United States Patent [19]

Kimmel

[11] **3,776,664**

[45] **Dec. 4, 1973**

[54] **SMALL DIAMETER IRRIGATION PUMP**

[76] Inventor: **Ardean Kimmel**, Rt. 3, Deleon, Tex. 76444

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[52] **U.S. Cl.** **417/243,** 415/501

[51] **Int. Cl.** **F04b 23/00**

[58] **Field of Search** 417/244; 415/501, 415/243

[56] **References Cited**

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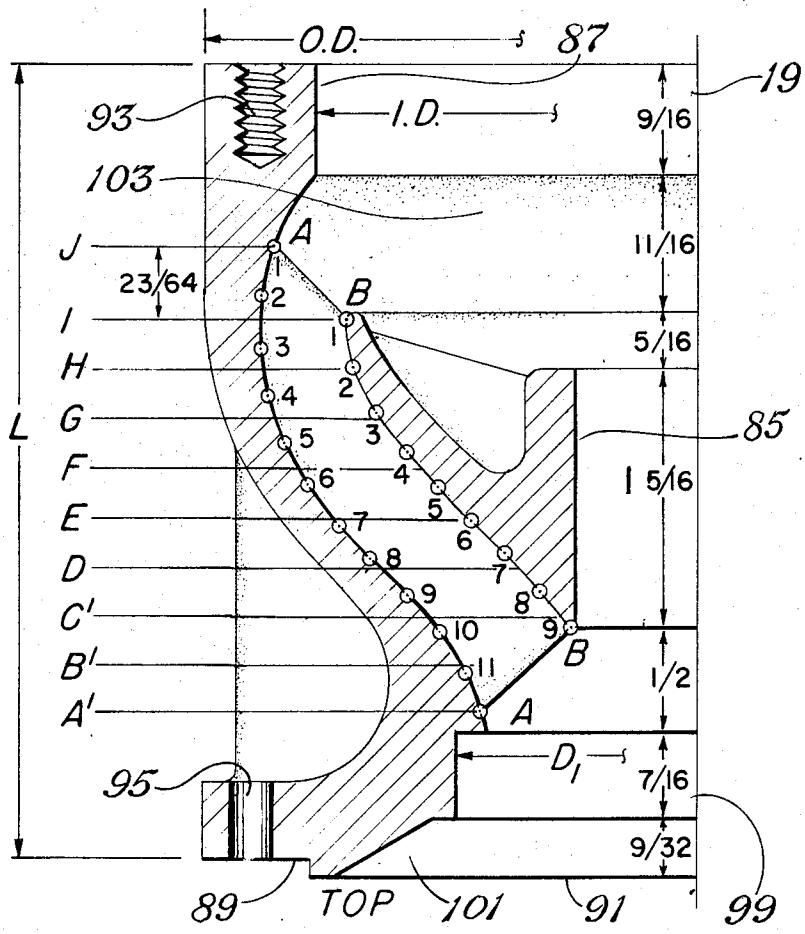
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Primary Examiner—C. J. Husar
Attorney—Wm. T. Wofford et al.

[57] **ABSTRACT**

An irrigation pump having exceptional flexibility and unusually large pumping capacity in terms of gallons pumped per inch of outside diameter characterized by: (1) unusually large flow passageways through its inlet adapter, impellers, bowls and top manifold in proportion to its outside diameter and (2) flexibility with one bowl that is adapted to take three specifically designed impellers for different ratings without infeasibly adversely affecting the efficiency of the pump. The impellers have a reduced outside diameter and enlarged inlet diameter, but compensate for the reduced diameter by specifically designed spirally exteriorly ascending passageways to effect the flow capacity as great as prior art pumps 20 percent larger. The irrigation pump of this invention is able to be installed in wells drilled with an 8 inch bit; whereas, pumps of the prior art having the same capacity required a well that was drilled with a twelve inch bit which more than doubled the cost of drilling the irrigation well.

