July 16, 1968 R. E. TAYLOR 3,392,675

CENTRIFUGAL PUMP

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FIG. 1

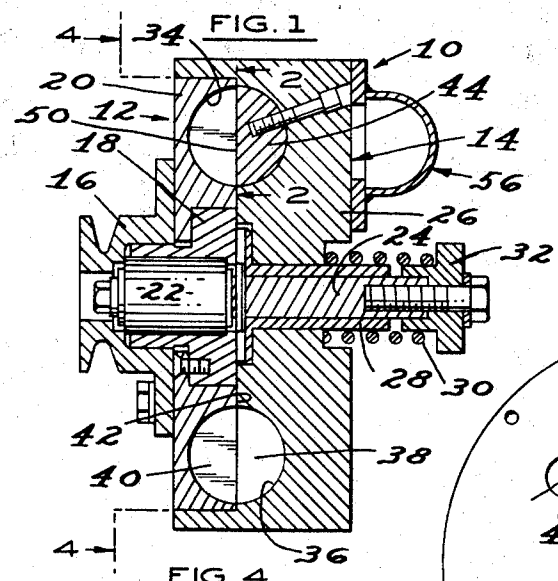

FIG. 5

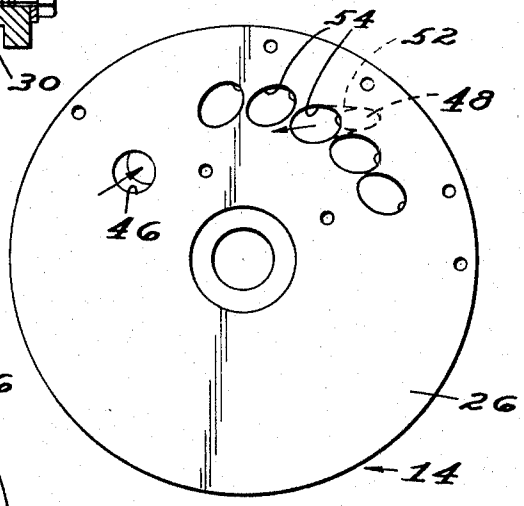

FIG. 4

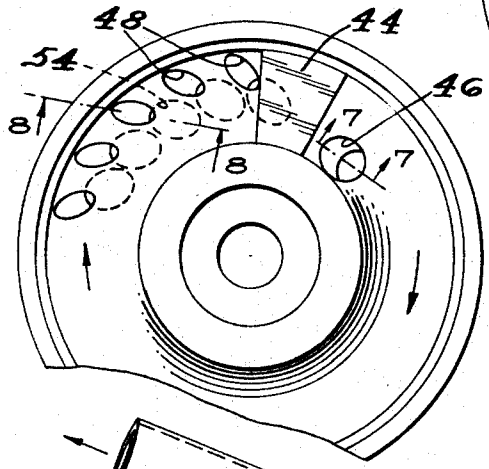

FIG. 7

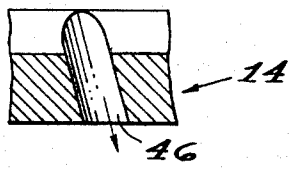

FIG. 8

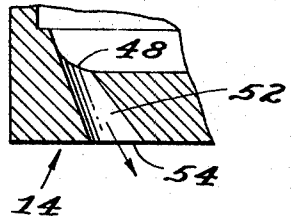

FIG. 6

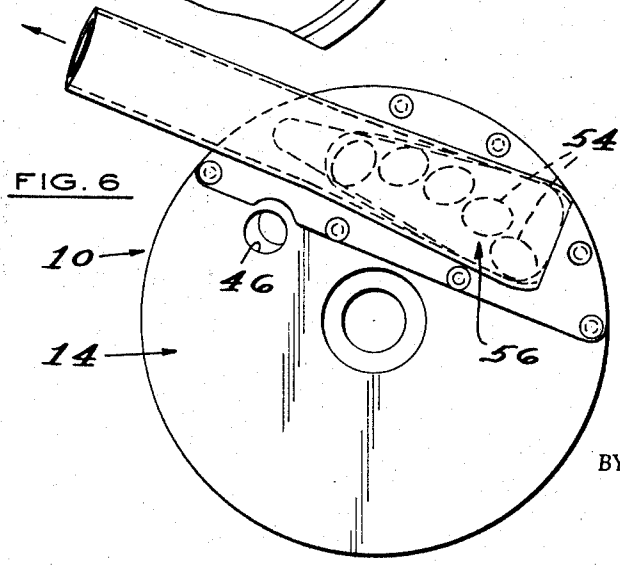

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FIG. 2

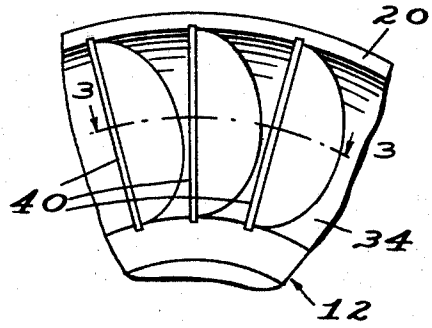


FIG. 3

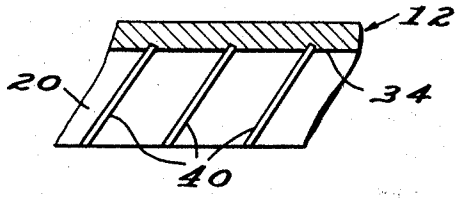


FIG. 9

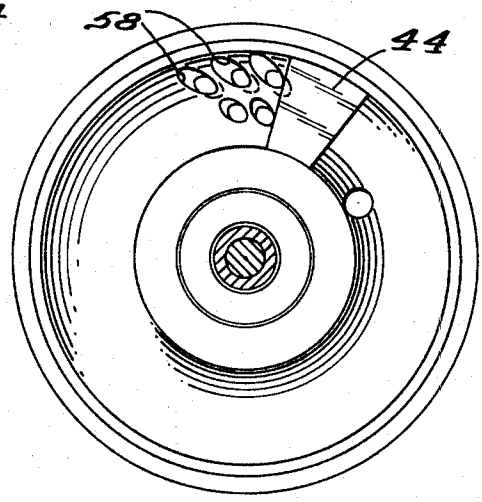


FIG. 10

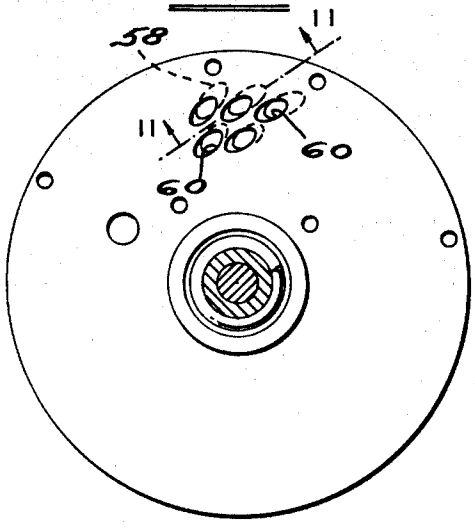
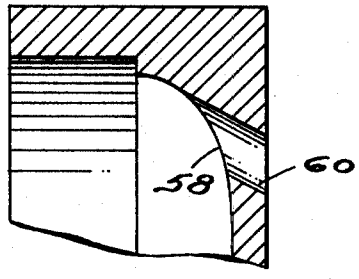


FIG. 11



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3,392,675

CENTRIFUGAL PUMP

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6 Claims. (Cl. 103—96)

ABSTRACT OF THE DISCLOSURE

A centrifugal type air pump having a toroidal air flow passage split along a plane normal to the axis of rotation, one-half containing blades and being rotatable, the other half being stationary and bladeless but containing a block seal that is slightly wider circumferentially than the space between rotor blades and separates the inlet and outlet passages as well as seals the space between rotor blades as they pass over the seal face, the air discharge outlets comprising a plurality of circumferentially spaced openings in different pressure zones of the pump all connected at all times to a common outlet manifold and each gradually increasing in cross-sectional area in a downstream or outlet direction.

