

Aug. 23, 1966

M. S. VARTAPETOV

3,267,869

MULTI-STAGE AXIAL FLOW HIGH PRESSURE PUMP

Filed Nov. 15, 1963

4 Sheets-Sheet 1

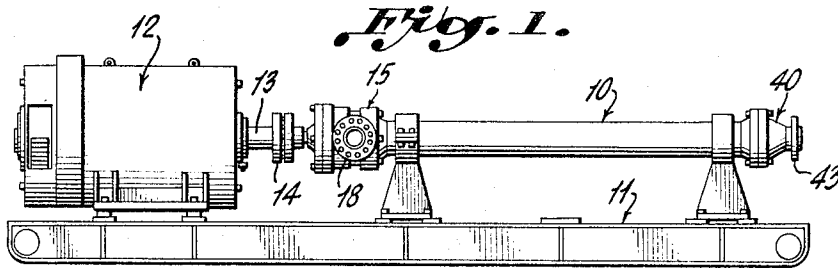
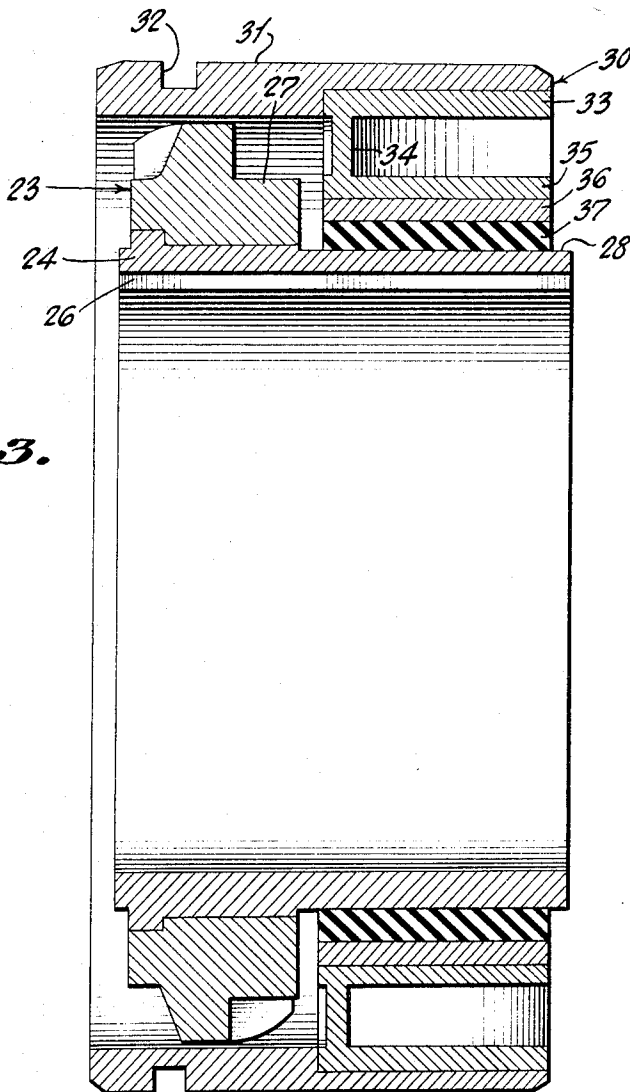


Fig. 3.