7 Claims, 23 Drawing Figures



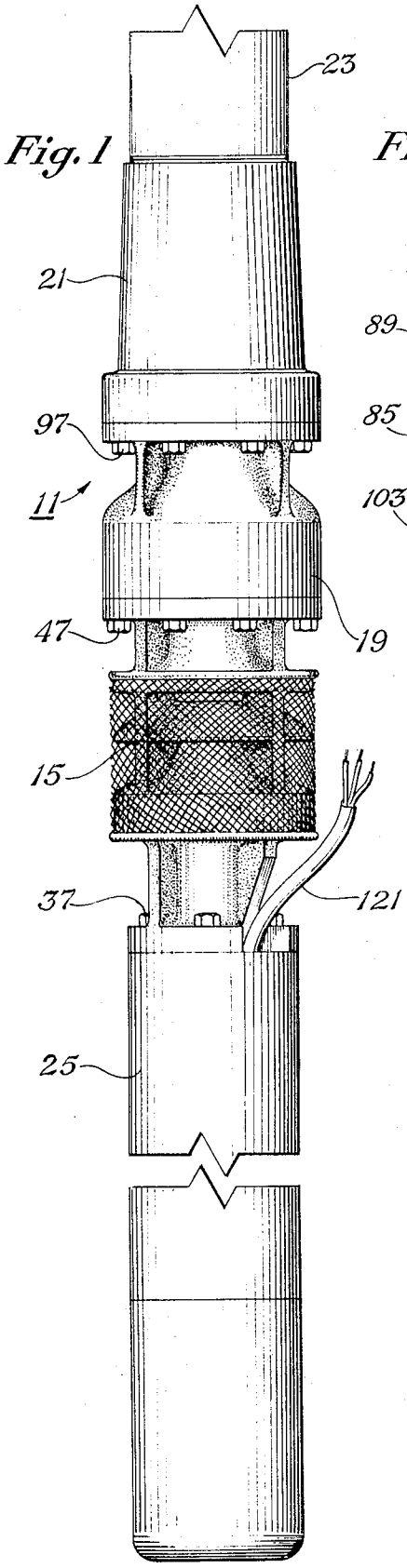


Fig. 1

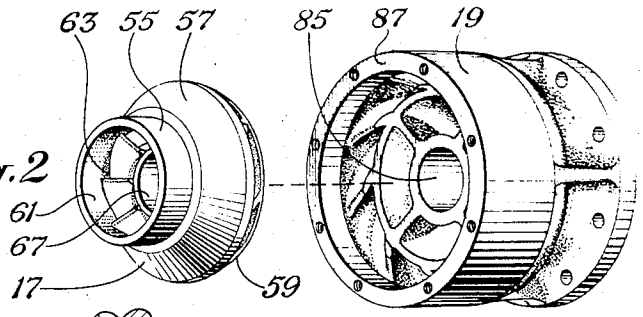


Fig. 2

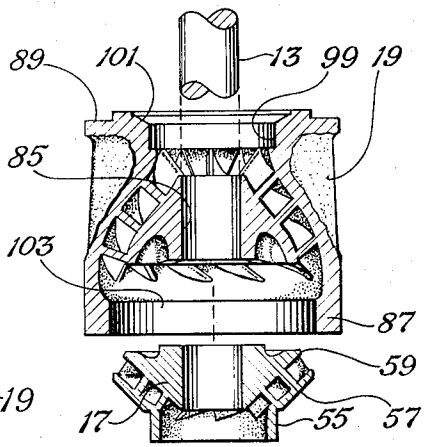


Fig. 2A

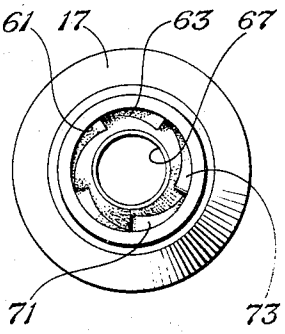


Fig. 3

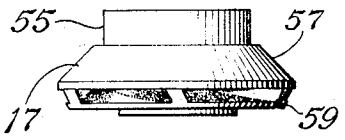


Fig. 3A

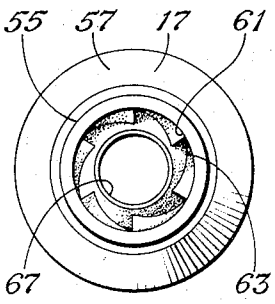


Fig. 4

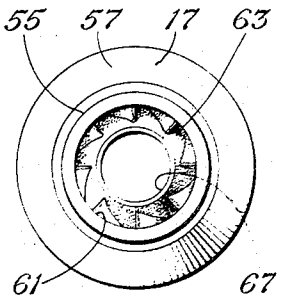


Fig. 5

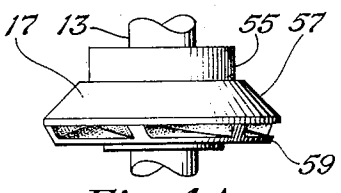


Fig. 4A

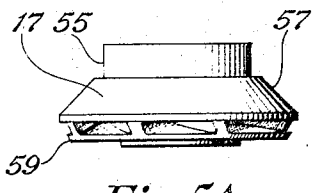
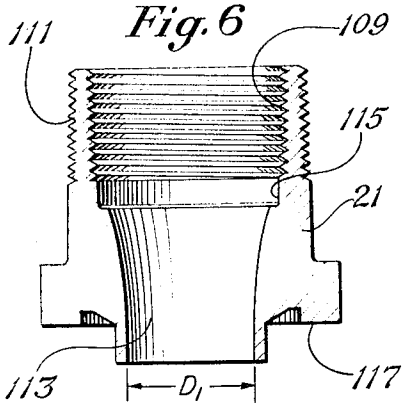