This invention relates in general to a fluid pump. More particularly, it relates to a fluid pump of the centrifugal type that has specific exhaust porting for improving the volumetric efficiency over known constructions.

A centrifugal pump of the type in mind generally contains a toroidal-shaped cavity that is split in two along a plane normal to the axis of rotation. One-half of the torus contains blades and is rotatable, the other half being bladeless and held stationary. The stationary or stator half usually has a single fluid inlet and outlet located on opposite sides of a block seal or fluid abutment. The block seal normally is of a circumferential width slightly greater than the distance between rotor blades and has a radial surface that sealingly cooperates with the peripheral edges of the blades. This prevents the fluid contained in the stator half of the torus from flowing between the outlet and inlet when the blades pass over the abutment.

When the rotor portion is driven, fluid is drawn through the inlet into the rotor blade cavities, and, by centrifugal force, is thrown outwardly in the general direction of movement of the blades into the stator torus cavity. Due to the shape of the stator torus wall, the fluid is redirected back into the rotor blade cavities where additional energy is imparted to it. The repetition of this cycle several times per revolution establishes a helical spiral motion to the fluid during its circumferential progression around the torus. The fluid is then expelled out through the single outlet.

In general, most of the fluid outlets of the prior art devices of this type impart a substantial change to the direction of motion to the discharging fluid. The use of such a port in effect causes the fluid to pile up at the outlet, and produce back pressures and other losses that decrease the volumetric efficiency of the pump. Also, at certain speed levels, the use of a single outlet port of this type appears to cause harmonic vibrations that interfere with a smooth discharge of fluid. It will be clear, therefore, that the prior art constructions in general do not provide a high volumetric efficiency because of the losses inherent with their particular exhaust port constructions.

The invention eliminates the above disadvantages by providing exhaust porting consisting essentially of a plurality of either circular, elliptical or rectangular ports that are circumferentially spaced from each other; and, each of the ports is connected to passages that have a longitudinal axis that is substantially tangent to the helical

spiral motion of the medium being pumped at the point of entry into each port. The attitudes of the exhaust ports provides a minimum change in the direction of movement of the discharging fluid and therefore minimizes losses. The circumferential spacing eliminates the resonant condition associated with a single outlet port construction by progressively discharging the fluid through ports upstream of the block seal where the velocity energy is lower. Additionally, in the preferred embodiment, the exhaust passages gradually increase in cross-sectional area towards the discharge end so that a diffusion occurs and the fluid velocity energy is converted into pressure.

It is, therefore, a primary object of the invention to provide a fluid pump of the type described having a plurality of exhaust ports that are circumferentially spaced from the fluid abutment or block seal to increase the pump volumetric efficiency over the known devices of this general type.

It is another object of the invention to increase the volumetric efficiency of centrifugal-type pumps by providing exhaust porting that decreases the losses of the fluid as it is discharged from the pump.

It is a still further object of the invention to provide a centrifugal pump of the type described above in which a plurality of radially spaced sets of circumferentially spaced exhaust ports are provided.

Another object of the invention is to provide centrifugal pump exhaust porting consisting of circumferentially spaced exhaust diffusion passages that each gradually increase in cross-sectional area to convert the velocity energy to pressure, and in which each passage longitudinal axis is substantially tangent to the direction of movement of the entering fluid.

It is a still further object of the invention to provide a centrifugal pump exhaust port construction consisting of a plurality of circumferentially spaced exhaust passages that are each of a length several times the mean diameter of the passage; the cross-sectional area of each of the passages gradually increases in the fluid discharge direction to diffuse the fluid and convert the velocity energy to pressure; and, the passages each have a longitudinal axis that is substantially tangent to the helical spiral motion of the entering fluid being pumped.