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4 Sheets-Sheet 2

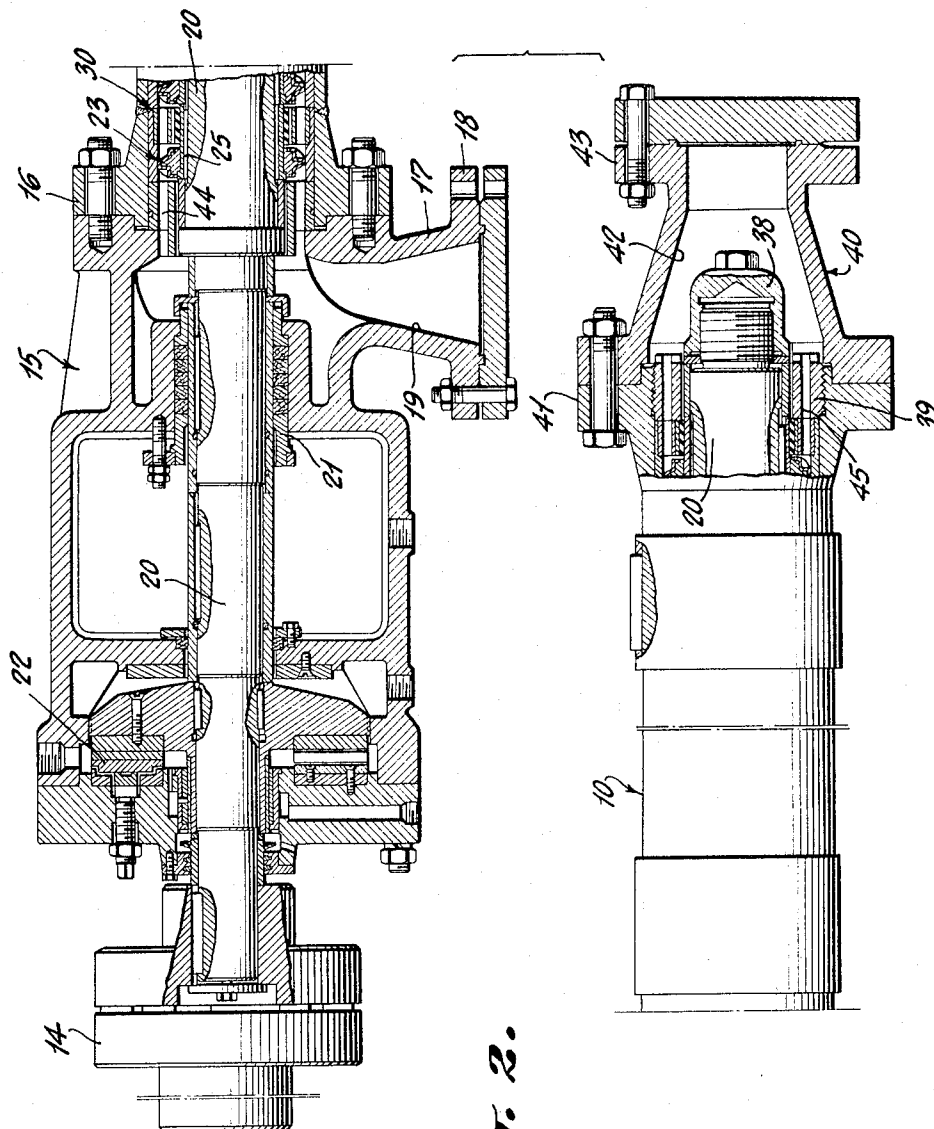


Fig. 2.

Aug. 23, 1966

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4 Sheets-Sheet 3

Fig. 5.

