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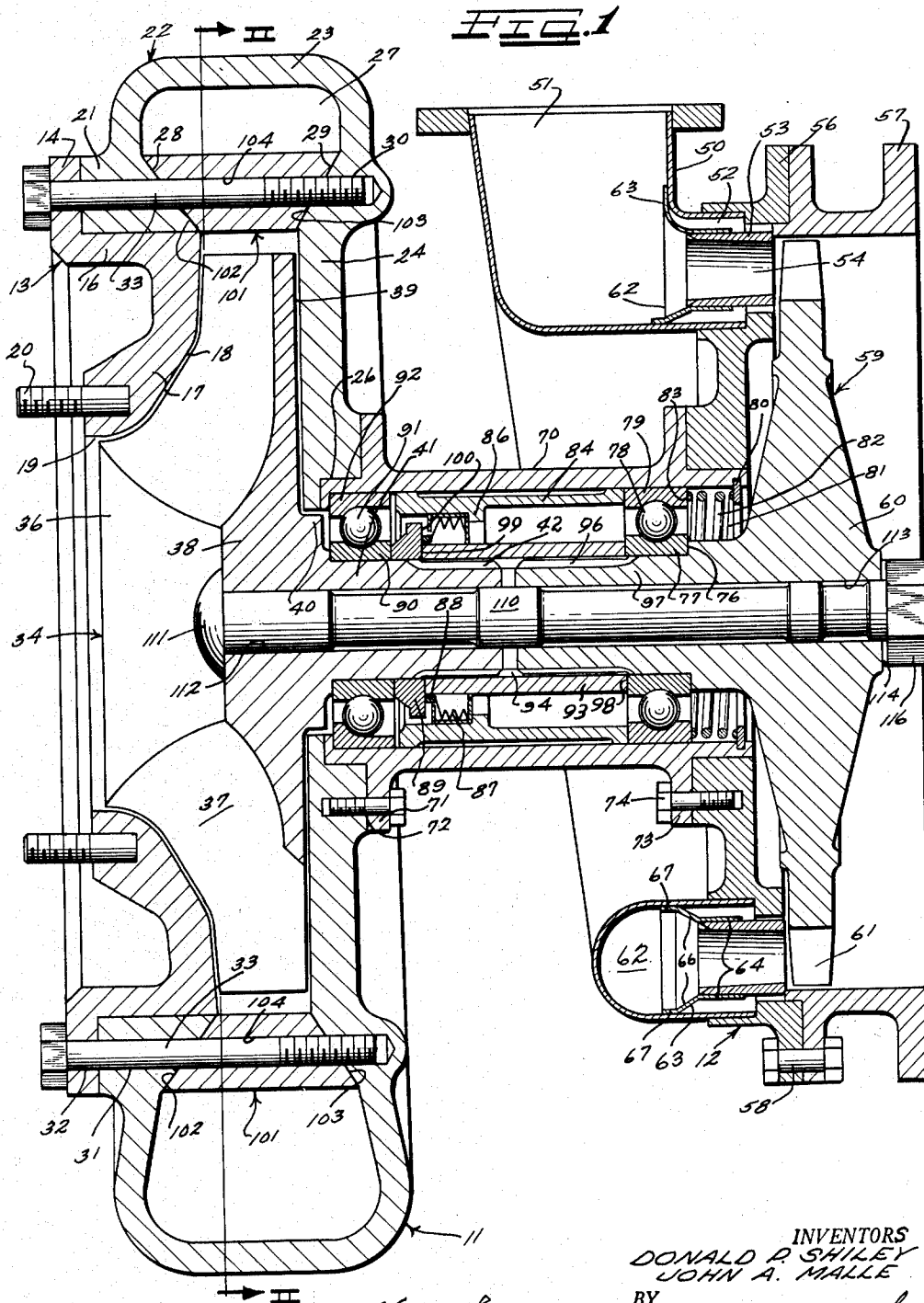
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LIQUID HYDROGEN TURBOPUMP

