

Dec. 25, 1962

K. R. LUNG
PUMPS

3,070,026

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2 Sheets-Sheet 1

FIG-1

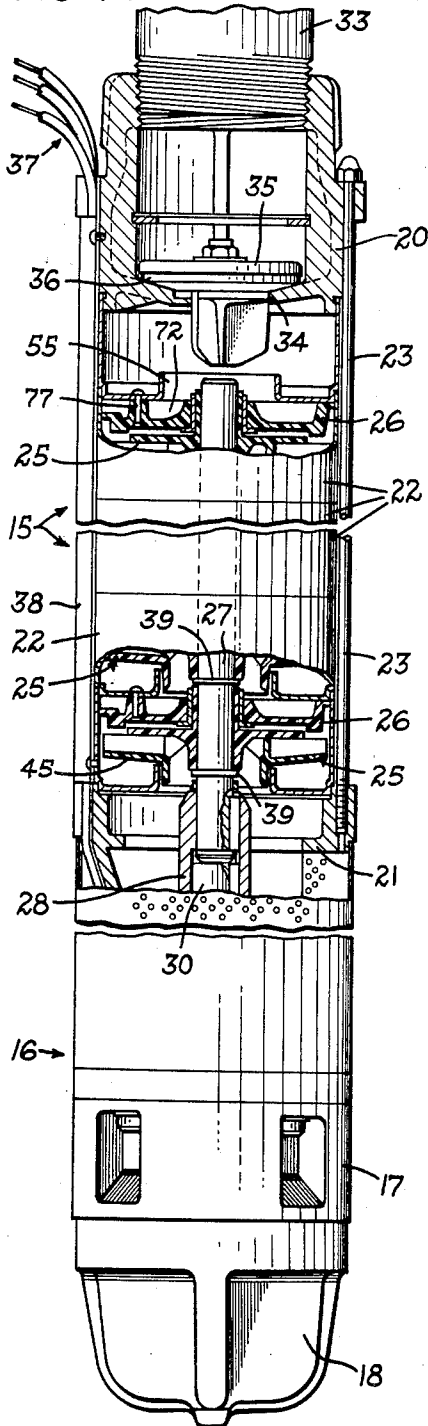


FIG-2

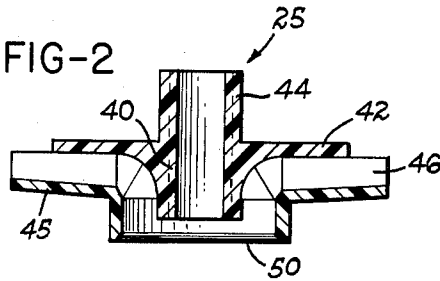


FIG-3

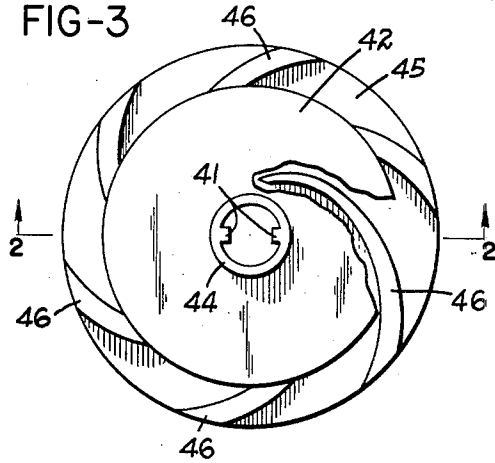
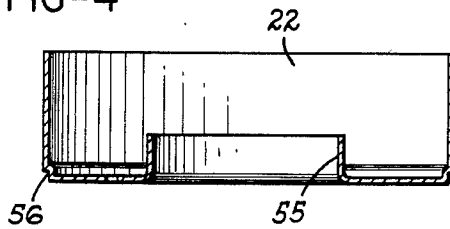


FIG-4



INVENTOR.

