Aug. 30, 1966 A. D. VAN ATTA 3,269,324

PUMPS

Filed Dec. 30, 1964

FIG-1

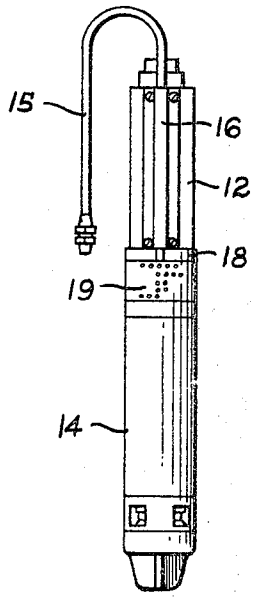


FIG-2

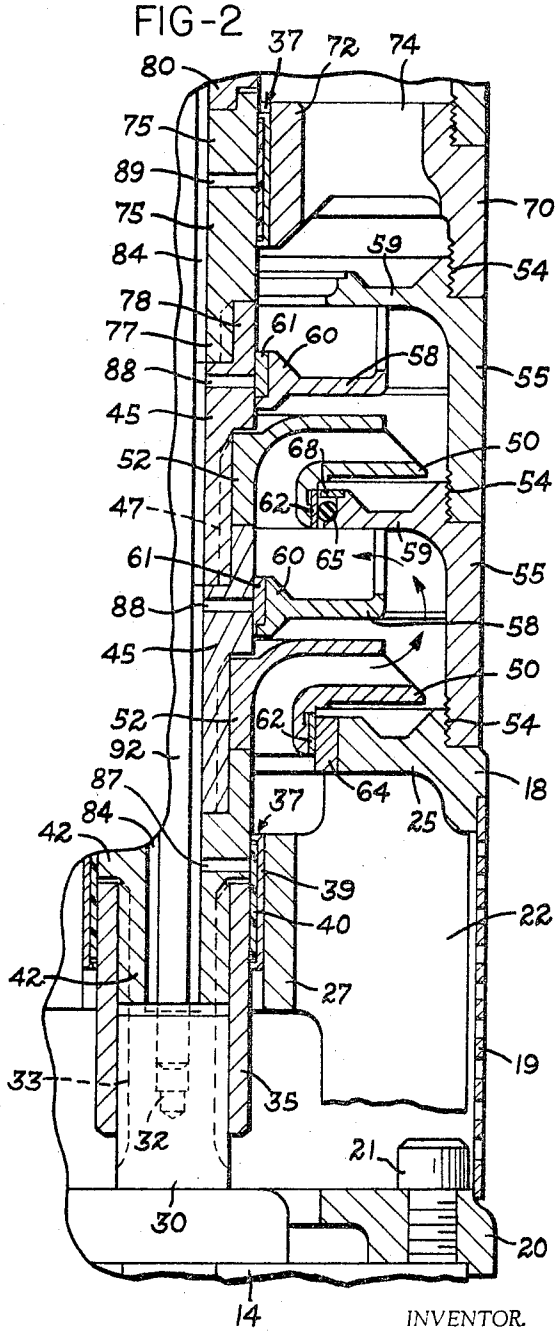
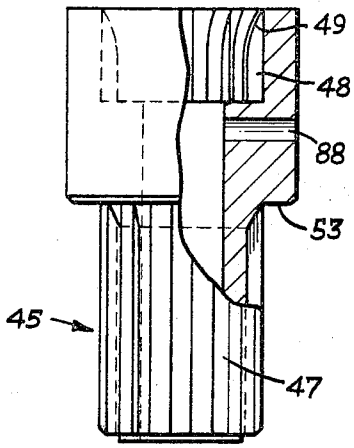


FIG-3



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PUMPS

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This invention relates to submersible pumps, and more particularly to a novel multi-stage submersible motor-pump assembly wherein the impellers are mounted on a pump shaft which is formed by a plurality of successively connected separable segments.