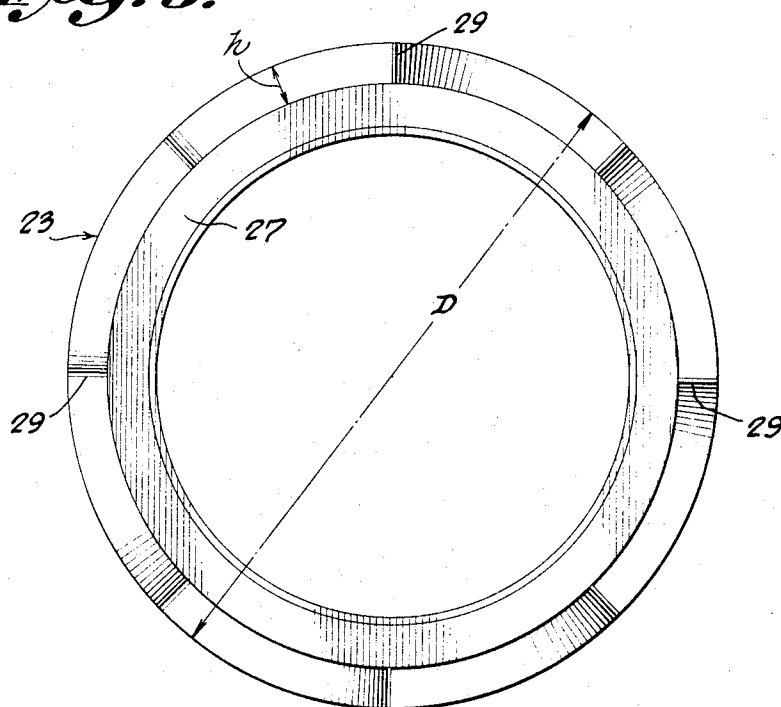
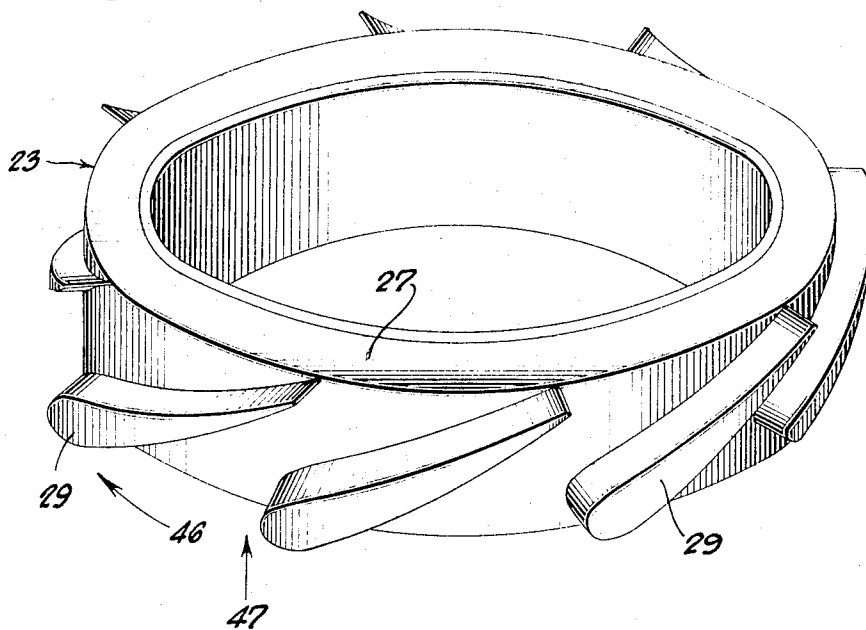


Fig. 4.



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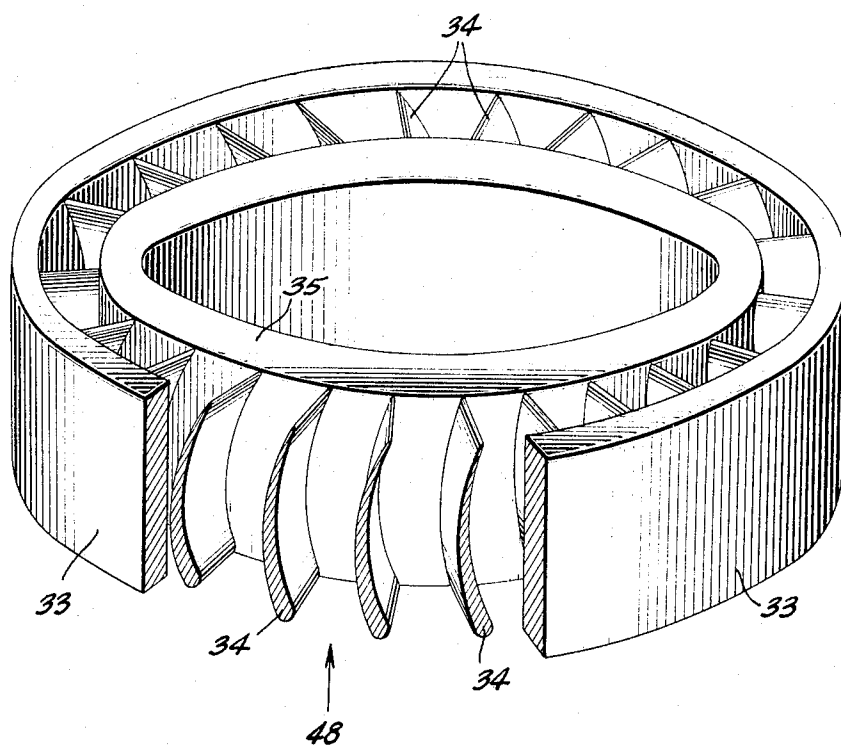
3,267,869