KENNETH R. LUNG

BY

Marchal, Bichel, French & Bugg

ATTORNEYS

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K. R. LUNG

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2 Sheets-Sheet 2

FIG-5

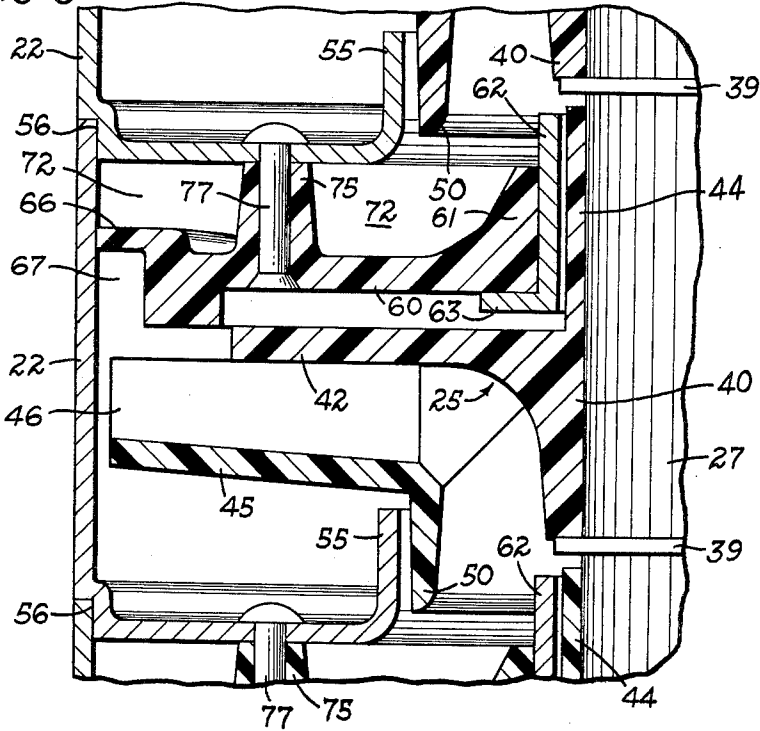


FIG-7

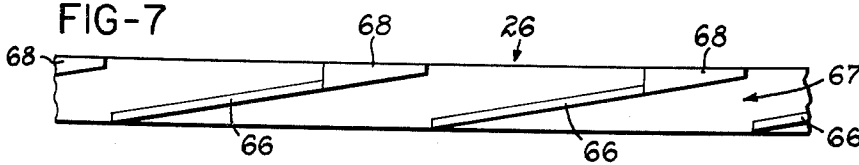


FIG-6

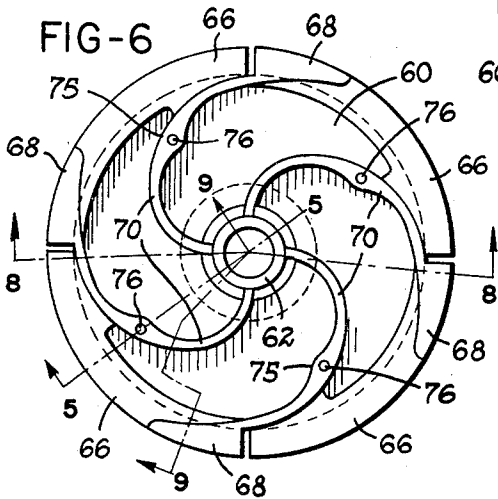


FIG-8

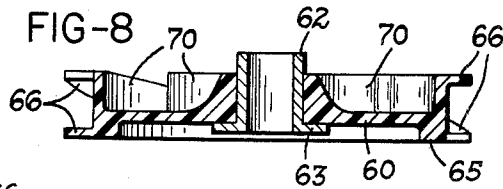
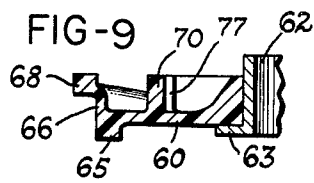


FIG-9



INVENTOR.