Fig. 5A

Fig. 6



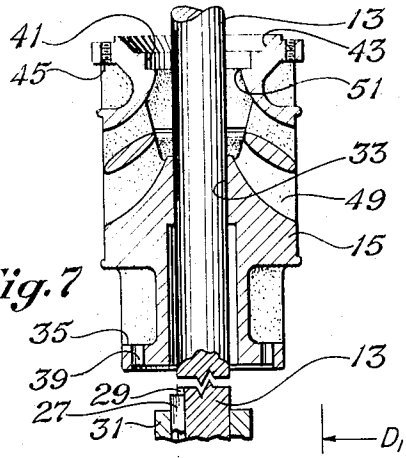


Fig. 7

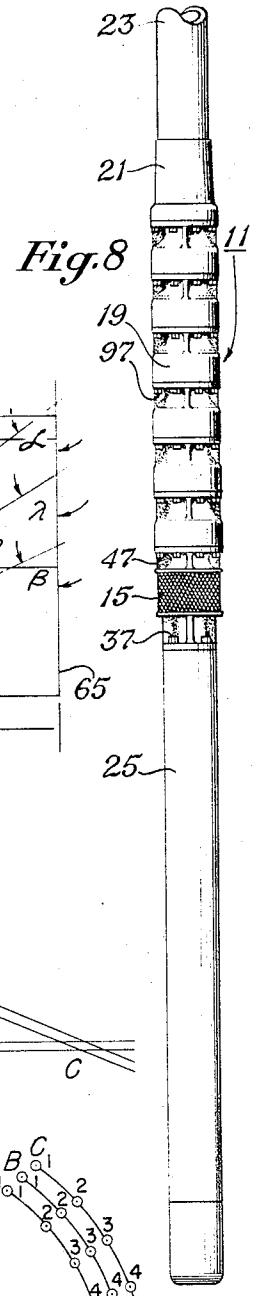


Fig. 8

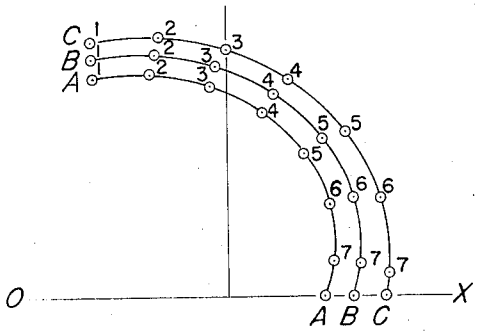


Fig. 9A

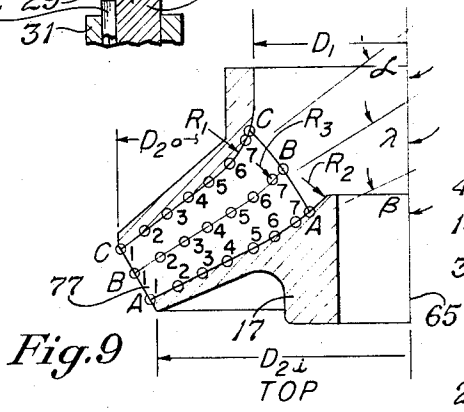


Fig. 9

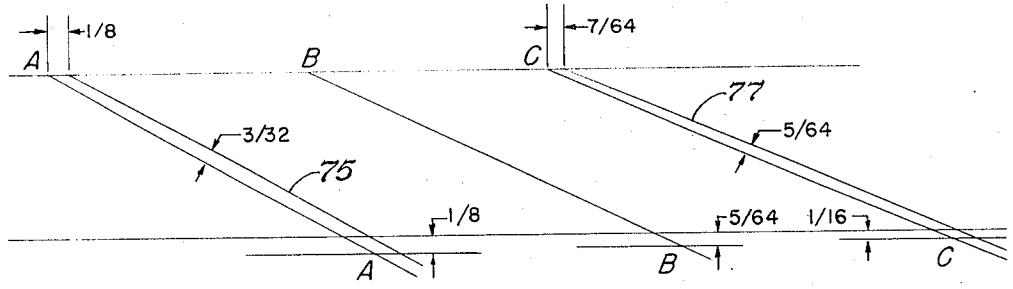


Fig. 9B

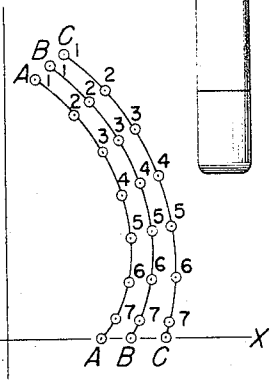
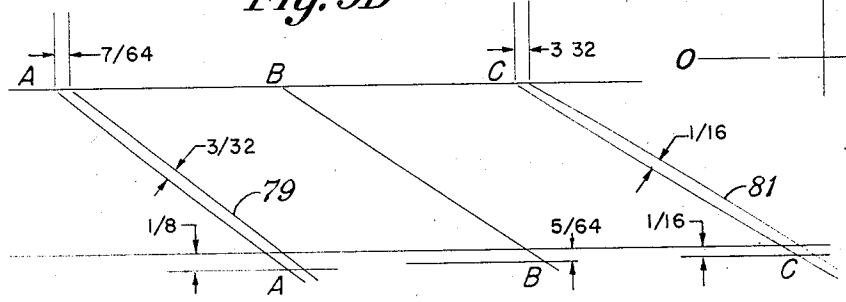


Fig. 9C

Fig. 9D



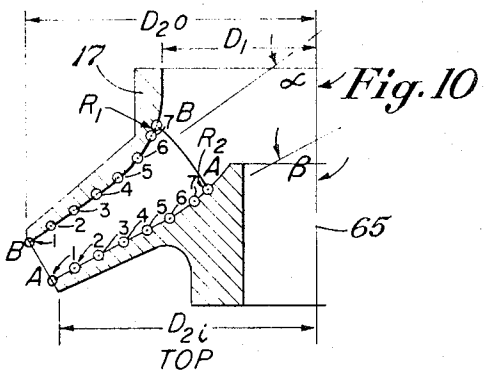


Fig. 10

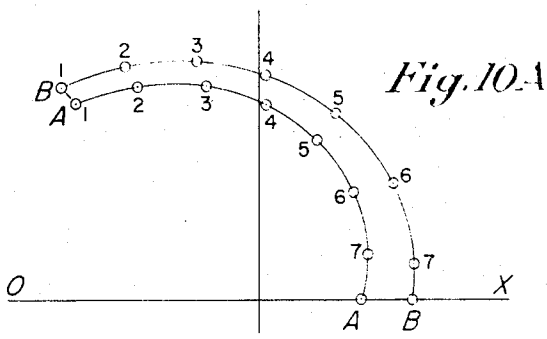


Fig. 10-1

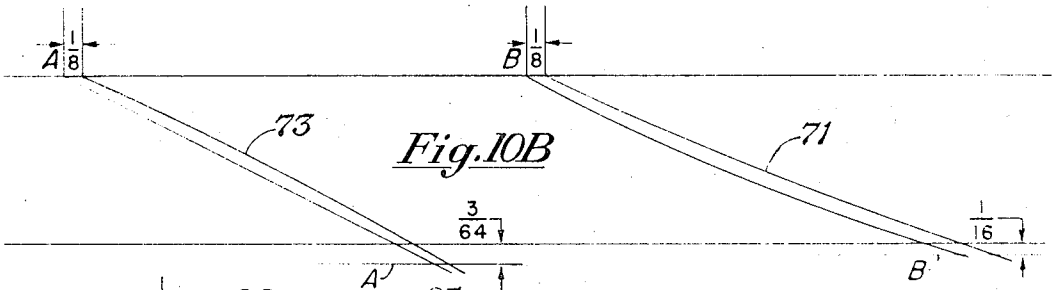


Fig. 10B

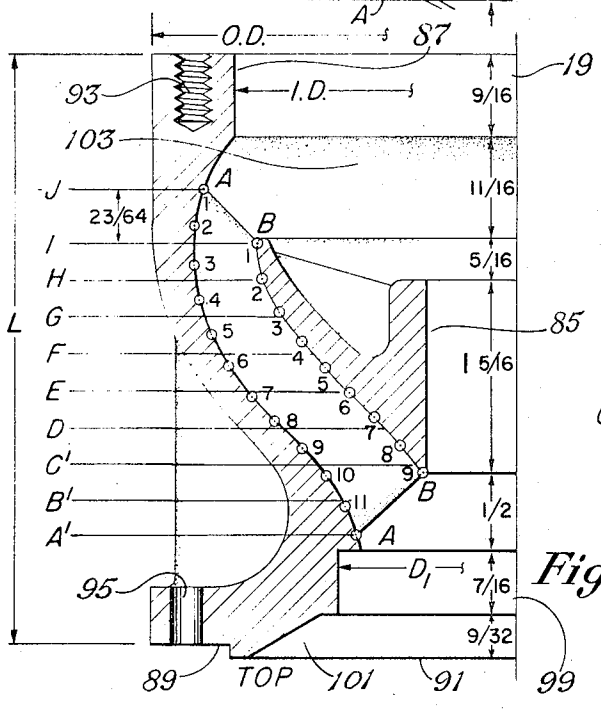


Fig. 11

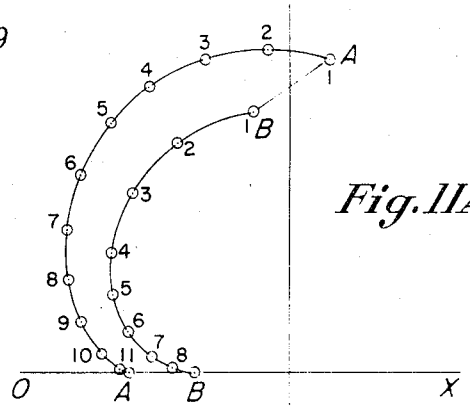


Fig. 11A

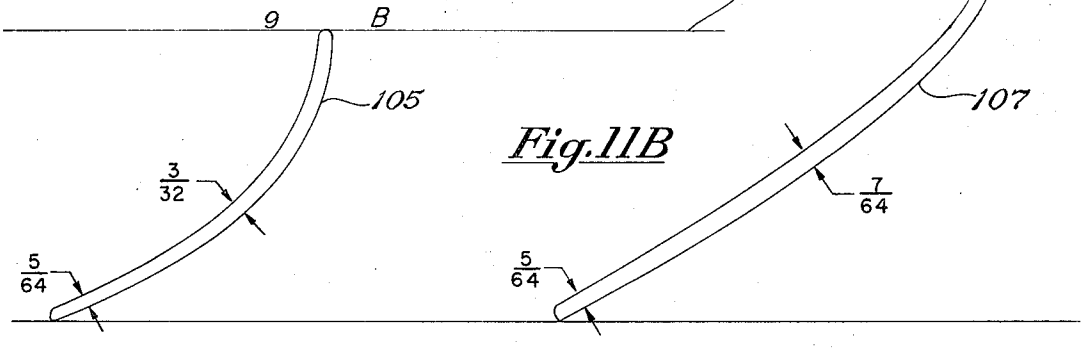


Fig. 11B

SMALL DIAMETER IRRIGATION PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to pumps. More particularly, it relates to vertically stacked centrifugal pumps such as are employed in irrigation pumps for pumping water from a subterranean formation to the surface of the earth for irrigation purposes.

