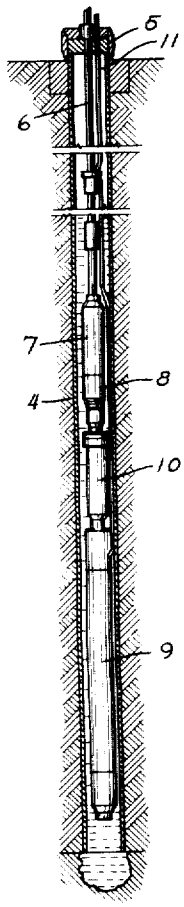
Jan. 1, 1957 A. ARUTUNOFF 2,775,945

SAND RESISTANT PUMP

Filed Aug. 27, 1953

Fig. 2

Fig. 1



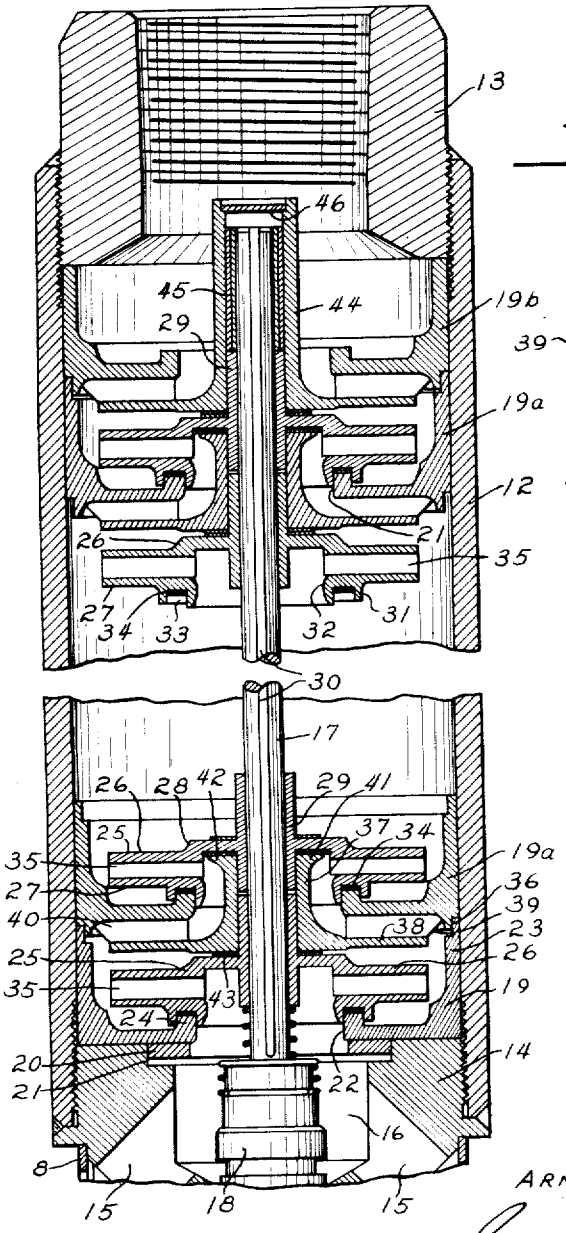
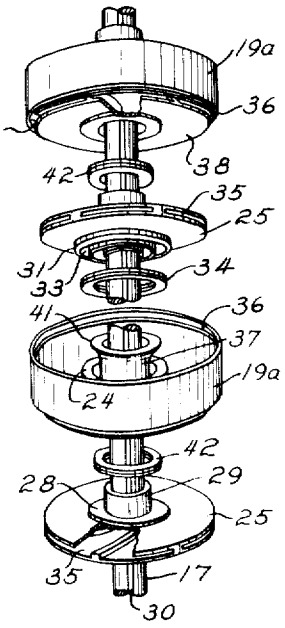


Fig. 3



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SAND RESISTANT PUMP

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7 Claims. (Cl. 103—108)

This invention relates to deep well centrifugal pumps of the electrically driven submergible type, adapted to be positioned at the bottom of a deep well. More particularly, the present invention consists in new and useful improvements in the deep well pump illustrated and described in my former Patent No. 2,270,666 issued on January 20, 1942, whereby the pump structure is rendered sand-resistant.