KENNETH R. LUNG

BY

Marshall, Riebel, French & Lugg

ATTORNEYS

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3,070,026
PUMPS

Kenneth R. Lung, Dayton, Ohio, assignor to The Tait Manufacturing Company, Dayton, Ohio, a corporation of Ohio

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2 Claims. (Cl. 103-102)

This invention relates to centrifugal pumps.

The invention has special relation to multistage centrifugal pumps of the type adapted to be entirely submerged in the water or other liquid to be pumped, and the invention is concerned among other factors with problems frequently encountered in such pump installations as a result of the presence of abrasive materials in the water, which for convenience are generally referred to as sand. Sandy water is capable of constituting a major problem in pump construction, particularly because sand in the water has a tendency to settle between complementary bearing surfaces when the pump is temporarily stopped, and such accumulated sand may and often does create sufficient friction to make it difficult or even impossible to restart the pump. Furthermore, even if the pump can restart, the presence of even relatively small quantities of sand in metal bearings is capable of doing sufficient damage by scoring as ultimately to interfere with proper operation of the pump.

It is a primary object of the present invention to provide a multistage centrifugal pump which is of novel construction facilitating both its initial assembly and also such maintenance as may be required after it is put in use, and particularly to provide such a pump which is not only capable of pumping water containing sand but also of efficient intermittent operation irrespective of the presence of even substantial quantities of sand in the water.

In general the most difficult operations from the standpoint of sand in the water are usually encountered when a new well is first put into use, since the concentration of sand is then highest but is likely to be reduced after the first few hours or days of use of the well. This means that the greatest potential damage to the pump by sandy water occurs when the pump is first installed in the water, and it is therefore an important object of the present invention to provide a multistage centrifugal pump which in addition to the properties outlined above has the further advantage that it has its maximum capacity for handling sandy water when it is first put into use.

An additional object of the invention is to provide a multistage centrifugal pump wherein the impeller is constructed of a material which has the property of swelling in the presence of water to a definitely limited but positive amount in such proportion to its initial dimensions prior to submersion that those portions of the impeller which operate as bearing surfaces with respect to surrounding portions of the diffuser or casing can be initially produced to provide adequate clearance therepast for particles of sand present in the water when the pump is first placed in use but which thereafter will swell to an extent establishing proper bearing relation with these surrounding parts.

Another object of the invention is to provide a multistage centrifugal pump wherein the casings for the several pumping units cooperate to form a composite outer casing for the pump which does not require a separate housing and which is therefore easily assembled and also readily taken apart as may be required for servicing after the pump has been used.

It is also an object of the invention to provide a multistage centrifugal pump having one or more of the novel features and advantages outlined above and in which also the diffuser for each pumping stage is initially separate from the other parts for economical production but

2

is permanently secured in use to the casing immediately upstream therefrom to facilitate final assembly of the component parts in the pump.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

FIG. 1 is a fragmentary view, partly in side elevation and partly in axial section, showing a multistage submersible pump and motor assembly constructed in accordance with the invention;

FIG. 2 is a detail section on the line 2—2 of FIG. 3 showing one of the impellers in the pump of FIG. 3;

FIG. 3 is a top view, partly broken away, of the impeller of FIG. 2;

FIG. 4 is a detail view in axial section of the casing for one of the pumping units in FIG. 1;

FIG. 5 is an enlarged view in axial section of a fragment of the pump of FIG. 1 taken on the line 5—5 of FIG. 6;

FIG. 6 is a detail elevational view of the back or upstream side of one of the diffusers of the pump of FIG. 1;

FIG. 7 is an enlarged developed view of a fragment of the outer periphery of the diffuser of FIG. 6;

FIG. 8 is a section on the line 8—8 of FIG. 6; and

FIG. 9 is a fragmentary section on the line 9—9 of FIG. 6.