2. Description of the Prior Art

A wide variety of centrifugal pumps are known and are cited in numerous texts, articles and nomographs to help the engineer make his selection intelligently. An excellent treatise on the design of centrifugal pumps is contained in CENTRIFUGAL AND AXIAL FLOW PUMPS; THEORY, DESIGN AND APPLICATION, A. J. Stepanoff, second edition, John Wylie and Sons, Inc., New York, N. Y., 1957. In Dr. Stepanoff's book there is described the fact that reduction of impeller outside diameter while achieving the same flow capacity is extremely difficult, particularly in the irrigation art where a high degree of development and relatively high pump efficiencies have already been obtained. One of the problems that has continued to plague farmers and the like employing irrigation was the large difference in capacity between a 6 inch pump such as were employed in wells drilled with 12 inch bits and the capacity of 4 inch pumps employed in wells drilled with 8 inch bits. The difference in cost of drilling a well several hundred feet deep with an 8 inch bit; ordinarily, less than half the cost of drilling the well with a 12 inch bit; was very significant to the profit picture of the farmer contemplating irrigation. Yet, in many instances, it was vital that a certain flow capacity be available for certain hot, dry seasons of the year; the flow capacity being greater than that obtainable with a 4 inch pump and heretofore obtainable only with a 6 inch pump.

Thus, insofar as I am aware, no one in the prior art has developed a pump small enough to be employed in a well drilled with an 8 inch bit that would have the same flow capacity as the 6 inch pumps ordinarily employed in wells drilled with a 12 inch bit. When I approached the pump manufacturers with regard to fulfilling this need, the experienced pump engineers informed me that it was theoretically impossible and that you could not compensate for the loss in outside diameter of the pump impeller by interior design of the spirally exteriorly ascending passageway, since the capacity decreased as a cube root of the diameter, whereas the mechanical losses, such as bearings, stuffing boxes and the like, remained the same. I was told that any pump attempting to do so would be so inefficient that the costs and power requirements of operation would be infeasible.

Accordingly, it is an object of this invention to obviate the disadvantages of the prior art irrigation pumps and to provide an irrigation pump that can be employed in a well drilled with an 8 inch bit, yet have flow capacities as great as pumps having at least 20 percent larger outside diameter and heretofore employed in wells drilled with 12 inch bits.

It is also an object of this invention to provide a pump having bowls that have a high degree of flexibility, in addition to the unusually large flow capacities, such that the bowl can receive any one of three different impellers to effect the desired flow capacity without adversely and intolerably affecting the efficiency of the pump.

The above and other objects will become apparent from the following descriptive matter, particularly when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view from the side, of a pump in accordance with one embodiment of this invention.

FIG. 2 is an isometric view of an impeller and bowl of the embodiment of FIG. 1.

FIG. 2A is a cross sectional view of the bowl and impeller of FIG. 2.

FIGS. 3 and 3A are, respectively, bottom plan and side elevational views of a five vane impeller in accordance with one embodiment of this invention.

FIGS. 4 and 4A are, respectively, bottom plan and side elevational views of a six vane impeller in accordance with another embodiment of this invention.

FIGS. 5 and 5A are, respectively, bottom plan and side elevational views of an eight vane impeller in accordance with still another and preferred embodiment of this invention.

FIG. 6 is a cross sectional view of the top manifold of the embodiment of FIG. 1, also showing external thread.

FIG. 7 is a cross sectional view of the inlet adapter of the embodiment of FIG. 1.

FIG. 8 is an isometric view from the side of a pump similar to the embodiment of FIG. 1, but having a plurality of bowls and impellers serially stacked to provide greater discharge volume and head, or pressure.

FIG. 9 is a partial cross sectional view showing the profile development of the six and eight vane impellers of FIGS. 4 and 5.

FIG. 9A is a plan view of the plan development of the six vane impeller of FIG. 4.

FIG. 9B is a graphical representation of the plane development of the six vane impeller of FIG. 4.

FIG. 9C is a plan view of the plan development of the eight vane impeller of FIG. 5.

FIG. 9D is a graphical representation of the plane development of the eight vane impeller of FIG. 5A.

FIG. 10 is a partial cross sectional view showing the profile development of the five vane impeller of FIGS. 3 and 3A.

FIG. 10A is a plan view of the plan development of the five vane impeller of FIG. 3.

FIG. 10B is a graphical representation of the plane development of the five vane impeller of FIG. 3A.

FIG. 11 is a partial cross sectional view showing the profile development of the bowl of FIGS. 2 and 2A.

FIG. 11A is a plan view of the plan development of the bowl of FIG. 11.

FIG. 11B is a graphical representation of the plane development of the bowl of FIG. 11.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 8, the irrigation pump 11 is connected with a submersible electric motor 25 with a first string of conduit 23 for moving water from a subterranean formation in a well to the surface of the earth for irrigation purposes. As can be seen in the various FIGS. 1–8, the irrigation pump 11 comprises the major elements of power shaft 13, inlet adapter 15, impeller 17, bowl 19 and top manifold 21.

The power shaft **13** extends centrally of the pump **11** and serves as means for imparting torque to the impellers. The power shaft **13** may be connected with the motor **25** by any suitable conventional means. As illustrated in FIG. **7**, the power shaft **13** has a means, such as key **27** and keyway slot **29** for connecting with a coupling **31** that is also connected with the shaft of motor **25.** The power shaft **13** is thus directly connected with the submersible electric motor **25.** The motor **25** may be any one of the conventionally available motors such as the Franklin or the Century motors. These conventional motors turn at 3,450 revolutions per minute (rpm). Accordingly, the power shaft **13** is rotated at 3,450 rpm. Any suitable motor and gear reducer can be employed if the pump **11** can be rotated at its design speed and capacity thereby. Since the power shaft **13** is the primary shaft of interest, it may be referred to hereinafter as simply shaft **13.** Ordinarily, the shaft **13** is made of corrosion-resistant material for use in a wide variety of waters of different corrosion and erosion potential. The shaft **13** is preferably formed of a material that is compatible with the composition of the impellers and the housing so as to have minimal galvanic cell action therebetween and still have minimal corrosion and erosion of the shaft. Suitable materials of construction comprise the copper alloys, such as brass for the shaft. As illustrated, the shaft **13** comprises a one inch brass shaft. Other materials, such as stainless steel, can be employed if desired; but such suitable materials are frequently more expensive initially.