Primarily, the present invention is directed to a pump assembly which is intended for submerging into a well, within the well casing. Preferably, the motor is mounted below the pump and is spaced therefrom to allow liquid to flow into the bottom of the multi-stage pump and discharge at the top through a supply line which extends up through the well casing and connects to a suitable pressure tank. More specifically, the invention is directed to an improved submersible pump assembly employing components which can be inexpensively constructed and easily assembled for economical manufacturing, in addition to being easily disassembled for servicing and replacement of the pump components which are subject to wear.

Accordingly, it is a primary object of the present invention to provide a novel multi-stage submersible pump assembly which can be quickly assembled using components of economical construction and can be quickly disassembled for servicing and replacement of the components most likely to wear without requiring replacement of the components which normally do not wear.

As another object, the present invention provides a novel multi-stage submersible pump as outlined above wherein the pump shaft is formed by a plurality of successively connected shaft segments which can be more economically produced from a corrosion resistant material than by forming the pump shaft as one continuous member from a corrosion resistant material.

Still another object of the present invention is to provide a multi-stage submersible pump as outlined above wherein each stage of the pump, including the impeller and stage housing, may be disassembled without disassembling other stages of the pump.

A further object of the invention is to provide a multi-stage submersible pump as outlined above wherein at least one of the segments of the segmental pump shaft is adapted to provide a bearing surface for rotatably supporting the pump shaft and to maintain the impellers in axial alignment with the motor shaft.

It is also a special object of the present invention to provide a submersible pump assembly wherein the pump shaft is formed from a plurality of successive segments having ends which are adapted to socket together to provide a driving connection and to maintain axial alignment between adjacent segments and wherein the hub of each impeller is provided with a driving connection with a shaft segment extending into the hub.

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

In the drawing:

FIG. 1 is an elevational view illustrating a submersible pump assembly which incorporates a segmented pump shaft and impeller assembly in accordance with the present invention;

FIG. 2 is an enlarged detailed view partly in axial section showing the pump construction of the submersible pump assembly shown in FIG. 1; and

FIG. 3 is an enlarged detailed view partly in part axial section of a typical pump shaft segment which is formed in accordance with the present invention.

Referring to the drawing, which illustrates a preferred embodiment of the present invention, the submersible pump assembly shown in FIG. 1 generally includes a pump **12**, which is of the multi-stage centrifugal type, and a motor **14** with leads **15** which are protected by the shield **16**. The lower end of the pump **12** includes an intake housing **18** which serves to connect the pump rigidly to the motor **14**. A cylindrically shaped perforated screen **19** is mounted around the intake housing **18** and serves to filter the liquid flowing into the pump **12**.

Referring to the enlarged detail view of FIG. 2, the intake housing **18** includes a bottom plate **20** which is mounted rigidly to the motor **14** by the screws **21**. A series of four radially spaced ribs **22** are integrally formed with the plate **20** and extend upward to join with the top plate **25**. Also formed as an integral part of the intake housing **18** and supported by the ribs **22** is a centrally located annular hub **27**.

Projecting upward from the top of the motor **14** is a motor shaft **30** which includes an axially extending threaded hole **32** and an external spline **33** formed thereon. A tubular coupling **35** having a continuous internal spline formed therein is mounted on the motor shaft **30** and extends upward into the hub **27** and is rotatably supported therein by a bearing **37** mounted within the hub. Preferably, the bearing **37** includes a metal sleeve **39** which retains a liner **40** formed from a material having a low coefficient of friction, as for example, a fluorinated hydrocarbon material. It is preferred that the liner **40** is free to rotate both on the coupling **35** and within the sleeve **39** and is adapted to rotate during operation but at a speed substantially less than that of the coupling **35**.

Mounted within the top portion of the coupling **35** is a tubular shaft segment **42** which is connected in a successive manner to the tubular shaft segments **45**, one of which is shown in detail in FIG. 3. The shaft segments **45** are formed substantially the same as the segment **42**, and each includes a male or external spline **47** formed along the lower portion and a corresponding female or internal spline **48** formed within the upper portion so that the lower portion of one segment will socket into the upper portion of the adjacent segment. These spline connections are made sufficiently tight to provide a positive drive and axial alignment between the segments. As shown in FIG. 3, the upper end of the internal spline **48** is provided with a radius **49** which enables the segments to be easily joined together.