Filed July 12, 1962

2 Sheets-Sheet 1



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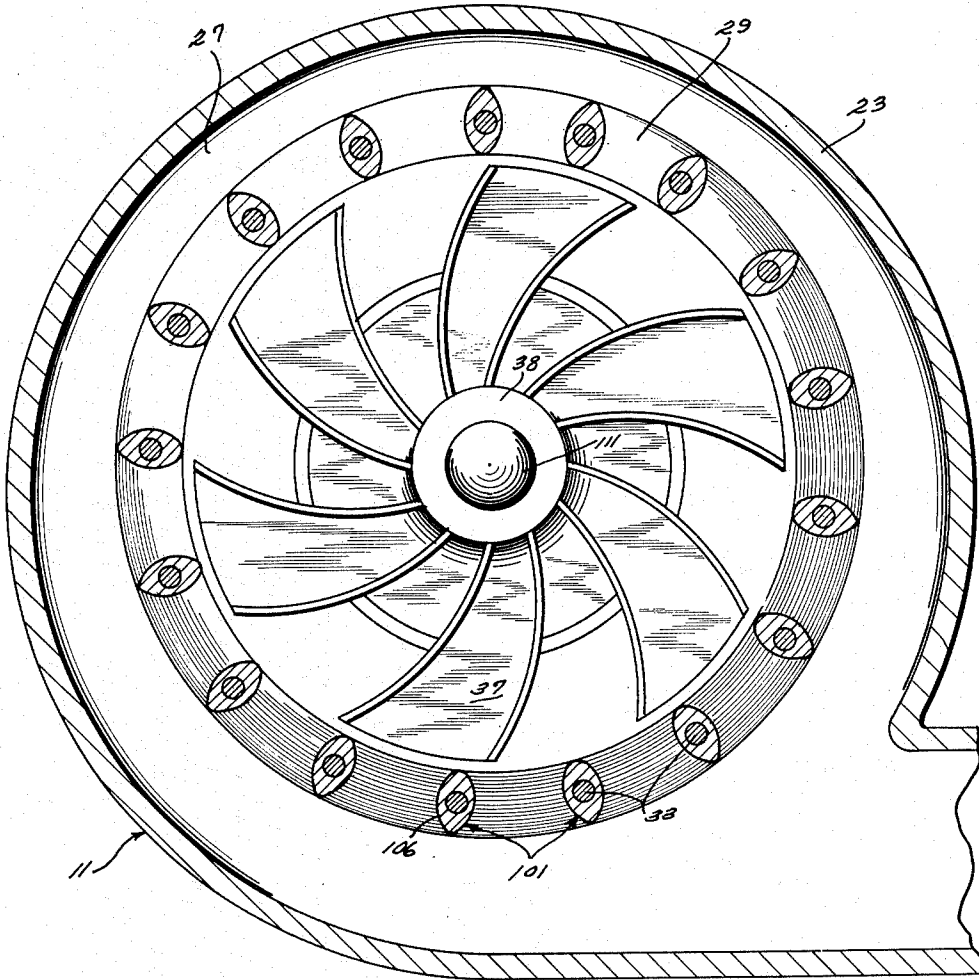
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FIG. 2



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LIQUID HYDROGEN TURBOPUMP

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This invention relates generally to pumping apparatus and more particularly relates to a turbine driven pump wherein the turbine includes a nozzle plate support which accommodates radial expansions and contractions and the pump is characterized by the utilization of diffuser insert vanes cooperating with supporting bolts to reduce the hoop stretch effect on the pump casing.

It is an object of the present invention to provide an improved turbine driven pump construction.

Yet another object of the present invention is to provide a pump construction driven by an axial flow turbine wherein a nozzle plate support is provided which accommodates radial expansions and contractions.

Another object of the present invention is to provide a turbine driven pump wherein the turbine hub and the pump impeller hub are interconnected by a spacer sleeve disposed between the races of a ball bearing assembly for each respective hub and wherein a special sealing means is provided to accommodate expansion and contraction between relatively movable parts.

A still further object of the present invention is to provide a pump construction wherein a center inlet impeller having radial pumping passages discharges through a diffuser section characterized by diffuser insert vanes each associated with a supporting bolt, thereby to cut down the hoop stretch effect on the pump casing.

Yet another object of the present invention is to provide a radial pump construction having diffuser insert vanes associated with supporting bolts, each diffuser vane and the casing having wedging surfaces disposed therebetween to assist in reducing the hoop stretch effect on the pump casing.