As explained in my said former patent, a deep well such as an oil well or a water well must necessarily be of comparatively small diameter and the lifting of oil or water from the great depths involved, necessitates a pump having a high discharge pressure. Due to the small diameter a large number of stages must be employed and the impeller elements must be rotated at comparatively high speed. The thrust of such an assembly under the speeds involved, requires a rugged construction and it is extremely important that the bearings be protected not only against the deleterious effects of penetration of liquids in the well in which the pump is submerged, but from the abrasive effects of the sand particles which are encountered during the pumping operation.

When one considers the fact that in some installations, pumps having as many as 300 stages are used, it will be apparent that the damage by sand abrasion to the many bearings involved, is a major consideration.

It is therefore the primary object of my present invention to provide in a centrifugal pump of the general type described in my said former patent, a novel multi-stage assembly which is especially designed to overcome the deleterious effects of sand abrasion heretofore encountered in pumps of this type.

Another object of the invention is to provide a novel bearing relationship between the diffusers and impellers of the respective stages, which acts to minimize the abrasive effect of sand particles carried by the liquids being pumped.

Still another object of the invention is to provide in connection with said novel bearing relationship of the diffusers and impellers, an improved thrust washer arrangement which assists in carrying the thrust of the impeller and at the same time seals and thus prevents passage of sand particles between the bearing surfaces of the impellers and the diffusers.

A further object of the invention is to provide a novel bearing means wherein a maximum extent of the pump shaft is supported by bearing surfaces, thus greatly extending the service life of the pump.

A still further object of the invention is to provide in each stage of the multi-tage pump, a fixed bearing unit forming a part of the diffuser, and including a radial bearing sleeve for the hub of the impeller and integral vertical thrust bearings for said impeller.

Another object is to provide for each impeller, a pair of concentric annular bearing surfaces formed on the diffuser, each provided with thrust washers which are

adapted to seal the bearing surfaces against penetration by sand particles.

With the above and other objects in view which will appear as the description proceeds, the invention consists in the novel features herein set forth, illustrated in the accompanying drawings and more particularly pointed out in the appended claims.

Referring to the drawings in which numerals of like character designate similar parts throughout the several views,

Figure 1 is a diagrammatic view of a cross section of a well provided with a pump unit comprising my invention.

Figure 2 is an enlarged sectional view of a pump embodying my improved sand resistant features, and

Figure 3 is an exploded perspective view showing the details of the pump assembly.

In the drawings, the numeral **4** designates a conventional well casing which is normally closed by a casing head **5**, eduction tubing **6** being provided for the removal of liquid from the well. The pump **7** which takes suction through a cylindrical screen unit **8**, discharges at its upper end into the eduction tubing **6** and is driven by an electric motor **9**. A motor protector unit **10** is preferably interposed between the pump **7** and the motor **9**, as in the case of my said former patent, although neither the motor nor the protector unit per se, forms any part of the present invention. The motor is furnished electrical energy for its operation through an electric cable **11** leading from a suitable source of electricity above ground.

Referring now to Figures 2 and 3 which show the pump proper, it will be seen that the pump comprises an elongated casing **12**, closed at its upper end by an annular head **13**, to which the eduction tubing **6** is connected. The lower end of the casing **12** is closed by a base member **14** provided with intake passages **15** which are surrounded by the cylindrical screen element **8**, previously referred to.

