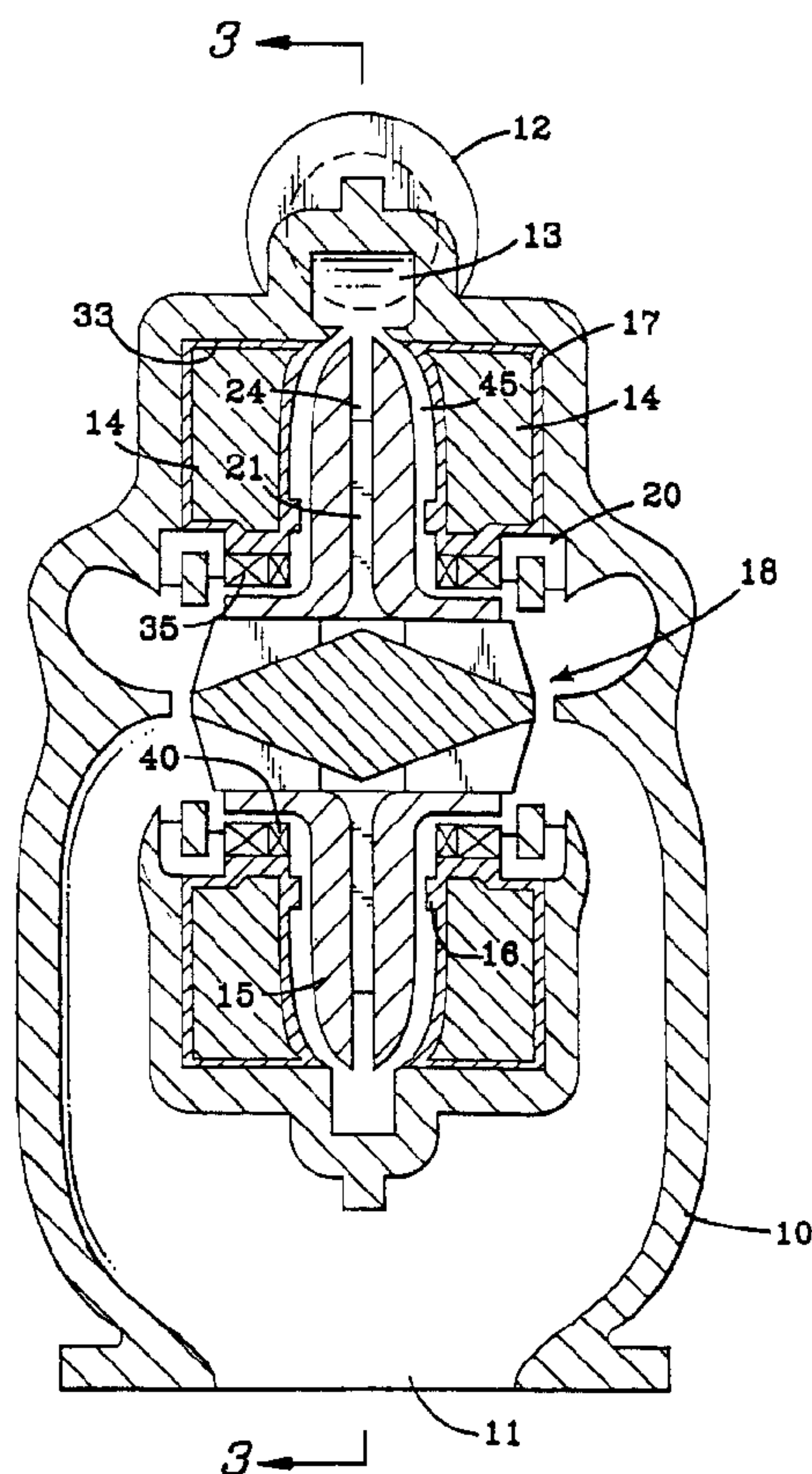




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(54) Titre : ENSEMBLE MOTEUR ET POMPE CENTRIFUGE
 (54) Title: INTEGRATED CENTRIFUGAL PUMP AND MOTOR