Many other features, advantages and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings in which a preferred structural embodiment of a turbine driven pump is shown by way of illustrative example.

As shown on the drawings:

FIGURE 1 is a cross-sectional view of a turbine driven pump provided in accordance with the principles of the present invention; and

FIGURE 2 is an irregular cross-section taken generally on line II—II of FIGURE 1 and showing additional details of construction of the pump.

As shown on the drawings:

The turbine driven pump of the present invention is shown generally at 10 and comprises a radial pump shown generally at 11 and a driving turbine shown generally at 12.

Referring more specifically to the pump 11, it will be noted there is provided a first casing part 13 having a radial flange 14, an axial body portion 16 and a generally radially extending irregularly shaped portion shown at 17 having an inner surface 18 which forms the contour of a pumping chamber.

The radially inwardly extending portion 17 terminates in an inlet opening 19 which is surrounded by a plurality of circumferentially spaced studs 20, thereby to facilitate connection of the pump to a source of supply.

The radial flange 14 and the axially extending portion

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16 together form a recess receiving a first portion 21 of a second casing part shown generally at 22. The second casing part 22 has an axially extending portion 23 and a second radially inwardly extending portion 24 terminating in a recessed end 26. The radially inwardly extending portion 21 is spaced axially from the radially inwardly extending portion 24, thereby to form a volute 27. There is also formed a diffuser section which is particularly characterized by outwardly divergent walls provided as shown at 28 on the radially inwardly extending part 21 and at 29 on the radially inwardly extending part 24.

The radial wall 24 is formed with threaded recesses as at 30 and the radially inwardly extending part 21 is provided with a corresponding plurality of through openings 31 as is the flange 14 as shown at 32, thereby to pass a corresponding plurality of fastening bolts 33.

Rotatable within the pumping chamber is an impeller shown generally at 34 and including a center inlet 36 and a plurality of radial pumping passages 37. The impeller 34 has a hub 38 formed with a back face 39. A stepped shoulder 40 is formed on the back face 39 and a reduced section 41 extends axially away from the stepped shoulder 40. The reduced section 41 is provided with external splines as at 42.

Referring now to the turbine 12, there is provided a first casing part 50 having an inlet 51 adapted to be connected to a suitable source of driving medium such as air, gaseous hydrogen or any available gas source. The casing 50 has an annular discharge portion 52 in which is positioned a nozzle ring 53 comprising a plate in the form of an annulus and having a plurality of axially extending nozzle openings 54 extending therethrough.

Casing parts 56 and 57 are connected together by a plurality of fastening means 58 and provide an expansion chamber in which is rotated a turbine wheel shown generally at 59. The turbine wheel 59 has a hub 60 and peripheral turbine blades shown at 61 disposed in register with the corresponding nozzle openings 54.

In accordance with the principles of the present invention, the nozzle ring 53 is supported by nozzle plate support means which accommodate radial expansions and contractions. Thus, there is provided inner and outer ring members shown generally at 62 and 63, respectively. Each ring member 62 and 63 includes a first portion 64 which engages a corresponding inner or outer surface of the nozzle ring 53 and each further has a medial portion 66 which extends radially and axially. An outside portion 67 on each inner and outer ring 62 and 63 engages an adjoining wall of the casing 50. Thus, the nozzle ring 53 is supported in proper register with the turbine vane 61, while fully facilitating the accommodation of radial expansions and contractions.

Interconnecting the casing part 56 and the casing part 22, there is provided a bearing housing 70 flanged as at 71 to accommodate passage of a plurality of circumferentially spaced fasteners 72, thereby placing the bearing housing 70 in firm assembly with the casing part 22 of the pump 11. The bearing housing 70 is similarly flanged as at 73 to accommodate a plurality of fastening bolts 74 placing the bearing housing 70 in firm assembly with the casing part 56 of the turbine 12.

The turbine hub 60 has a stepped shoulder 76 formed thereon against which abuts a race ring 77 of a bearing assembly which includes a plurality of circumferentially spaced shiftable members such as balls 78 and an outer race ring 79 engaged against the walls of the bearing housing 70.