The inlet adapter **15,** FIGS. **1** and **7,** has a central shaft aperture **33** in which is journalled power shaft **13.** The inlet adapter **15** has a base means, such as base **35,** that is adapted for sealingly connecting with the housing of the driving motor **25,** as by way of bolts **37,** FIGS. **1** and **8.** The interconnecting bolts **37** are passed through apertures **39,** FIG. **7,** and into suitable threaded sockets in the housing of the motor **25.** The threaded sockets are conventional and need not be described in detail herein. The inlet adapter **15** has a top that comprises a cylindrical section **41** and a frustoconical section **43** that are adapted to receive the bottom of an impeller that is one of three optional impellers, as described later hereinafter. The inlet adapter **15** also has a top end that is adapted for sealing connection with the bottom of a bowl. Specifically, the inlet adapter has a top end with apertures **45** through which bolts **47,** FIGS. **1** and **8,** may be inserted into threaded apertures in the bowl **19.** Thus, the top end of the inlet adapter **15** is connected with the bottom end of the lowermost bowl **19.**

The inlet adapter **15** has a plurality of smoothly interiorly ascending inlet passageways **49.** The passageways **49** define a smooth continuum of respective flow areas. The respective flow areas affect a total flow area greater than the first flow area of the central aperture **51.** The central aperture **51** has a diameter equal to the diameter D_1 of the impellers described hereinafter and greater than 0.4 times the outside diameter of the pump. For example, in the commercial embodiments of this pump, I have employed a diameter of 2-⅛ inches when the outside diameter (O.D.) of the pump was only 5 inches, giving a ratio D_1:O.D. of 0.42. This diameter passageway is also unusually large with respect to the 4 inch impellers which are employed; since it affords a ratio of $D_1:D_{20}$ of its diameter D_1 to the largest diameter D_{20} of the impeller of 0.53 or a ratio $D_1:D_{2i}$ of 0.576 with respect to the 3-11/16 inch inner diameter D_{2i} of the largest impeller employed, as discussed hereinafter.

The impeller **17** may comprise one of three specially designed impellers for a wide degree of flexibility without impairing the efficiency of the pump so severely as to be infeasible in practical operation. The three impellers may be employed in one or more respective bowls **19** alone, vertically stacked with other impellers of the same kind, or vertically stacked in a mixture of any of the three impellers in the pumps to obtain the desired pump output against a given discharge head with a predetermined horsepower motor and to do the desired job of pumping irrigation water from a predetermined well. This unusual flexibility is made possible by essentially the same exterior dimensions and design of the impellers, while employing either a five vane impeller, less vanes than heretofore predicted useful in this art; a six vane impeller, the minumum predicted useful; or an eight vane impeller. As illustrated in FIGS. **2–5A,** all of the impellers have common characteristics of having a plurality of vanes within the range of 5–8, inclusive; and having a bottom cylindrical section **55** and a frustoconical section **57** thereabove, illustrated below in FIGS. **3A, 4A** and **5A.** The impellers **17** have a frustoconical discharge section **59** to facilitate smooth delivery of the water into the bowl **19,** which will be described later hereinafter. Each of the impellers has a plurality of spirally ascending passageways connected at the center with an inlet aperture **61.** The inlet aperture **61** has the same diameter D_1 as the inlet aperture **51** of the inlet adapter **15.** Specifically, it has a diameter D_1 greater than one-half the outside diameter of the impeller and greater than 0.55 times the inner discharge diameter D_{2i} of the impeller. As indicated hereinbefore, this relatively large flow area and large inlet diameter with respect to the reduced discharge diameters of the impeller is surprising in view of prior art irrigation pumps. The relative ratios of inlet diameters have been described hereinbefore and I have found it advantageous to employ the same 2-⅛ inch diameter D_1 inlet aperture for the impellers that was employed for the inlet adapter. The inlet aperture of 2-⅛ inches in a 4 inch diameter impeller affords a flow area of 0.244 square inches about the illustrated power shaft **13.** Each of the spirally ascending passageways **63** flows from the central aperture exteriorly such that the passageways are exteriorly ascending through each impeller **17,** forming a smooth cross sectional profile. As can be seen in FIGS. **9** and **10,** the passageways define a discharge port having a top discharge angle β within the range of 62°–65° and a bottom discharge angle α of about 54°, the angles being measured with respect to the central longitudinal axis **65** of the impeller.

Each impeller **17** is connected to the power shaft **13** by way of shaft aperture **67** disposed about and in unifying relationship with the power shaft **13.** Any of the means conventionally employed in this art may be employed for affixing the impellers to the power shaft **13.** For example, suitable key and keyways may be provided for connecting the impeller **17** with the power shaft **13.** On the other hand, locking set screws may be employed, with or without the keys and keyways to firmly affix the impellers to the power shaft and prevent inadvertent slipping or release therefrom. The impeller **17** is illustrated correctly in FIG. **2A,** but is shown inverted with respect to its normally installed direction in

FIGS. 3A, 4A, 5A, 9 and 10. It will be apparent, of course, that the pump itself may be inverted or installed at the desired angle in certain installations; although in a conventional irrigation well, it is installed as illustrated in FIGS. 1 and 8, with the impeller installed as illustrated in FIG. 2A with respect to the bowl 19.

It is believed instructive to consider at this point the construction of the individual impellers illustrated, respectively, in FIGS. 3–5A. For example, the five vane impeller illustrated in FIGS. 3 and 3A is constructed as illustrated in FIGS. 10, 10A and 10B. Therein, the impeller 17 has an outside diameter D_{2o} of 4 inches; a diameter D_{2i} to the inside of the discharge passageway of 3-11/16 inches; and an inner diameter D_1 of the inlet passageway 2-⅛ inches. The discharge passageway has a bottom discharge angle α of 54° and a top discharge angle β of 62°. The cross sectional curve of the profile view of the bottom, or exterior, passageway has a planar radius R_1 of three-fourths inch with its radial center displaced five thirty-seconds inch upwardly on the impeller 17, or downwardly as illustrated in FIG. 10. The top, or interior, wall has a radius of curvature R_2 of 1-11/32 inch with its radial center eleven sixty-fourths of an inch downwardly from the bottom of the impeller, upwardly in FIG. 10. The respective points A and B at the inlet and exit of the respective passageways defined in part by the respective vanes, and the specifically numbered points in the profile view of FIG. 10 are shown in plan view of FIG. 10A illustrating the plan development for the five vane impeller. Table I illustrates the chord distance in inches from the respective points from the base line O–X of FIG. 10A.