Referring to the drawings, which illustrate a preferred embodiment of the invention, FIG. 1 shows somewhat fragmentarily a submersible motor and pump assembly comprising a pump section 15 and a motor section 16 which is completed at its lower end by an extension housing 17 and an end cap 18. The pump section 15 is composed of an upper end cap 20, an inlet cap 21, and a plurality of annular cup shaped casings 22 which are stacked axially between the two end caps and retained in clamped relation therewith by a plurality of tie rods or bolts 23 extending along the outside of these casings and forming direct connections between the end caps 20 and 21. Each of the casings 22 except the uppermost such casing encloses an impeller 25, and each of these impellers is in turn provided with a cooperating diffuser 26 which is enclosed within the same casing 22 but is secured to the front of the next higher casing 22. All of the impellers 25 are splined on a common drive shaft 27 which is shown as connected by a coupling 28 with the motor drive shaft 30.

The upper end cap 20 of the pump section 15 is threaded at its upper end for connection to the lower end of the usual down pipe 33 by which the entire apparatus is suspended in a well. The end cap 20 also incorporates an outlet port 34 to the pipe 33 which is controlled by a check valve 35 and sealing washer 36. The cable 37 for providing power to the motor is also shown in FIG. 1 and is retained in a suitable shield 38 secured along the outside of the pumping section 15.

All of the impellers 25 are of identical structure, and one is shown in detail in FIGS. 2 and 3 as molded of a plastic material. It includes a hub 40 having internal splines 41 for driving engagement in a corresponding keyway in the shaft 30, and the individual impellers are also limited against forward or downward movement along the shaft by snap rings 39 as shown. The back shroud 42 of the impeller extends radially from the hub 40, and a cylindrical sleeve portion 44 projects rearwardly from the hub beyond the back shroud 42. The front shroud 45 of the impeller is connected with the back shroud 42 by a plurality of impeller vanes 46, and the front shroud 45 also includes an annular boss 50 which forms the inlet to the interior of the impeller. The inner diameter of the back shroud 42 is substantially smaller than that of the front shroud 45, and the outer

diameter of the back shroud is therefore substantially reduced with respect to that of the front shroud in order to provide the outer surfaces of both shrouds with more nearly the same effective areas for balancing the thrust pressures thereon in use.

The casings 22 are all of identical construction, and one is shown in detail in FIG. 4. It includes a cylindrical inlet flange 55 proportioned to receive therethrough the inlet boss 50 of the associated impeller. The remainder of the casing is generally cup-shaped, and each casing is provided at the outer edge of its front or bottom face with a circumferential notch or shoulder 56 which forms a seat for the upper edge of the adjacent lower casing to facilitate stacking of the several casings in assembling the complete pump section as shown in FIG. 1. Since the uppermost of the casings 22 does not have an impeller therein, its inlet flange 55 forms the outlet from which the discharge of all of these pumping units passes upwards to the outlet port 34 in the upper end cap 20.

The diffusers 26 are all of identical construction, and one is shown in detail in FIGS. 6 and 7 as molded from a plastic material although it can equally well be cast from brass or other suitable metal. The main portion of the diffuser is an annular web 60 radiating from a central hub 61 which is lined with a metal sleeve 62 to form a bearing for the sleeve portion 44 of the associated impeller. The sleeve 62 also includes a flange 63 on its forward end which forms a thrust bearing with respect to the associated impeller.

The web 60 of the diffuser 26 is of greater diameter than the back shroud 42 of the associated impeller, and it includes a cylindrical rim 65 which overhangs the periphery of the shroud 42 and thus in effect forms a continuance of the shroud for cooperating with the front shroud 45 to guide the liquid flow outwardly from the impeller. This rim 65 is of sufficiently smaller outer diameter than the inner diameter of the casings 22 to provide an annular space therebetween, and the diffuser includes a plurality of generally helical fins 66 which project outwardly from the rim 65 into this annular space and cooperate with the outer periphery of the diffuser and the inner surface of the associated casing to form a plurality of helical passageways 67 leading rearwardly from the outer periphery of the impeller along the inner surface of the casing toward the back of the diffuser. The fins 66 terminate at the back of the diffuser in foot portions 68 which seat on the adjacent upper casing 22, and the diffuser 26 includes a plurality of generally spiral vanes 70 on the back surface of the web 60 which extends from the fins 66 to the hub 61 and cooperate with the web portion of the diffuser and the lower face of the adjacent upper casing 22 to define diffuser passageways 72 of increasing flow area leading inwardly from the passages 67 to the inlet flange 55 of the adjacent casing.