The bearing housing 70 carries a snap ring 80 which bottoms one end 81 of a coil spring 82, the opposite end of which is engaged as at 83 against one side of the outer race ring 79. The other side of the outer race

ring 79 engages against an outer spacer sleeve 84 suitably flanged as at 86 to shoulder and retain a diaphragm seal shown generally at 87 and characterized principally by a seal ring 88 which engages against a seal nose ring 89 carried on the reduced section 41 of the impeller hub 38. Immediately adjacent the seal nose ring 89 there is a race ring 90 of a bearing assembly which includes a plurality of circumferentially spaced shiftable members such as balls 91 and an outer race ring 92. Disposed between the seal nose ring 89 and the inner race ring 77, there is provided a spacer sleeve 93 which has internal splines as at 94, thereby to facilitate splined connection to the external splines 42 formed on the hub 38 of the pump impeller and with the external splines 96 formed on a reduced section 97 extending axially into the bearing housing 70 from the hub 60 of the turbine 59.

One end of the spacer sleeve 93 engages the race ring 77 as at 98, while the opposite end of the spacer sleeve engages the nose ring 89 as at 99. Accordingly, the race rings 90 and 77 and the nose ring 99 as well as the spacer sleeve 93 all rotate with the pump hub 38 and the turbine hub 60. Further, the seal ring 88 engages against the sealing surface 100 formed on the nose ring 89 because the outer spacer sleeve 84 is retained in assembly with the bearing housing 70.

In accordance with the principles of the present invention, diffuser blades are inserted into the diffuser zone radially outwardly of the pumping passages 37 of the pumping impeller 34. It will be noted that each diffuser vane is indicated generally at 101 and includes tapered wall portions as at 102 and 103 which are complementary in shape to the adjoining tapered walls 28 and 29 of the casing part 23.

Further, each diffuser vane 101 is apertured with a through opening as at 104, thereby to pass a corresponding fastener bolt 33 therethrough. As shown in FIGURE 2, each diffuser vane 101 has a characteristic vane shape on its outer peripheral surface as shown at 106. By virtue of the arrangement shown, the supporting bolts 33 combined with the diffuser vane insert arrangement cuts down the hoop stretch effect on the pump casing.

To further insure corotation of the pump impeller 34 and the turbine wheel 59, a fastening means is extended through the hub portions 38 and 60, respectively. Thus, it will be noted there is a bolt-like member 110 having a head 111 which engages the edges of an opening 112 extending through the hub 38 and through an opening 113 in the hub 60. A lock washer 114 is engaged on the bolt 110 and a nut 116 is threaded onto the protruding end, thereby to lock the impeller and turbine wheel in corotatable assembly with one another.

The bolt 110 is formed with spaced bearing portions and recess portions to facilitate proper support of the hubs 38 and 60.

Although minor modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. In a turbine, an annular nozzle ring having a circumferential row of nozzle openings extending axially therethrough, an axial flow turbine wheel having turbine vanes in register with said nozzle openings, and a nozzle ring support comprising a ring having inner and outer radially spaced axially extending walls engaging said nozzle ring and an adjoining casing wall, said inner and outer radially spaced axially extending walls being interconnected by a portion accommodating radial expansions and contractions while supporting the nozzle ring with the openings in register with the turbine vanes.

2. In a turbine, a casing having a chamber formed therein, a nozzle ring in said chamber having a plurality of circumferentially spaced openings, and a support ring including a first axially extending portion engaging and

supporting said nozzle ring, a second portion extending axially and radially outwardly of said nozzle ring and a third axially extending portion engaging an adjoining wall of said casing, thereby to accommodate radial expansions and contractions while retaining the nozzle ring openings in proper axial alignment.

3. A turbine driven pump comprising a casing having a pumping chamber with an inlet and an outlet, a rotary fluid displacement means rotatable in said pumping chamber to move fluid from the inlet to the outlet, a shaft connected to said rotary fluid displacement means, a turbine wheel on said shaft having a row of vanes, a nozzle ring in register with said vanes, and a nozzle ring support comprising a support ring including a first axially extending portion engaging and supporting said nozzle ring, a second portion extending axially and radially outwardly of said nozzle ring and a third axially extending portion engaging an adjoining wall of said casing, thereby to accommodate radial expansions and contractions while retaining the nozzle ring in axial registry with the vanes.