MULTI-STAGE AXIAL FLOW HIGH PRESSURE PUMP

Filed Nov. 15, 1963

4 Sheets-Sheet 4

Fig. 6.



1

3,267,869

MULTI-STAGE AXIAL FLOW HIGH PRESSURE PUMP

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8 Claims. (Cl. 103-93)

This invention relates to the handling of liquid and more particularly to a multi-stage axial flow high pressure pump which serves to deliver liquid at high pressure and relatively low volume and this application is a continuation in part of our co-pending application Serial No. 840,493, filed September 10, 1959, now abandoned.

Heretofore multi-stage axial flow pumps comprising a plurality of impellers mounted on a common shaft and with guide vane structure disposed between the impellers have been proposed and utilized, but with these prior art pumps it has not been possible to provide a high pressure output without increasing the capacity of the pump beyond necessary limits and this has been due to the fact that with the impeller design employed in these pumps, the necessary speed factor to produce a desired high pressure discharge also results in needlessly increasing the capacity of the pump. In other words, in prior art pumps of this type it has been necessary to utilize a relatively high speed factor in order to provide a high pressure discharge and only by providing a different design of impeller which permits the use of a relatively low speed factor while providing a high discharge pressure, is it possible to provide a pump of this type capable of a high discharge pressure and a relatively low volume.

It is accordingly an object of the invention to provide a multi-stage axial flow pump capable of a high pressure discharge and a relatively low volume.

A further object of the invention is the provision of a multi-stage axial flow high pressure pump in which the stages are provided as independent units incorporating an impeller and a guide vane structure, any desired number of such stages being assembled in a common housing with the impellers mounted on a common shaft extending through the housing.

A still further object of the invention is the provision of a multi-stage axial flow high pressure pump in which the stages are provided as individual units, including an impeller and a guide vane structure, each stage also incorporating a bearing means for the common shaft on which the impellers are mounted thereby providing adequate support for the shaft, even though a large number of stages, i.e. from three to two hundred may be utilized.

Another object of the invention is the provision of a multi-stage axial flow high pressure pump in which each stage includes an impeller and a guide vane structure, each impeller having radially disposed blades with the ratio of the radial length of the blades with respect to the outside diameter of the impeller being not greater than 0.1 thereby permitting use of a speed factor of the order of one twenty to two hundred which serves to provide a high pressure relatively low volume pump.

2

A further object of the invention is the provision of a multi-stage axial flow high pressure pump in which each stage constitutes a single unit, including an impeller and a guide vane structure with the impeller received on a common shaft and the guide vane structure received in the pump housing, all of the impellers being clamped on the shaft by means of a single securing means, such as a nut and all of the guide vane structures being clamped in place in the housing by means of a single securing means, such as a nut thereby materially facilitating the manufacture and assembly of the pump with any desired number of stages.