(57) Abrégé/Abstract:

An integrated centrifugal pump and motor is provided by an impeller disk which contains permanent magnets and functions as the rotor for a brushless DC motor. The rotor is supported by non-contacting radial bearings and is hydrodynamically balanced against any axial thrust so that there is no contact between rotating and stationary elements during operation. Since the impeller disk is also the motor rotor, there is no need for a shaft, in the ordinary sense, which would penetrate the case and, thus, require seals. The resulting pump is compact and can be operated electronically at variable speeds.



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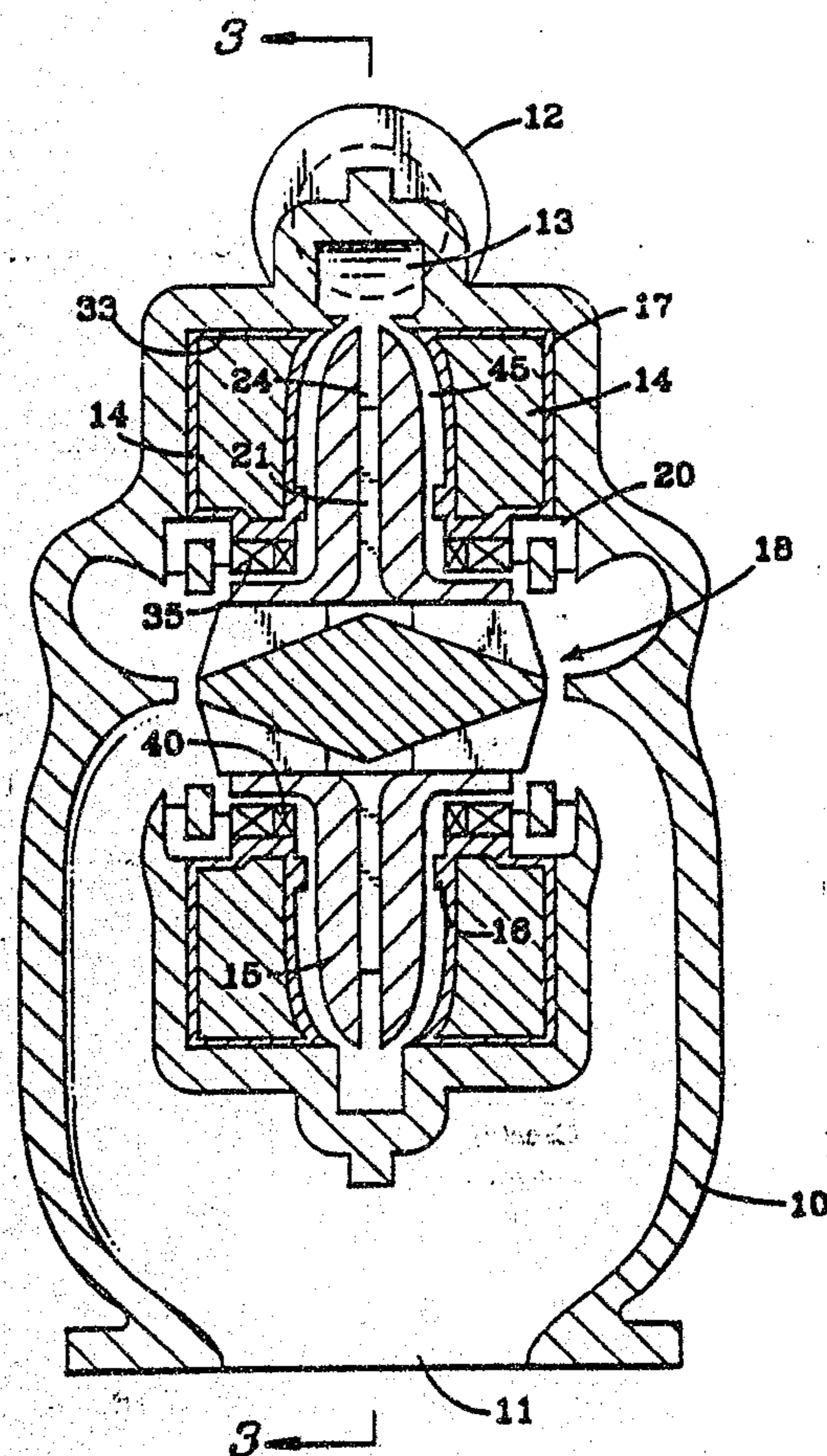
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(54) Title: INTEGRATED CENTRIFUGAL PUMP AND MOTOR