As already noted, each of the diffusers 26 is secured to the adjacent upper casing 22, and the means for securing these parts together are best illustrated in FIGS. 5 and 6. Each of the vanes 70 includes a thickened portion 75 intermediate its radially inner and outer ends, and these thickened portions are bored at 76 to receive rivets 77 which secure the diffuser directly to the lower end face of the casing. This arrangement is of substantial benefit in facilitating assembly of the pump as a whole, while it also assures proper construction of the individual diffusers since they can be inspected and cleaned after molding before they are mounted in place on the associated casings.

As is best illustrated in FIG. 5, the outer diameter of the impeller front shroud 45 is only sufficiently less than the inner diameter of the casing 22 to assure running clearance in operation, while the outer diameter of the rim 65 is less than the outer diameter of the shroud 45, so that the discharge from the impeller is forced to flow

first axially and then inwardly of the casing as its velocity is converted to pressure by flow through the diffuser passageways 72. More specifically, the liquid flows first axially and circumferentially through the relatively restricted helical passageways 67, and it then enters the rapidly widening diffuser passageways 72 extending between the back surface of the diffuser web 60 and the lower face of the next upper casing 22. The velocity conversion therefore takes place almost entirely behind the impeller and within its outer diameter, thus making possible the use of an impeller of the maximum size and capacity for the over-all diameter of the pump.

It is also significant for the purposes of the invention that there are no bearings for the pump shaft 30 except the support provided by the several impeller hubs 40 in the bearing sleeves 62 of their associated diffusers. This arrangement promotes simplicity and economy in the production of the pump, and at the same time it offers highly satisfactory results in operation provided the related parts are constructed and proportioned with proper relation to this bearing function. On the other hand, it is also necessary in this connection to give careful consideration to the fact that when pumps of this type are first put into use in a new well, the maximum concentration of sand in the water being pumped is likely to occur at the beginning of operation but to be substantially reduced after the first few hours or days of use of the well. This means that the greatest potential for damage to the pump by sandy water occurs when the pump is first installed in the well, and the invention makes special provision for affording maximum protection against such damage with minimum sacrifice of efficiency of operation.

There are at least two significant factors involved in achieving the results outlined in the preceding paragraph, namely the selection of the materials used in the related parts of the pump and the proportions of these parts. As already noted, the diffusers 26 are readily molded of a plastic material and each provided with an insert bearing sleeve 62 of a metal having suitable bearing qualities such as stainless steel. However, if the impellers 45 were fabricated of metal, such as brass or bronze as has commonly been done in the past, and if the parts are fabricated to provide proper metal to metal bearing clearances, severe damage from sand might result. Conversely, if the parts were fabricated of metal in proportions providing adequate passage for sand particles through the bearing clearances, there would be too much play between these parts, which would cause excessive noise in operation as well as ultimately tending to result in damage to the parts as a result of this undue play.

The invention provides a solution to all the difficulties outlined above by constructing the impellers of a plastic material which has the dual characteristics of good bearing qualities and also of swelling in water to an extent which is substantial but which is definitely predictable in terms of total percentage of diameter, and which in addition requires an appreciable time in terms of days or weeks before it is completed. Further according to the invention, each impeller is produced initially in such proportions with respect to both the bearing clearances to be established and also the swelling properties of its component material that there is initially adequate space between cooperating bearing surfaces for passage there-through of the sand particles likely to be entrained with the water when the pump is first installed in a well. This necessarily means that the bearing fit will initially be too loose for normally preferred operation, but when the plastic material of the impeller has completed its swelling, the bearing clearances will have been reduced to the extent establishing proper bearing support for the impellers and pump shaft.

