprising a submersible electric motor suspended from said lower pump and having its drive shaft operatively connected to the impeller shaft of said lower pump, and a prime mover at the surface of the well and drive means extending from said prime mover downwardly within the well into operative driving relation with the impeller shaft of said upper pump.

3. Deep well pumping apparatus comprising, in combination: a pump discharge column extending downwardly within the well from the surface; a pump supported at the lower end of said column and adapted to discharge thereinto; a prime mover mounted at the surface; drive means extending from said prime mover to said pump for imparting pumping motion to the latter; an inlet chamber enclosing the inlet of said pump, said chamber having inwardly opening check valve means adapted to permit flow of well liquid from the well into said chamber but preventing outward flow from the chamber to the well; and a submersible motor-pump unit suspended below said chamber, said unit comprising a submersible electric motor and a pump driven thereby, said last-named pump discharging into said inlet chamber and through said first-named pump into said discharge column, and the check valve means in said inlet chamber being adapted to close to seal said chamber from direct communication with the well during operation of said last-named pump and being adapted to open said chamber to direct communication with the well during operation of said first-named pump.

4. Deep well pumping apparatus as set forth in claim 3, and including a screened outlet between said last-named pump and said chamber, thereby preventing entrance of solids above a predetermined size from said chamber downwardly into said last-named pump during operation of said first-named pump.

5. Deep well pumping apparatus as set forth in claim 3, in which said check valve means comprises a plurality of check valves movable between a first position wherein they seal said chamber from direct communication with the well during operation of said last-named pump, and a second position wherein they substantially close said chamber from communication with said second-named pump, thereby preventing entrance of solids from said chamber downwardly into said second-named pump during operation of said first-named pump.

ALADAR HOLLANDER.