(57) Abstract

An integrated centrifugal pump and motor is provided by an impeller disk which contains permanent magnets and functions as the rotor for a brushless DC motor. The rotor is supported by non-contacting radial bearings and is hydrodynamically balanced against any axial thrust so that there is no contact between rotating and stationary elements during operation. Since the impeller disk is also the motor rotor, there is no need for a shaft, in the ordinary sense, which would penetrate the case and, thus, require seals. The resulting pump is compact and can be operated electronically at variable speeds.



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INTEGRATED CENTRIFUGAL PUMP AND MOTOR

This invention relates generally to centrifugal pumps and more particularly to electrically driven centrifugal pumps
5 which require no shaft seals.

Centrifugal fluid pumps are well known in the hydraulic and pneumatic fields. They commonly consist of a motor to drive a shaft on which a fluid impeller is mounted. Generally,
10 the fluid inlet port, or suction port, feeds fluid to the centre, or hub, of the impeller. A number of impeller vanes generally project outward from the hub in spiral paths and are supported between shrouds which, together with the vanes, define pumping channels. The rotor is encased in a
15 housing which channels the working fluid from the inlet port to the hub, or inducer, where it is inducted into the pumping channels between the vanes and shrouds. The centrifugal action of the impeller drives the working fluid outward to a diffuser at the periphery of the impeller disc
20 where it enters a scroll shaped volute and, from there, is channelled to the discharge port of the pump.

The motor shaft, which supports the impeller, requires bearings which are sometimes lubricated by the working
25 fluid, but, in many cases, they require separate lubrication due to incompatibility of the working fluid. In all cases, seals are required to prevent leakage of the working fluid around the impeller shaft where it enters the pump housing. After some time in service, the bearings may deteriorate to
30 the point where they permit some radial displacement of the rotating shaft. This causes accelerated wear and deterioration of the shaft seal and results in leakage of the working fluid from the pump housing.

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FR-A-591,315 discloses a balancing device for centrifugal pumps which comprises two balancing chambers formed on either side of the cheeks of an impeller and interconnected by a duct. If e.g. as a result of inequalities in the plays
5 existing on either side of the impeller, different pressures become established in the balancing chambers. Fluid thus flows through the duct to restore the equilibrium of the pressures.

According to a broad aspect of the present
10 invention there is provided a centrifugal pump comprising a housing having an internal chamber with inlet and discharge ports. An impeller having a hub section is supported in the chamber for rotation about an axis to pump a working fluid. The impeller has a central opening, first and second disk
15 shaped shrouds supported from the hub section, at least one of the shrouds containing permanent magnets, and a plurality of pumping channels defined by a plurality of impeller blades projecting outwardly from the hub section in a common plane between the first and second shrouds so as to rotate
20 in the common plane normal to the said axis. At least one motor stator coil is provided for rotatably driving the impeller. The stator coil is disposed adjacent the at least one shroud containing the permanent magnets, so as to form a gap between the stator coil and the shroud. The gap
25 receives a small quantity of pumped working fluid. The stator coil further has a central opening therein with the working fluid passing through the impeller central opening and through the stator coil central opening. Means is provided for axial hydrodynamic balancing of the impeller.
30 This means comprises a ring disposed in the gap for restricting the flow of the small quantity of pumped working fluid. Means is provided for inducing flow of working fluid toward the pumping channels from opposite directions. The said means for inducing flow comprises an opening between
35 the hub section and each of the first and second shrouds and

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an inducer in each of the openings. The inducer comprises a pumping member which is separate from the impeller. A recirculation passage is provided adjacent each inducer.