It will be apparent that the conditions to be met in accordance with the invention as just explained will dictate different proportions for the impeller depending both on the material of which it is composed and also on the over-

all size of the parts. It is also important that while in the specific construction described herein there are two pairs of bearing surfaces, namely the hub 40 and sleeve 62 and also the boss 50 and flange 55, it is the cooperating surfaces of the parts 40 and 62 which carry the primary bearing load and should therefore have the minimum acceptable clearance after all swelling of the impellers is completed. On the other hand, since the hub 40 is of substantially smaller diameter than the inlet boss 50, its cross-sectional dimensions will change to a lesser extent than those of the boss 50 for the same percentage of swelling.

It is therefore important for the purposes of the invention not only that the material of the impeller should swell to a definite extent in water, but also that its water absorption have a definite maximum value in terms of the final dimensions of the part as compared with its original dimensions prior to submersion. Materials having these characteristics, and which also possess good bearing qualities, are known and information as to their properties in this respect are available from the manufacturers thereof. Preferred results have been obtained with nylon resins, and typical examples thereof which have been successfully utilized include the nylon resins currently identified commercially as Zytel 101 and Nylatron G.S. It has also been found desirable to utilize such resins which include a small proportion of molybdenum disulphate as a lubricant enhancing the bearing properties of the resin.

The initial dimensions of the related portions of each impeller in accordance with the invention are closely related to the properties of the particular material employed therein and to the final conditions desired as outlined above. More specifically, it is desirable to maintain a clearance of the order of .020-.030 inch on a diameter for the hub 40 in the bearing sleeve 62 after the swelling of the impeller has been completed. If therefore the impeller is molded of a resin which swells a total of 3% of its initial dimensions, the initial diameter of the hub 40 should be controlled to provide such total clearance after a 3% increase. Furthermore, since the inlet boss 50 is of substantially larger diameter than the hub 40 and will therefore swell to a correspondingly greater linear amount, it initially should be correspondingly smaller than the inlet flange 55 to provide a final clearance of the order of .040-.050 inch on a diameter with respect to the flange 55.

The factors just discussed lead to the further proposition that it is desirable to use a resin having a relatively smaller total swellability in water as the size of the pump increases. In other words, if the dimensions of the impeller hub are such that a total swelling of 1% will be sufficient to reduce the clearance for the hub from a value permitting the desired passage of sand to a proper bearing clearance as outlined above, a resin which swells only 1% is preferred in order to prevent the initial clearance from being undesirably too great. In this connection, the use of a nylon resin filled with molybdenum disulphate as noted above has proved to be particularly desirable, since the presence of the molybdenum disulphate appears to reduce the total swelling of the resin as well as to contribute to the improvement of its bearing properties.

The advantages, particularly in the handling of sandy water, provided by constructing the impeller in accordance with the principles of the invention as outlined above are further enhanced by the over-all construction of the pump as described, with the pump shaft supported only by the cooperating bearing portions of the impellers and diffusers. More specifically, since the shaft is not supported in a fixed radial position with respect to all of the diffusers, it can have some side play to provide greater clearance for sand particles on one side of the shaft than the other if such condition should be necessary, especially during the early period of use when both this clearance

and the concentration of sand in the water are normally near their maximums. In addition, the over-all construction of the pump, including use of the individual casings 22 to form the outer casing of the pump section, is advantageous from the standpoint of initial economy as well as ease of maintenance in that access to the interior of the pump for replacement purposes are particularly simple.