While the shaft segments **42** and **45** are adapted to be molded from a plastic material, it is preferred that the segments be formed as metal parts, as for example, from sintered bronze, in order that close tolerances may be held which, in turn, provide for accurate axial alignment among the shaft segments.

Mounted to each of the shaft segments **45** is an impeller **50** which has a hollow hub **52** having an internal spline corresponding to the internal spline **48** formed on the upper portion of the associated shaft segment **45**. This spline connection provides means for driving each of the impellers **50** from a separate shaft segment **45**. The axial length of the hub **52**, however, is slightly less than the axial spline length provided on the assembled shaft segments between the shoulder **53** and the upper end of the adjacent shaft segment. This arrangement prevents any axial compression of the impeller hub **52** but does serve to space the impellers accurately.

Mounted in a successive stacked manner onto the top plate **25** of the inlet housing **18** by threaded connections **54** are the stage housings **55** in each of which an impeller **50** is rotatably mounted. While only two pump stages

are shown, it is to be understood that more than two may be employed if a higher discharge pressure is desired. A diffuser **58** is mounted within each of the stage housings **55** and cooperates with the top plate **59** of the associated housing **55** to direct the liquid from the discharge of one impeller **50** upwardly and radially inwardly to the inlet of the adjacent impeller **50** with minimum turbulence. A hub **60** is formed as an integral part of each diffuser **58** and serves to support a bearing ring **61** spaced around the upper portion of the shaft segment **45**. In addition to assisting in maintaining axial alignment among the shaft segments and the motor shaft **22**, the bearing rings **61** serve to prevent recirculation of the liquid flowing around the diffuser **58**.

Surrounding the inlet portion of each of the impellers **50** is a clearance ring **62** which is snapped on over the impeller for rotation therewith. In the case of the lower impeller **50**, the clearance ring **62** is adapted to engage a wear ring **64** mounted within the top plate **25** of the intake housing **18**. The corresponding clearance ring **62** which surrounds the upper impeller **50** is adapted to touch slightly an O-ring **65** which is positioned within the top plate **59** of the stage housing **55** and removably retained therein for servicing by a flat retaining member **68**.

Mounted by the threaded connection **54** to the uppermost stage housing **55** is a bearing housing **70** which includes an annular hub **72** centrally spaced by a series of four equally spaced ribs **74**. Mounted within the hub **72** is another bearing **37** which rotatably supports the shaft segment **75** having an extension **77** which fits snugly within the upper portion of the upper shaft segment **45**. Extending upwardly from the shaft segment **75** is a tubular filter **80** (partially shown) which preferably is formed from a porous bronze or comparable material and is adapted to clean the sand or the like from the high pressure liquid which passes through the filter **80** and into the axially extending center passageway **84**.

Radially extending through the center portion of each of the shaft segments **52**, **45** and **75** is a laterally extending passageway **87**, **88** and **89** respectively, which serve to permit the high pressure liquid within the passageway **84** to flow to the supporting surfaces of the bearing rings **61** and bearings **37** in order to lubricate and flush the bearings with high pressure clean liquid so as to prevent foreign particles such as sand and the like from seeping between the shaft segments and the supporting surfaces of the bearings and thus prevent excessive wear of the bearings.

Extending axially through the passageway **84** defined within the hub segments is a bolt **92** which is threaded into the tapped hole **32** within the motor shaft **30** and serves to retain the shaft segments in their stacked interlocking relationship. In addition, the bolt **92** serves to transfer the upward axial thrust which is developed by the impellers under certain operating conditions to the motor shaft **22** in order that the thrust may be opposed by suitable thrust bearings (not shown) within the motor **14**.