The inner extremities of the intake passages **15** communicate with a central inlet chamber **16** which opens concentrically into the lower end of the casing **12**, a pump shaft **17** extending longitudinally throughout the length of the casing **12**. This pump shaft is operatively connected at its lower end to the shaft of motor **9**, by conventional coupling means although the motor shaft and coupling are not shown in the drawings. A sealing assembly **18** surrounds the shaft **17** adjacent the point where it emerges into the intake chamber **16**.

The assembly and relationship of the parts of the multi-stage pump unit will best be seen in Figure 2. Starting at the lower end of the casing **12**, a bottom diffuser **19** rests upon the top surface of the base **14**, and its web is provided with a concentric reinforcing and centering ring **20** which engages a complementary annular recess **21** in the top of the base **14** to center the diffuser **19**. A central opening **22** in the web of diffuser **19** surrounds the shaft **17** in radially spaced relation to provide a fluid passageway leading to the interior of the diffuser, from the intake chamber **16**. The vertical, cylindrical wall **23** of the diffuser fits concentrically within the casing **12**.

A vertically disposed annular flange **24** bounds the diffuser passageway **22** and extends upwardly within the diffuser wall **23** where it serves as a thrust bearing for the first of a series of impellers **25**.

Each of the impellers **25** is of identical construction and comprises spaced upper and lower shrouds **26** and **27** respectively. The upper shroud **26** is provided with a raised boss **28**, the central portion of which carries a vertical hub **29**, concentrically arranged for longitudinal sliding engagement with the pump shaft **17** to which it is operatively connected by a key rib **30**. The hub **29**

of each impeller projects both above and below the web of its boss **28**, and as in the case of my said former patent, the opposite ends of each hub are spaced from the corresponding ends of the hut of an adjacent impeller, to permit limit of longitudinal movement on the shaft **17**.

The lower shroud **27** of the impeller is provided on its under surface with an annular rib **31** which bounds an axial fluid passageway **32** surrounding the shaft **17** and the under face of this rib is recessed to form an annular groove **33** adapted to receive and register with the annular flange **24** on the respective diffuser **19—19*a***. An annular thrust washer **34** is interposed between the opposed bearing faces of each of the flanges **24** and the grooves **33**, to receive the down thrust of its respective impeller. Each impeller is provided with a plurality of radial passages **35** through which the fluid is adapted to be thrown outwardly by centrifugal force into the diffuser space.

Immediately above the bottom diffuser **19** is the first of a series of intermediate diffusers **19*a***, each of which is of identical construction. The adjoining annular edges of adjacent diffusers are provided with complementary flanges and recesses, as at **36** whereby, when the diffusers are inserted within the casing **12** they bear a nested relationship. The intermediate diffusers **19*a*** differ from the bottom diffuser **19** in that each is provided with a central bearing sleeve **37** having a bore, coaxial with the shaft **17** and of an internal diameter to receive the adjacent ends of the hubs **29** of the impellers next above and below. The lower portion of the bearing sleeve **37** flares outwardly and terminates in a horizontal bottom disc **38**, connected to the main web of the diffuser by a series of radial fins **39** which in turn define a series of radial passages **40**. As seen in Figure 2, the depending disc **38** and the passages **40** of one diffuser extend downwardly into the top portion of the diffuser next below, the radial limits of the disc **38** and the ports or passageways **40** being spaced from the inner periphery of the diffuser within which they fit to permit fluid intake.

The upper end of each bearing sleeve **37** flares outwardly and terminates in a bearing head or rim **41** which is received in a complementary recess on the inner side of the boss **28** of the corresponding impeller. A thrust washer **42** is interposed between the opposite faces of the bearing head **41** and boss **28**. A second thrust washer **43** is inserted between the boss **28** of each impeller and the under surface of the disc **38** of the diffuser next above. Thus, each impeller is afforded radial bearing support by the engagement of its hub portions with the sleeves **37** of adjacent diffusers, its down-thrust being jointly borne by the concentric thrust bearings **24** and **41** and its up-thrust being borne by the thrust washer **43**.