4. In a pump, a casing having a pumping chamber formed therein including a volute spaced radially outwardly thereof and an intermediate diffuser portion, said diffuser portion having axially spaced walls disposed in outwardly divergent relation with respect to one another, and a plurality of diffuser vanes in said diffuser portion spaced circumferentially from each other and each including correspondingly tapered wall portions for engaging said walls, and a corresponding plurality of screw-threaded bolt fastener means each extending through a corresponding one of said diffuser vanes and threadedly engaged with the casing, thereby to cut down hoop stress on the pump casing.

5. A pump comprising an impeller having a center inlet and radial pumping passages, first and second casing parts together forming a diffuser vane section radially outwardly of said radial pumping passages and a volute pumping chamber in which said impeller is rotated, a plurality of fastener bolts extending through and threadedly engaged with said casing parts at said diffuser vane section, a corresponding plurality of diffuser vanes each intersected by a corresponding fastener bolt, and tapered wedging surfaces formed between each said vane and the adjoining casing walls wedging together when said fastener bolts are drawn up, thereby to cut down hoop stress in the casing.

6. In a pump comprising a driving motor and a rotary fluid displacement means each having hub members separated from one another, the improvement of a bearing assembly for each hub member, each bearing assembly comprising an inner race ring for a corresponding hub member, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, and coupling connections between said hubs and said spacer sleeve interconnecting said hubs for corotation.

7. In a pump comprising a driver motor and a rotary fluid displacement means each having separate hub members interconnected for unison rotation, the improvement of a bearing assembly for each hub members, each comprising an inner race ring for a corresponding hub member, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, said spacer sleeve being splined to each of said hubs, thereby to assist in interconnecting said hubs for unison rotation.

8. A pump comprising a driving motor and a rotary fluid displacement means each having separate hub members interconnected for unison rotation, a casing for said pump providing an inlet and an outlet and a pumping

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chamber in which said rotary fluid displacement means is rotated to move fluid from said inlet to said outlet, a bearing assembly for each hub member each comprising an inner race ring for a corresponding hub member, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, an outer race ring for each bearing assembly in said casing, a spring-pressed seal ring engaging said seal nose ring, an outer spacer sleeve carrying said spring-pressed seal ring, one end of said outer spacer sleeve engaged against one of said outer race rings on one side thereof, a continuous biasing means engaged against said one of said outer race rings on the opposite side thereof, and shoulder means on said casing bottoming the continuous biasing means, thereby to assist in preloading the bearing assembly.

9. A pump comprising a centrifugal impeller having a center inlet and radial pumping passages and a turbine wheel, said impeller and said turbine wheel each having separate hub members, a bearing assembly for each hub member comprising inner race rings for corresponding hub members, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, coupling connections between said hubs and said spacer sleeve interconnecting said hubs in corotatable assembly, a casing for said pump, an outer race ring for each bearing assembly mounted in said casing, a spring-pressed seal ring engaging against said seal nose ring, an outer spacer sleeve carrying said spring-pressed seal ring, one end of said outer spacer sleeve engaged against one of said outer race rings on one side thereof, a continuous biasing means engaged against said one of said outer race rings on the opposite side thereof, and shoulder means on said casing bottoming the continuous biasing means.

10. A pump comprising a centrifugal impeller having a center inlet and radial pumping passages and a turbine wheel, said impeller and said turbine wheel each having separate hub members, a bearing assembly for each hub member comprising inner race rings for corresponding hub members, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, coupling connections between said hubs and said spacer sleeves, a casing for said pump, an outer race ring for each bearing assembly mounted in said casing, a spring-pressed seal ring engaging against said seal nose ring, an outer spacer sleeve carrying said spring-pressed seal ring, one end of said outer spacer sleeve engaged against one of said outer race rings on one side thereof, a continuous biasing means engaged against said one of said outer race rings on the opposite side thereof, and shoulder means on said casing bottoming the continuous biasing means, said casing having a chamber formed therein adapted to be connected to a source of pressurized fluid, a nozzle ring in said chamber having a plurality of circumferentially spaced nozzle openings, said turbine wheel having turbine blades in register with said nozzle openings, and a support means for carrying said nozzle ring in said chamber, said support means including a ring-like member having a first axially extending portion engaging and supporting said nozzle ring, a second portion extending axially and radially outwardly of said nozzle ring and a third axially extending portion engaging an adjoining casing wall, thereby to accommodate radial expansions and contractions.