One of the features which results from the segmented pump shaft and the separate stage housing is the easy servicing of the pump. It has been found that the upper portions of the shaft segments receive the greatest wear as a result of the change in flow direction of the liquid adjacent the inlet portion of the impellers. Thus the shaft segments may be replaced without replacing the impellers **50**. This may be accomplished at any stage simply by unthreading the stage housing and removing the shaft segment associated with that particular stage. Furthermore, this can be done without disturbing the other stages.

Another important feature which results from the segmented construction of the pump shaft is the ability to make the shaft segments as molded parts from a corrosion resistant material such as a suitable plastic or a powdered metal, as for example, sintered bronze. It has been found that the total cost of the separate shaft segments, which can be inexpensively formed within close tolerances, provides a substantial cost savings over forming one continuous shaft from a corrosion resistant material, as for example, stainless steel.

It is also an important feature of the segmented pump shaft in accordance with the invention that each shaft segment is driven by an adjacent segment such that the torque loading on the pump shaft is not transferred through the hub of one impeller to the hub of the next successive impeller. As a result of this arrangement, the impellers **50** may be formed from a suitable corrosion resistant plastic material with reasonably thin wall thickness. Furthermore, as a result of the spline connection between a shaft segment and the impeller hub, the torque loading is uniformly distributed around the hub of the impeller which thus eliminates concentration of torsional forces on the impeller hub **52**.

An advantage of forming the shaft segments from powdered metal is the close dimensional tolerances which can be obtained without requiring finishing of the segments after forming. As a result of the close dimensional tolerances and the square surfaces which can be held (on the shaft segments), the overall stack up dimensions and axial alignment can be accurately maintained so that the impellers **50** may be properly spaced in relation to the stage housings for obtaining the maximum pump efficiency.

While the form of apparatus herein described constitutes a preferred embodiment of the invention, it is to be understood that the invention is not limited to this precise form 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 submersible pump comprising a motor having a submersible casing and including a projecting motor shaft, means defining a multi-stage pump housing rigidly connected to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing, a separate shaft segment extending through the hub of each of said impellers and connected thereto for positive rotation, means on said shaft segments providing a socket engagement between each pair of adjacent said segments to maintain axial alignment and positive drive therebetween, coupling means mounted on said motor shaft for providing a positive drive connection and axial alignment between said motor shaft and the adjacent said shaft segment, bearing means affixed to said housing for rotatably supporting at least one of said shaft segments, and means for retaining said shaft segments in said engaged relationship.

2. A submersible pump comprising a motor having a submersible casing and including an upwardly projecting motor shaft, means defining a multi-stage pump housing spaced above said motor and connected rigidly to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing, a separate shaft segment extending through the hub of each of said impelers and positively locked thereto, said shaft segments having an upper and lower portion for driving engagement between the upper portion of one segment and the lower portion of the next adjacent segment and to maintain axial alignment therebetween, coupling means positively connected to said motor shaft and having means for driving engagement with the lower portion of the bottom shaft segment and to provide axial alignment therebetween, bearing means affixed to said housing for rotatably supporting at least one of said shaft segments, and means for retaining said shaft segments in said engaged relationship.

3. A submersible pump comprising a motor having a submersible casing and including an upwardly projecting motor shaft, means defining a multi-stage pump housing spaced above said motor and connected rigidly to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing and each having a hub, a pump shaft rotatably mounted in said hous-

ing, said pump shaft being defined by a plurality of shaft segments including a separate segment extending through the hub of each of said impellers, means defining a positive driving engagement between the hub of each said impeller and said shaft segment extending through said hub thereof, means providing driving engagement and axial alignment between the top portion of each of said segments with the lower portion of the next adjacent segment, coupling means providing positive drive and axial alignment between said motor shaft and the lower portion of the bottom shaft segment, and means for retaining said shaft segments in said engaged relationship.