Further objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a side elevational view of a pump constructed in accordance with this invention;

FIG. 2 a top plan view with parts broken away and in section for greater clarity and showing the general structure of the pump of this invention;

FIG. 3 a transverse sectional view of one of the stages of the pump of this invention showing the relationship between the impeller and the guide vane structure of each stage;

FIG. 4 a view in perspective showing the impeller utilized in the pump of this invention;

FIG. 5 an end elevational view of the impeller shown in FIG. 4; and

FIG. 6 a view in perspective showing the guide vane structure utilized in the pump of this invention.

With continued reference to the drawings and particularly FIG. 1, there is shown a multi-stage axial flow high pressure pump constructed in accordance with this invention and which may well comprise an elongated tubular housing 10 mounted on a base 11 and also mounted on the base 11 is a drive motor 12 provided with a shaft 13 connected to the shaft of the pump through a suitable coupling 14.

With particular reference to FIG. 2, an intake casing 15 is secured to one end of the housing 10 by a flanged coupling 16 and the intake casing 15 is provided with an intake fitting 17 having a suitable flange coupling 18 thereon for connecting the same to an intake pipe. A passage 19 in the intake fitting 17 communicates with the interior of the pump housing 10.

A shaft 20 extends through the pump housing 10 and also through the intake casing 15 and a suitable stuffing box 21 may be provided in the intake casing 15 to prevent leakage of liquid along the shaft 20. Also provided in the intake casing 15 is a suitable thrust bearing 22 which serves to absorb thrust transmitted to the shaft 20 by the impellers of the pump stages to be later described.

Any desired number of pump stages may be installed in the pump housing 10 and the number of stages may vary between three and two hundred depending upon the results desired and all of the stages are identical, each comprising a unit including an impeller and a guide vane structure. With particular reference to FIG. 3, there is shown one pump stage which is representative of all of the stages and as shown in FIG. 3, there is included an impeller 23 mounted on an elongated bushing 24 and the bushing 24 may be slidably received on the shaft 20 and prevented from rotation with respect thereto by a key 25 on the shaft 20 received in a keyway 26 in the

3

bushing 24. The impeller 23 may be welded to the bushing 24 or fixed thereto in any other suitable manner. With particular reference to FIGS. 3 and 4, the impeller 23 includes an impeller body ring 27 fixed to the bushing 24 adjacent one end in any desired manner and a peripheral bearing surface 28 is provided on the bushing 24 between the impeller body ring 27 and the opposite end of the bushing 24. As best shown in FIG. 4, the impeller body ring 27 is provided with a plurality of circumferentially spaced radially projecting blades 29 on the peripheral surface of the body ring 27 and as will be apparent from FIG. 4, the blades 29 are elongated and provided with a generally airfoil cross section and the blades 29 are disposed at an angle to the axis of the shaft 20 on which the impeller is mounted. It is further to be noted as shown in FIG. 5, that the ratio of the radial length h of the blades 29 with respect to the outside diameter of the impeller 23 is not greater than 0.1.

With particular reference to FIGS. 3 and 6, the guide vane structure 30 of each pump stage may well comprise an outer sleeve 31 which is adapted to be slidably received in the pump housing 10 with a portion of the sleeve 31 surrounding the impeller 23 and the sleeve 31 may be provided with an annular groove 32 for receiving a packing ring to engage the interior surface of the pump housing 10 to prevent leakage of fluid between the sleeve 31 and the pump housing 10. The guide vane structure 30 also includes a ring 33 fixed within the sleeve 31 and projecting inwardly from the ring 33 are a plurality of guide vanes 34 which terminate in an inner ring 35. As best shown in FIG. 6, the guide vanes 34 are circumferentially spaced and such vanes are elongated and provided with a curved generally airfoil cross section and are disposed substantially axially of the pump housing 10. Fixed to the inner ring 35 in any suitable manner is a bushing 36 and secured to the inner surface of the bushing 36 is non-metallic bearing 37 of rubber, plastic or any other suitable material and the bearing 37 engages the bearing surface 28 on the bushing 24.