According to a still further broad aspect of the present invention there is provided a centrifugal pump which
5 comprises a housing having an internal chamber with inlet and discharge ports. An impeller is supported in the chamber for rotation about an axis. The impeller has a hub section. At least a first disc shaped shroud (is also
10 provided and contains permanent magnets. At least a first stator coil is provided adjacent the permanent magnets. A plurality of pumping channels are defined by a plurality of impeller blades projecting outwardly from the hub section and fixed to a face of the shroud. Means is provided for
15 supplying fluid to the pumping channels and comprises at least a first central opening between the hub section and the shroud. The centrifugal pump is characterised by at least a first inducer in the opening and comprising a first flow directing pumping member which is separate from the
20 impeller blades. A recirculation passage is provided adjacent the or each inducer.

According to a still further broad aspect of the present invention there is provided a centrifugal pump which comprises a housing having an internal chamber connecting
25 inlet and discharge ports. A disc shaped impeller having permanent magnets disposed therein is supported within the chamber for rotation about an axis to pump a working fluid. A motor stator coil is provided for rotatably driving the impeller. The stator coil is disposed at a side of the
30 impeller so as to form a gap between the stator coil and the impeller for receiving a small quantity of pump working fluid. The centrifugal pump is characterised by a means for axial hydrodynamic balancing of the impeller and comprising a ring disposed in the gap for restricting flow of the small
35 quantity of pumped working fluid therethrough.

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For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

5 Figure 1 is a schematic sectional elevation view illustrating one embodiment of a centrifugal pump;

 Figure 2 is a schematic sectional elevation view of another embodiment of the pump; and

10 Figure 3 is a fragmentary view along line 3-3 of the pump shown in Figure 1.

DETAILED DESCRIPTION

Fig. 1 is a schematic cross sectional view of one embodiment of the pump of the present invention, which is seen to be laterally symmetrical about the vertical center plane represented by the centerline of Fig. 1. The housing 10 has an inlet port 11 and a discharge port 12 which are connected by means of inducer assembly 18, impeller shrouds 15, rotating vaneless diffuser 24, and volute 13. The pump fluid enters at the inlet port 11; divides and passes into the two sides of the inducer assembly 18; passes between the two impeller shrouds 15 through pumping channels 55 (shown in Fig. 3) which are defined by the spaces between neighboring impeller blades 21 and the impeller shrouds 15, between which the impeller blades 21 are disposed; passes through the rotating vaneless diffuser 24; then passes through the volute 13 and into discharge port 12. Between diffuser 24 and volute 13 a small amount of the high pressure fluid feeds back through axial thrust balance passages 45. These narrow passages provide the gap necessary for rotation of the rotor shrouds 15 between the stators 14 and, by admission of the feedback fluid, provide a hydrodynamic balance to counteract any axial thrusts of the rotor 15 so that it remains centered between stators 14. Axial thrust balancing rings 16 are provided in the balance passage 45 either on the surface of the stator can 17 or on a projection of housing 10. By narrowing the axial gap between the impeller shrouds 15 and stator cans 17 or housing 10, these rings cause an increase of fluid pressure in the balance passage 45 which enhances the axial thrust balance performance.