4. A submersible pump comprising a motor having a submersible casing and including an upwardly projecting motor shaft, a plurality of successively stacked stage pump housings spaced above said motor and connected rigidly to one end of said motor casing, a corresponding plurality of impellers spaced in stacked relationship within said housing and each having a hub, a pump shaft rotatably mounted in said housing, said pump shaft being defined by a plurality of shaft segments including a separate segment extending through the hub of each of said impellers, means defining positive driving engagement between the hub of each of said impeller and said shaft segment extending through said hub thereof, socket means providing driving engagement and axial alignment between the top portion of each of said segments with the lower portion of the adjacent said segment, coupling means providing positive drive and axial alignment between said motor shaft and the lower portion of the bottom shaft segment, and means for retaining said shaft segments in said engaged relationship.

5. A submersible pump comprising a motor having a submersible casing and including an upwardly projecting motor shaft, means defining a multi-stage pump housing spaced above said motor and connected rigidly to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing and each having a hub, a pump shaft defined by a series of connected shaft segments with a separate said segment extending through the hub of each of said impellers and positively locked thereto, each of said shaft segments having an external and internal mating spline adapted for socket engagement between the upper portion of each said segment with the lower portion of the adjacent said segment and for maintaining axial alignment therebetween, coupling means positively connected to said motor shaft and having a spline connection with the lower portion of the bottom said shaft segment and adapted to provide axial alignment between said segment and said motor shaft, bearing means affixed to said housing for rotatably supporting at least one of said shaft segments, and means for retaining said shaft segments in said engaged relationship.

6. A submersible pump comprising a motor having a submersible casing and including an upwardly projecting motor shaft, means defining a multi-stage pump housing spaced above said motor and connected rigidly to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing and each having a hub, a pump shaft rotatably mounted in said housing, said pump shaft being defined by a plurality of interconnecting tubular shaft segments including a separate said segment extending therough the hub of each of said impellers, means defining a spline driving engagement between the hub of each said impeller and the said shaft segment extending through said hub thereof, means defining a splined socket connection between the top portion of each of said segments with the lower portion of the above adjacent said segment, a coupling having an internal spline for providing a positive drive connection and axial alignment between said motor shaft and the lower spline portion of the bottom said shaft segment, and means for retaining said shaft segments in said engaged relationship.

7. A submersible liquid pump comprising a motor having a submersible casing and including a projecting motor shaft, means defining a multi-stage pump housing rigidly connected to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing, a separate tubular shaft segment extending through the hub of each of said impellers and connected thereto for positive rotation means on said shaft segments providing a socket engagement between each pair of adjacent said segments to maintain axial alignment and positive drive therebetween, coupling means mounted on said motor shaft for providing a positive drive connection and axial alignment between said motor shaft and the adjacent said shaft segment, at least one tubular bearing shaft segment connected to said impeller shaft segments and defining a central axially extending passageway, bearing means affixed to said housing for rotatably supporting said bearing shaft segment, a laterally extending passageway formed within the wall of each said bearing shaft segment, inlet means on the discharge side of at least one of said impellers for allowing high pressure liquid to enter each said axially extending passageway and lubricate said bearing means through said passageway, and means for retaining said shaft segments in said engaged relationship.

8. A submersible pump comprising a motor having a submersible casing and including a projecting motor shaft, means defining a multi-stage pump housing rigidly connected to one end of said motor casing, a plurality of impellers spaced in stacked relationship within said housing and each having a hub, a separate shaft segment associated with each said impeller and having an external spline on one end portion longer than the axial length of said hub to project beyond said hub while engaging said hub for positive rotation, internal spline means on the other end portion of each said shaft segment for receiving said projecting portion of the adjacent said segment and providing a socket engagement between each pair of adjacent said segments to maintain axial alignment and positive drive therebetween, coupling means mounted on said motor shaft for providing a positive drive connection and axial alignment between said motor shaft and the adjacent said shaft segment, bearing means affixed to said housing for rotatably supporting at least one of said shaft segments, and means for retaining said shaft segments in said engaged relationship.

9. A submersible pump as defined in claim 8 wherein each said shaft segment includes an external radial shoulder at the base of said external spline portion, and the end of said external spline portion of said shaft segment engages the bottom of said female spline portion of said adjacent segment to define an axial space between said shoulder and the end of said adjacent segment which is slightly greater than the axial length of said hub to prevent axial compression of said hub.

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