Other objects, features and advantages of the invention will become apparent upon reference to the succeeding, detailed description thereof, and to the drawings illustrating the preferred embodiment thereof, wherein:

FIGURE 1 is a cross-sectional view of a centrifugal type fluid pump embodying the invention;

FIGURE 2 is an enlarged cross-sectional view of a detail of FIGURE 1 taken on the plane indicated by and viewed in the direction of the arrows 2—2 of FIGURE 1;

FIGURE 3 is a cross-sectional view taken on a plane indicated by and viewed in the direction of the arrows 3—3 of FIGURE 2;

FIGURE 4 is a cross-sectional view taken on a plane indicated by and viewed in the direction of the arrows 4—4 of FIGURE 1;

FIGURES 5 and 6 are rear-elevational views of the pump of FIGURE 1 as viewed from right to left of FIGURE 1, and showing in FIGURE 5, the stationary pump portion disassembled from the exhaust port manifolding, and in FIGURE 6, the two in an assembled condition;

FIGURES 7 and 8 are cross-sectional views of details taken on planes indicated by and viewed in the direction of the arrows 7—7 and 8—8 of FIGURE 4;

FIGURES 9 and 10 are views corresponding to those of FIGURES 4 and 5 illustrating a modification thereof; and,

FIGURE 11 is an enlarged cross-sectional view taken

on a plane indicated by and viewed in the direction of the arrows **11—11** of FIGURE 10.

FIGURE 1, which is essentially to scale, shows a centrifugal-type pump **10** consisting essentially of annular rotatable and stationary members **12** and **14** that are nested in a fluid sealing manner. Rotor member **12** is made up of three portions that are bolted or otherwise secured together: a driving pulley **16**, a flanged hub or sleeve **18**, and a radially extending torus shell member **20**. Sleeve **18** is journaled on the enlarged end **22** of a shaft **24** that extends axially to the right for support of the stator shell portion **26**. The stator shell **26** is essentially a thick plate or disc and is axially slidably mounted on a sleeve **28**. The sleeve is slidable axially on shaft **24**, and nonrotatably pinned to it, as shown. Stator **14** is biased toward rotor **12** by a spring **30** that abuts the stator hub at one end, as shown, and is seated at its opposite end against the flange of a retainer **32**. The retainer is axially adjustably secured to shaft **24**.

The construction described above permits axial movement of the stator shell **26** relative to rotor shell **20** when the internal pressure of the pump exceeds a predetermined level, as will be described in more detail later.

Turning now to the invention, the rotor and stator shells **20** and **26** are formed respectively with semi-toroidal-shaped cavities **34** and **36**. The cavities face each other and are substantially contiguous so as to form a toroidal chamber **38** for the circumferential flow of a fluid through it. As best seen in FIGURES 1, 2 and 3, rotor cavity **34** has a number of circumferentially spaced blades **40** that extend in the general direction of rotation of the rotor and are of an axial width to extend to the inner radial face **42** of rotor disc **20**.

Stator cavity **36**, on the other hand, is void of blades. As best seen in FIGURE 4, the stator cavity is provided with a single fluid abutment or block seal **44** that circumferentially separates a fluid inlet port **46** from a number of circumferentially spaced fluid outlet ports **48**. The block seal **44** is fixed to the stator, as seen in FIGURE 1, and is of a circumferential width that is slightly greater than the circumferential distance between rotor blades **40** (see FIGURES 2 and 3). Block seal **44** is of an axial thickness to fill up the stator cavity **36** at the point where it is located, and has an inner radial or face surface **50** in sealing relationship to the tips of rotor blades **40**. Surface **50** effectively seals the individual cavities between the rotor blades as the blades rotate between the last of the discharge ports **48** and inlet **46**. This thereby, insofar as the discharged fluid in the stator cavity is concerned, prevents a bypass of this fluid to inlet **46**.

In FIGURES 4 and 5, discharge ports **48** are shown as substantially elliptical in cross section, and are connected by tapered bores **52** (FIGURE 8) to outlet ports **54** on the back side of stator shell **26**. The tapered passages preferably are of a length several times the mean diameter of the passage. The passages **52** thus gradually increase in cross-sectional area to gradually diffuse the fluid as it leaves the toroidal cavity **38** of the pump, and thereby effect a conversion of velocity energy to pressure. As also seen in FIGURES 4 and 5, the outlet ports are spaced an equal distance apart circumferentially for more accurate control.