TABLE I

Chord Distance from Line O-X

	A—A	B—B
1	3 3/8	3 21/32
2	2 52/64	3 3/16
3	2 3/8	2 21/32
4	1 29/32	2 7/64
5	1 5/16	1 1/2
6	25/32	27/32
7	5/16	15/64
A	0	—
B	—	0

The plane development of the impeller passageway, showing vanes 71 and 73, is illustrated in FIG. 10B. The perpendicular thickness of the respective vanes is three thirty-seconds of an inch in the illustrated embodiment. As initially drawn, the figures were at full scale and through the use of Table I can be corrected back to full scale for any dimension needed. The impellers 17 of FIGS. 3 and 3A were fabricated by the foundry from the drawings of FIGS. 10, 10A and 10B. The dimensions that are shown on all the drawings and in all the Tables are in inches unless otherwise specified.

A six vane impeller was fabricated in accordance with FIGS. 9, 9A and 9B. Therein, the impeller 17 has an outside diameter D_{2o} of 4 inches; a diameter D_{2i} to the inside of the discharge passageway of 3-9/16 inches; and an inner diameter D_1 of the inlet passageway of 2-⅛ inches. The discharge passageway 77 has a bottom discharge angle α of 54° and a top discharge angle β of 65°. In the six vane impeller, a meridional row of points illustrated by the line B—B was employed. The meridional angle λ formed with respect to the central longitudinal axis 65 of the impeller 17 was 59°. The cross sectional curve of the profile view of the bottom, or exterior, passageway has a planar radius R_1 of three-fourths inch with its radial center displaced five thirty-seconds inch upwardly on the impeller 17, or downwardly as illustrated in FIG. 9. The top, or interior, wall has a radius of curvature R_2 of 1-½ inch with its radial center eleven sixty-fourths of an inch downwardly from the bottom of the impeller, upwardly in FIG. 9. Moreover, the meridional line has a radius of curvature R_3 of 1-⅛ inch with its radial center displaced three sixty-fourths inch downwardly from the bottom of the impeller, upwardly in FIG. 9. The respective points A, B and C at the inlet and exit of the respective passageways defined in part by the respective vanes and the specifically numbered points in the profile view of FIG. 9 are shown in the plan view of FIG. 9A, illustrating their plan development. Table II illustrates the chord distance in inches from the respective points on the base line O–X of FIG. 9A.

TABLE II

Chord Length from O-X

	A—A	B—B	C—C
1	3 1/8	3 9/32	3 27/64
2	2 5/8	2 51/64	2 29/32
3	2 1/8	2 9/32	2 25/64
4	1 39/64	1 3/4	1 53/64
5	1 1/8	1 7/32	1 1/4
6	21/32	11/16	43/64
7	7/32	13/64	5/32
A	0	—	—
B	—	0	—
C	—	—	0

The plane development of the impeller passageway, showing vanes 75 and 77 is illustrated in FIG. 9B. The perpendicular thickness of the respective vanes is indicated. As initially drawn, the figures were at full scale and through the use of Table II can be corrected back to full scale for any dimension needed. The impellers 17 of FIGS. 4 and 4A were fabricated by the foundry from the drawings of FIGS. 9, 9A and 9B.

An eight vane impeller was fabricated in accordance with FIGS. 9, 9C and 9D. Therein, the impeller 17 had the outside diameter D_{2o}, diameter D_{2i}, inner diameter D_1, bottom discharge angle α, top discharge angle β, meridional angle λ and the respective cross sectional curvatures the same as described with respect to FIG. 9 for the six vane impeller. The respective points A, B and C at the inlet and exit of the respective passageways defined in part by the respective vanes, and the specifically numbered points in the profile view of FIG. 9 are shown in plan view of FIG. 9C illustrating the plan development for the eight vane impeller. Table III illustrates the chord distance in inches from the respective points from the base line O–X of FIG. 9C.

TABLE III

Chord Length from O-X

	A—A	B—B	C—C
1	2 23/64	2 7/16	2 1/2
2	1 29/32	1 63/64	2 1/32
3	1 31/64	1 9/16	1 5/8
4	1 5/64	1 5/32	1 3/16
5	45/64	49/64	25/32
6	3/8	18/32	18/32
7	7/64	7/64	3/32
A	0	—	—
B	—	0	—
C	—	—	0

The plane development of the impeller passageway, showing vanes 79 and 81, is illustrated in FIG. 9D. The perpendicular thickness of the respective vanes is illus-

trated. As initially drawn, the figures were at full scale and through the use of Table III can be corrected back to full scale for any dimension needed. The impellers **17** of FIGS. **5** and **5A** were fabricated by the foundry from the drawings of FIGS. **9, 9C** and **9D**.

The bowls **19**, FIGS. **2, 2A** and **11** have a central shaft aperture **85** in which is journalled the power shaft **13**. The bowl **19** has its respective ends conformingly matching such that it can be serially connected with a plurality of adjacent similar bowls in a vertical stack of the desired length to form a pump of the desired work potential. Specifically, the bowl **19** has a cylindrical bottom section **87** that sealingly fits into recess **89** in the top **91** in order that a plurality of bowls may be stacked in vertical configuration in sealing relationship. The cylindrical section **89** has a plurality of tapped apertures **93** aligned with apertures **95** in a flange at the top. In this way, a plurality of bolts **97**, FIGS. **1** and **8**, can be inserted through the apertures **95** and screwed into the tapped apertures **93** to hold the serially stacked bowls in sealing relationship. The bowl **19** has a flow area at any cross sectional plane and a flow capacity at predetermined pressure drops as great as pumps of the prior art that had an outside diameter at least **20** percent larger. For example, the five inch pump bowls have a flow area and a pressure drop at a given flow rate comparable to the 6 inch irrigation pumps of the prior art. Moreover, the minimum flow area through the bowl **19** is at least as great as the minimum flow area through the impeller so that the bowl **19** does not restrict flow. Bowl **19** has a plurality of spirally ascending passageways that provide a smooth continuum for the effluent water from the impeller. The spirally ascending passageways traverse outwardly a short distance and then smoothly traverse interiorly to terminate centrally of the bowl and annularly about the shaft adjacent the top at a point of entrance into any impeller emplaced in the top so as to achieve a smooth flow pattern effecting low pressure drops with respect to water discharge from the lower impeller **17** therein.

The top **91** of the bowl **19** has two sections that are adapted to receive the bottom of an impeller. Specifically, the top **91** has a cylindrical section **99** and a frusto-conical section **101** for receiving the bottom of an impeller **17**. The bowl **19** also has a bottom **103** having frusto-conical unobstructed space that is adapted to receive the top of an impeller and allow its rotation, as illustrated in FIGS. **2** and **2A**.