As best shown in FIG. 2, the impellers 23 are slidably received on the shaft 20 in end-to-end relationship and such impellers may be clamped in position on the shaft 20 by any suitable means, such as a nut 38 threadably received on the end of the shaft 20. In a similar manner, the sleeves 31 together with the guide vane structure 30 are slidably positioned in end-to-end relationship within the pump housing 10 and the guide vane structure 30 are clamped in position in the pump housing 10 by any suitable means, such as a nut 39 in the end of the housing 10. It will, therefore, be seen that the impeller and guide vane structure constituting each stage of the pump is securely held in position on the shaft 20 and in the housing 10 and the single securing means for the impellers and the single securing means for the guide vane structures may be utilized with any desired number of stages.

A discharge fitting 40 is secured to the pump housing 10 by a suitable flange coupling 41 at the end of the housing 10 opposite the intake casing 15 and the discharge fitting 40 is provided with a passage 42 communicating with the interior of the housing 10 and also with a suitable coupling 43 for connecting the discharge fitting 40 to a discharge pipe. The passage 19 in the intake fitting 17 may communicate with the space between the shaft 20 and the housing 10 through axial passages 44 and the passage 42 in the discharge fitting 40 may communicate with the space between the shaft 20 and the housing 10 through axial passages 45.

In operation, the impellers 23 rotate in the direction of the arrow 46 in FIG. 4 and fluid flows through the impellers in the direction of the arrow 47. The fluid flow through the guide vane structure is in the direction of the arrow 48 in FIG. 6. The rotation of the impellers 23 serve to force fluid axially of the casing 10 and any rotary motion imparted to the fluid by the

4

impellers 23 is counteracted by the guide vane structure 30 which serves to direct the fluid in a substantially axial direction into the impeller of the next stage. In this manner, an axial flow pump is provided having a high pressure output of the order of twelve hundred meters and more with a volume of one hundred twenty cubic meters per hour and an efficiency of seventy-two percent. Since any number of stages may be provided within reasonable limits the pressure and output characteristics of the pump may be varied as desired and even though a relatively large number of stages may be employed the common shaft is adequately supported by the provision of a bearing in each stage.

It will be obvious to those skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is shown in the drawings and described in the specification, but only as indicated in the appended claims.

What is claimed is:

1. A multi-stage axial flow high pressure pump comprising a base, an elongated tubular housing mounted on said base, a shaft extending axially through said housing in concentric relationship, an intake casing secured to one end of said housing and surrounding said shaft, a thrust bearing having one part fixed to said casing and a relatively rotating part fixed to said shaft, an intake fitting on said casing communicating with the annular space between said housing and shaft, a drive motor mounted on said base and coupled to said shaft exteriorly of said casing, a discharge fitting secured to the opposite end of said housing and communicating with the annular space between said housing and shaft, a plurality of axially spaced pump stages disposed in the annular space between said housing and shaft, each stage comprising an impeller including an elongated bushing slidably and non-rotatably received on said shaft, an impeller body ring fixed to said bushing adjacent one end, a peripheral bearing surface on said bushing between said ring and the opposite end and a plurality of circumferentially spaced radially projecting blades on the peripheral surface of said ring, said blades being elongated and having a generally airfoil cross section and being disposed at an angle to the axis of said shaft, a guide vane structure spaced downstream from said impeller and comprising an outer sleeve slidably and non-rotatably received in said housing with a portion of said outer sleeve surrounding said impeller, a plurality of circumferentially spaced guide vanes projecting radially inwardly from said outer sleeve, said vanes being elongated and having a curved generally curved airfoil cross section and being disposed substantially axially of said housing, an inner ring on the inner side of said vanes and a non-metallic bearing ring fixed to the inner surface of said inner ring and engaging said bearing surface, whereby a shaft supporting bearing is provided for each stage, a nut threadably received on the end of said shaft adjacent said discharge fitting for clamping said bushings on said shaft and a nut threadably received in said housing adjacent said discharge fitting for clamping said outer sleeve in said housing.