This application is a continuation-in-part of my co-pending applications Serial No. 557,054 filed January 3, 1956, now Patent No. 2,954,739, and Serial No. 601,054 filed July 30, 1956 and now abandoned.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A multi-stage submersible centrifugal pump comprising an upper end cap, an inlet end cap, a plurality of annular cup-shaped casings stacked axially between said end caps and each including inlet flange means, means connecting said end caps in clamping relation with said casings, impeller means within each said casing including an annular inlet boss extending within said flange means of said casing, diffuser means associated with each said impeller means and said casing, means securing each said diffuser means within said associated casing, each impeller means including an axially extending hub, cylindrical bearing means on each said diffuser means enclosing said hub on the associated said impeller means in bearing relation to support said impeller means for rotation within the associated said casing, a drive shaft extending through all said impeller means in splined driving relation with said hubs, each of said impeller means being formed of a plastic material having the property of swelling in water over an extended period of time to a predetermined appreciable limited extent proportional to the diameter thereof, the initial cross-sectional dimension of said hub and said inlet boss of each said impeller means being coordinated and correlated with respect to the inner diameters of said bearing means and said inlet flange means respectively during the initial service period so that the outer diameters of said hub and inlet boss are sufficiently less than the inner diameters of said bearing means and said inlet flange means respectively to provide running clearance for passage of sand therebetween, the outer diameters of said hub and inlet boss being sufficiently close to but less than the inner diameters of said bearing means and inlet flange means respectively for proper bearing relation therebetween upon limiting swelling of said impeller means, and means secured on said shaft at each end of each hub adjacent said impeller means for limiting axial movement of each of said impeller means in either direction along said shaft.

2. A multi-stage submersible centrifugal pump comprising an upper end cap, an inlet end cap, a plurality of annular cup-shaped casings stacked axially between said end caps and each including a cylindrical inlet flange, means connecting said end caps in clamping relationship with said casing, a plurality of rods extending along the outside of said casings and connecting said end cap in clamping relation with said casings, an impeller within each said casing including an annular inlet boss extending within said inlet flange of said casing, a diffuser associated with each said impeller and casing, means securing each said diffuser within each said casing, each said impeller including an axially extending cylindrical hub, cylindrical bearing means on each said diffuser enclosing said hub on the associated said impeller in bearing relation to support said impeller for rotation within the associated said casing, a drive shaft extending through all

7

said impellers in splined driving relationship with said hubs, each of said impellers being formed of a plastic material having the property of swelling in water over an extended period of time to a predetermined appreciable limited extent proportional to the diameter thereof, each of said impellers being of predetermined initial cross-sectional dimensions in said hub and in said inlet boss in proportion to the inner diameters of said bearing means and said inlet flange respectively so that when said pump is first placed in service, the outer diameters of said hub and said inlet boss are sufficiently less than the inner diameters of said bearing means and said inlet flange respectively to provide substantial running clearance for the passage of sand therebetween and upon completion of said limited swelling of said impeller, the outlet diameters of said hub and inlet boss are sufficiently close to but less than the inner diameters of said bearing means and inlet flange respectively for proper bearing relation therebetween, and means secured on said shaft at each end of each hub adjacent said impellers for limiting axial movement of each of said impellers in both directions along said shaft.

1,980,337
2,271,961
2,660,122
2,667,128
2,747,513
2,753,807
2,764,099
2,775,945
2,854,926

10

29,260
62,273
342,065
544,747
622,669

15

20

8

Hollander ----- Nov. 13, 1934
Wakeman ----- Feb. 3, 1942
Landberg ----- Nov. 24, 1953
Berg ----- Jan. 26, 1954
Atkinson ----- May 29, 1956
Lung ----- July 10, 1956
Wernert ----- Sept. 25, 1956
Arutunoff ----- Jan. 1, 1957
Haight et al. ----- Oct. 7, 1958

FOREIGN PATENTS

Great Britain ----- of 1909
Austria ----- Nov. 25, 1913
Great Britain ----- Jan. 29, 1931
Great Britain ----- Apr. 27, 1942
Great Britain ----- May 5, 1949

OTHER REFERENCES

Publication, Polychemicals, by E. I. du Pont de Nemours & Co., copyright 1954, 22 pages.

References Cited in the file of this patent

UNITED STATES PATENTS

25

966,428 Comstock ----- Aug. 9, 1910
1,798,787 Conant ----- Mar. 31, 1931