To afford the flexibility desired, the bowl **19** has seven passageways and has profile, plan and planar development of the passageways as illustrated in FIGS. **11, 11A** and **11B**. As illustrated in FIG. **11**, the bowl **19** has an outside diameter O.D. of 5 inches and an internal diameter I.D. at its bottom of 4 inches. The bowl **19** has a minimum diameter D_1 of 2-⅛ inches, similarly as do the impellers that are emplaced therein. As can be seen in FIG. **11**, the cross sectional view of each respective passageway affords a smooth curve. Table IV shows the respective planar radii in inches at the respective bowl contour planes A′, B′, C′ and D–J. The respective planes represented by the letters on the side of the bowl are spaced one-fourth inch apart unless otherwise noted.

TABLE IV

Radii of Bowl Contour

Designation	Inside	Outside	Thickness
A′	—	1 3/32	—
B′	—	1 13/64	—
C′	23/32	1 25/64	11/32
D	59/64	1 5/8	5/16
E	1 3/16	1 7/8	5/16
F	1 13/32	2/3/64	9/32
G	1 5/8	2 5/32	9/32
H	1 3/4	2 7/32	9/32
I	1 25/32	2 1/4	9/32
J	—	2 3/16	—

The respective points A and B at the inlet and exit of the respective passageways defined in part by the respective vanes, and the specifically numbered points in the profile view of FIG. **11** are shown in plan view in FIG. **10A** illustrating the plan development for the bowl. Table V illustrates the chord distance in inches from the respective points from the base line O–X to the respective numbered points in FIG. **11A**.

TABLE V

Chord Distance from Line O-X

Number	B—B	A—A
1	2 11/32	3 9/32
2	1 7/8	3 1/32
3	1 23/64	2 23/64
4	⅞	2 21/64
5	19/64	1 57/64
6	9/32	1 29/64
7	7/64	1 1/32
8	1/64	21/32
9	0	23/64
10	—	9/64
11	—	1/64
A	—	0
B	0	—

The plane development of the bowl passageways, showing vanes **105** and **107**, is illustrated in FIG. **11B**. The perpendicular thickness of the respective vanes are indicated at the respective points. As initially drawn, the figures were at full scale and through the use of Tables IV and V can be corrected back to full scale for any dimension needed. The bowls **19** of FIGS. **2** and **2A** were fabricated by the foundry from the drawings of FIGS. **11, 11A** and **11B**.

The top manifold **21** is sealingly connected with the top of its adjacent bowl **19**, FIGS. **1** and **8**, by way of bolts **97** engaging tapped apertures in the top manifold **21** and inserted through suitable apertures **95** in the top flange of the bowl **19**. The top manifold **21**, FIG. **6**, has optional internal thread **109** and an external thread **111**. The internal thread **109** is provided for connecting with a string of conduit for conducting a volumetric rate of flow less than a predetermined maximum of water from a subterranean formation at which the pump is emplaced to the surface of the earth for irrigation. The external thread **111** is provided for optional connection with a second, larger diameter string of conduit for conducting a volumetric rate of flow greater than the predetermined maximum of water to the surface for irrigation. The top manifold **21** has an internal diameter D_1 defining a flow passageway greater than 0.4 times the outside diameter of the pump and of the same 2-⅛ inch dimension as the interior dimension of the impeller **17** and the bowl **19**. Thus, the top manifold **21** does not unnecessarily restrict the flow of water. Moreover, it has an interiorly disposed passageway **113** that expands smoothly to minimize losses due to sudden expansion and contraction. The passageway **113** terminates in an annular recess **115** for receiving the end of a string of conduit to minimize interference with the flow of water. The top manifold **21** has

a short cylindrical section 117 that conformingly and sealingly seats within the recess 89 at the top of a bowl 19.

In operation, the respective impellers 17 and bowls 19 are assembled about the central power shaft 13 into the desired number of stages, each stage comprising one impeller and one bowl. The number of stages and the type of impeller employed in the respective bowls are selected to provide the desired flow capacity and head, or discharge pressure, with respect to the power available. For highest capacity at a given head with greatest efficiency, the eight vane impeller is employed in the respective impeller 17 and respective bowls 19. On the other hand, one or more of the five or six vane impellers may be employed to lessen horsepower demand where a given horsepower submersible motor is available or where the source of power, such as the electric line, is capable of delivering only a limited amount of power. Ordinarily, these variables can be adjusted in new installations for the greatest efficiency. The motor is assembled onto the completed pump having its inlet adapter 15 and its discharge manifold 21 emplaced. The motor-pump combination is connected with its conduit 23 and lowered into the well, playing out the conductor 121 which conducts power to the submersible electric motor 25 and adding to the string of conduit 23 as necessary. Once emplaced in the well, the wellhead connections are made secure; the source of power connected with the motor via suitable switches and safety controls; and the pump is ready for pumping water to the surface for irrigation. The installation and workovers of the pump are accomplished in the conventional manner. It is noteworthy, however, that this pump can be installed in wells drilled with an 8 inch bit which are usually less than one-half as expensive as drilling with a 12 inch bit that was formerly required for 6 inch irrigation pumps that were necessary to obtain the desired capacity.

EXAMPLE I

In the following example, five vane impellers were employed in vertically staged bowls in a pump connected with a suitable motor and pumping data, or pump capacity data, obtained, as illustrated in Table VI. Table VI shows the pumping capacity of the five vane impellers in gallons per minute (gpm) when pumping at 3,450 rpm against the indicated head (hd.) in feet (ft.) of water. The amperage in amps is indicated, as well as the power factor. The data for Table VI was obtained using a Franklin 5 horsepower (hp.) motor rated for 8.6 amps at 460 volts employing the 5 inch Crown bowl described hereinbefore. The impeller was a model LC impeller having a rated diameter of 3.95 inches. The pump had seven stages. The water had a temperature of 70° Fahrenheit (°F) with a "water to base" head of 3 feet. The lateral available for this test was one-sixteenth inch and the head gauge was located five feet above the surface of the water.

TABLE VI

Volts	Kilowatts	Power factor	Amps A	Amps B	Amps C	Hd. ft. corrected	G.p.m.
465	.238	79	8.8	8.7	8.9	0	82
465	.232	76	8.2	8.3	8.3	20	80
465	.22	77	8.2	8.3	8.2	40	90
465	.22	77	8.2	8.4	8.3	60	90
465	.22	78	8.3	8.5	8.4	80	88

Table VI—Continued

Volts	Kilowatts	Power factor	Amps A	Amps B	Amps C	Hd. ft. corrected	G.p.m.
465	.23	78	8.5	8.7	8.4	100	88
465	.235	78	8.6	8.8	8.6	120	86
465	.24	79	8.7	8.9	8.7	140	82
465	.243	80	8.8	9	8.8	160	80
465	.245	80	8.9	9.1	8.9	180	75
462	.25	80	8.9	9.1	9	200	70
462	.25	80	8.9	9.1	9	220	65
462	.245	80	8.7	9	8.9	240	60
462	.24	80	8.5	8.7	8.7	260	55
462	.235	80	8.2	8.5	8.5	280	48
462	.215	78	7.7	8	8	290	42
465	.190	76	7.3	7.7	7.7	350	0

EXAMPLE II

In Example II, eight vane impellers were employed in the bowls and a pump capacity data was obtained, as illustrated in Table VII. Table VII shows the pumping capacity of the eight vane impellers in gallons per minute when pumping at 3,450 rpm against the indicated head in feet of water. The amperage is indicated, as well as the power factor. The data for Table VII was obtained using a Franklin 7-½ horsepower motor rated at 11.9 amps at 460 volts employing the 5 inch Crown bowl described hereinbefore. The impeller was the model HC impeller having a rated diameter of 3.95 inch. The pump had six stages. The water had a temperature of 75°F, with the "water to base" head of 3 feet. The lateral available for this test was one-fourth inch and the head gauge was located 5 feet above the surface of the water. The same conventional abbreviations are employed in Table VII as were employed in Table VI and explained hereinbefore.