2. A multi-stage axial flow high pressure pump as defined in claim 1, in which the ratio of the radial length of the impeller blades with respect to the outside diameters of the impeller is not greater than 0.1.

3. A multi-stage axial flow high pressure pump comprising an elongated tubular housing, a shaft extending axially through said housing in concentric relationship, an intake casing secured to one end of said housing and surrounding said shaft, a thrust bearing having one part fixed to said casing and a relatively rotating part fixed to said shaft, an intake fitting on said casing communicating with the annular space between said housing and shaft, a discharge fitting secured to the opposite end of said housing and communicating with the annular space between said housing and shaft, a plurality of axially

5

spaced pump stages disposed in the annular space between said housing and shaft, each stage comprising an impeller including an elongated bushing slidably and non-rotatably received on said shaft, an impeller body ring fixed to said bushing adjacent one end, a peripheral bearing surface on said bushing between said ring and the opposite end and a plurality of circumferentially spaced radially projecting blades on the peripheral surface of said ring, said blades being elongated and having a generally airfoil cross section and being disposed at an angle to the axis of said shaft, a guide vane structure spaced downstream from said impeller and comprising an outer sleeve slidably and non-rotatably received in said housing with a portion of said outer sleeve surrounding said impeller, a plurality of circumferentially spaced guide vanes projecting radially inwardly from said outer sleeve, said vanes being elongated and having a curved generally airfoil cross section and being disposed substantially axially of said housing, an inner ring on the inner sides of said vanes and a non-metallic bearing ring fixed to the inner surface of said inner ring and engaging said bearing surface, whereby a shaft supporting bearing is provided for each stage, a nut threadedly received on the end of said shaft adjacent said discharge fitting for clamping said bushings on said shaft and a nut threadedly received in said housing adjacent said discharge fitting for clamping said outer sleeve in said housing.

4. A multi-stage axial flow high pressure pump comprising an elongated tubular housing, a shaft extending axially through said housing in concentric relationship, an intake casing secured to one end of said housing and surrounding said shaft, a thrust bearing having one part fixed to said casing and a relatively rotating part fixed to said shaft, an intake fitting on said casing communicating with the annular space between said housing and shaft, a discharge fitting secured to the opposite end of said housing and communicating with the annular space between said housing and shaft, a plurality of axially spaced pump stages disposed in the annular space between said housing and shaft, each stage comprising an impeller including an elongated bushing slidably and non-rotatably received on said shaft, an impeller body ring fixed to said bushing adjacent one end, a peripheral bearing surface on said bushing between said ring and the opposite end and a plurality of circumferentially spaced radially projecting blades on the peripheral surface of said ring, said blades being elongated and having a generally airfoil cross section and being disposed at an angle to the axis of said shaft, a guide vane structure spaced downstream from said impeller and comprising an outer sleeve slidably and non-rotatably received in said housing with a portion of said outer sleeve surrounding said impeller, a plurality of circumferentially spaced guide vanes projecting radially inwardly from said outer sleeve, said vanes being elongated and having a curved generally airfoil cross section and being disposed substantially axially of said housing, an inner ring on the inner sides of said vanes and a non-metallic bearing ring fixed to the inner surface of said inner ring and engaging said bearing surface, whereby a shaft supporting bearing is provided for each stage, means for clamping said bushings on said shaft and means for clamping said outer sleeve in said housing.