The alternative provided for placement of the axial thrust balancing rings 16 is required because, in some cases, stators 14 will not be canned or encapsulated. In such cases, it is necessary to place the axial thrust balancing rings 16 on projections of housing 10. Each half

of housing 10 has a toroidal recess 33 in which a stator 14 is secured. In addition, recirculation passages 20 are provided to assure smooth inducer action at off-design flow rates.

The rotor assembly which includes inducer assembly 18, shrouds 15, impeller blades 21, and rotating diffuser 24 is supported on journals provided on the outside of the tubular axial extensions of shrouds 15 in radial magnetic bearings 35 and auxiliary bearings 40. During operation, the rotor is supported by the radial magnetic bearings 35 which have a large enough clearance to provide non-contact bearing support to the rotor. Should the magnetic bearings 35 fail to support the rotor, auxiliary bearings 40 are provided for the ensuing emergency rundown of the rotor only, and they have a smaller clearance than do magnetic bearings 35.

Impeller shrouds 15 each contain a peripheral array of permanent magnets required for a rotor in a brushless DC motor when used in conjunction with stators 14 containing the windings and electrical connections required for operation as a motor. Because impeller shrouds 15 contain permanent magnets, and because shrouds 15 are supported in radial magnetic bearings 35 and auxiliary bearings 40, there is no need for any shaft to penetrate the housing 10 and, thus, no need for rotary shaft seals which can cause wear of the shaft and will eventually leak.

Fig. 2 illustrates another embodiment of the pump of the present invention. In this case the housing 10 is composed of several sections, and it has two inlets 11. Otherwise, in all other respects, the pumps are functionally identical. For this reason, numbering of the various components has been retained consistent with that used in Fig. 1.

Fig. 3 shows a fragmentary schematic sectional view of the rotor and housing along line 3-3 of Fig. 1. Vanes 21 are attached to shroud 15. Inducer assembly 18 feeds fluid

to the impeller blades which pump it radially outward through pumping channels 55 defined by blades 21 and shrouds 15. Diffuser 24 is defined by that space between the two shrouds 15 radially outside that which is occupied by blades 21. Pressurized fluid from diffuser 24 is carried away through volute 13.

The particular design parameters for a given pumping application are determined by pressure and volume requirements, space constraints, working fluid properties, and desired orientation of inlet and discharge ports. These are the considerations that determine the diameter of the impeller shrouds 15, the spacing between the shrouds and consequently the width of the impeller blades 21, the size of diffuser 24 if needed, the size of inducer assembly 18, and the size and shape of the pump housing 10 and recirculation passages 20 which are provided to assure smooth inducer action at off-design flow rates. Stators 14 and impeller shrouds 15 are matched according to pumping power requirements. Stators 14 may or may not be encapsulated in cans 17, depending upon whether the working fluid is compatible with the stators.

This invention provides an integrated centrifugal pump and motor having the advantages of compactness, the ability to operate electronically at variable speeds, a shaftless rotor which requires no seals, non-contact radial bearing supports during operation, and hydrodynamic axial thrust balance for the rotor. These advantages are obtained when pumping either compressible or incompressible fluids.

CLAIMS:

1. A centrifugal pump comprising:
 - a housing (10) having an internal chamber with inlet (11) and discharge (12) ports:
 - an impeller having a hub section and supported in said chamber for rotation about an axis to pump a working fluid; said impeller having a central opening, first and second disk shaped shrouds (15) supported from said hub section, at least one of said shrouds containing permanent magnets, and a plurality of pumping channels (55) defined by a plurality of impeller blades (21) projecting outwardly from the hub section in a common plane between said first and second shrouds so as to rotate in said common plane normal to said axis;
 - at least one motor stator coil (14) for rotatably driving said impeller, said stator coil being disposed adjacent said at least one shroud (15) containing said permanent magnets, so as to form a gap between said stator coil and said shroud, the gap receiving a small quantity of pumped working fluid, the stator coil (14) further having a central opening (45) therein, the working fluid passing through the impeller central opening and through the stator coil central opening;
 - means for axial hydrodynamic balancing of said impeller, said means comprising a ring (16) disposed in said gap for restricting the flow of the small quantity of pumped working fluid;
 - means for inducing flow of working fluid toward the pumping channels from opposite directions, said means comprising an opening between the hub section and each of said first and second shrouds and an inducer in each said opening, the inducer comprising a pumping member which is separate from said impeller; and
 - a recirculation passage adjacent each said inducer.