TABLE VII

Volts A	Volts B	Volts C	Kilowatts	Power factor	Amps A	Amps B	Amps C	Hd. ft. corrected	G.p.m.
475	475	482	.31	80	10.7	10.6	11.5	0	210
479	480	482	.30	81	10.6	10.6	11.3	20	205
476	479	481	.29	81	10.5	10.3	11	40	195
479	480	482	.28	80	10.1	10	10.8	60	188
479	479	483	.30	81	11	10.2	11	80	175
479	480	485	.31	80	12	10.5	11.4	100	169
485	489	490	.32	81	11.2	11	11.7	120	160
489	489	490	.33	80	11.5	11.2	11.9	140	149
488	490	495	.34	81	11.5	11.5	12.2	160	139
479	481	485	.34	82	11.3	11.5	12.4	180	130
479	481	481	.34	83	11.7	11.7	12.2	200	115
475	480	482	.33	83	11.4	11.2	11.9	220	98
475	480	481	.31	82	10.4	10.6	11.4	240	75
478	485	489	.25	79	9	9	10	260	49
480	489	490	.20	73	7.5	7.6	9	290	0

The materials of construction ordinarily employed in this art may be employed in making the pump of this invention and no exotic new materials are necessary. The pumps of this invention have attained commercial acceptance.

From the foregoing descriptive matter and from the drawings and Tables it can be seen that this invention accomplishes the objects delineated hereinbefore and provides a 5 inch diameter irrigation pump that can be emplaced in small diameter drilled wells, yet have the capacity formerly available only in pumps that were at least 20 percent larger and required a much larger bit that at least doubled the cost of drilling the irrigation well.

Although this invention has been described with a certain degree of particularity, it is understood that the present disclosure is made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of this invention.

What is claimed is:

1. An irrigation pump having exceptional flexibility and unusually large pumping capacity in terms of gallons pumped per unit of outside diameter, comprising:

a. a power shaft extending centrally of said pump and having means for connection with a driving motor;

b. an inlet adapter having a central shaft aperture in which said power shaft is sealingly journalled, and having a base means for sealingly connecting with a housing of said driving motor; said inlet adapter having an inlet passage defining a first flow area about said shaft and having a diameter greater than 0.4 times the outside diameter of said pump and greater than one-half the outside diameter of an impeller emplaced therewithin and a plurality of smoothly interiorly ascending passageways having a smooth continuum of respective flow areas that affect a total flow area greater than said first flow area; said inlet adapter having a top that includes a short cylindrical section and an adjoining frusto-conical section that is adapted to receive the bottom of an impeller and having a top end that is adapted to conformingly fit and be connected with a bowl;

c. at least one impeller connected with said power shaft by way of a central shaft aperture disposed about and in unifying relationship with said power shaft; having an inlet aperture defining a second flow area about said shaft that is as large as said first flow area; said inlet aperture having a diameter D_1 that is greater than 0.4 times the outside diameter of said pump, greater than one-half times the outside diameter D_{2o} of said impeller and greater than 0.55 times the inner discharge diameter D_{2i} of said impeller, each said spirally exteriorly ascending passageway having a smooth cross sectional profile and defining a discharge port having a top discharge angle β within the range of 62°–65° and a bottom discharge angle α of about 54°; said angle being measured with respect to the central longitudinal axis of said impeller; said impeller having a plurality within the range of 5–8, inclusive, vanes that define spirally exteriorly ascending water flow passageways;

d. at least one bowl having a central shaft aperture in which is sealingly journalled said power shaft; said bowl having its respective ends conformingly matching such that it can be serially connected with a plurality of adjacent said bowls to form a pump of a desired work potential; said bowl having a flow area at any cross sectional plane at least as great as said first flow area; said bowl having a plurality of spirally ascending passageways that provide a smooth continuum of the effluent of a vane imposed therein and initially traverse exteriorly a short distance and smoothly traverse interiorly for the remaining distance to terminate centrally of said bowl and annularly about said shaft adjacent the top at a point of entrance into any impeller emplaced in said top so as to achieve a smooth flow pattern effecting minimal low pressure drop with respect to water discharged from said impeller; said bowl having a top that has a cylindrical section connected with a frusto-conical section and is adapted to receive the bottom of an additional impeller; having a bottom that is adapted to receive the top of an impeller; and having one said impeller emplaced rotatably within its bottom; the bottom end of the lowermost bowl being connected with said inlet adapter; and

e. a top manifold sealingly connected with the top of the uppermost said bowl, said top manifold having an internal thread for connection with a string of conduit for conducting a volumetric rate of flow less than a predetermined maximum of water from a subterranean formation to the surface for irrigation and at least space and wall thickness for an external thread for connection with a second string of conduit having a second diameter larger than said first string for conducting a volumetric rate of flow greater than said predetermined maximum of water to the surface for irrigation; said top manifold having an internal flow passageway of a diameter greater than 0.4 times the outside diameter of said pump.

2. The pump of claim 1 wherein a plurality of said bowls and said impellers are serially stacked and said shaft is drivingly connected with a submersible electric motor and said top manifold is sealingly connected to a string of conduit for conducting said water from said subterranean formation to said surface.

3. The pump of claim 1 wherein said bowl has seven said spirally ascending passageways and said passageways have respective profile, plan and plane developments as defined by FIGS. 11, 11A and 11B.

4. The pump of claim 3 wherein said impeller has five vanes, has said top discharge angle β of about 62° and has respective profile, plan and plane development as defined by FIGS. 10, 10A and 10B.

5. The pump of claim 3 wherein said impeller has six vanes, has said top discharge angle β of about 65° and has respective profile, plan and plane development as defined by FIGS. 9, 9A and 9B.

6. The pump of claim 3 wherein said impeller has eight vanes, has said top discharge angle β of about 65° and has respective profile, plan and plane development as defined by FIGS. 9, 9C and 9D.

7. The pump of claim 6 wherein said top manifold has an external thread that is sealingly connected with the internal thread of a said second string of conduit.

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