The mushroom-like cross-sectional profile of each bearing sleeve **37** defines an annular fluid chamber which connects the passageways **40** of the diffuser and the passageways **35** of the respective impellers, so that the liquid will be thrown out through the passages **35** of the impellers and will be conducted by the diffusers inwardly to the intake of the next impeller, for continued travel through the pump, the liquid being thrown outwardly through the impeller passages **35** and flowing inwardly through the diffuser passages **40** to the central port **32** of the next impeller.

After the last stage of diffusers and impellers is inserted in the casing **12**, a top diffuser **19*b*** generally similar to the others with the exception of its bearing portion, is inserted. Instead of the mushroom-like bearing sleeve **37**, the top diffuser **19*b*** has a cylindrical bearing member **44** which is elongated to enclose the upper end of the pump shaft **17** and is provided with a diffuser bushing **45** of cylindrical shape to fit between the shaft **17** and the inner periphery of the bearing **44**, filling the space above the uppermost hub **29** of the top impeller. The upper end of the bearing **44** may be closed by a top washer **46**, secured in place by any suitable means.

The casing head **13** is screwed into the top of the casing **12**, firmly securing the nested diffusers in proper relation between the head **13** and the base **14**, thus forming a rigid multi-stage assembly.

It will be seen that by this particular arrangement of diffuser bearing sleeves **37**, embracing the oppositely directed hub portions **29** of adjacent impellers, I achieve a maximum bearing supported surface for the shaft **17**. It will be apparent from Figure 2 of the drawings that at least 90% of the shaft is supported in bearing surfaces forming a rigid part of the nested diffusers, through the medium of the intervening hubs **29** of the impellers.

It will also be apparent that by supporting the impellers of each stage on their respective diffusers through the annular bearing flanges **24** and rims **41**, and providing the respective thrust washers **34**, **42** and **43**, a dual function is performed. These thrust washers assist in carrying the thrust of the impellers and at the same time seal the complementary surfaces to prevent passage of sand particles between the bearing areas. This protection is further increased by arranging the impeller hubs **29** so that the ends of adjacent hubs are enclosed within a diffuser bearing sleeve **37**. In other words, each sleeve **37** and its washers **42**, acts as a shield for the adjoining hubs and prevents sand from reaching the clearance between the hub **29** and bearing sleeve **37**.

It naturally follows that by increasing to a maximum the bearing support of the pump shaft and protecting the bearing surfaces of the impellers from sand abrasion, I have provided a pump assembly capable of a far greater service life than pump structures heretofore known.

All of the advantages of the structure of my former patent are maintained in this improved sand resistant pump in which the impellers are constrained to rotate with the shaft but are free to move axially thereof, whereby each individual impeller thrust is carried by respective diffuser sections, instead of being transmitted to the shaft. However in the present structure this thrust support is borne at two points on each diffuser, instead of one.

From the foregoing it is believed that my invention may be readily understood by those skilled in the art without further description, it being borne in mind that numerous changes may be made in the details of construction without departing from the spirit of the invention as set forth in the following claims.

I claim:

1. In a vertical multi-stage centrifugal pump, including nested diffusers forming impeller chambers and impellers therein; a sand-resistant bearing assembly for each stage, comprising a fixed radial bearing sleeve, axially supported by a diffuser, said sleeve defining the inner limits of the respective impeller chambers and terminating at its upper end in an annular down thrust bearing rim, the impeller of said stage having a hub longitudinaly slidable on said shaft and projecting axially in opposite directions beyond the impeller body, opposed projecting portions of adjacent hubs being interposed between the shaft and a common bearing sleeve, an annular bearing surface on the underside of said impeller body, complementary to said bearing rim and means keying the impellers to said shaft.