2. A centrifugal pump comprising:
 - a housing (10) having an internal chamber with inlet (11) and discharge (12) ports;
 - an impeller supported in said chamber for rotation about an axis, the impeller having a hub section; at least a first disc shaped shroud (15) containing permanent magnets; at least a first stator coil 14 adjacent said permanent magnets; a plurality of pumping channels (55) defined by a plurality of impeller blades projecting outwardly from the hub section and fixed to a face of the shroud; and means for supplying fluid to the pumping channels, said means comprising at least a first central opening between the hub section and the shroud; characterised by at least a first inducer (18) in said opening, said inducer comprising a first flow directing pumping member which is separate from the impeller blades; and there being
 - a recirculation passage adjacent the inducer.
3. A centrifugal pump as claimed in claim 2, wherein said impeller includes a second disc shaped shroud (15), said impeller blades (21) being located between said first and second shrouds.
4. A centrifugal pump as claimed in claim 3, wherein said second disc shaped shroud (15) includes a plurality of permanent magnets and wherein a second stator coil (14) is disposed adjacent said second shroud.
5. A centrifugal pump as claimed in claim 4, wherein said second shroud has a second central opening coaxial with the central opening in said first shroud and said second stator coil has a further central opening therein, and second flow directing pumping member for directing fluid flow from said inlet port to said pumping channels (55) through the central openings in said second shroud and said second stator coil.

6. A centrifugal pump as claimed in claim 5, wherein said first and second flow directing pumping members include inducers (18) for inducing flow in one direction through the central opening in said first shroud and in the opposite direction through the central opening in said second shroud.

7. A centrifugal pump as claimed in claim 6, wherein said housing has first and second inlet ports and said first and second flow directing pumping members comprise means for inducing fluid flow from said first and second inlet ports respectively, through the central openings in said first and second shrouds, respectively.

8. A centrifugal pump as claimed in claim 5, 6 or 7, wherein said second flow directing pumping member comprises a volute (13), at least a portion of which is located within said internal chamber.

9. A centrifugal pump as claimed in claim 8, wherein said inlet and discharge ports, said volute and said pumping channels are located in a common plane.

10. A centrifugal pump as claimed in any one of claims 5 to 9, further comprising a second stator coil (14), wherein said first and second flow directing pumping members include first and second flow channels located between said housing and said stator coils, respectively.

11. A centrifugal pump as claimed in any one of claims 4 to 10, wherein the or each stator coil is encapsulated to prevent contact with the fluid.

12. A centrifugal pump comprising:
a housing (10) having an internal chamber connecting inlet (11) and discharge (12) ports;

a disc shaped impeller having permanent magnets disposed therein, said impeller being supported within said chamber for rotation about an axis to pump a working fluid;

5 a motor stator coil (14) for rotatably driving said impeller, said stator coil being disposed at a side of said impeller so as to form a gap between the stator coil and the impeller for receiving a small quantity of pumped working fluid; characterised by

10 a means for axial hydrodynamic balancing of said impeller, the means comprising a ring (16) disposed in said gap for restricting flow of the small quantity of pumped working fluid therethrough.

15 13. A centrifugal pump as claimed in claim 12 and further comprising a second motor stator coil and a second ring, said impeller being disposed between the first and second motor stator coils and said second ring being disposed in a second gap between said second motor stator coil and said impeller for restricting the flow of pumped working fluid
20 therethrough.