Each of passages **52** is so located and disposed that its longitudinal axis will be substantially tangent to the direction of motion of the fluid as it enters a particular port **48**. This results in a minimum reduction in the change in direction of the air and, therefore, causes a minimum loss of energy. The circumferential spacing of the outlet ports **48** permits shorter and smaller diameter ports, and eliminates the tendency of the fluid to pile up at the block seal **44**. It also eliminates the resonance condition associated with a single outlet port design by the progressive tapping off of fluid upstream where the velocity energy is lower.

FIGURE 6 shows a collecting manifold **56** that is bolted to the back of stator shell **26** over the discharge ports **54**.

In operation, the toroidal cavity **38** initially would be filled with whatever medium is to be pumped, which, in this case, is preferably air. Rotation of pulley **16** in FIGURE 1 by any suitable means, such as by a fan belt connected to the crankshaft of an internal combustion engine, for example, drives rotor shell **20** and blades **40** in a clockwise direction, for example out of the plane of FIGURE 1. The movement of the air by blades **40** creates a suction at the inlet **46** and induces a flow of air into the toroidal cavity.

Because of the rotation and direction of inclination of blades **40**, the air is thrown forwardly and outwardly by centrifugal force from the roots to the tips of the blades and into the stator cavity **36**. The dish-like cross-sectional shape of the stator wall then guides the fluid back into the rotor blade cavities where it has additional energy imparted to it by the blades. The repeated resultant forward ejection and return of the air establishes a helical spiral motion to the fluid during its circumferential progression around the toroidal cavity. The fluid velocity thus progressively increases, and as it approaches outlet ports **48**, the fluid is flowing in a helical spiral path. Since the discharge begins upstream of block seal **44**, and the axis of each discharge passage **52** is substantially tangent to the direction of movement of the fluid at this point, the fluid is discharged efficiently into manifold **56**.

If the fluid pump described is to be used in connection with an automotive vehicle for providing secondary air for antismog control purposes, for example, a point is reached at higher speeds when a further increase in the volume and pressure of air is no longer necessary; any further increase, therefore, merely results in a horsepower loss and a decrease in the efficiency of the engine.

With the construction as described in connection with FIGURE 1, when the pump pressure in cavity **38** reaches a value sufficient to overcome the force of spring **28**, the stator shell **26** will move to the right and provide a clearance between the rotor and stator. This interrupts the flow pattern of the air, permits bleeding off of the air, with a resultant decrease in the output of the pump. The movement, of course, would be controlled so as to maintain a desired output at the desired speed levels of the pump.

FIGURES 9, 10 and 11 show an alternate manner of distributing the outlet ports. In these figures, two radially spaced shorter rows of circumferentially spaced ports **58** are provided instead of the single circumferentially longer row of spaced ports **48** of FIGURES 4 and 5. Also, the ports **58** are essentially circular and the connecting passages **60** (FIGURE 11) are of a substantially constant cross-sectional area. The remaining details, however, are essentially the same as described in connection with FIGURES 1–8.

The operation of the pump of FIGURES 9–11 is also substantially the same as that of the FIGURES 1–8 embodiment. The output pressure would be slightly lower, however, due to the lack of diffusion in passages **60**. It will be clear, however, that passages **60** could taper so as to gradually increase the cross-sectional area for a diffusion effect in the same manner as described in connection with FIGURES 4 and 5.

While the outlet ports have been shown as substantially elliptical in cross section in FIGURES 4 and 5, and circular in FIGURES 9 and 10, it will be clear that rectangular and other suitably shaped ports could be provided without departing from the scope of the invention.

From the foregoing, it will be seen that the invention provides a pump with a good volumetric efficiency by providing a plurality of circumferentially spaced discharge passages having longitudinal axes that are substantially tangent to the direction of motion of the discharging fluid, and that diffusion of the velocity energy to pressure can be achieved by the use of a discharge passage of in-

creasing cross-sectional area, and one wherein the passage length is several times the mean diameter of the passage.