2. In a multi-stage centrifugal pump, a diffuser and impeller assembly comprising a series of annular diffuser housings, each adapted to be nested with adjacent diffuser housings, impeller chambers formed by adjacent diffuser housings, the central portion of each diffuser housing forming an upstanding radial bearing sleeve which defines the inner limits of said chamber, a pump shaft extending axially through said diffuser housings impellers in said housings having hubs keyed to said shaft and rotatably supported in respective sleeves, each of said hubs having portions which project longitudinally in opposite directions beyond the body of the impeller, the opposed pro-

jecting portions of adjacent hubs being jointly supported by the sleeves of adjacent diffusers, the downwardly projecting portions of said hubs being bounded by a down thrust bearing surface adapted to be rotatably supported on the upper ends of respective sleeves, and means for preventing relative rotation between said hubs and shaft.

3. Apparatus as claimed in claim 2, wherein the opposed ends of adjacent hubs are spaced from one another within the respective diffuser sleeves, the latter forming shields which isolate the hubs and shaft from the chambers of said diffusers.

4. In a multi-stage centrifugal pump, including a series of nested diffusers forming impeller chambers, a shaft extending axially through said diffusers, impellers having hubs mounted on said shaft for rotation therewith in respective chambers, each impeller having top and bottom shrouds, the top shroud being fixed to and extending radially from a point intermediate the ends of its hub, respective differs having axially positioned hub-bearing sleeves, separated longitudinally of the shaft at intervals to accommodate respective top shrouds, each sleeve terminating at its upper end in a thrust bearing rim adapted to rotatably support the under side of the respective top shroud, down thrust washers between the under side of each top shroud and its supporting rim, up thrust washers between the upper side of each top shroud and the base of the adjacent diffuser sleeve, a second thrust bearing spaced radially from each bearing sleeve, and a complementary bearing surface on the bottom shroud of the respective impeller, the uppermost diffuser being provided with an axially positioned bearing sleeve to receive the top of said shaft.

5. A multi-stage centrifugal pump as claimed in claim 4, wherein opposite ends of the hubs of two adjacent impellers are spaced from one another and are received by the radial bearing sleeve of a common intervening diffuser.

6. In a vertical, multi-stage centrifugal pump, including a series of nested annular diffusers forming impeller chambers having fluid passageways, a shaft extending axially through said diffusers, and impellers mounted on said shaft for rotation in respective chambers, sand resistant bearing assemblies for respective stages, each comprising a substantially spool-shaped radial bearing sleeve supported at its base by a diffuser, the outer periphery of said sleeve defining the axial boundary of the fluid passageway of the respective diffuser and its inner periphery encircling said shaft in spaced relation, the upper end of said sleeve terminating in an annular radially extended thrust-bearing rim, hubs on each impeller, keyed to said shaft in vertical succession, each hub having a pair of oppositely directed coaxial shaft-engaging extensions, opposed hub extensions of adjacent impellers, being rotatably embraced by the inner periphery of a common, intervening bearing sleeve, and an annular thrust bearing surface on each impeller rotatably supported by the thrust-bearing rim of the corresponding sleeve.

7. A vertical, multi-stage centrifugal pump comprising a series of nested diffusers forming impeller chambers having fluid passageways, shaft receiving openings at the axis of said diffusers, a shaft extending axially through said openings, impellers in said chambers, hubs on each impeller, keyed to said shaft in vertical succession, each hub having a pair of oppositely directed, coaxial shaft engaging extensions, one extension of each hub being directed downwardly within its respective diffuser and the opposite extension of said hub being directed upwardly within the diffuser next above and terminating contiguous to the adjacent hub extension of the succeeding impeller, a substantially spool-shaped, radial bearing sleeve supported by each diffuser, extending upwardly therein and bounding its shaft receiving opening, said sleeve defining the axial boundary of the fluid passageway in the respective diffuser and rotatably receiving the opposed extensions of adjacent hubs with its intermediate portion overlying the contiguous extremities of said opposed extensions, said sleeve terminating at its upper end in an annular thrust bearing rim, and an annular thrust bearing surface on the respective impeller, rotatively supported by said rim.

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