SUBSTITUTE SHEET

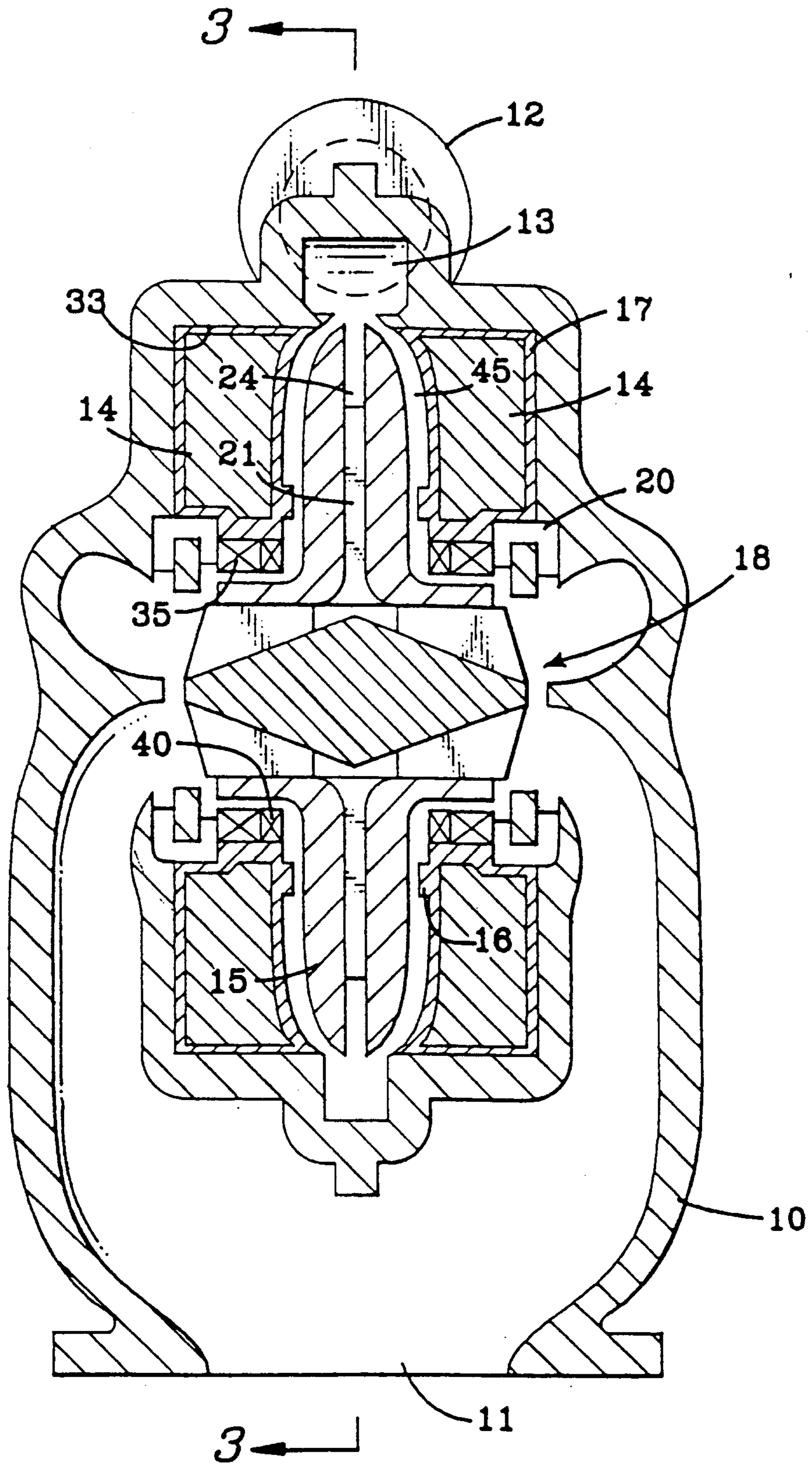