While the invention has been illustrated in its preferred embodiments in the drawings, it will be clear to those skilled in the arts to which the invention pertains that many changes and modifications may be made thereto without departing from the scope of the invention.

I claim:

1. A fluid pump of the centrifugal type comprising axially aligned stator and rotor members in substantially contiguous relationship each having a semitoroidal-shaped fluid cavity defined therein, said cavities facing each other and together defining a single toroidal-shaped cavity for the flow of fluid therearound, said rotor member cavity having circumferentially spaced blades mounted therein and extending across the axial width thereof, said stator member cavity having a fluid inlet and a plurality of spaced fluid outlets and a fluid seal member blocking communication between and circumferentially separating said inlet from said outlets, said fluid outlets being circumferentially separated from each other and each connected to an outlet manifold common to all of said outlets for effecting the progressive and cumulative discharge of fluid into said manifold from progressively varying pressure zones of said cavity, whereby rotation of said rotor member effects an induction of fluid into said toroidal cavity and a propelling of the fluid circumferentially therearound in a swirl path from one member cavity to the other and return and out said plurality of outlets with low losses, said fluid outlets comprising radially spaced sets of circumferentially spaced openings whereby the harmonic vibrations that interfere with a smooth flow are materially reduced.

2. A fluid pump of the centrifugal type comprising axially aligned annular stationary and rotatable members in substantially contiguous relationship each having a semitoroidal-shaped fluid cavity defined therein, said cavities facing each other and together defining a single toroidal-shaped cavity for the flow of fluid therearound, said rotatable member cavity having circumferentially spaced blades mounted therein and extending across the axial width thereof, said stationary member cavity having a fluid inlet and a plurality of spaced fluid outlets and a fluid seal member blocking communication between and circumferentially separating said inlet from said outlets, said outlets being circumferentially separated from each other and each connected to an outlet manifold common to all of said outlets for effecting the progressive and cumulative discharge of fluid into said manifold from progressively varying pressure zones of said cavity, said outlets each consisting of a longitudinally extending passage gradually increasing in cross-sectional area in the direction of discharge of fluid therethrough to slowly diffuse the fluid and convert the velocity energy thereof to a pressure head, said passages also each having a longitudinal axis substantially tangent to the direction of the entering swirling fluid whereby rotation of said rotatable member effects an induction of fluid into said toroidal cavity and a centrifuging of the fluid circumferentially therearound in a helical-like swirl path from one member cavity to the other and return and out said outlets with a high volumetric efficiency.

3. A fluid pump as in claim 2, wherein said fluid plurality of outlets are equally spaced circumferentially from each other.

4. A fluid pump as in claim 2, wherein the entrance and exit portions of each of said fluid outlet passages are substantially elliptical in cross section.

5. A fluid pump as in claim 2, said fluid outlets each consisting of a longitudinally extending passage having a length that is a multiple greater than 1 of the mean diameter of said passage.

6. A fluid pump of the centrifugal type comprising axially aligned stator and rotor members in substantially contiguous relationship each having a semitoroidal-shaped fluid cavity defined therein, said cavities facing each other and together defining a single toroidal-shaped cavity for the flow of fluid therearound, said rotor member cavity having circumferentially spaced blades mounted therein and extending across the axial width thereof, said stator member cavity having a fluid inlet and a plurality of spaced fluid outlets and a fluid seal member blocking communication between and circumferentially separating said inlet from said outlets, said fluid outlets being circumferentially separated from each other and each connected to an outlet manifold common to all of said outlets for effecting the progressive and cumulative discharge of fluid into said manifold from progressively varying pressure zones of said cavity, whereby rotation of said rotor member effects an induction of fluid into said toroidal cavity and a propelling of the fluid circumferentially therearound in a swirl path from one member cavity to the other and return and out said plurality of outlets with low losses, said fluid outlets each comprising entrance and exit portions connected by a diffusion passage diverging towards said exit portion to convert the velocity energy of said fluid into a pressure head, said entrance and exit portions being substantially elliptical in cross-section.

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