5. A multi-stage axial flow high pressure pump comprising an elongated tubular housing, a shaft extending axially through said housing in concentric relationship, an intake casing secured to one end of said housing and surrounding said shaft, an intake fitting on said casing communicating with the annular space between said housing and shaft, a discharge fitting secured to the opposite end of said housing and communicating with the annular space between said housing and shaft, a plurality of axially spaced pump stages disposed in the annular space between said housing and shaft, each stage comprising an impeller including an elongated bushing slidably and non-rotatably received on said shaft, an impeller

6

body ring fixed to said bushing adjacent one end, a peripheral bearing surface on said bushing between said ring and the opposite end and a plurality of circumferentially spaced radially projecting blades on the peripheral surface of said ring, said blades being elongated and having a generally airfoil cross section and being disposed at an angle to the axis of said shaft, a guide vane structure spaced downstream from said impeller and comprising an outer sleeve slidably and non-rotatably received in said housing with a portion of said outer sleeve surrounding said impeller, a plurality of circumferentially spaced guide vanes projecting radially inwardly from said outer sleeve, said vanes being elongated and having a curved generally airfoil cross section and being disposed substantially axially of said housing, an inner ring on the inner sides of said vanes and a non-metallic bearing ring fixed to the inner surface of said inner ring and engaging said bearing surface, whereby a shaft supporting bearing is provided for each stage, means for clamping said bushings on said shaft and means for clamping said outer sleeve in said housing.

6. A multi-stage axial flow high pressure pump comprising an elongated tubular housing, a shaft extending axially through said housing in concentric relationship, an intake casing secured to one end of said housing and surrounding said shaft, an intake fitting on said casing communicating with the annular space between said housing and shaft, a discharge fitting secured to the opposite end of said housing and communicating with the annular space between said housing and shaft, a plurality of axially spaced pump stages disposed in the annular space between said housing and shaft, each stage comprising an impeller including an elongated bushing slidably and non-rotatably received on said shaft, an impeller body ring fixed to said bushing adjacent one end, a peripheral bearing surface on said bushing between said ring and the opposite end and a plurality of circumferentially spaced radially projecting blades on the peripheral surface of said ring, said blades being disposed at an angle to the axis of said shaft, a guide vane structure spaced downstream from said impeller and comprising an outer sleeve slidably and non-rotatably received in said housing with a portion of said outer sleeve surrounding said impeller, a plurality of circumferentially spaced guide vanes projecting radially inwardly from said outer sleeve, said vanes being disposed substantially axially of said housing, an inner ring on the inner sides of said vanes and a non-metallic bearing ring fixed to the inner surface of said inner ring and engaging said bearing surface, whereby a shaft supporting bearing is provided for each stage, means for clamping said bushings on said shaft and means for clamping said outer sleeve in said housing.

7. A multi-stage axial flow high pressure pump comprising an elongated tubular housing, a shaft extending axially through said housing in concentric relationship, an intake casing secured to one end of said housing and surrounding said shaft, an intake fitting on said casing communicating with the annular space between said housing and shaft, a discharge fitting secured to the opposite end of said housing and communicating with the annular space between said housing and shaft, a plurality of axially spaced pump stages disposed in the annular space between said housing and shaft, each stage comprising an impeller including an elongated bushing slidably and non-rotatably received on said shaft, an impeller body ring fixed to said bushing adjacent one end, a peripheral bearing surface on said bushing between said ring and the opposite end and a plurality of circumferentially spaced radially projecting blades on the peripheral surface of said ring, said blades being disposed at an angle to the axis of said shaft, a guide vane structure spaced downstream from said impeller and comprising an outer sleeve slidably and non-rotatably received in said housing with a portion of said outer sleeve surrounding said impeller, a plurality of circumferentially spaced guide vanes projecting radially

7

inwardly from said outer sleeve, said vanes being disposed substantially axially of said housing, an inner ring on the inner side of said vanes and a bearing on the inner surface of said inner ring engaging said bearing surface, whereby a shaft supporting bearing is provided for each stage, means for clamping said bushing on said shaft and means for clamping said outer sleeve in said housing.

8. A multi-stage axial flow high pressure pump as defined in claim 7, in which the ratio of the radial length of the impeller blades with respect to the outside diameter of the impeller is not greater than 0.1.

8

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