FIG. 1

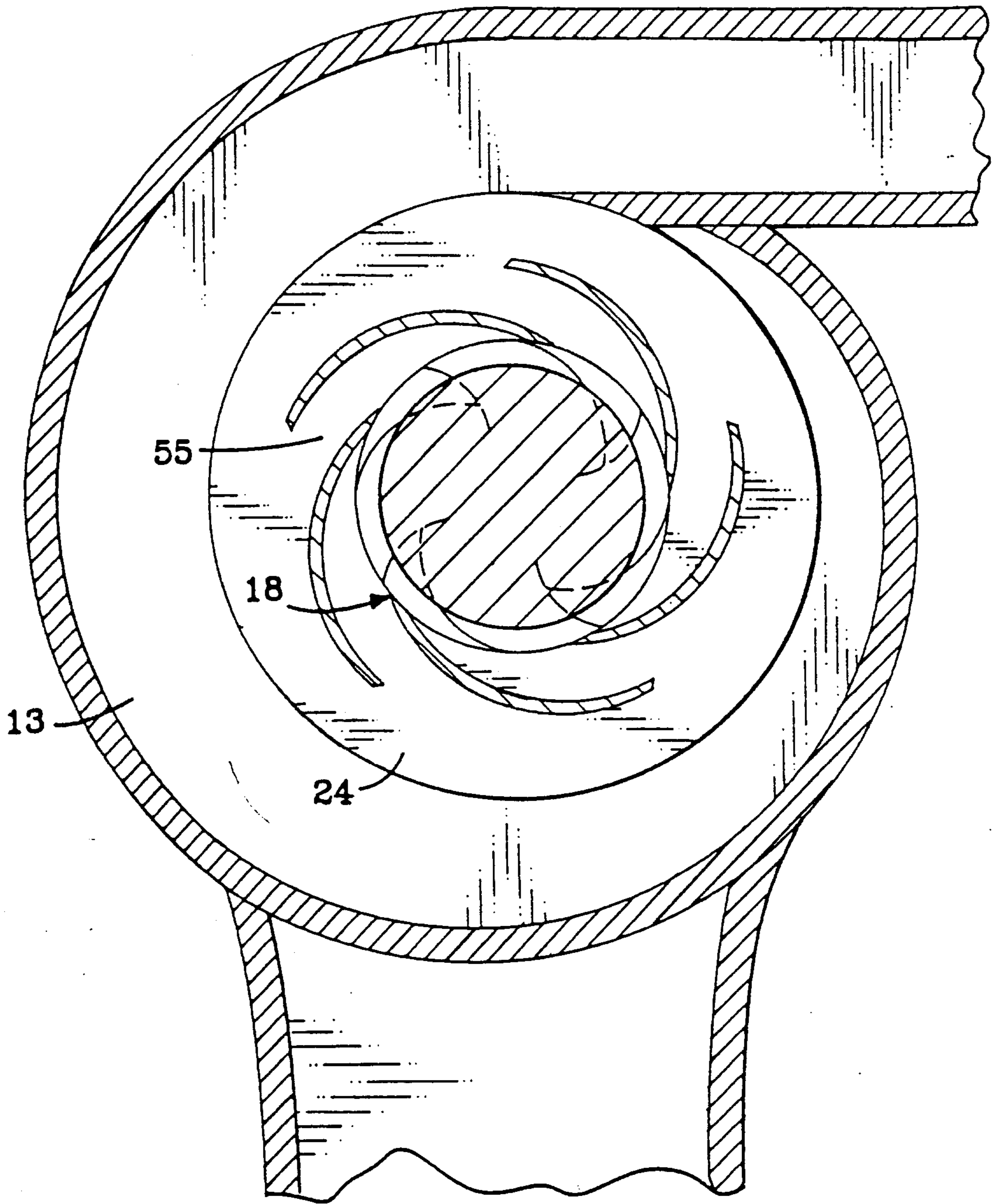


FIG. 3