11. A pump comprising a centrifugal impeller having a center inlet and radial pumping passages and a turbine wheel, said impeller and said turbine wheel each having separate hub members, a bearing assembly for each hub

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member comprising inner race rings for corresponding hub members, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, coupling connections between said hubs and said spacer sleeves, a casing for said pump, an outer race ring for each bearing assembly mounted in said casing, a spring-pressed seal ring engaging against said seal nose ring, an outer spacer sleeve carrying said spring-pressed seal ring, one end of said outer spacer sleeve engaged against one of said outer race rings on one side thereof, a continuous biasing means engaged against said one of said outer race rings on the opposite side thereof, and shoulder means on said casing bottoming the continuous biasing means, said casing having a chamber formed therein adapted to be connected to a source of pressurized fluid, a nozzle ring in said chamber having a plurality of circumferentially spaced nozzle openings, said turbine wheel having turbine blades in register with said nozzle openings, and a support means for carrying said nozzle ring in said chamber, said support means including a ring-like member having a first axially extending portion engaging and supporting said nozzle ring, a second portion extending axially and radially outwardly of said nozzle ring and a third axially extending portion engaging an adjoining casing wall, thereby to accommodate radial expansions and contractions, said pumping chamber of said pump including a volute spaced radially outwardly of the radial pumping passages and an intermediate diffuser portion disposed between the volute and the radial pumping passages, said diffuser portion having axially spaced walls diverging outwardly, and a plurality of diffuser vanes in said diffuser portion spaced circumferentially and each including tapered walls for engaging said wall portions.

12. A pump comprising a centrifugal impeller having a center inlet and radial pumping passages and a turbine wheel, said impeller and said turbine wheel each having separate hub members, a bearing assembly for each hub member comprising inner race rings for corresponding hub members, a seal nose ring on one of said hub members and engaging the corresponding inner race ring, a bearing spacer sleeve engaged at one end against said seal nose ring and engaged at its opposite end against the other inner race ring, coupling connections between said hubs and said spacer sleeves, a casing for said pump, an outer race ring for each bearing assembly mounted in said casing, a spring-pressed seal ring engaging against said seal nose ring, an outer spacer sleeve carrying said spring-pressed seal ring, one end of said outer spacer sleeve engaged against one of said outer race rings on one side thereof, a continuous biasing means engaged against said one of said outer race rings on the opposite side thereof, and shoulder means on said casing bottoming the continuous biasing means, said casing having a chamber formed therein adapted to be connected to a source of pressurized fluid, a nozzle ring in said chamber having a plurality of circumferentially spaced nozzle openings, said turbine wheel having turbine blades in register with said nozzle openings, and a support means for carrying said nozzle ring in said chamber, said support means including a ring-like member having a first axially extending portion engaging and supporting said nozzle ring, a second portion extending axially and radially outwardly of said nozzle ring and a third axially extending portion engaging an adjoining casing wall, thereby to accommodate radial expansions and contractions, said pumping chamber of said pump including a volute spaced radially outwardly of the radial pumping passages and an intermediate diffuser portion disposed between the volute and the radial pumping passages, said diffuser portion having axially spaced walls diverging outwardly, and a plurality of diffuser vanes in said diffuser portion spaced circumferentially and each including tapered walls for engaging

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said wall portions, and a bolt fastener extending through each respective diffuser vane for connection to the casing, thereby to cut down hoop stress in the casing.

13. In a turbine having a casing and turbine vanes in said casing,

an annular nozzle ring,
and a nozzle ring support to retain the nozzle ring in said casing in proper axial registry with the turbine vanes while accommodating radial expansions and contractions comprising

inner and outer support rings,
each including a first portion engaging a corresponding inner or outer surface of said nozzle ring,

a medial portion extending axially and radially with respect to said nozzle ring and an

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outer portion for engaging an adjoining wall of said casing.

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